Chassin's Operative Strategy *in* General Surgery

AN EXPOSITIVE ATLAS

FOURTH EDITION

Carol E.H. Scott-Conner

Springer

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Editor

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An Expositive Atlas

Fourth Edition

Illustrations by Caspar Henselmann

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To Harry, my helpmeet throughout all things.

Dr. Chassin's Foreword to the Third Edition

Eight years have passed since the publication of the second edition of this atlas. During that period, I retired from the practice of surgery and from the chairmanship of the Department of Surgery at the New York Hospital Medical Center of Queens, concluding an exciting and stimulating run of 34 years, the highlight of which was teaching several generations of residents the intellectual and technical details of surgery. A vital component of this program was the atlas *Operative Strategy in General Surgery*, the first edition of which was published in 1980. The success of this work was due in large part to the fact that it was based on my day-to-day learning and teaching in the operating room. Having retired from the operating room, I felt that I could not produce a quality, up-to-date product for the third edition of this work. Fortunately, we were able to recruit an outstanding surgeon-teacher to edit the third edition.

Dr. Carol Scott-Conner, whom I taught when she was a resident in 1980, has the intellect, teaching skills, and drive to have functioned as an author, surgeon, teacher, and Head of the Department of Surgery at the University of Iowa. In editing this volume, she has reviewed each chapter to make sure that the text and references are up to date. Although the previous editions were the work of a single author (me), it is a fact that surgery and medical science have advanced so rapidly that it is no longer feasible for a single author to write a comprehensive surgical text like this one. Consequently, 13 prominent surgeons have each contributed a chapter that reviews and analyzes recent advances in the fields of the contributor's special expertise. Eight new operations have been added, most of which are laparoscopic procedures. In addition, 77 operations from my last edition, having proven themselves worthy by the test of time, are included in this volume, together with the meticulous operating room illustrations by Caspar Henselmann. Many of these procedures are complex, such as esophagectomy, total colectomy with ileoanal pouch, and pancreatoduodenectomy. Special attention has been paid to emphasize in the drawings the detailed teaching points that will make these operations safe for the patient.

I hope that our combined efforts have produced an atlas that you will find useful.

New York, NY, USA — Jameson L. Chassin, MD

Dr. Spencer's Foreword to the First Edition

This surgical atlas should be of great value to all clinical surgeons, both those in training and those in surgical practice, and Dr. Chassin is superbly qualified to author this work. During more than three decades as a member of the faculty of the New York University School of Medicine, he has taught countless residents many aspects of the art of surgical technique. One measure of Dr. Chassin's unusual teaching ability is that he is both Professor of Clinical Surgery at New York University and Director of Surgery at Booth Memorial Hospital where our fourth-year surgical residents have rotated regularly for the past 12 years. Booth Memorial is the only hospital outside the New York University Medical Center to which New York University residents rotate. This simple fact well underlines Dr. Chassin's remarkable capability for teaching.

When a surgical complication develops after an operation, two or three possibilities should be considered. First, of course, was the diagnosis correct? If it was, then the cause of the complication is usually either an inadequate operative technique or a flawed concept underlying the selection of the operative procedure. When the surgical technique seems faultless, a postoperative complication would strongly indicate that the concept was erroneous, albeit cherished perhaps for decades.

Unlike any other atlas on operative technique, this book specifically discusses the conceptual basis of the operation as well as the strategy that will help the surgeon avoid common pitfalls. The operative technique is then described step by step.

I am confident that in the years ahead this atlas will be regarded as one of the major contributions to our literature of surgical technique.

New York, NY, USA Frank C. Spencer, MD

Preface

The year was 1979. I was a fourth-year surgical resident at New York University, sent for a 2-month rotation to the (then) Booth Memorial Medical Center. Many university programs have a similar rotation: residents are sent to an outlying affiliated hospital for a couple of months of intensive bread-and-butter surgery and an experience of what life is like in the real world of private practice. Jim Chassin, his associates Jim Turner and Kenny Rifkind, and the Booth Memorial residents welcomed me and shared their busy surgical practice with me. My notes from the time indicate I scrubbed on a wide variety of cases, many with Jim Chassin. The procedures were the very operations described in this text, and I hear his voice coaching me as I read his words.

Surgical staplers were just coming into common use that year. My university program had not yet adopted these devices, reasoning that residents need to learn how to suture before using staplers. Thus it was from Jim Chassin that I learned how to do a low anterior resection with a circular stapled anastomosis. He reinforced his instructions with copies of the typed manuscripts of the relevant chapters from a book he was writing, complete with rough sketches by his artist. When the first volume of the first edition of Chassin's *Operative Strategy in General Surgery* came out, I bought it and literally wore out my copy. The second volume followed in due course, and eventually a second edition. I recommended the book to untold numbers of residents.

It was thus with a sense of the circle coming around to full closure that I undertook the editorship of the third edition. Searching through my files, I found original manuscript copies with my handwritten notes from that 1979 rotation. Eleven years have now passed since that third edition was published. Significant new procedures and bright new authors have been recruited. New references have been added, and new illustrations created by Wieslawa Langenfeld and Wendy Vetter of Springer in the style set by Caspar Henselmann, the talented illustrator of the first three editions.

The purpose of this volume remains, as it was so eloquently stated by Frank C. Spencer, MD, in the Foreword to the First Edition, to serve "all clinical surgeons, both those in training and those in surgical practice" by "specifically discussing the conceptual basis of the operation as well as the strategy that will help the surgeon avoid common pitfalls … the operative technique is then described step by step." *No procedure has been deleted*. No surgeon who has relied on the third edition need keep a dog-eared copy of that volume out of concern that technical material has been cut. Think of this fourth edition as the edition for the continuing current awkward state of surgical evolution: where most, but not all, abdominal operations can be performed through laparoscopic approaches; where most, but not all, ulcers can be managed medically; where sentinel node biopsy is now standard of care in selected cases; and where most, but not all, subphrenic abscesses are drained percutaneously.

As an academic surgeon, I am struck by how frequently a resident will comment "I've never even seen one of these" when we embark upon certain formerly common operations, such as an open common bile duct exploration. For this new generation of surgeons, I've included all the procedures that were in the second and third editions. Those that are rarely used are labeled *Surgical Legacy Technique*, for that is what this book is—the legacy of a master surgeon: an extraordinary surgeon and a kind and gentle man I have been privileged to scrub with and to have as a friend. I hope that you will still hear his voice speaking through these pages.

This work could not have been completed without the wise counsel of Richard Hruska, my editor, and the skilled assistance of Margaret Burns, developmental editor. The library at the Marine Biological Laboratory in Woods Hole, Massachusetts, provided a refuge and quiet working space for me as it has for generations of scholars. Finally, my patients, students, residents, and coworkers continue to teach and inspire me.

Iowa City, Iowa, USA Carol E.H. Scott-Conner, MD, PhD

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Part I

General Principles

1 Concepts and Strategies of Surgery

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Developing a Concept

Successful surgery requires study, advance planning, clear thinking, and technical skill. Brilliant execution of the wrong operation at the wrong time can only lead to disaster. To achieve consistently good results for each surgical condition, the surgeon must develop a concept that combines analysis of the literature, study of the disordered physiology, and comprehension of the hypothesis underlying the contemplated operation.

To develop a concept properly, a surgeon must:

- *Know* the normal and pathologic physiology and anatomy.
- *Explore* the relative merits of alternative operations and treatment options.
- *Analyze* the operation selected for the problem at hand: Are there *valid data* to demonstrate that it can accomplish the desired goal? Is the mortality rate for the procedure such that the benefit outweighs the risk? Are there alternative treatments that may offer lower morbidity and potential mortality?
- *Reflect on personal experience* with complications and deaths following the operation selected. This information is more relevant than are the results that may be reported from some renowned medical center, where one surgeon may have developed expertise in a particular operation. Superior results under such circumstances obviously do not indicate that less-experienced surgeons are as successful. Participation in national databases such as NSQIP (the National Surgical Quality Improvement Project) (American College of Surgeons National Surgical Quality Improvement Program 2011) as well as efforts at your own hospital facilitate tracking results compared with national and local norms. The American Board of Surgery requires such activities as part of Maintenance of Certification (The American Board of Surgery 2011).
- *Review* postoperative complications and poor results. When a complication or a death occurs, analyze the case carefully and attempt to make an objective appraisal of what went wrong. Was there poor judgment regarding the choice of operation? Was the diagnosis inaccurate? Was the assessment of the risk incorrect? Was there an error of technique? Did the surgeon lack the technical expertise required to undertake the procedure?
- *Keep records* of mortality and morbidity for each operation. Frequent analysis of results increases the database of the surgeon's own experience. Knowledge the surgeon gains leads to self-renewal and improved performance: Without it the surgeon learns nothing from experience.
- *Persist* in a lifetime study of the published literature in basic science and clinical surgery. Only in this way could one become aware that the trauma of surgery induces the release of inflammatory mediators that make the patient feel weak and ill after surgery; that long abdominal incisions, large retractors, and rough surgical technique produce more mediators; and that gentle dissection and minimally invasive techniques with 5- or 10-mm incisions and "retraction" by 15 mmHg CO_2 reduce the mediator cascade and minimize postoperative pain and malaise. These scientific advances support the development of laparoscopic surgery.

Establishing Strategy

Establishing an *operative strategy*—advance planning of the technical steps of the operation—is vital to the safety and efficiency of complex surgical procedures. The operative

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strategy is what the surgeon ponders the night before the operation: What are the major steps of the procedure? How should it be modified for this particular case? Where are the potential pitfalls? How can they be avoided? In some ways, this exercise is similar to the visualization employed by highly skilled athletes. The thesis of this book is that by creating a strategy, the surgeon can reduce the incidence of operative misadventures and postoperative complications.

Anticipating and analyzing potential problems and danger points before an operation leads to success more surely than does frenzied activity in the operating room after the surgeon and patient are in deep trouble. Anticipation enhances the surgeon's capacity for prompt decision making in the operating room.

Making the Operation Easy

The main goal of any successful operative strategy is to make the operation easy. The main goal of this book is to show how to develop such strategy. Easy operations are safe operations. A prime requirement for making an operation simple is good exposure with excellent light. Strategy also means planning the sequence of an operation to expose vital structures clearly early during the dissection to avoid damaging them.

Even more important is to *do the easy steps of any operation first*. This practice often makes the next step easy. If the surgeon continues to do easy steps, there may never be any difficult steps with which to contend. Another aid to making an operation easy is for the surgeon to adopt the proper foot and body position for each surgical maneuver (see Chap. 2).

The reputation for being a rapid operator is highly prized by some surgeons. More important than speed, however, are accuracy and delicacy of technique, especially when good anesthesia and patient support technology are available. Nevertheless, time should not be wasted. A reduction in operating time is not achieved merely by performing rapid hand motions. An operation can be expedited without sacrificing safety only when thoughtful advance planning, anticipation, and alert recognition of anatomic landmarks are combined with efficiency of execution. Together, they eliminate wasted motion and wasted time.

The surgeon in difficulty should stop cutting and start thinking. Why is the step difficult? Poor exposure? Bad light? Bloody field? The good surgeon makes operations look easy because of good operative strategy, rarely needing to resort to spectacular maneuvers to extricate the patient from danger.

The surgeon in real trouble should call for help from a senior colleague. Situations such as hemorrhage from the vena cava or laceration of the common bile duct are best managed with the calming influence of an experienced consultant who is not burdened by the guilt and anxiety of having caused the complication.

The chapters that follow in Part I discuss in detail the general principles that underlie successful open and laparoscopic surgery. Subsequent sections work through the anatomic regions and operations that are the familiar terrain of the general surgeon. The "concepts" chapter introduces each section. The technical chapters that then follow deal with specific surgical procedures. No procedure, however, rarely used, has been omitted. These uncommon procedures are labeled "legacy" material. In each technical chapter, a discussion of the concept underlying the operation and the operative strategy precedes the description of each operative technique.

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2 Mechanical Basics of Operative Technique

Carol E.H. Scott-Conner and Jameson L. Chassin†

Rare is the novice who has the inborn talent to accomplish all the mechanical manipulations of surgery with no more thought or analysis than the natural athlete gives to hitting a ball. Most surgeons in training can gain much from analyzing such basics of surgery as foot position, hand and arm motion, and efficient use of instruments. This chapter describes the basics as applied to open surgery. Please see Chap. 9 for a similar discussion of laparoscopic mechanics. Ergonomics, a science devoted to maximizing efficiency, is increasingly being applied to the operating room environment. Sound ergonomic principles such as those described here help to diminish stress and the possibility of injury.

When considering the mechanics discussed here, remember that underlying all aspects of surgical technique are the fundamental principles articulated by Halsted, who emphasized that the surgeon must minimize trauma to tissues by using gentle technique. Halsted also stressed the importance of maintaining hemostasis and asepsis.

This text has been written from the vantage point of the right-handed surgeon. Left-handed surgeons face the decision of whether to learn to operate with the right hand or to operate left-handed. Finding a left-handed mentor is extremely helpful. The surgeon who operates with the left hand will need to reverse the instructions where appropriate.

Before You Scrub

Before you scrub, ensure that any relevant radiographs are up on the view screens in the operating room. Review the proposed operation with your team and make sure that all instruments, supplies, and equipment are available and in working order.

Verify that the patient is in the appropriate position and that extremities and bony prominences are properly secured and padded. Check the position of electrocardiograph leads, ground pad for electrocautery, and any other ancillary equipment to make certain that you have free access to the surgical field.

Position the lights. Most operations can be done with two operating lights. These work best when brought in at 45° angles from opposite sides to converge on the operative site. In the typical situation, the surgeon and first assistant will stand across the operating table from each other. The lights may converge from above and below, so that neither surgeon nor first assistant's head shadows the field. Make certain that the "elbows" of the lights are positioned to allow the lights to be maneuvered easily and that the light handles are within easy reach of the operative team. As the operation progresses, it is likely that the lights will be repositioned so that their illumination continues to converge in the operative field.

Preoperative Verification Process

Before surgery, the surgeon must mark the operative site in such a manner that the marks are visible after the patient is prepped and draped. After draping, the entire team should pause and hold a "time-out" to verify patient identity, laterality and site, and nature of the procedure to be performed (American Academy of Orthopaedic Surgeons and American Association of Orthopaedic Surgeons 2011). Be familiar with the protocol in use at your hospital and follow it carefully.

Importance of Surgeon's Foot and Body Position

A comfortable, relaxed stance enables the surgeon to spend hours at the operating table without back or neck strain and

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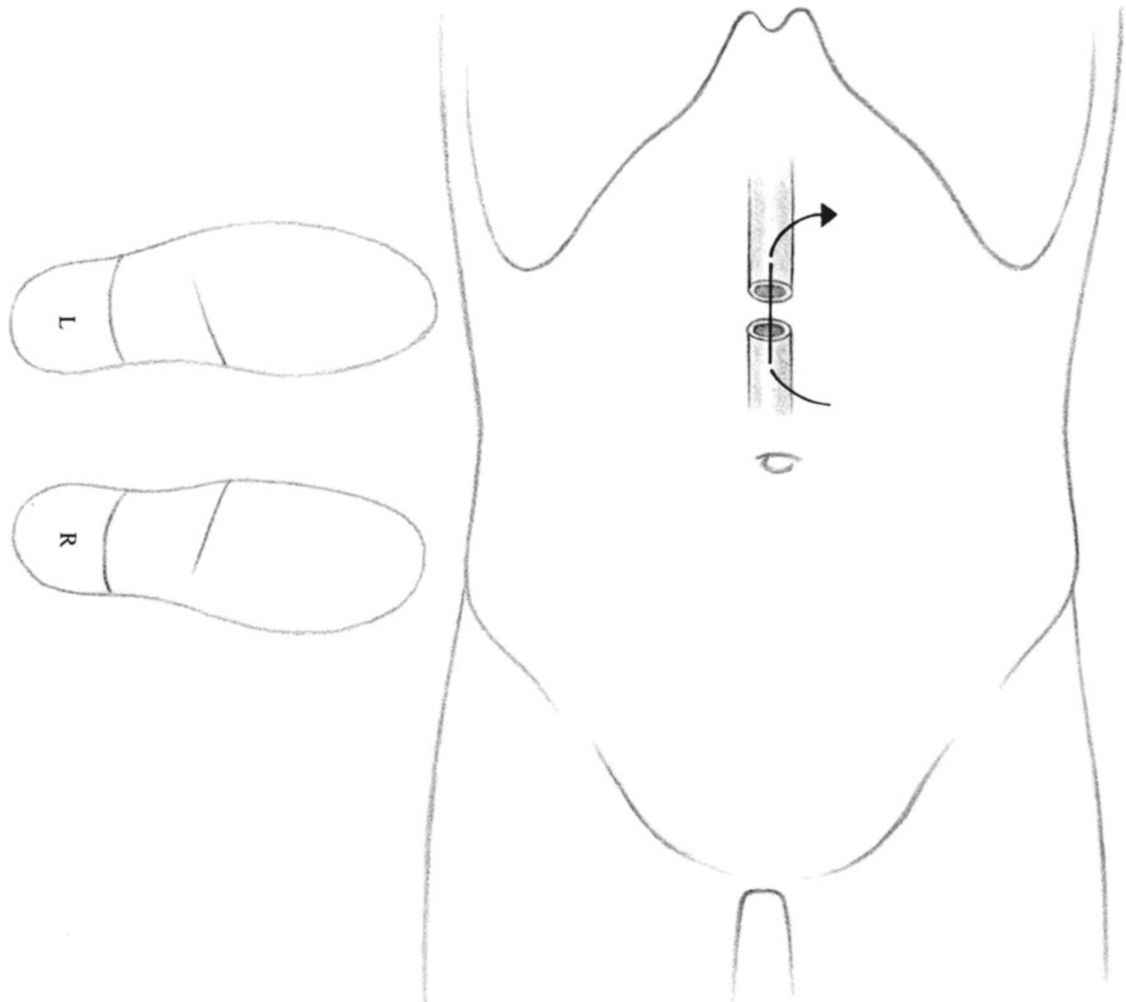

Fig. 2.1

the accompanying muscle tremors. It is particularly important to keep the shoulders and elbows relaxed. The novice surgeon commonly tenses and elevates the shoulders and elbows. A relaxed posture is facilitated by dropping the operating table a few inches. The tense posture is often accompanied by a tendency to hunch over the field, bringing the face close in a natural attempt to concentrate. This crouching posture makes it difficult for assistants to see, may cause shadows in the operative field, and in the extreme circumstance may even compromise sterility by allowing instruments to touch the surgeon's mask. Tension in the shoulders and forearms also makes it difficult to hold instruments steady and potentiates tremor.

When deciding which side of the operating table is the "surgeon's side," consider which side allows you to most easily use you right arm and hand to reach into the area of pathology. For every activity involving the use of hands and arms, there is a body stance that allows the greatest efficiency of execution. For example, the right-handed professional who uses a baseball bat, tennis racket, wood chisel, or golf club places the left foot forward and the right foot 30–50 cm to the rear; the right arm and hand motion are then directed toward the left foot.

It may help to stand at one side or the other of the table and imagine moving your right arm into the field of the pathology. This exercise will generally convince you that one side offers advantages over the other. When in doubt, stand facing the anticipated pathology.

Similarly, for the greatest efficiency when suturing, the surgeon assumes a body position such that the point of the needle is aimed toward the left foot. This is termed "forehand suturing." It allows the shoulder, arm, and wrist to occupy positions that are free of strain and permits the surgeon to perceive proprioceptive sensations as the needle moves through the tissues. Only in this way can the surgeon "feel" the depth of the suture bite. Combining

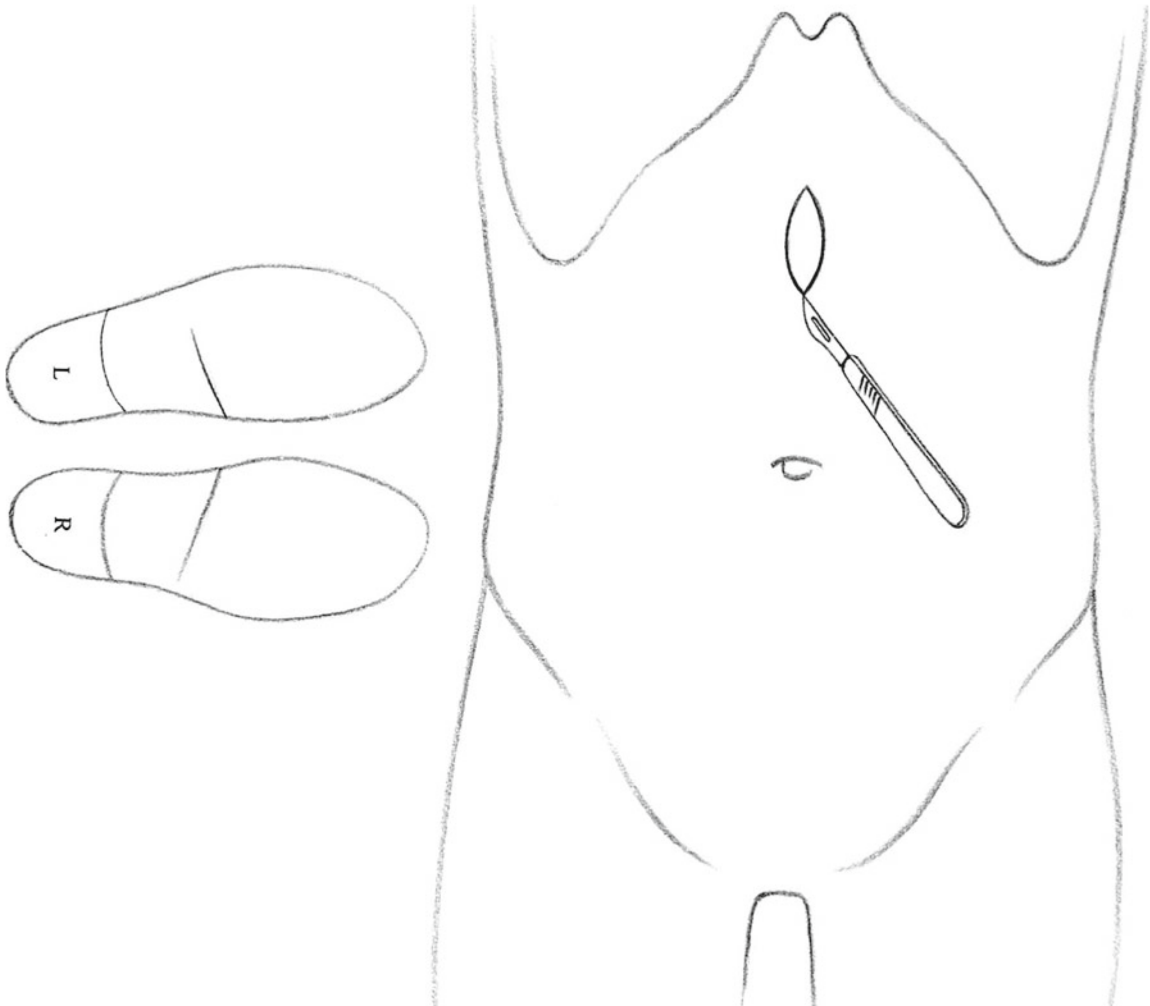

Fig. 2.2

this proprioceptive sense with visual monitoring of the depth of the needle bite is the best way to ensure consistency when suturing. Because accurate placement of sutures through the submucosa is one of the most important factors during construction of an intestinal anastomosis, the surgeon must make every effort to perfect this skill.

Forehand suturing maneuvers use the powerful biceps to move the hand from a pronated to a supinated position in a natural rolling motion. Backhand maneuvers require the surgeon to begin from a supinated position and roll backward to return to a pronated position. With practice this action becomes smooth but is not as easy or natural as forehand suturing. Whenever possible, establish your position relative to the field to allow forehand suturing. When placing a running suture, begin at the farthest aspect of the suture line and sew toward yourself.

Figure 2.1 illustrates the proper foot position of the surgeon inserting Lembert sutures during construction of an anastomosis situated at right angles to the long axis of the body. To insert sutures backhand, the needle is directed toward the surgeon's right foot. If only a few backhand sutures are needed, it is not necessary to change position. If an entire row of sutures requires backhand suturing, however, consider reversing your position relative to the surgical field so the row may be placed in the more natural forehand manner.

Some maneuvers require a backhand motion. For instance, cutting by scalpel is properly performed with a backhand motion directed toward the surgeon's right foot (Fig. 2.2). Similarly, when electrocautery is used as a cutting instrument, it is commonly drawn toward the right foot in a manner analogous to using a scalpel. In contrast, when using scissors the point of the scissors should be

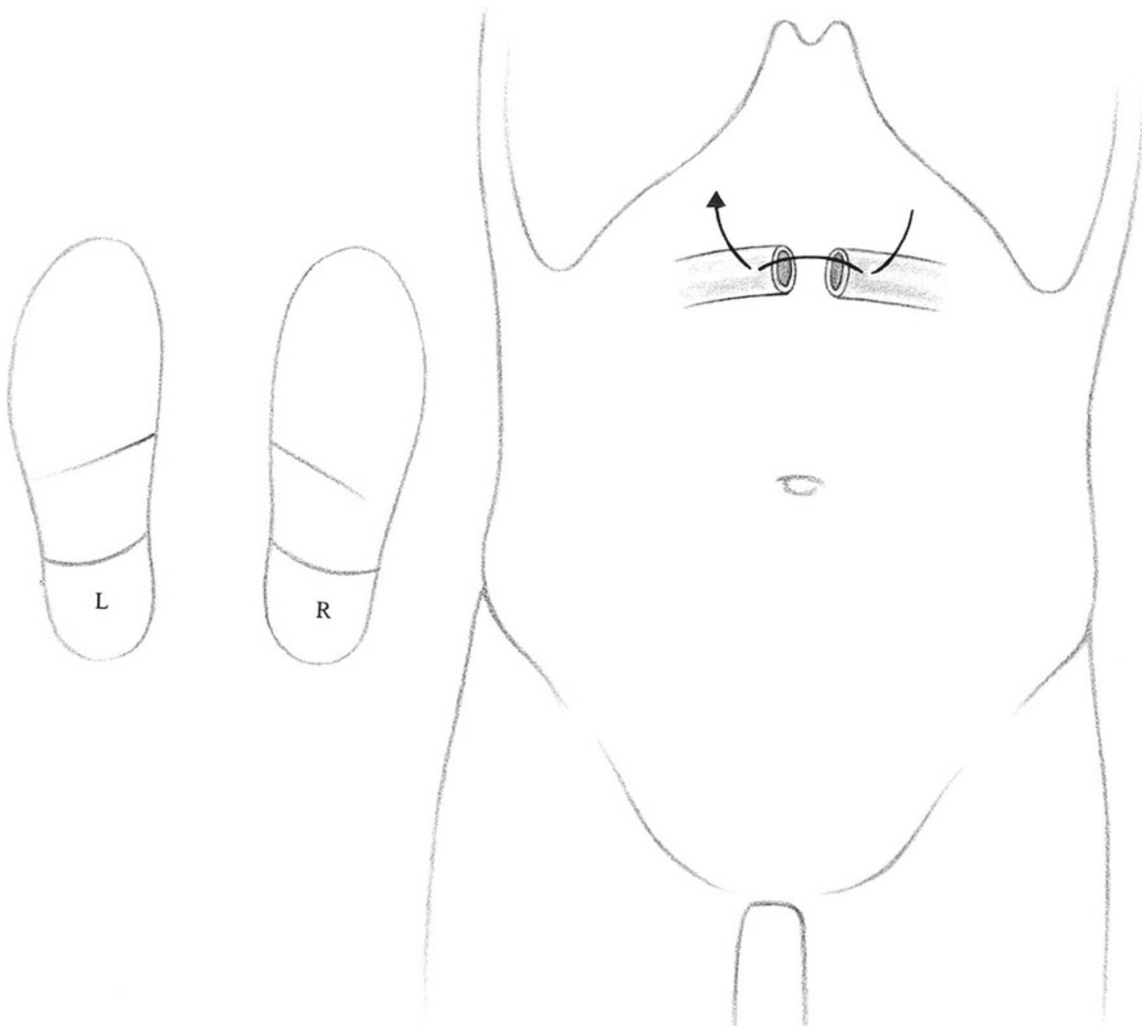

Fig. 2.3

directed toward the surgeon's *left* foot. The proper foot position for inserting Lembert sutures in an anastomosis oriented in a line parallel to the long axis of the body is shown in Fig. 2.3.

Some surgeons do not have a highly developed proprioceptive sense when they use the backhand suture. Therefore, whenever feasible they should avoid this maneuver for seromuscular suturing, which is almost always possible if the surgeon rearranges the direction of the anastomosis or assumes a body stance that permits optimal forehand suturing. This is sometimes termed "reversing the field." Consider reversing the field when-

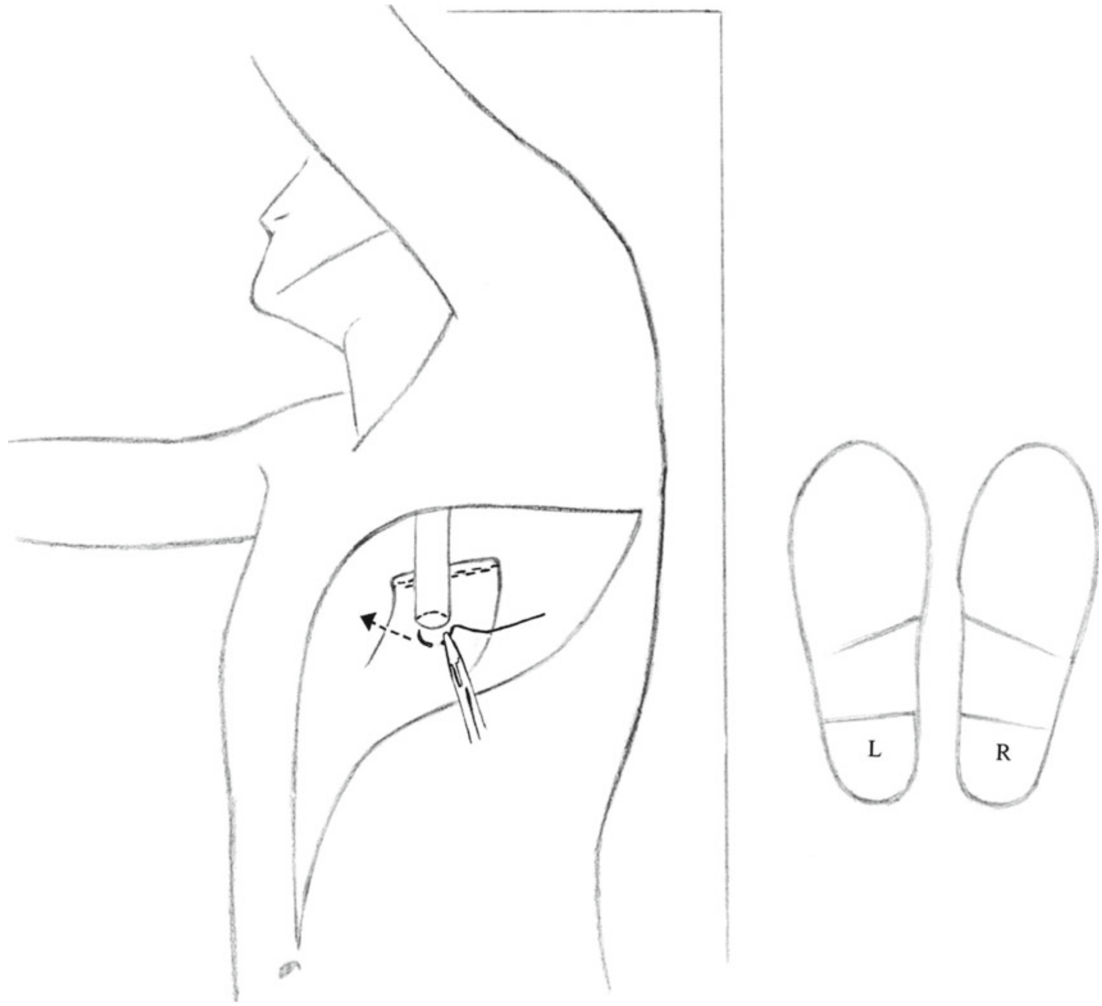

Fig. 2.4

ever you find yourself in a mechanically awkward situation.

The method of changing body position so all sutures can be placed with a forehand motion is illustrated in Fig. 2.4, which shows Cushing sutures being inserted into an esophagogastric anastomosis, with the surgeon standing on the left side of the patient. When the needle is passed through the gastric wall from the patient's left to right, the surgeon's left foot is planted close to the operating table along the *left* side of the patient's abdomen. The surgeon's right foot is placed more laterally. When the suture is passed from the patient's right to left, on the posterior aspect of the esophageal wall, the surgeon's right foot is placed alongside the operating table. The surgeon's

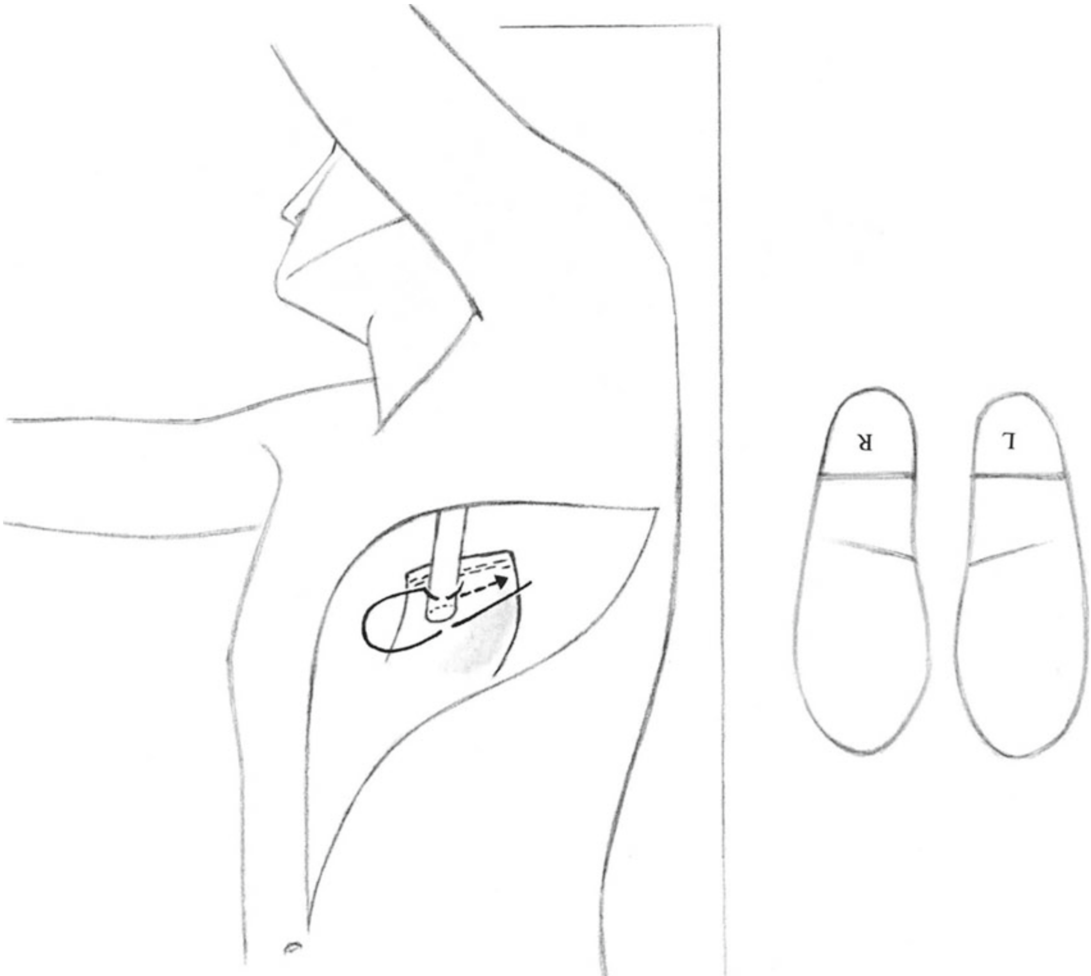

Fig. 2.5

body faces the patient's feet, and the surgeon's left foot is somewhat lateral to the right foot (Fig. 2.5). This positioning directs the point of the needle toward the surgeon's left foot at all times.

A similar change in body stance is illustrated in Figs. 2.6 and 2.7, where Cushing sutures are being inserted into a low-lying colorectal anastomosis. Of course, if the surgeon chose to use the Lembert-type suture for an esophagogastrostomy

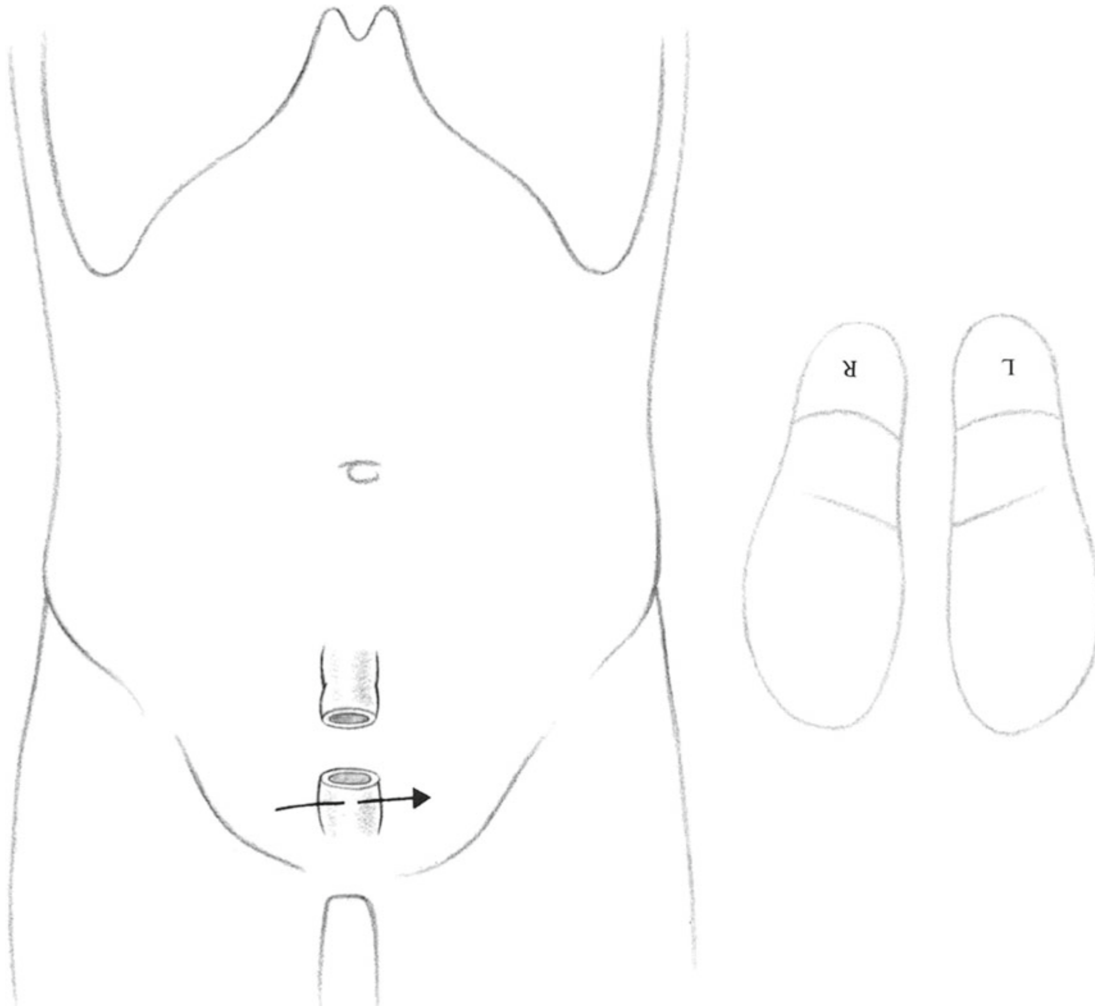

Fig. 2.6

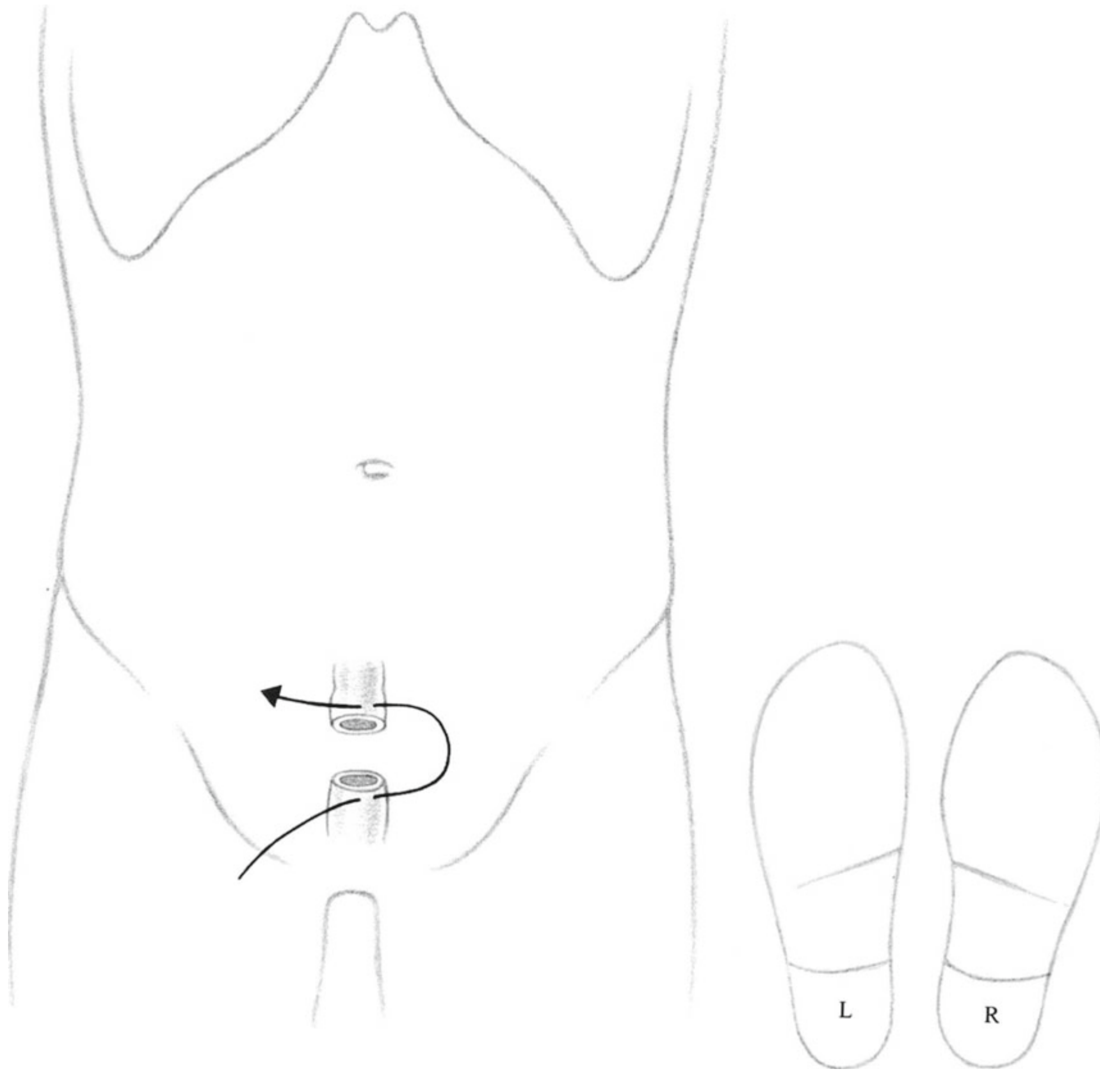

Fig. 2.7

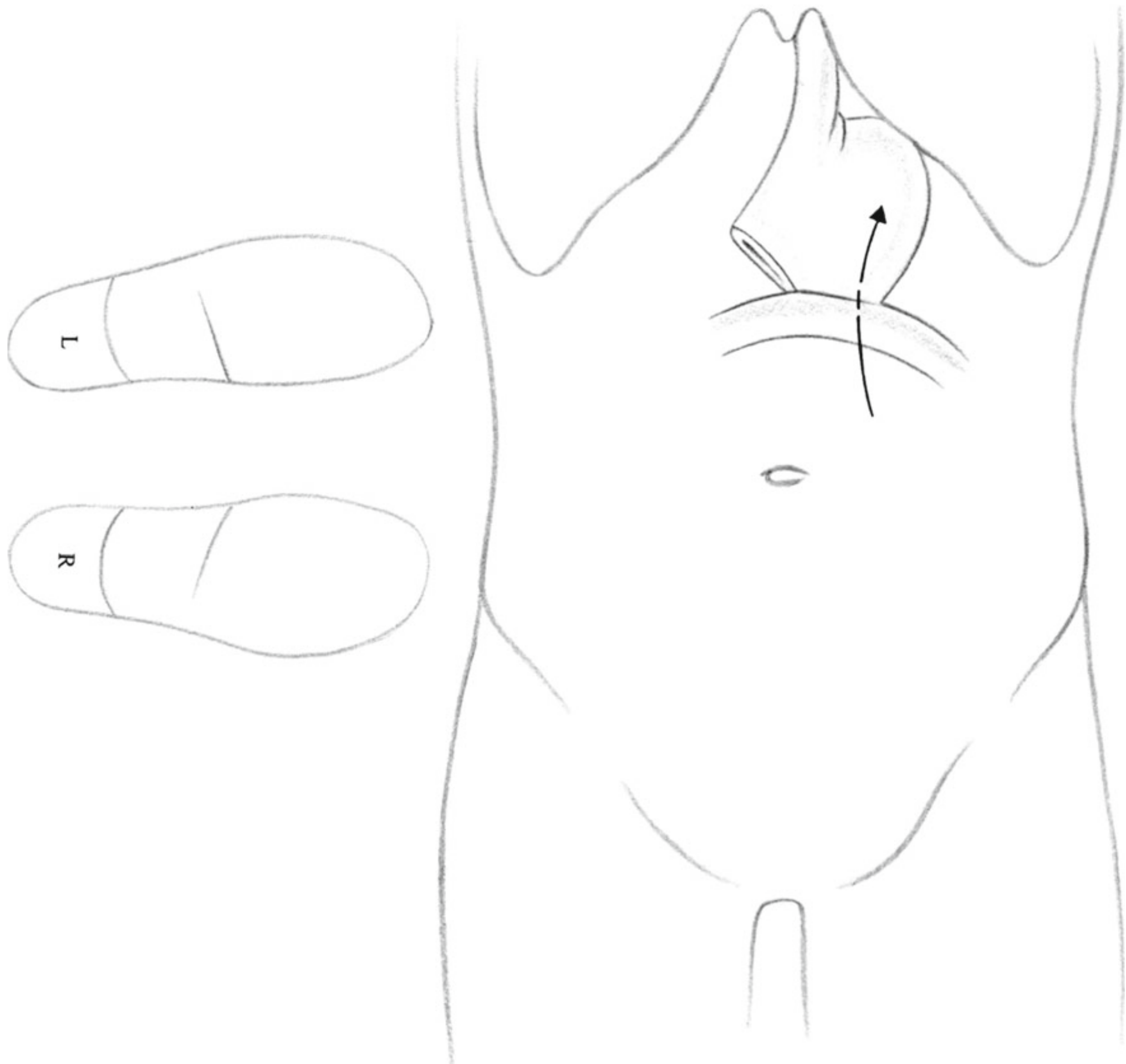

Fig. 2.8

or a coloproctostomy, a single stance would be efficient for the entire anastomosis.

Figures 2.8 and 2.9 illustrate insertion of Lembert sutures for the final layer of a gastrojejunal anastomosis, showing the foot position of the surgeon who is standing on the patient's right side, compared with a position on the patient's left side.

Figure 2.10 illustrates closure of an upper vertical midline abdominal incision. Figure 2.11 shows a lower midline incision with the surgeon standing at the patient's right side.

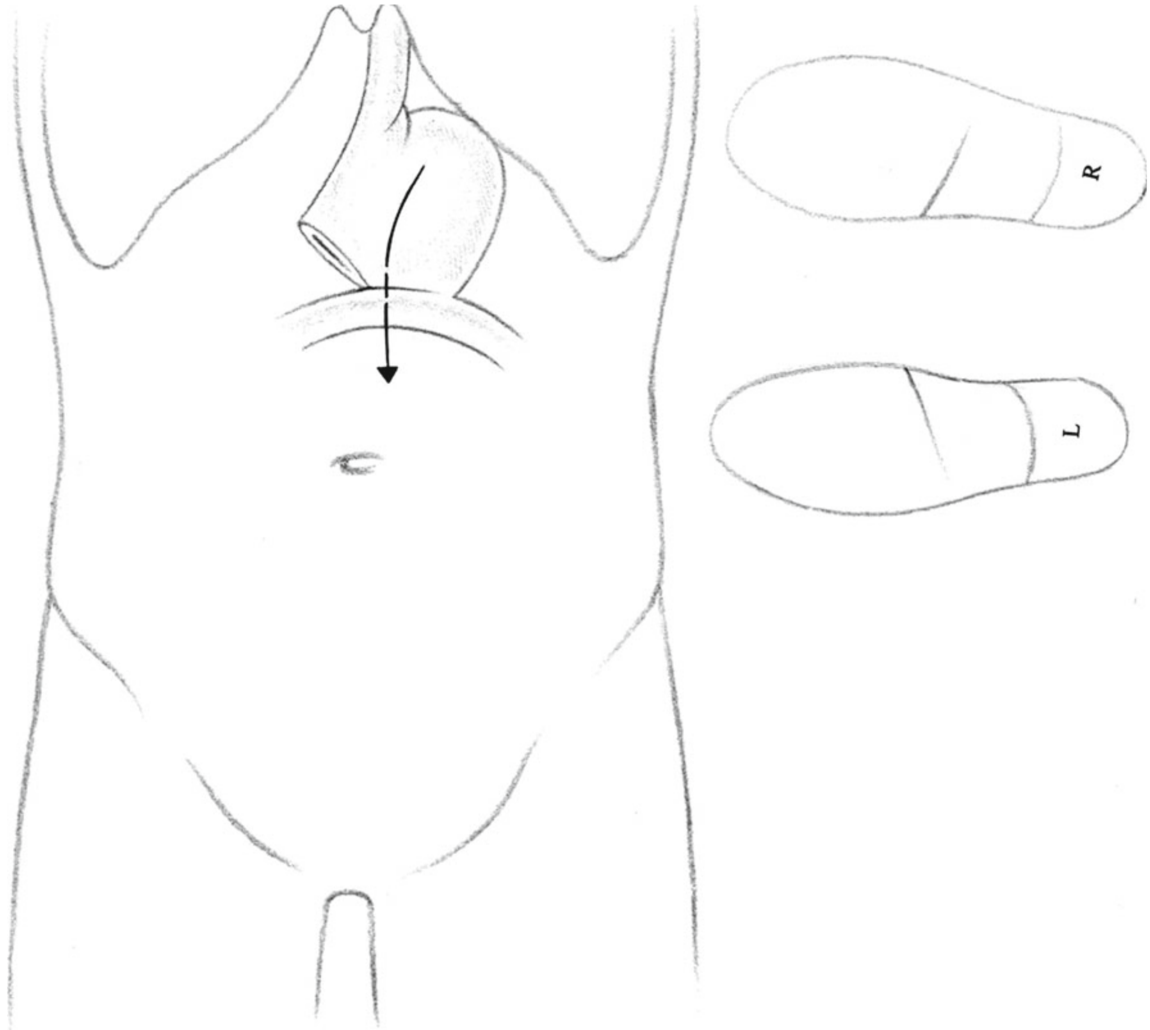

Fig. 2.9

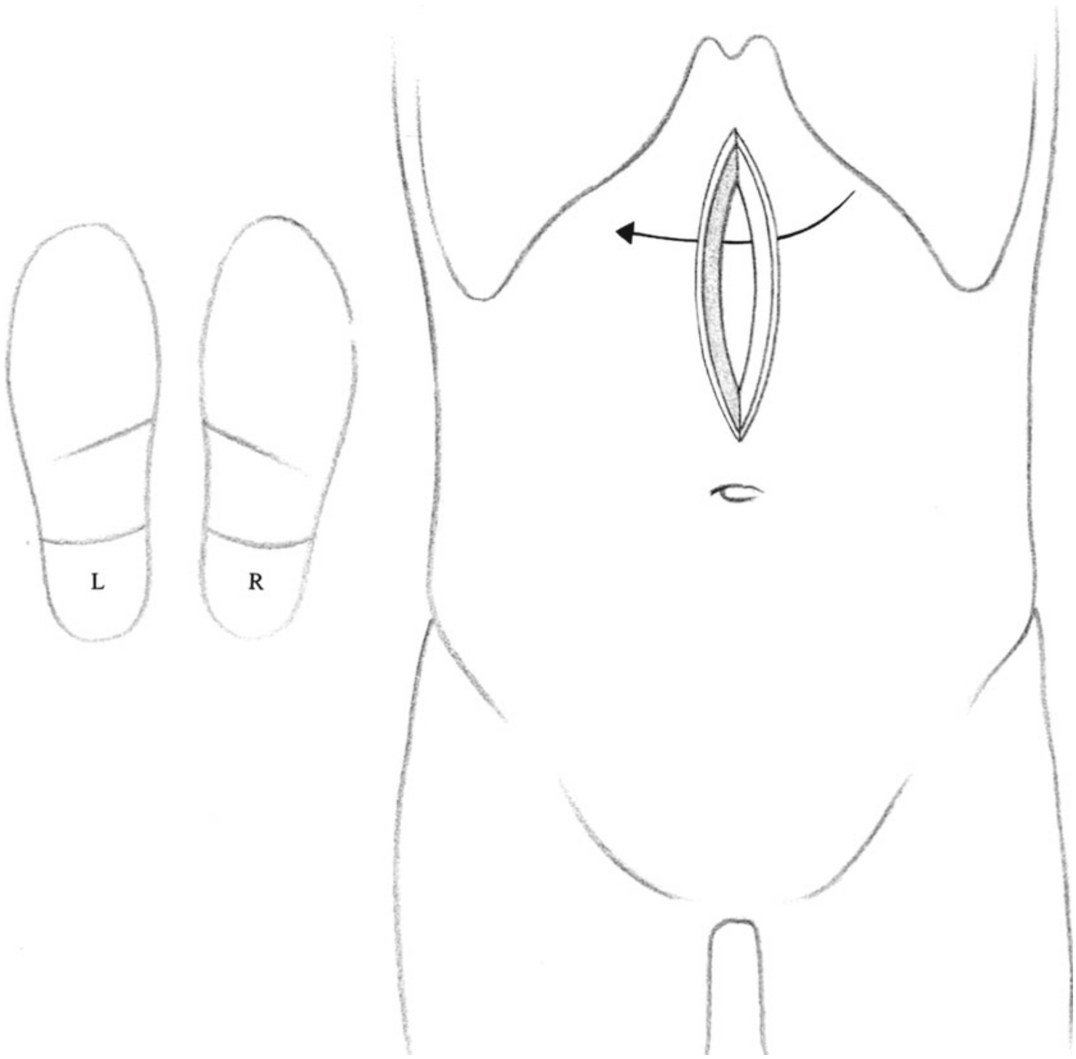

Fig. 2.10

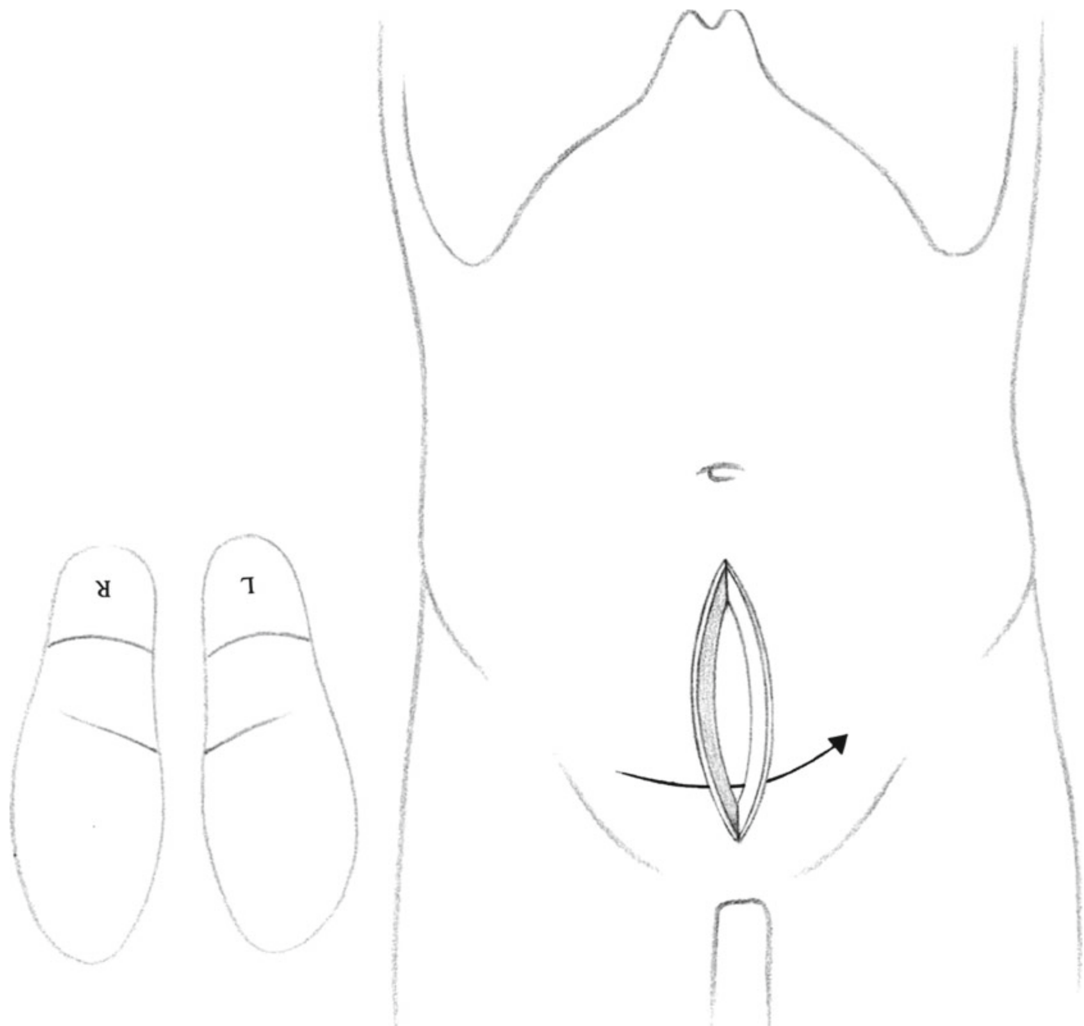

Fig. 2.11

Although it is true that some surgeons are able to accomplish effective suturing despite awkward or strained body and hand positions, it must be emphasized that during surgery, as in athletics, good form is an essential ingredient for producing consistently superior performance.

Use of Instruments

Learn the names of the instruments that you will be using. Chapter 11 provides an illustrated glossary of some common instruments. Recognize that common terminology may differ, and it is not rare for an instrument to go by one name in one hospital and another in a different hospital (particularly in another geographical region).

With rare exceptions, all surgical instruments used for soft tissue dissection should be held with fingertip pressure rather than in a tight, vise-like grip. A loose grip is essential if the surgeon is to perceive proprioceptive sensations as the instrument is applied to the tissue. A relaxed grip also helps avoid fatigue, which contributes to muscle tremors. This requirement applies whether the instrument used is a scalpel, forceps, needle holder, or scissors.

Scalpel

When making the initial scalpel incision in the skin, the surgeon can minimize tissue trauma by using a bold stroke through the skin and subcutaneous fat. It requires a firm grip. In most other situations, however, the scalpel should be held gently between the thumb on one side of the handle and the other fingers on the opposite side. Long, deliberate strokes with the scalpel are preferred. Generally, cutting is best done with the belly of the scalpel blade, as it enables the surgeon to control the depth of the incision by feel as well as by vision. The scalpel is a particularly effective instrument when broad surface areas are to be dissected, as during radical mastectomy or inguinal lymphadenectomy.

In such situations as an attempt to define the fascial ring surrounding an incisional hernia, the surgeon can clear overlying adherent fat rapidly from broad areas of fascia using a scalpel. The efficiency of knife dissection is greatly enhanced when the tissues being incised are kept in a state of tension, which can be brought about by traction between the surgeon's left hand and countertraction by the first assistant.

The surgeon must always be alert to the nuances of anatomy revealed by each scalpel stroke, especially if a structure appears in an unexpected location. This is not possible if the surgeon is in the habit of making rapid, choppy strokes with the scalpel, like a woodpecker. Rapid, frenzied motions do not afford sufficient time for the surgeon's brain to register and analyze the observations made during the dissection. Nor do they allow sufficient time for feedback to control the hand motions. Slow, definitive, long sweeping strokes with the scalpel make the most rapid progress and yet allow enough time to permit activation of cerebral control mechanisms and prevent unnecessary damage.

Metzenbaum Scissors

The round-tipped Metzenbaum scissors are valuable because they serve a number of essential functions. Closed, they are an excellent tool for dissection. They may be inserted behind adhesions or ligaments to elevate and delineate planes of dissection before dividing them. Properly held, with the fourth finger and thumb in the two rings and the index finger and middle finger extended along the handle, this instrument serves as an extension of the hand when detecting sensations and provides the surgeon with information concerning the density, pliability, and thickness of the tissue being dissected. As with other instruments, this proprioceptive function is enhanced if the hand grasps the instrument gently.

Electrocautery as a Cutting Device

Some surgeons prefer to use electrocautery, set for the "cutting" current, for such maneuvers as elevating skin flaps during mastectomy or incising subcutaneous fat. Transecting fat with a cutting current makes hemostasis only partially effective but minimizes tissue trauma. If the current is set for "coagulation," considerable heat may be generated, causing the fat to boil. Excessive tissue trauma contributes to postoperative wound infection.

On the other hand, transection of muscle bellies (e.g., during a subcostal or thoracic incision) may be accomplished efficiently when the electrocautery is set for "coagulation" or "blend" current. This setting provides good hemostasis and appears not to injure the patient significantly. Occasionally, the peritoneum and ligaments in the paracolic gutters are somewhat vascular secondary to inflammation. Electrocautery can be used here to divide these normally "avascular" structures.

In many areas, such as the neck, breast, and abdominal wall, it is feasible to cut with electrocautery, now set for "cutting," without causing excessive bleeding. To divide a small blood vessel, change the switch from "cutting" to "coagulation" and occlude the isolated blood vessel by electrocautery. Carefully performed, this sequence of dissection seems not to be damaging. If the incidence of wound infections, hematoma, or local edema is increased using this technique, the surgeon is overcoagulating the tissues and not isolating the blood vessels effectively.

Forceps

Care must be taken to avoid unnecessary trauma when applying forceps to body tissues. As with other instruments, hold the forceps gently. It is surprising how little force need be applied when holding the bowel with forceps while inserting a suture. If the imprint of the forceps appears on the wall of the bowel after the forceps have been removed, it is a clear warning that excessive force was applied when grasping the tissue.

With the goal of avoiding unnecessary trauma, when selecting forceps recognize immediately that "smooth" and "mouse-toothed" forceps are contraindicated when handling delicate tissue. Applied to the bowel, smooth forceps require excessive compression to avoid slipping. In this situation, Debakey-type forceps do not require excessive compression to prevent tissue from slipping from the forceps' jaws. For more delicate dissection, the Brown-Adson-type forceps are even more suitable. This instrument contains many tiny interdigitating teeth, which allow the surgeon to hold delicate tissues with minimal force.

Needle Holder

Match the size and weight of the needle holder to the size of the needle and suture. For example, do not use a delicate needle holder to manipulate the heavy needle and suture used for fascial closure. Similarly, a heavy needle holder is too cumbersome to allow accurate suturing of bowel or blood vessels. Ideally, needle holders are paired so the scrub assistant is loading one with a suture while the surgeon is suturing.

It should be obvious that a curved needle must be inserted with a circular motion to avoid a tear at the site of the needle's point of entry into the tissue. It requires a rotatory motion of the surgeon's wrist, which in turn is aided by proper body stance and relaxed shoulder and elbow positions. Stability is enhanced if the elbow can be kept close to the body. Many novices tend to ignore the need for this rotatory wrist motion, especially when the suture line is in a poorly accessible anatomic location. They tend to insert a curved needle with a purely horizontal motion of the needle holder, causing a small laceration at the entrance hole.

Using the same hand grip throughout the suturing sequence enhances the surgeon's capacity to detect proprioceptive impulses from the needle holder. It is difficult to sense the depth of the needle bite accurately if the surgeon's fingers are sometimes in the rings of the instrument's handle and at other times are not. For gastrointestinal suturing, where proprioception is of great importance, we prefer a grip with the thumb in one ring and the ring finger in the other, steadying the handle with the extended index and middle fingers.

With practice, a delicate needle holder may be palmed, that is, manipulated, opened, and closed without placing the thumb or ring finger through the rings. It requires facility and practice and should not be attempted by the novice, who is apt to find it necessary to put the thumb and finger into the rings to open and close the needle holder after palming the needle holder to place the stitch. This sequence is awkward, increases tissue trauma, and significantly slows suture placement.

Although most suturing is accomplished using a needle holder with a straight shaft, some situations require a needle holder whose shaft is angled or curved (e.g., for low colorectal and some esophagogastric anastomoses). In both instances, inserting the suture with a smooth rotatory motion may not be possible unless a curved needle holder such as the Stratte or Finochietto is used.

Hemostat

Ideally, a hemostat is applied to a vessel just behind the point of bleeding, and the bite of tissue is no larger than the diameter of the vessel. Obtaining hemostasis may *seem* to take less time if large bites of tissue are grasped by large hemostats than if small, accurate bites are taken. On the other hand, with small bites *many* bleeding points can be rapidly controlled by electrocautery rather than ligature, a technique that is especially helpful during such operations as those for radical mastectomy.

The choice between straight- and curve-tipped hemostats is a matter of personal preference, as either may be applied with equal accuracy. Curve-tipped hemostats make it somewhat easier to bring a ligature around the back and tip of the clamp for tying. The manner in which the curved hemostat is applied differs depending on whether the vessel is to be cauterized or tied. The hemostat should be applied points down and then lifted clear of all adjacent tissue to cauterize the vessel. It should be applied points up if the vessel is to be tied.

Whenever possible, small Halsted or Crile hemostats should be employed. For deeper vessels (e.g., the cystic artery), Adson clamps provide more handle length combined with delicate jaws. Hemostats vary in the length of the serrated segment. Some are fully serrated, whereas others are serrated only at the distal portion. Only the serrated portion of the clamp grasps tissue.

Occasionally it is more efficient to use a single, large Kelly hemostat to grasp a large pedicle containing a number of vascular branches than to cause additional bleeding by dissecting each small branch away from the pedicle. An example is ligation of the left gastric artery-coronary vein pedicle along the lesser curvature of the stomach during gastric resection. A right-angled Mixter clamp is useful for obtaining hemostasis in the thoracic cavity and when dividing the vascular tissue around the lower rectum during the course of anterior resection.

In all cases, the preferred hand grip for holding hemostats is identical with that for holding the needle holder and scissors. When the hemostat has a curved tip, the instrument should be held so the tip curves in the same direction in which the surgeon's fingers flex.

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Incision, Exposure, Closure

3

Carol E.H. Scott-Conner and Jameson L. Chassin†

Achieving Exposure

Many dangerous surgical mishaps occur because the operative exposure is inadequate. The *first step* toward obtaining good exposure is to make a well-planned incision of sufficient length. The *second step* during abdominal surgery is to pack the intestines away from the area of operation. If a dissection requires exposure of a large portion of the abdominal cavity, such as for left hemicolectomy or excision of an abdominal aortic aneurysm, it may be necessary to exteriorize the small intestine for the duration of the dissection. The *third step* is retraction of the wound edges.

Retraction of the wound edges may be accomplished by simple retractors, such as the handheld Richardson (see Chap. 11 for illustrations of various retractors and other instruments), or by fixed retractors, such as the simple Balfour or the more complex but adaptable Omni-track.

In the initial exploration phase of an operation, simple retractors are extremely useful because they can rapidly be moved as needed to explore various quadrants of the abdomen and identify the extent of the pathology. Richardson retractors are used to retract the skin, subcutaneous fat, and musculofascial layers of the abdominal wall. Harrington or heart-shaped retractors may be used to gently retract and expose deeper structures.

Once the extent of pathology has been determined, there are advantages to using a fixed retractor. For small abdominal incisions where simple retraction of the abdominal wall is all that is required, a Balfour retractor may suffice. Place moist laparotomy pads under the blades to help minimize tissue trauma and to avoid slippage of the blades. For thoracotomy and thoracoabdominal incisions, a Finochietto retractor is excellent for separating the ribs.

More complex fixed retractors are anchored in some way to the operating table and thus provide very constant exposure. These vary from the simple "chain" retractor to fancy systems such as the Omni. The "*chain*" *retractor* (Fig. 3.1) is an inexpensive improvisation that permits insertion of a retractor blade underneath the lower end of the sternum or underneath either costal margin. It may seem primitive in comparison with modern systems but can be adapted to the humblest operating room in the most difficult circumstances and remote locations. The retractor (the third blade of a Balfour-type system works well) is attached to an ordinary link chain, which can be purchased in a hardware store. The anesthesiologist attaches a curved steel post borrowed from the gynecologic lithotomy stirrup set to the side rail at the head of the operating table. When the post is adjusted to the proper height, the chain is fixed to a snap at the tip. By rotating the post in the proper direction, the lower end of the sternum and the thoracic cage can be retracted forcefully cephalad and anteriorly to elevate the sternum by as much as 8–10 cm.

This device is ideal for operations around the lower esophagus, such as hiatus hernia repair. It does not require purchase of new instruments other than 25–30 cm of chain. It may be installed when necessary without preparation, even during an operation. It is also helpful for liberating the splenic flexure of the colon. Here the device is placed on the left side of the operating table, and the retractor is positioned to draw the left costal margin to the left, cephalad, and anteriorly, significantly improving exposure. Whenever exposure for operations on the biliary tract is difficult, applying the "chain" retractor to the right costal margin can be of benefit.

A slightly more complex retractor that attaches to the operating table to improve upper abdominal exposure is the *upper hand retractor* (Fig. 3.2). This device is a steel bridge

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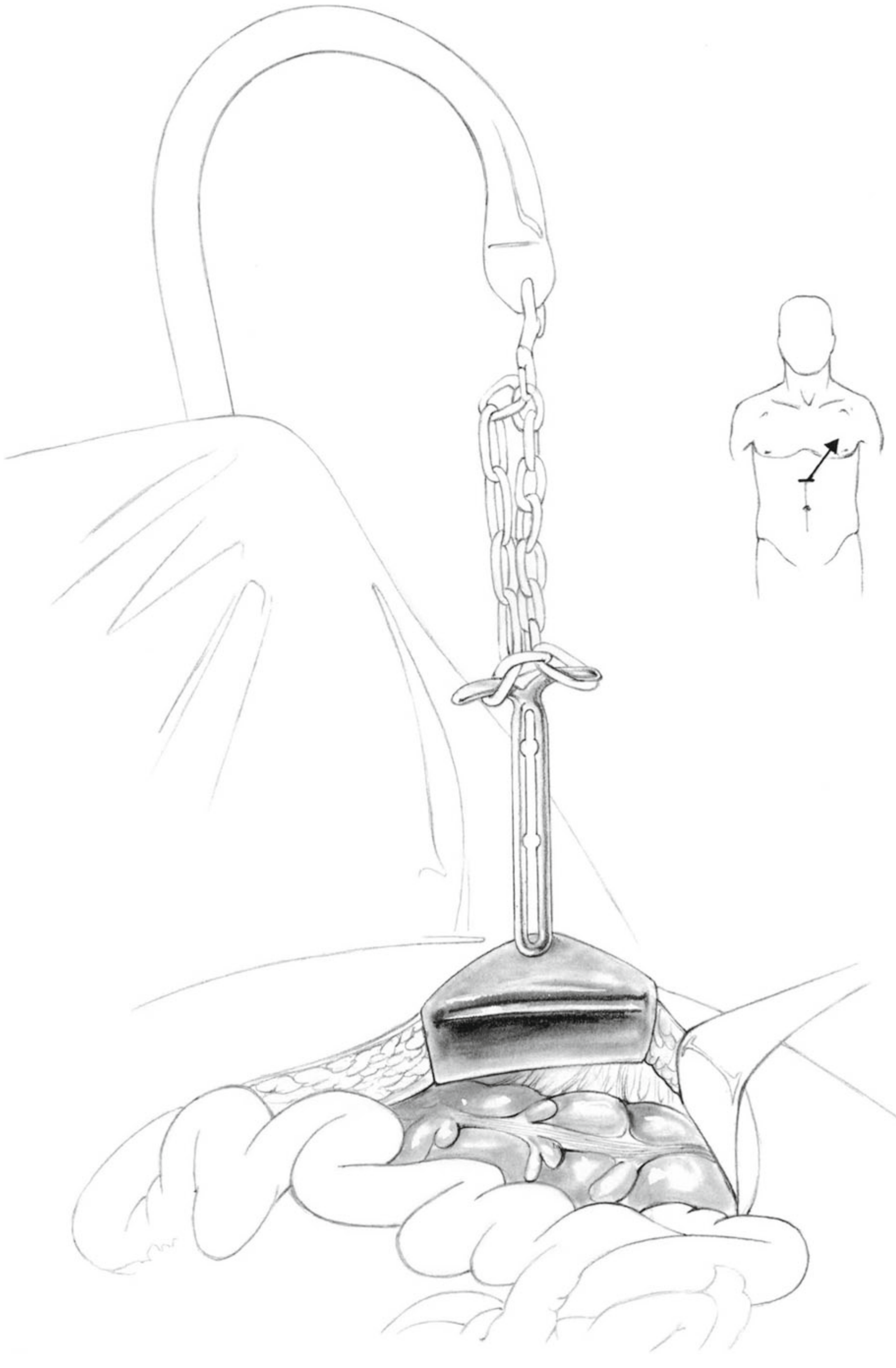

Fig. 3.1

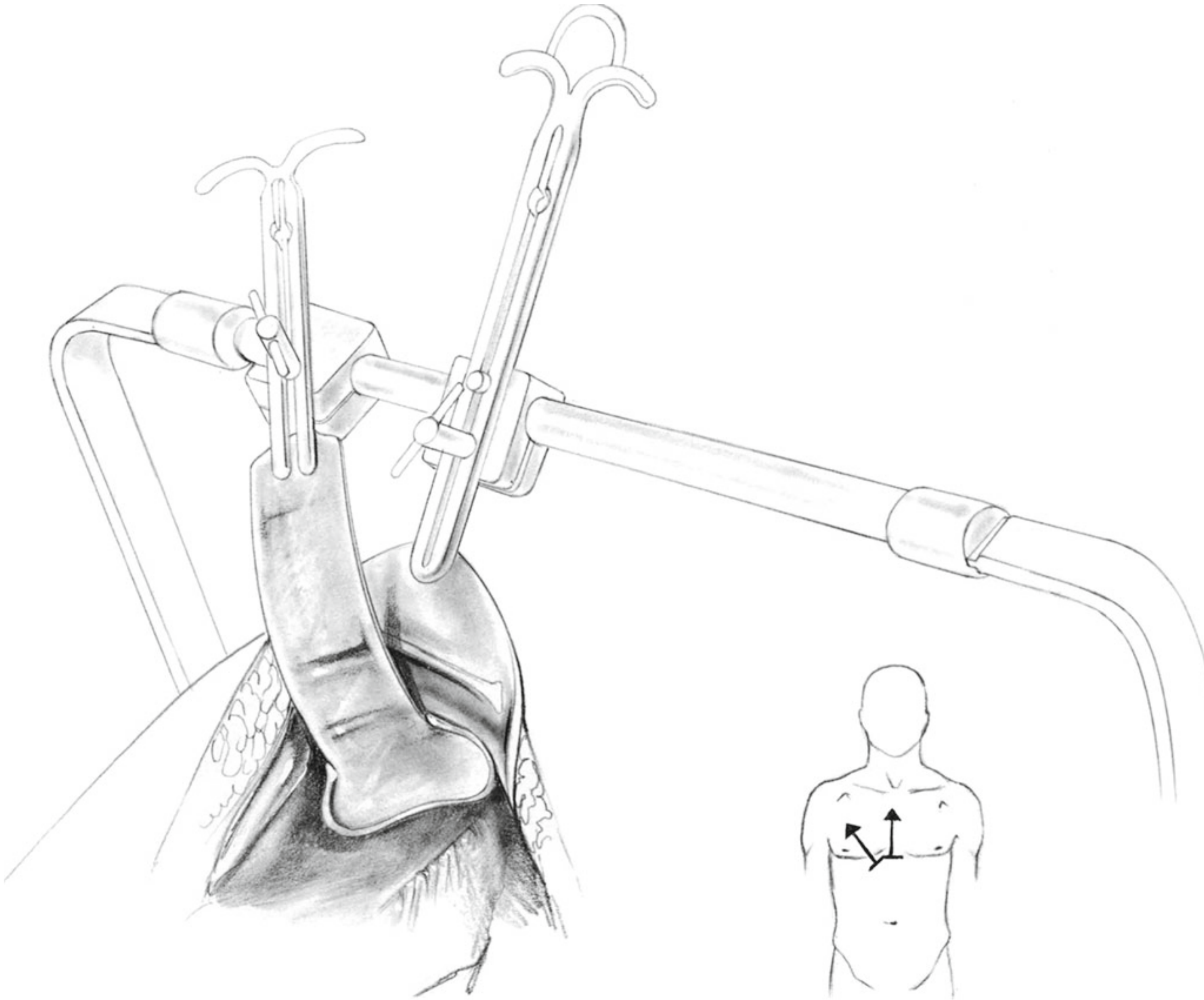

Fig. 3.2

that is attached to both sides of the operating table and passes across the patient at the midsternal level. Its height is set at 4–10 cm above the sternum, depending on the type of retraction desired. Two retractor blades can be attached to the steel bridge, one of which may be used to elevate the lower sternum in a manner similar to the "chain" retractor. A second blade may be attached to the bridge to retract the liver for biliary tract surgery; this method sometimes eliminates the need for a second assistant.

For most operations, a more complex system of self-retaining retractors such as the Thompson or Omni (see Chap. 11) is useful. This particular system chosen depends on personal preference and availability. These retractors attach to the operating table and have a large variety of components for retraction. These devices are more flexible during operation than is the upper hand retractor.

The primary aim of all fixed retractors is not to reduce the number of assistants in the operating room but to provide better and more stable exposure. One disadvantage of using a mechanical self-retaining retractor in the abdomen is that it may inflict trauma if intense pressure is exerted against the rectus muscles. This pressure can be lessened by using long incisions and padding the musculature with moist gauze pads. A second potential disadvantage when deep blades are used to retract intra-abdominal viscera is distortion of normal anatomy, which may make it difficult for the surgeon to identify vital structures. If the field is difficult to interpret, consider removing any fixed deep blades and reassessing the exposure.

Incisions for Abdominal Surgery

Although many surgeons have long believed that transverse incisions are stronger and have a lower incidence of dehiscence than midline incisions, this belief is false (see following section). Some think that the upper transverse incision interferes less with respiration than does the upper midline incision. Clinically, this does not appear to be important. A long, vertical *midline incision* gives excellent exposure for all parts of the abdomen. It also provides flexibility, as extensions in either direction are simple to execute. Reoperation for other pathology is simpler if the previous operation was performed through a midline incision rather than a paramedian incision. Finally, the midline incision creates minimal inferences with abdominal wall blood supply, facilitating subsequent creation of TRAM (transverse rectus abdominis) flaps for reconstructive breast and other surgery. Creation of ostomies is simpler because the surgical incision is not in proximity to the stoma.

Splenectomy, splenic flexure resection, hiatus hernia repair, vagotomy, pancreatectomy, and biliary tract surgery are easily done with the aid of the "chain" or more sophisticated retractors. Whenever exposure in the upper abdomen by this technique is inadequate, it is a simple matter to extend the midline incision via median sternotomy or into a right or left *thoracoabdominal approach*. Yet another advantage of midline incisions is the speed with which they can be opened and closed.

Despite these advantages, we often use a *subcostal approach* for open cholecystectomy because a short incision provides direct exposure of the gallbladder bed. If the gallbladder has already been removed and a secondary common duct exploration is necessary or a pancreaticoduodenectomy is contemplated, a midline incision extending 6–8 cm below the umbilicus provides excellent exposure and may be preferred.

When considering whether an upper midline incision or subcostal might provide better exposure, study the angle of your patient's ribs. If the patient has a narrow chest with a high xiphoid process (a rib cage like the high arches of a gothic church), an upper midline may be better. The thickset individual with a wide costal angle may do better with a subcostal incision.

For the usual appendectomy, the traditional *McBurney incision* affords reasonable exposure, a strong abdominal wall, and a good cosmetic result. It heals extremely well and hernias are rare. Accomplishing the same exposure with a vertical incision would require either a long midline or a paramedian incision or an incision along the lateral border of the rectus muscle, which might transect two intercostal nerves and produce some degree of abdominal weakness.

Avoiding Wound Dehiscence and Hernia

Wound dehiscence spans a spectrum from catastrophic evisceration through occult dehiscence. Major wound disruption is associated with significant postoperative mortality; and even minor degrees of occult dehiscence may result in a postoperative incisional hernia.

The major causes of wound disruption are as follows:

- Inadequate strength of suture material, resulting in breakage
- Suture material that dissolves before adequate healing has occurred (e.g., catgut)
- Knots becoming untied, especially with some monofilaments (e.g., nylon and Prolene)
- Sutures tearing through tissue

All these causes except the last are self-explanatory; suture tears are poorly understood by most surgeons. A stitch tears tissue if it is tied too tightly or encompasses too little tissue. Although it is true that in some patients there appears to be diminution in the strength of the tissue and its resistance to tearing, especially in the aged and extremely depleted individuals, this does not explain the fact that many wound disruptions occur in healthy patients. The sutures must hold throughout the initial phase of wound healing, which lasts several weeks and involves softening of the collagen around the wound edges. Recent randomized trials with careful follow-up have shown that the actual incidence of wound infection and hernia is much higher than previously suspected and there is still much to be learned about the best method of incisional closure.

When the incision is disrupted following an uncomplicated cholecystectomy in a healthy, middle aged patient with good muscular development, there must be a mechanical explanation. Often the surgeon has closed the wound with multiple small stitches of fine suture material. Under these circumstances, a healthy sneeze by a muscular individual tears the sutures out of the fascia and peritoneum because the muscle pull exceeds the combined suture-tissue strength.

If the problem, then, is to maintain tissue approximation during a sneeze or abdominal distension for a period of time sufficient for even the depleted patient to heal, what is the best technique to use? Adequate bits of tissue must be included in each suture; the sutures must be placed neither too close nor too far apart; and they must be tied securely in a manner that approximates but does not strangulate the tissue.

Unfortunately, there is as yet no consensus as to the best technique. Several points appear to have emerged from recent trials. First, a running suture of a heavy slowly absorbable material (such as PDS) appears to have advantages. Second, suture length to incision length should approximate 4:1.

Many surgeons believe that a patient who is at increased risk of wound dehiscence by virtue of malnutrition, chronic steroid therapy, or chronic obstructive pulmonary disease should have an abdominal incision closed with "retention sutures" that go through the skin and the entire abdominal wall. If retention sutures are used, they should be considered an adjunct to good closure rather than a substitute for it.

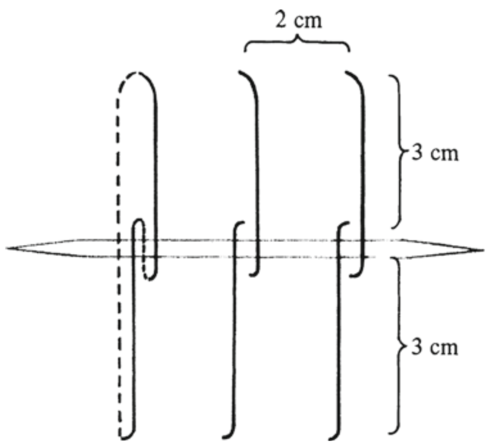

Fig. 3.3

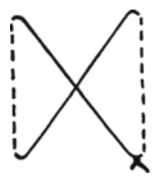

Fig. 3.4

Suture bridges protect the skin, and retention sutures tied loosely do not cut through the fascia. Retention sutures should be used only when delayed healing is anticipated and should be left in place until healing is complete, which often is signaled by the previously snug retention sutures becoming loose as the wound contracts.

The Smead-Jones suture, recently modified as a continuous rather than interrupted technique, creates a row of internal retention sutures by taking bites through the fascia and muscle layers but avoiding the skin (Figs. 3.3 and 3.4) and provides an alternative to external retentions that may be more palatable to the patient. Although this text describes the interrupted Smead-Jones technique, some have used a similar running suture technique with great success.

Operative Technique for a Midline Incision

Making the Incision

Hold a large gauze pad in the left hand and apply lateral traction on the skin; the first assistant does the same on the opposite side of the incision. Use the scalpel with a firm sweep along the course of the incision (Fig. 3.5). The initial stroke should go well into the subcutaneous fat. Then reapply the gauze pads to provide lateral traction against the subcutaneous fat; use the belly of the scalpel blade to carry the incision down to the linea alba, making as few knife strokes as

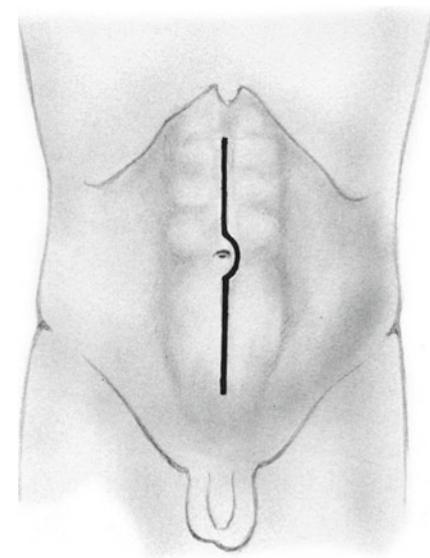

Fig. 3.5

possible. In morbidly obese individuals, a strong pull by surgeon and assistant will often "cleave" the fat along the bloodless midline to the linea alba. The linea alba can be identified in the upper abdomen by observing the decussation of fascial fibers. It can be confirmed by palpating the tip of the xiphoid, which indicates the midline.

The former custom of discarding the scalpel used for the skin incision (in the belief that it incurred bacterial contamination) is not supported by data or logic and is no longer observed. Because subcutaneous fat seems to be the body tissue most susceptible to infection, every effort should be made to minimize trauma to this layer. Use as few hemostats and ligatures as possible; most bleeding points stop spontaneously in a few minutes. Subcutaneous bleeders should be electrocoagulated accurately and with minimal trauma.

Continuing lateral traction with gauze pads, divide the linea alba with the scalpel. If the incision is to be continued around and below the umbilicus, leave a 5- to 8-mm patch of linea alba attached to the umbilicus to permit purchase by a suture during closure. Otherwise, a gap between sutures may appear at the umbilicus, leading to an incisional hernia.

Open the peritoneum to the left of the falciform ligament. Virtually no blood vessels are encountered when the peritoneum is opened close to its attachment to the undersurface of the left rectus muscle. Elevate the peritoneum between two forceps and incise it just above and to the left of the umbilicus. Using Metzenbaum scissors, continue this incision in a cephalad direction until the upper pole of the incision is reached. If bleeding points are encountered here, electrocoagulate them.

So as not to cut the bladder, be certain when opening the peritoneum in the lower abdomen to identify the prevesical fat and bladder. As the peritoneum approaches the prevesical region, the preperitoneal fat cannot be separated from the peritoneum and becomes somewhat thickened and more vascular. If there is any question about the location of the upper margin of the bladder, note that the balloon of the indwelling Foley catheter can be milked in a cephalad direction. It is easy to identify the upper extremity of the bladder this way. It is not necessary to open the peritoneum into prevesical fat, as it does not improve exposure. Rather, simply retract this fat in a caudal direction. However, opening the fascial layer down to and beyond the pyramidalis muscles to the pubis does indeed improve exposure for low-lying pelvic pathology.

Closure of Midline Incision by Modified Smead-Jones Technique

In the upper abdomen, it is unnecessary to include the peritoneum or falciform ligament in the suture. Below the umbilicus there is no distinct linea alba, and the rectus muscle belly is exposed. In this region include the peritoneum in the stitch.

Apply Allis clamps to the linea alba at the midpoint of the incision, one clamp on each side. Below the umbilicus, the Allis clamps should include a bite of peritoneum and of anterior fascia. With no. 1 polydioxanone suture (PDS), encompass 3 cm of tissue on each side of the linea alba; then take a small bite of the linea alba, about 5 mm in width, on each side. This results in a small loop within a large loop (Fig. 3.6). The purpose of the small loop is simply to orient the linea alba so it remains in apposition rather than one side moving on top of the other. Place the small loop 5–10 mm below the main body of the suture to help eliminate the gap between adjacent sutures. Insert the next suture no more than 2 cm below the first. Large, curved Ferguson needles are used for this procedure.

For an interrupted closure, tie the sutures with at least four square throws. *Avoid excessive tension*. When half of the incision has been closed, start at the other end and approach the midpoint with successive sutures (Fig. 3.6). With a running stitch, it may be tempting to use a single

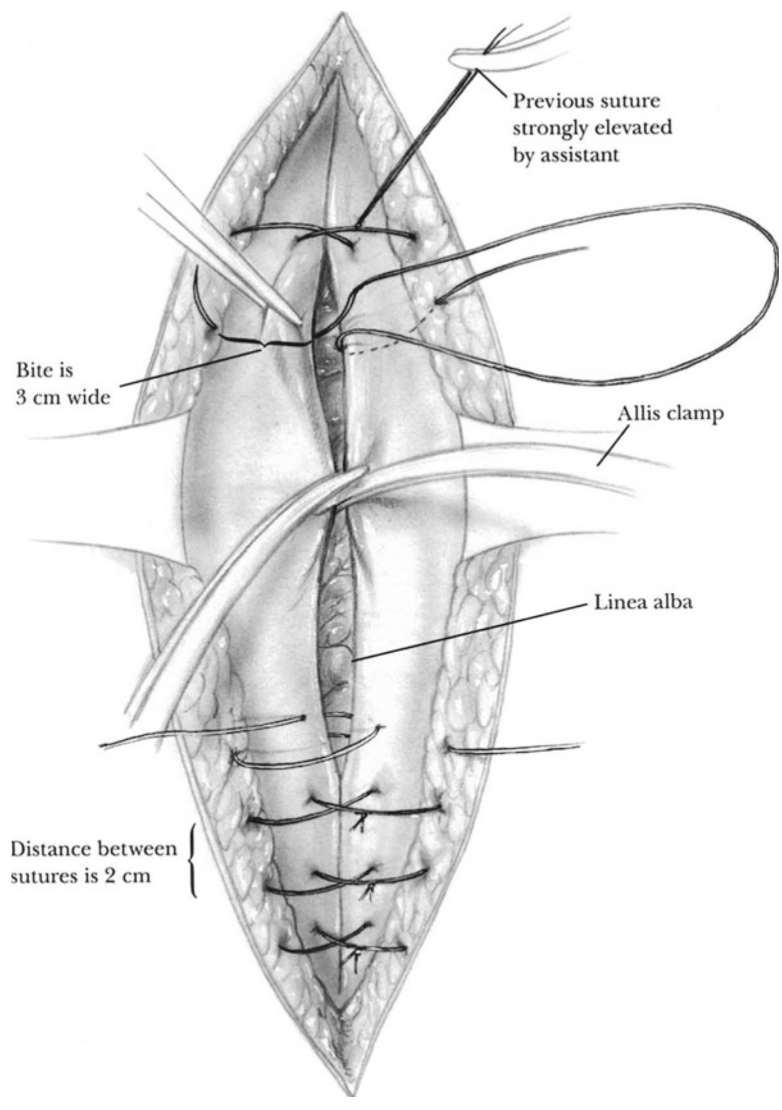

Fig. 3.6

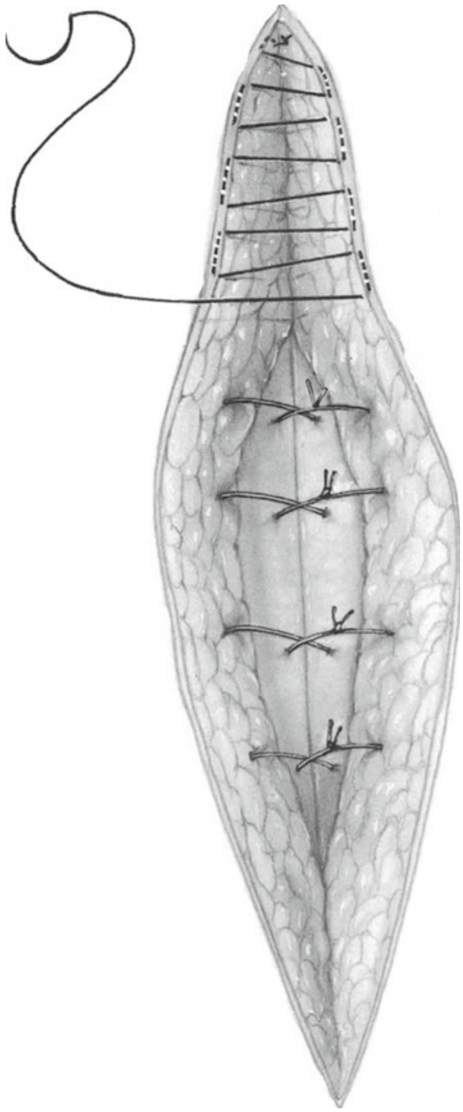

Fig. 3.7

length of suture for the entire incision, but it is far easier and safer to begin from the ends and finish in the middle. Do not tie the last few stitches, leaving enough space to insert the remaining stitch under direct vision. In no case should the surgeon insert a stitch without seeing the point of the needle at all times. Tie all the remaining sutures (Fig. 3.7). Close the skin with interrupted 4-0 nylon vertical mattress sutures, a continuous subcuticular suture of 4-0 polyglycolic (PG), or staples.

Other special incisions such as the *McBurney* (see Chap. 46), *subcostal* (see Chap. 77), and *Pfannenstiel* (see Chap. 66) incisions are found elsewhere in this volume where the operations most commonly performed through these exposures are introduced.

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Dissecting and Suturing

4

Carol E.H. Scott-Conner and Jameson L. Chassin†

Art of Dissecting Planes

Of all the skills involved in the craft of surgery, perhaps the single most important is the discovery, delineation, and separation of anatomic planes. When this is skillfully accomplished, there is scant blood loss and tissue trauma is minimal. The delicacy and speed with which dissection is accomplished can mark the difference between the master surgeon and the tyro. The particular anatomic planes (often bloodless embryologic fusion planes) that are used are described for each operation in the remainder of the book. This chapter deals with general techniques for developing these planes.

Of all the instruments available to expedite the discovery and delineation of tissue planes, none is better than the surgeon's *left index finger*. (References here are again to right-handed surgeons.) This digit is insinuated behind the lateral duodenal ligament during performance of the Kocher maneuver, behind the renocolic ligament during colon resection, and behind the gastrophrenic ligament during a gastric fundoplication. These structures can then be rapidly divided, as the underlying left index finger is visible through the transparent tissue. Dissection of all these structures by other techniques not only is more time consuming, it is frequently more traumatic and produces more blood loss.

To identify adhesions between the bowel and peritoneum, pass the left index finger behind the adhesion. This maneuver produces gentle traction on the tissue to be incised. If the finger is visible through the adhesion, it can aid dissection.

If there is insufficient space for inserting the surgeon's left index finger, often *Metzenbaum scissors*, with blades closed, can serve the same function when inserted underneath an adhesion for delineation and division. This maneuver is also useful when incising adventitia of the auxiliary vein during a mastectomy. To do this, the closed Metzenbaum scissors are inserted between the adventitia and the vein itself, they are then withdrawn, the blades are opened, and one blade is inserted underneath the adventitia. Finally, the jaws of the scissors are closed, and the tissue is divided. This maneuver is repeated until the entire adventitia anterior to the vein has been divided.

In many situations, a closed blunt-tipped right-angle *Mixter clamp* may be used the same way as Metzenbaum scissors for dissecting and delineating anatomic structures. Identification and skeletonization of the inferior mesenteric artery or the cystic artery and delineation of the circular muscle of the esophagus during cardiomyotomy are some uses to which this instrument can be put.

The *scalpel* is the instrument of choice when developing a plane that is not a natural one, such as when elevating skin flaps over the breast. When the scalpel is held at a 45° angle to the direction of the incision (Fig. 4.1), it is useful for clearing fascia of overlying fat.

More important, when the surgeon must cope with advanced pathologic changes involving dense scar tissue, such as may exist when elevating the posterior wall of the duodenum in the vicinity of a penetrating duodenal ulcer, the scalpel is the only instrument that can divide the dense scar accurately until the natural plane of cleavage between the duodenum and pancreas is reached, beyond the diseased tissue.

The *peanut sponge* (Kutner dissector), a small, 1.5 cm gauze sponge grasped in a long hemostat, is an appropriate device for separating fat and areolar tissue from anatomic structures. It should not be used to tear tissues while making a plane. After the peritoneum overlying the cystic duct and artery has been incised, the peanut sponge can separate the peritoneum and fat from the underlying duct and artery. It is similarly useful for elevating a thyroid lobe from its capsule. After sharp dissection has exposed the major arteries during

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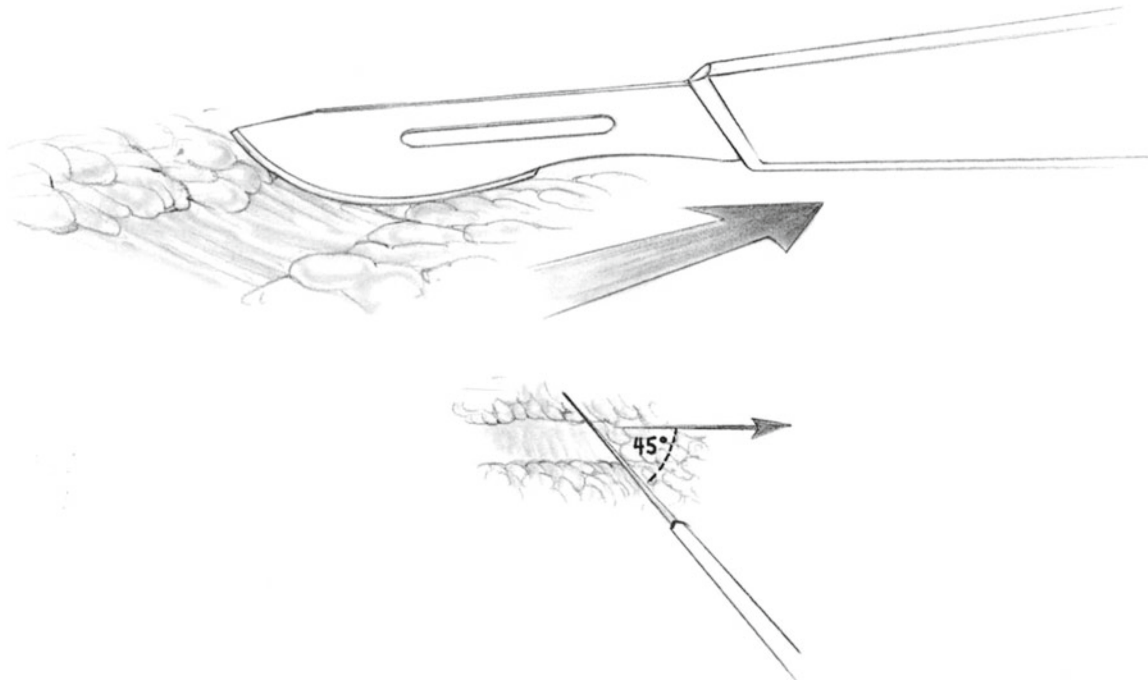

Fig. 4.1

the course of a colon resection, the peanut sponge can be used to skeletonize the vessels and sweep the lymphatic and areolar tissue toward the specimen.

A folded 10×10 cm *gauze square* grasped in a sponge holder has occasional application for sweeping perirenal fat from the posterior aspect of the peritoneum during lumbar sympathectomy. It is useful also for separating the posterior wall of the stomach from peripancreatic filmy peritoneal attachments. Because the use of a large sponge does not permit anatomic precision, small veins may be torn during this type of gross dissection; therefore, the sponge's applicability is limited to avascular planes.

The surgeon who wants to perform accurate dissections is greatly aided by a *talent for quickly recognizing tissues and structures* as they are revealed by the scalpel or scissors. A truly alert surgeon can promptly evaluate the structural characteristics of a nerve, blood vessel, ureter, or common bile duct, so each is identifiable at a glance, even before the structure is thoroughly exposed. An intimate knowledge of anatomy is required for the surgeon to know *exactly where each structure will appear* even before it has been revealed by dissection.

Sewing Technique

Use of a Needle Holder

Smooth rotatory wrist action and the surgeon's awareness of what it feels like when a needle penetrates the submucosa of the bowel are important when suturing with a typical half-circle needle on a needle holder (see Chap. 2).

Selection of Needle

The needle selected for any use should have the least possible thickness commensurate with adequate strength to achieve its purpose. Tapered-point needles are used to insert sutures into soft tissue such as the fascia, fat, or gastrointestinal viscera. Cutting needles are used for the skin and occasionally for tough fibrous tissue such as breast. Use of a too delicate needle risks bending or breaking the needle. More often such damage is due to failure to follow the curve of the needle as it passes through the tissue or placing the needle too far back on the needle holder.

Size of Bite

The width of the tissue enclosed in the typical seromuscular suture varies between 4 and 6 mm, depending on the thickness and consistency of the tissue involved. Hypertrophied gastric wall requires a larger bite than the normally thin colon. As discussed in Chap. 3, our version of the Smead-Jones closure includes a bite of abdominal wall 3 cm wide for the "internal retention suture" part of the closure. Thus, the size of the bite must be matched to the purpose of the suture, the size of the suture, and the amount of force the suture line must withstand.

Distance Between Sutures

The distance between bites for a typical approximation of the seromuscular layer with interrupted Lembert sutures is 5 mm. When continuous mucosal or other sutures are used, the width of the bites and the distance apart should be approximately the same as those specified for interrupted stitches.

After one layer of sutures has been inserted, tentatively test the degree of inversion that is required to allow the second layer to be inserted without tension. Invert as little tissue as possible, consistent with avoiding tension.

Size of Suture Material

As there must never be any tension on an anastomosis in the gastrointestinal tract, it is not necessary to use suture material heavier than 4-0 or 3-0. Failure to heal often is due to a stitch tearing through the tissue; it is almost never due to a broken suture. When two layers of sutures are used for an anastomosis in the gastrointestinal (GI) tract, the inner layer should be 5-0 or 4-0 PG. This layer provides immediate, accurate approximation of the mucosa and, in some instances, hemostasis.

When taking large bites of tissue with considerable tensile strength, such as with the Smead-Jones closure of the abdominal wall, heavier suture material is indicated. Here, 1-0 PDS is suitable. Obviously, the size of the suture material must be proportional to the strength of the tissues into which it is inserted and to the strain it must sustain.

Continuous Versus Interrupted Sutures

End-to-end anastomosis of the GI tract should be done with interrupted seromuscular sutures to avoid the possibility that the purse-string effect of the continuous stitch would narrow the lumen. A continuous suture is permissible in the mucosal layer if it is inserted with care to avoid narrowing. When an anastomosis is large, as with gastrojejunostomy, the use of two continuous layers of PG appears safe.

How Tight the Knot?

If the knot on a suture approximating the seromuscular coats of two segments of intestine is tied so tightly it causes ischemic necrosis, an anastomotic leak may follow. This is especially likely if the stitch has been placed erroneously through the entire wall of the bowel into the lumen. Because considerable edema follows construction of an anastomosis, knots should be tied with tension sufficient only to provide apposition of the two seromuscular coats. Caution must be exercised when tying suture material such as silk or Prolene, which are slippery enough that each knot may have the effect of a noose that is repeatedly tightened with the tying of each additional knot. Nylon sutures also exhibit excessive slippage; even when the first knot has been applied with proper tension, each succeeding knot often produces further constriction. When nylon sutures in the skin have been tied with too much tension, marked edema, redness, and cross-hatching can be seen at the site of each stitch. The same ill effects occur when intestinal sutures are made too tight, but the result is not visible to the surgeon.

Catching Both Walls of Intestine with One Pass of the Needle Holder

Most surgeons who insert seromuscular sutures to approximate two segments of intestine were taught to insert the Lembert suture through the intestine on one side of the anastomosis. They then pick up the needle with the needle holder to take another Lembert stitch in the opposite wall of the bowel. Occasionally, under ideal conditions, it is possible to pass a needle of proper length through one side of the intestine and then, without removing the needle holder, pass the needle through the opposite wall before pulling the thread through. The danger associated with this shortcut is that one may traumatize the entrance wound made on the side of the intestine through which the needle was first inserted. This problem can occur as the surgeon moves the needle and the intestinal wall in a lateral direction to bring it closer to the opposing intestine, thereby making a small tear at the entrance hole (Fig. 4.2). With proper technique, this shortcut can be accomplished without undue trauma. After the needle has been passed through the first segment of the intestine, the surgeon should avoid any *lateral* movement of the needle holder. Instead, the surgeon *gently* picks up the opposing

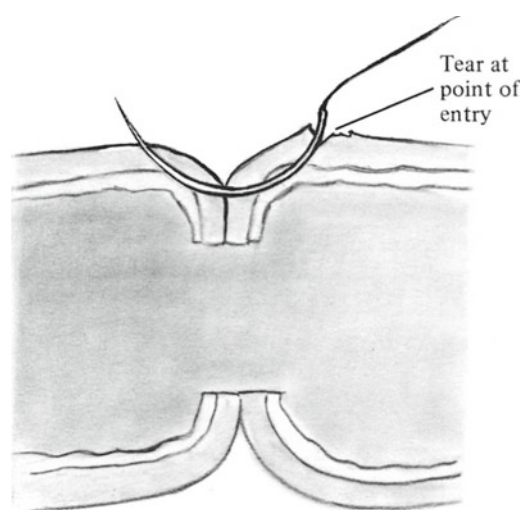

Fig. 4.2

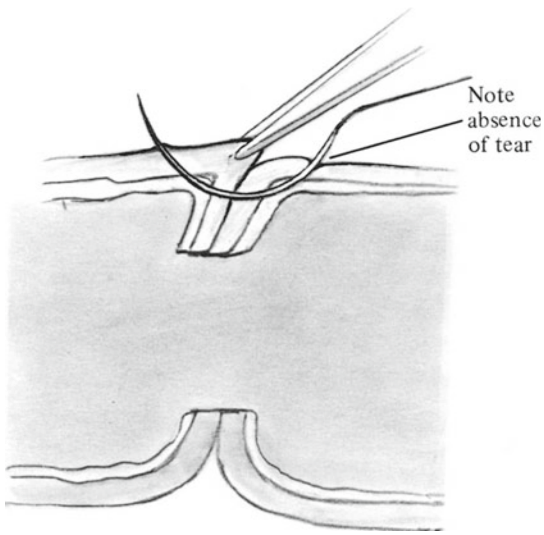

Fig. 4.3

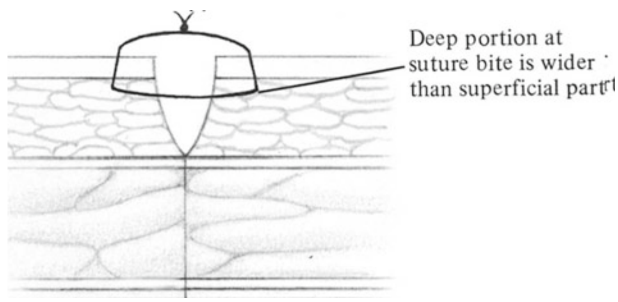

Fig. 4.4

segment of intestine with a forceps and brings this portion of bowel to the needle. Then, with a purely *rotatory* motion of the wrist, the surgeon allows the needle to penetrate the second side (Fig. 4.3). If the surgeon is conscious of the need to avoid trauma and uses a rotatory maneuver, there are situations in which this technique is acceptable and efficient.

Types of Stitch

Simple Everting Skin Stitch

Eversion of the edges is desired when closing the skin. Consequently, the wrist should be pronated and the needle inserted so the deeper portion of the bite is slightly wider than the superficial portion (Fig. 4.4). When this stitch is tied, the edges are everted (Fig. 4.5).

Vertical Mattress (Stewart) Stitch

With the classic Stewart method of skin suturing, eversion is guaranteed by the nature of the vertical mattress stitch (Figs. 4.6 and 4.7). Neither of these two types of skin suture

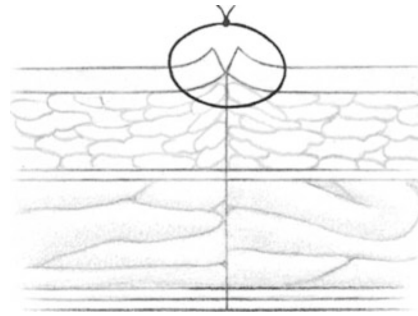

Fig. 4.5

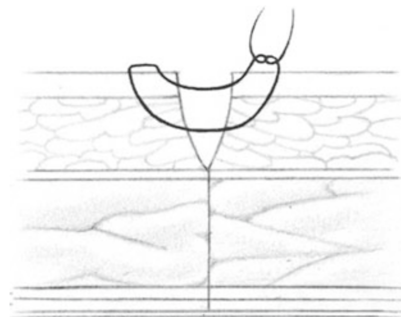

Fig. 4.6

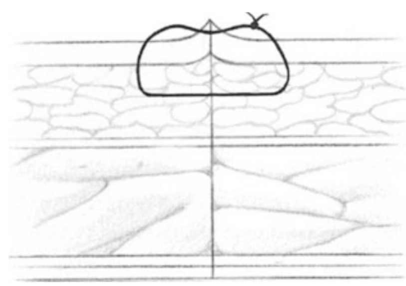

Fig. 4.7

should be tied with excessive tension if cross-hatching is to be avoided.

Continuous Subcuticular Stitch

For the continuous subcuticular stitch, 4-0 PG may be employed on an atraumatic, curved, cutting needle. With practice the surgeon may insert it rapidly and obtain a good cosmetic result (Fig. 4.8). Because it is absorbable, there are no sutures to remove postoperatively. If preferred, continuous 3-0 nylon may be used, with lead shot or an external knot fixing the stitch at its points of origin and termination. This stitch should not be removed for 10–14 days following the operation. If the nylon stitch is longer than 7–8 cm, it may break during removal.

Skin Staples

Skin staples can be applied with force just sufficient to achieve approximation without producing cross-hatching of the skin.

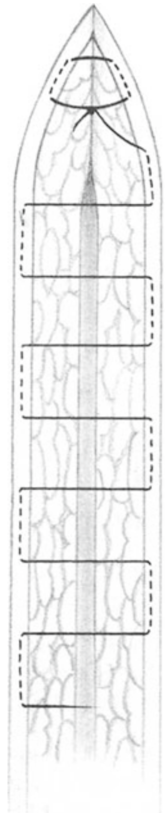

Fig. 4.8

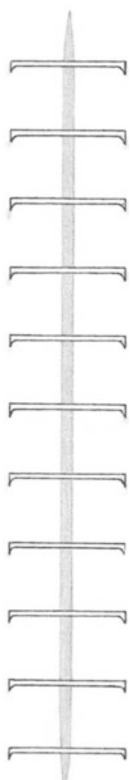

Fig. 4.9

They allow good cosmetic results. Depending on the thickness of the skin and the underlying structures, staples may be placed 5–10 mm apart (Fig. 4.9). Align the skin edges to produce good apposition with slight eversion. When working with a less-skilled assistant, it is preferable for the surgeon to align the edges and allow the assistant to place the staples.

Simple Interrupted Fascial Stitch

The McBurney and other special incisions may be closed by simple interrupted fascial sutures. These sutures are placed so they include 8–10 mm of tissue with each bite, as shown in Fig. 4.10. Except for use in the McBurney and Pfannenstiel incisions, this abdominal wall closure should be considered obsolete.

Continuous Simple Over-and-Over Stitch

Figure 4.11 illustrates the simple over-and-over continuous stitch frequently used for closure of the peritoneum. It is sometimes applied to the mucosal layer of bowel anastomoses as well.

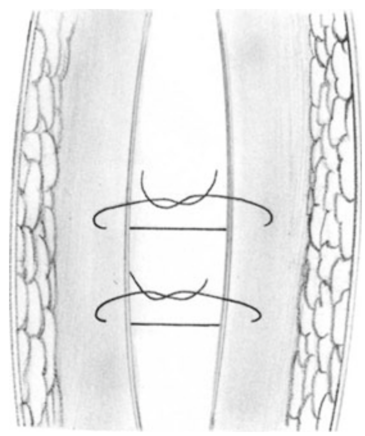

Fig. 4.10

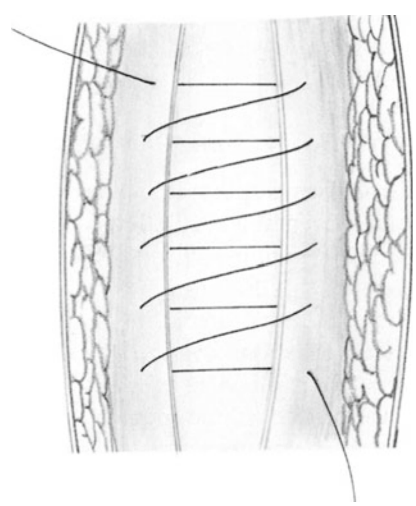

Fig. 4.11

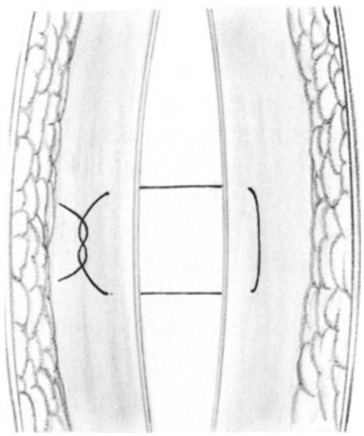

Fig. 4.12

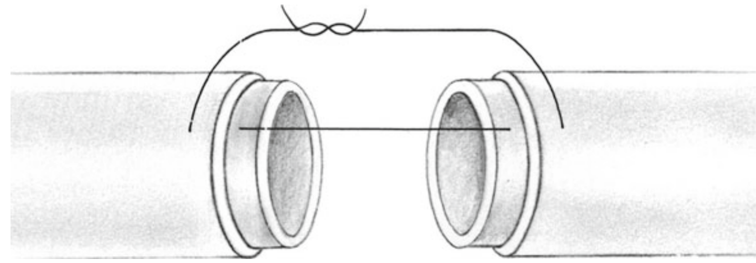

Fig. 4.13

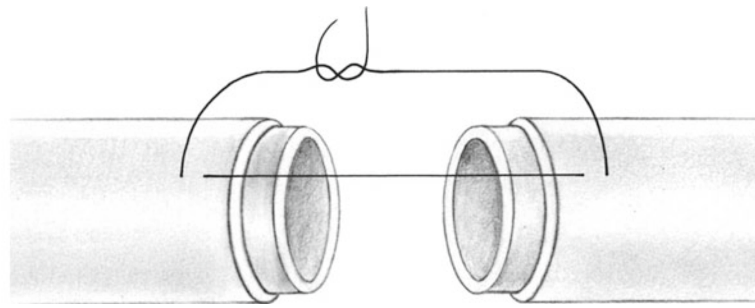

Fig. 4.14

Horizontal Mattress Stitch

The mattress suture is occasionally used to close fascia and sometimes for ventral hernia repair (Fig. 4.12). It can also serve as a hemostatic stitch.

Smead-Jones Stitch

The Smead-Jones stitch is well suited for closure of major abdominal incisions. It is, in essence, a buried "retention" suture, as it encompasses all layers of the abdominal wall, except the skin, in its large loop. The large loop is followed by a small loop, which catches only 4–5 mm of linea alba on each side. The purpose of this small loop is to orient the abdominal wall in perfect apposition. It is described in detail in Chap. 3.

Hemostatic Figure-of-Eight Stitch

The classic hemostatic figure-of-eight stitch is used for occlusion of a bleeding vessel that has retracted into the muscle or similar tissue. It is illustrated in Fig. 3.4.

Single-Layer Bowel Anastomosis

Bowel anastomoses employing one layer of sutures have become acceptable. An effective method for accomplishing inversion and approximation simultaneously is the use of the seromucosal stitch (Fig. 4.13), which is an inverting stitch that catches the seromuscular and submucosal layers and a small amount of mucosa. When properly applied, it produces slight inversion of the mucosal layer and approximation. It is not necessary to pass this stitch deeper than the submucosal layer.

If it is passed into the lumen before emerging from the mucosal layer, it is identical with that described by Gambee, whose technique was at one time applied to one-layer closure of the Heineke-Mikulicz pyloroplasty. Used in an interrupted or a continuous fashion, it is an excellent alternative to the Connell stitch for inversion of the anterior mucosal layer of a two-layer bowel anastomosis. When used for construction of a single-layer intestinal anastomosis, it should of course be done only in interrupted fashion.

Lembert Stitch

Perhaps the most widely used technique for approximating the seromuscular layer of a bowel or gastric anastomosis is the Lembert stitch (Fig. 4.14). This stitch catches about 5 mm of tissue, including a bite of submucosa, and emerges 1–2 mm proximal to the cut edge of the serosa. It also has been used for one-layer intestinal anastomoses. Under proper circumstances, it may be applied in a continuous fashion.

Cushing Stitch

The Cushing stitch is similar to the Lembert stitch, except it is inserted parallel to and 2–4 mm from the cut edge of the bowel. It should catch about 5 mm of the bowel, including the submucosa. It is especially applicable to seromuscular approximation for anastomoses in poorly accessible locations, such as the low colorectal anastomosis. The interrupted Cushing technique is illustrated in Fig. 4.15a. When used as a continuous stitch (Fig. 4.15b), the Cushing is a good alternative to the Connell stitch for inverting the anterior mucosal layer of an anastomosis. The main difference between the Connell stitch (see below) and a continuous Cushing suture is that the former penetrates the lumen of the bowel, whereas the latter passes only to the depth of the submucosal layer. The continuous Cushing suture is also much easier and more efficient to accomplish than the Connell stitch.

Halsted Stitch

The Halsted stitch (Fig. 4.16) provides excellent seromuscular approximation in a bowel anastomosis. It shares with the Cushing stitch the danger that when tied with excessive

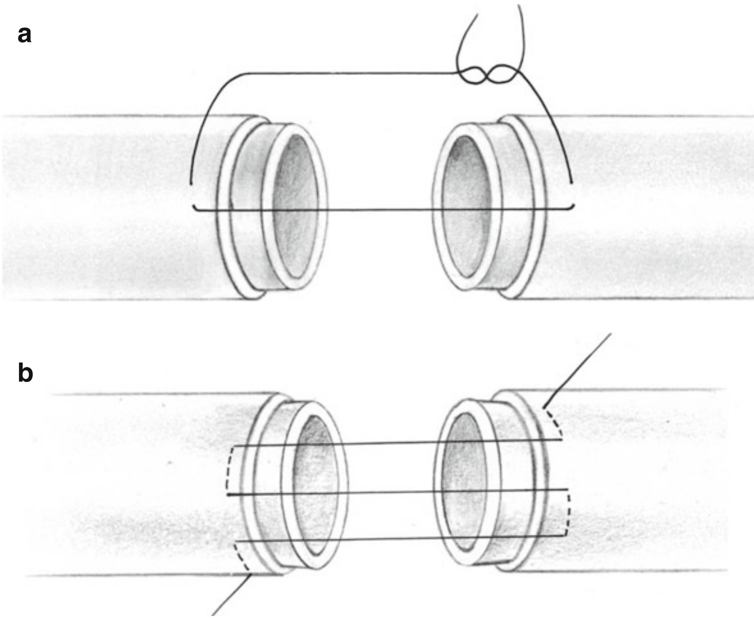

Fig. 4.15

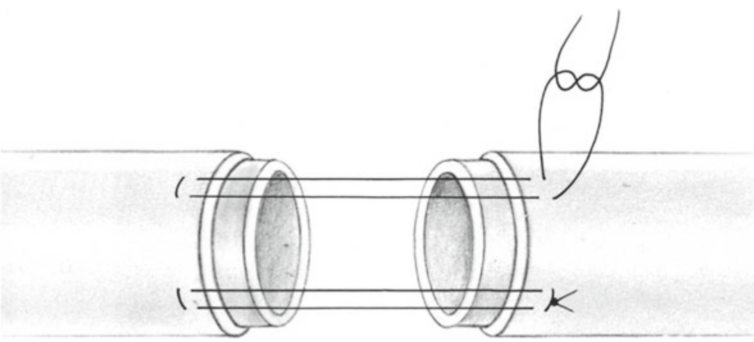

Fig. 4.16

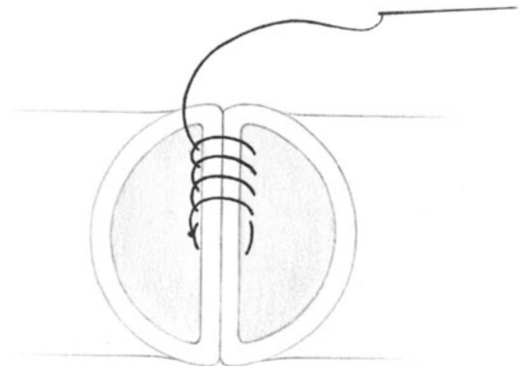

Fig. 4.17

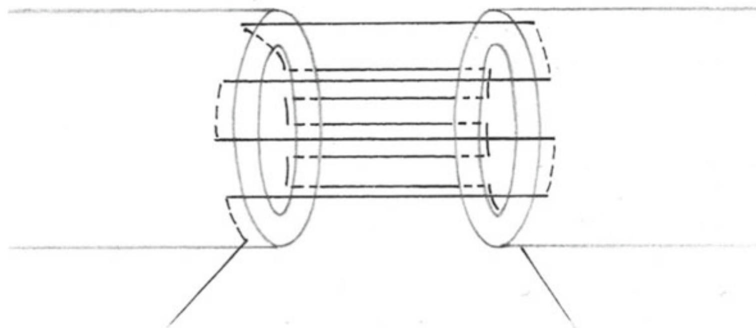

Fig. 4.18

tension, it causes strangulation of a larger bite of tissue than does the Lembert suture.

Continuous Locked Stitch

Figure 4.17 illustrates approximation of the posterior mucosal layer of a bowel anastomosis with a continuous locked stitch. This stitch ensures hemostasis and approximation. When hemostasis is not a problem, some surgeons prefer to close this layer with a simple over-and-over continuous stitch (see Fig. 4.11).

Connell Stitch

The Connell suture was originally described as a technique for performing a single-layer end-to-end anastomosis of the bowel. This suture has been used for many decades as the method for inverting the anterior mucosal layer of a *two-layer* bowel anastomosis. The stitch goes from the serosa through all layers of intestine into the lumen (Fig. 4.18), comes out through all the layers on the same side, and passes over to the opposite segment of the bowel, where the same sequence takes place.

Because it forms a loop on the mucosa, the Connell stitch is slightly hemostatic, but one should not depend entirely on it for that purpose. The suture is placed loosely to avoid purse-stringing the anastomosis and hence is inadequate to produce hemostasis for small arterial bleeders. As the bowel is inverted, intraluminal bleeding does not remain visible to the surgeon and may go undetected. This is particularly common with the stomach, which has a rich submucosal blood supply. Rather than rely on the Connell stitch, individually ligate the bleeding points or secure them with electrocautery.

Technique of Successive Bisection

The technique we named "successive bisection" ensures consistently accurate intestinal anastomoses, especially when the diameters of the two segments are not identical. As illustrated in Fig. 4.19, the first stitch is inserted at the antimesenteric border and the second at the mesenteric border. The third is then inserted at a point that exactly bisects the entire layer. The fourth stitch bisects the distance between the first and third stitches. This pattern is then repeated until the anastomotic layer is complete (Fig. 4.20).

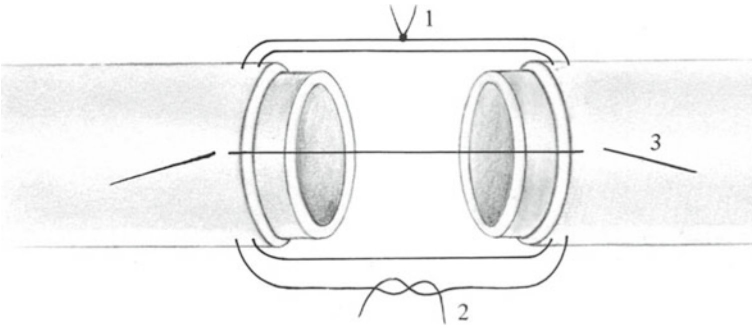

Fig. 4.19

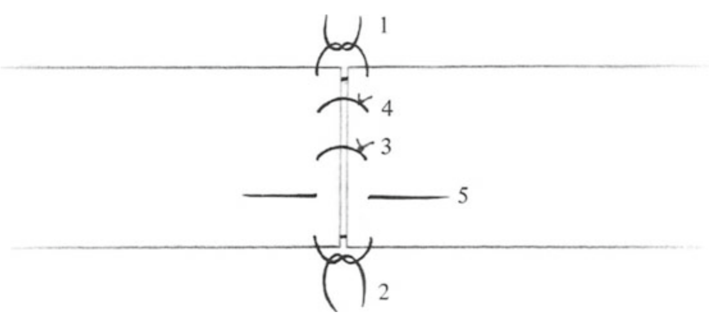

Fig. 4.20

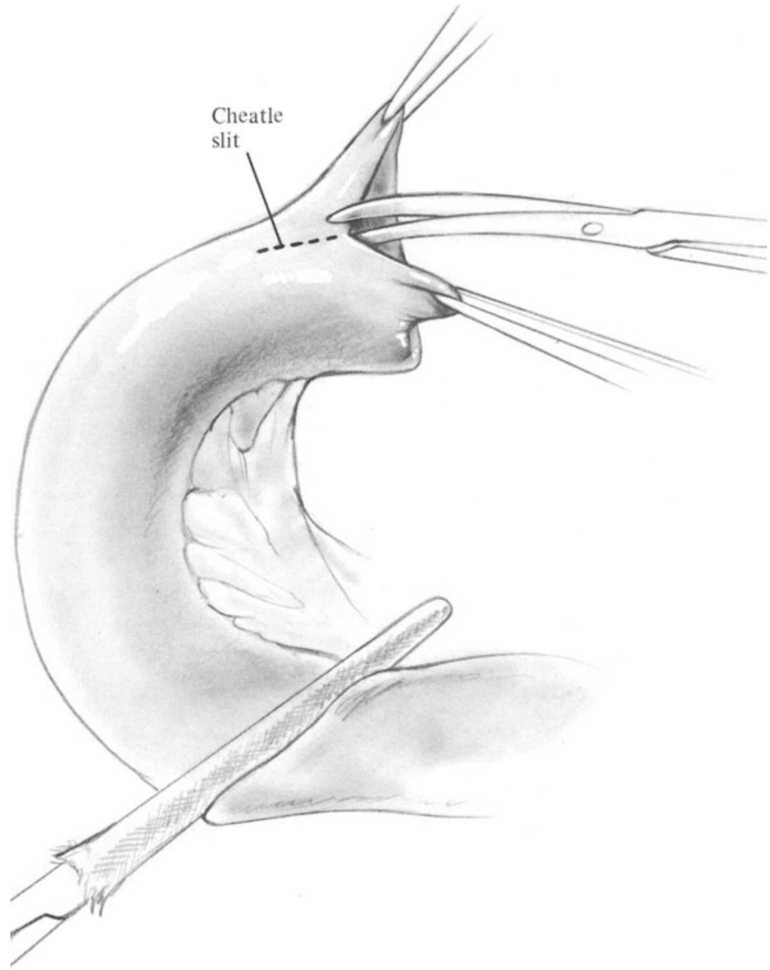

Fig. 4.21

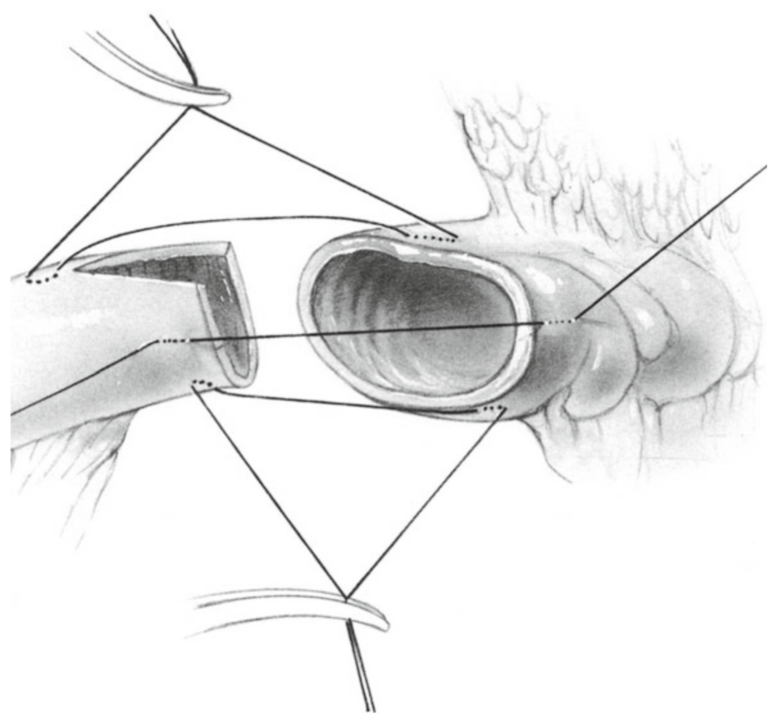

Fig. 4.22

Intestinal Anastomoses

One Layer or Two?

Although abundant data confirm that an intestinal anastomosis can be performed safely with one or two layers of sutures, to our knowledge there is no consistent body of randomized data conclusively demonstrating the superiority of one or the other in humans. It is obvious that the one-layer anastomosis does not turn in as much intestine and consequently has a larger lumen than the two-layer anastomosis. However, in the absence of postoperative leakage, obstruction at the anastomotic site is rare except perhaps when the esophagus is involved. It seems reasonable, though, to assume that if the seromuscular layer sutured by the surgeon suffers from some minor imperfection the mucosal sutures may compensate for the imperfection and prevent leakage. Although we have had good results with one-layer techniques, we recommend that each surgeon master the standard two-layer technique before considering the other.

End-to-End or End-to-Side Technique?

In most situations, the end-to-end technique is satisfactory for joining two segments of bowel. If there is some disparity in diameter, a *Cheatle slit* is performed on the antimesenteric border of the narrower segment of intestine to enable the two diameters to match each other (Figs. 4.21 and 4.22). If there is a large disparity in the two diameters (>1.5–2.0 cm), the end-to-side anastomosis has advantages, provided the anastomosis is not constructed in a manner that permits a blind loop to develop. If the end-to-side anastomosis is placed within 1 cm of the closed end of the intestine, the blind loop syndrome does not occur. Stapled closure of the end segment is rapid and efficient.

There are two instances in which the end-to-side anastomosis is clearly superior to the end-to-end procedure. We have reported that for the esophagogastric anastomosis following esophagogastrectomy, the incidence of leakage, postoperative stenosis, and mortality is distinctly less with the end-to-side technique. This is probably true also for an esophagojejunal anastomosis. The second instance is the low colorectal anastomosis. With this procedure, the ampulla of the rectum is often much larger in diameter than the descending colon.

Sutured or Stapled Anastomosis?

The question of whether to use sutures or staples for anastomoses is less frequently asked as techniques for gastrointestinal stapling (see Chap. 5) have become standardized. When done by surgeons whose techniques are sophisticated, stapling and suturing can achieve equally good results. Some anastomoses are naturally easier to suture (e.g., choledochojejunostomy), whereas others are more rapidly and easily stapled. A clear example would be a stapled low rectal anastomosis. Another, less obvious one, would be the stapled side-to-side functional end-to-end anastomosis—an easy way to create an ileocolonic anastomosis after right hemicolectomy because it eliminates the problems previously described for joining bowel of varying size.

Suture Material

Absorbable Sutures

Plain Catgut

Plain catgut is not commonly used during modern surgery. Although its rapidity of absorption might seem to be an advantage, this rapidity is the result of an intense inflammatory reaction that produces enzymes to digest the organic material. Plain catgut is acceptable for ligating bleeding points in the subcutaneous tissues and not for much else. Electrocautery has largely rendered that application unnecessary.

Chromic Catgut

Chromic catgut has the advantage of a smooth surface, which permits it to be drawn through delicate tissues with minimal friction. It thus may be good for splenorrhaphy or hepatorrhaphy. Moisten the chromic catgut with saline and allow it to soften for a few seconds before inserting the suture. Chromic catgut generally retains its strength for about a week and is suitable only when such rapid absorption is desirable. It is completely contraindicated in the vicinity of the pancreas, where proteolytic enzymes produce premature absorption, or for closure of abdominal incisions and hernia repair, where it does not hold the tissues long enough for adequate healing to occur.

Chromic catgut is useful for approximating the mucosal layer during two-layer anastomosis of the bowel. For this purpose, size 4-0 is suitable. Bear in mind that wound infection increases the rapidity of catgut digestion. Chromic catgut has largely been supplanted by synthetic absorbable sutures for the purpose.

Chromic catgut swells slightly as it absorbs water after contact with tissue, with the knots becoming more secure. It is used for some endoscopic pretied suture ligatures for this reason.

Similarly, hydrated chromic catgut suture become soft and thus may be preferred for splenorrhaphy or hepatorrhaphy in trauma surgery, as it is less likely to cut through.

Polyglycolic Synthetics

Polyglycolic synthetic sutures (PG), such as Dexon or Vicryl, are far superior to catgut because the rate at which they are absorbed is much slower. About 20 % of the tensile strength remains even after 15 days. Digestion of the PG sutures is by hydrolysis. Consequently, the proteolytic enzymes in an area of infection have no effect on the rate of absorption of the sutures. Also, the inflammatory reaction they incite is mild compared to that seen with catgut. The chief drawback is that their surface is somewhat rougher than that of catgut, which may traumatize tissues slightly when the PG suture material is drawn through the wall of the intestine. This characteristic also *makes tying secure knots somewhat more difficult* than with catgut. However, these factors appear to be minor disadvantages, and these products have made catgut an obsolete suture material for many purposes.

Nonabsorbable Sutures

Natural Nonabsorbable Sutures

Natural nonabsorbable sutures, such as silk and cotton, have enjoyed a long period of popularity among surgeons the world over. They have the advantage of easy handling and secure knot tying. Once the knots are set, slippage is rare. On the other hand, they produce more inflammatory reaction in tissue than do the monofilament materials (stainless steel, Prolene) or even the braided synthetics. Silk and cotton, although classified as nonabsorbable, disintegrate in the tissues over a long period of time, whereas the synthetic materials appear to be truly nonabsorbable. Despite these disadvantages, silk and cotton have maintained worldwide popularity mainly because of their ease of handling and surgeons' long familiarity with them. Because there are no clear-cut data at this time demonstrating that anastomoses performed with synthetic suture material have fewer complications than those performed with silk or cotton, it is not yet necessary for surgeons to abandon the natural nonabsorbable sutures if they can handle them with greater skill.

With the exception of the monofilaments, a major disadvantage of nonabsorbable sutures is the formation of chronic draining sinuses and suture granulomas. This problem is especially marked when material larger than size 3-0 is used in the anterior abdominal fascia or subcutaneous tissue. For this reason, many surgeons do not use nonabsorbable sutures above the fascia.

Synthetic Nonabsorbable Braided Sutures

Synthetic braided sutures include those made of Dacron polyester, such as Mersilene, Ticron (Dacron coated with silicone), Tevdek (Dacron coated with Teflon), and Ethibond (Dacron with butilated coating). Braided nylon (Surgilon or Nurolon) is popular in the UK. All these braided synthetic materials require four or five knots for secure closure, compared to the three required of silk and cotton.

Synthetic Nonabsorbable Monofilaments

Monofilament synthetics such as nylon and Prolene are so slippery and have such a strong "memory" (the tendency to return to the original untied shape) that as many as six or seven knots may be required. They and monofilament stainless steel are the least reactive of all the products available. For this reason, 2-0 or 0 Prolene has been used by some surgeons for the Smead-Jones abdominal closure in the hope of eliminating suture sinuses. Because of the large number of knots, this hope has not been realized, but there are fewer sinuses than when nonabsorbable braided materials are used. Prolene size 4-0 on atraumatic needles has been used for the seromuscular layer of intestinal anastomoses. Both Prolene and various braided polyester sutures have achieved great popularity for vascular surgery.

Monofilament Stainless Steel Wire

Monofilament stainless steel wire has many of the characteristics of an ideal suture material, but it is difficult to tie. Also, when used for closure of the abdominal wall, patients have occasionally complained of pain at the site of a knot or of a broken suture. True suture sinuses and suture granulomas have been rare when monofilament stainless steel has been used: no more than 1 in 300 cases. Size 5-0 monofilament wire has been used for single-layer esophagogastric and colon anastomoses. Three square throws are adequate for a secure knot with this material. Stainless steel has largely been supplanted by the synthetic monofilament sutures but is still used for closing median sternotomy incisions and for other highly selected applications.

Knot-Tying Technique

The "three-point technique" for tying knots is important when ligating blood vessels. The surgeon's left hand grasping one end of the ligature, the vessel being ligated, and the surgeon's right hand grasping the opposite end of the ligature are positioned in a straight line, as illustrated in Fig. 4.23a, b.

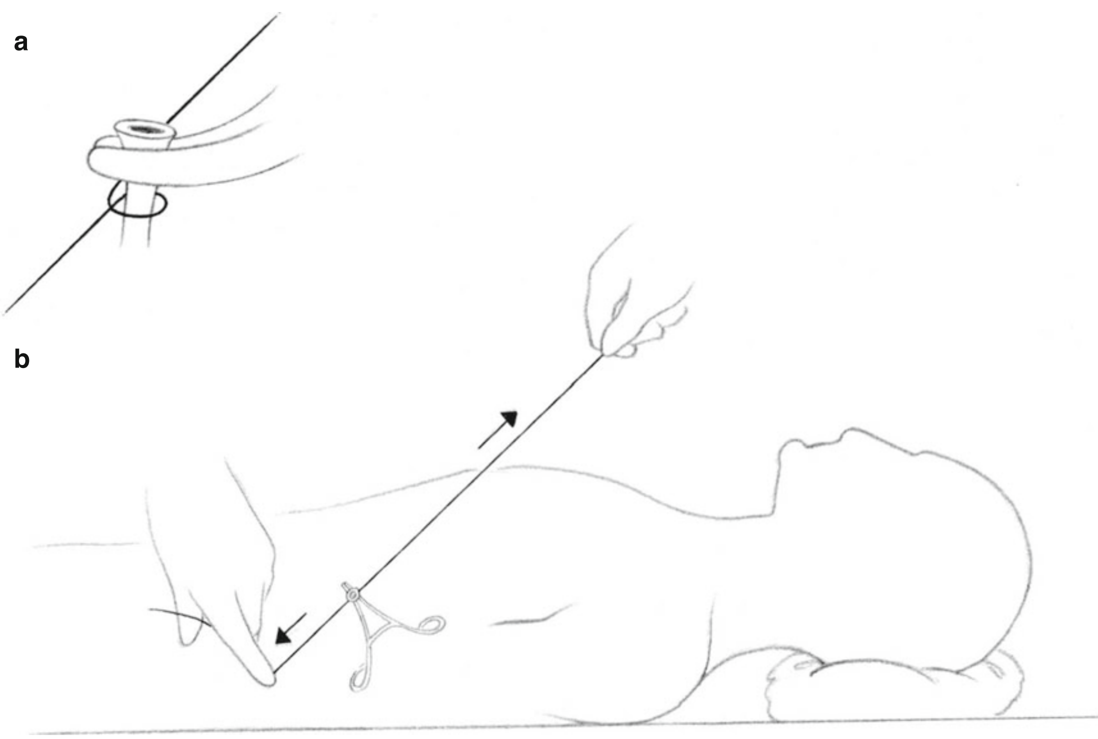

Fig. 4.23

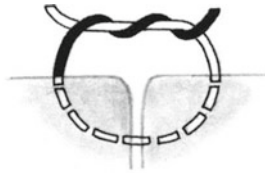

Fig. 4.24

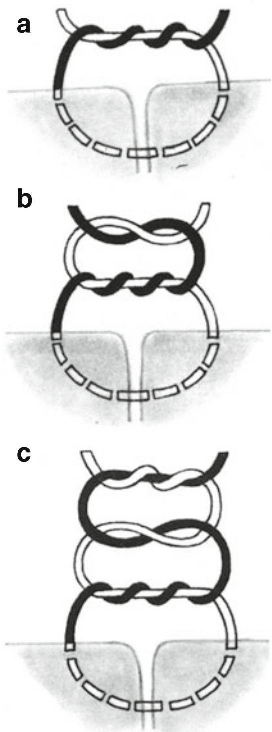

Fig. 4.25

If this is not the case, as the surgeon's hands draw apart when tightening the knot, they exert traction against the vessel. When tying deep bleeding points, this traction tears the vessel at the point of ligature and exacerbates bleeding. When tying a deep structure, such as the cystic artery, the surgeon's left index finger should draw the deep end of the ligature deep to the artery so the left index finger, the cystic artery, and the surgeon's right hand always form a straight line.

When using silk, three square throws provide adequate security. With PG sutures, four throws are necessary. With the various coated polyester sutures, four or five knots must be tied. When using the synthetic materials, many prefer the "surgeon's knot" (Fig. 4.24) as a first throw.

For heavy monofilament suture material such as 0 or 1 Prolene, we have used modified fisherman's 3-1-2 knot: First, make a triple-throw "surgeon's knot" (Fig. 4.25a) and then square it with a single throw (Fig. 4.25b). Complete the knot with the usual double-throw "surgeon's knot" (Fig. 4.25c). This knot seems to hold without slipping.

When tying a knot in a deep or poorly accessible location, it is vital that the two-hand tying technique be used. For superficial bleeding points in the skin and subcutaneous tissues, one- or two-hand knots are efficacious.

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Surgical Stapling: Principles and Precautions

5

Carol E.H. Scott-Conner and Jameson L. Chassin†

To Staple or To Sew?

Surgical staplers facilitate gastrointestinal surgery by rapidly closing or anastomosing bowel. Some anastomoses (e.g., choledochojejunostomy) are best done by hand. For other purposes, such as joining colon to a rectal remnant after a low anterior resection, stapling is easier and faster, or it creates a more consistent anastomosis in an inaccessible location. For most procedures, however, the choice is up to the surgeon. The advantages and disadvantages of various techniques are pointed out throughout this volume in the appropriate chapters.

Stapled anastomoses, when constructed with proper technique, are no better and no worse than those done with sutures. Stapling has the disadvantage of increased expense but the advantage of speed: A stapled anastomosis can generally be completed within 2–5 min, which is a significant benefit in the poor-risk patient who is critically ill and who may be undergoing an emergency operation. Even with the availability of skilled anesthesiologists expert in the physiologic support of desperately ill patients, there is indubitably an advantage to completing the operation speedily.

Stapled anastomoses cannot be expected to succeed under conditions that would make construction of a sutured anastomosis dangerous. There is no evidence that staples are safer than sutures, for instance, in the presence of advanced peritonitis or poor tissue perfusion.

Whereas sutures can be inserted and tied to appropriate tension to approximate but not strangulate a wide range of tissue thicknesses, staplers are much less tolerant. The stapler must be matched to the task and the tissue thickness (see below). In some situations (e.g., stricturoplasty for Crohn disease), the bowel may be too thick and diseased to staple accurately.

There are occasional, though rare, instances in which the exposure does not allow enough room to insert a stapling instrument into a body cavity. If this is the case, do not apply traction to the tissues to bring them within stapler range.

Characteristics of Staples

Modern gastrointestinal staplers are designed to preserve the viability of the tissues distal to the staple line. This is analogous to the "approximate but do not strangulate" principle used when a bowel anastomosis is hand sewn. Figure 5.1a, b shows how two common staples sizes are designed to enter the tissue straight and then bend into a B configuration. This allows blood to flow through the staple line. If staple size and tissue thickness are appropriately matched, one sees blood oozing through the staple line. Occasionally a figure-of-eight suture of fine PDS must be inserted to stop a small bleeder, particularly when the stomach is being stapled. This technique is contraindicated if the tissues are so thick; compression by the stapling device is likely to produce necrosis. On the other hand, if the tissues are so thin the staples cannot provide a firm approximation, bleeding and anastomotic leakage may occur.

There is some leeway when approximating tissues of varying thickness. Two standard staple sizes are available for the standard linear stapler. The 3.5 mm staple is 3.5 mm in leg length and 4.0 mm wide across the base. The 4.8 mm staple also is 4.0 mm wide across the base, but its leg length is 4.8 mm. The 3.5 mm stapler achieves a closed size of 1.5 mm, and the 4.8 mm stapler closes to 2 mm. For some staplers, the smaller (3.5 mm) cartridge is blue and the larger (4.8 mm) cartridge is green, hence the mnemonic "little boy blue and the jolly green giant." As a general rule, the 3.5 mm cartridge

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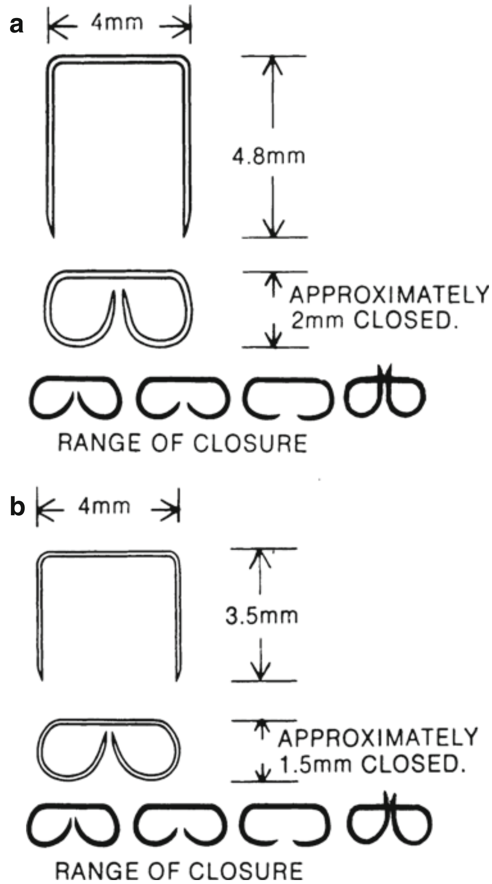


Fig. 5.1

is appropriate for most tasks. The 4.8 mm cartridge is used for thicker tissues, such as the stomach. Some stapling devices are continuously variable within this range, and the thickness may be tested with a gauge and then dialed in. Become familiar with the particular stapling devices used in your operating room and learn their operating characteristics.

The endoscopic linear cutting stapler compresses tissues to a thickness of approximately 1.75 mm.

Stapling in Inversion

The circular stapler and the linear cutting stapler create inverted staple lines that mimic the equivalent hand-sutured anastomosis. In many situations, both inverted and everted staple lines are created, as illustrated by the completed functional end-to-end anastomosis shown in Fig. 5.2. Here a linear cutting stapler was used to create the first (inverting) staple line, which brought the two segments of the colon into side-to-side alignment. A single stitch at the apex of this suture line helps provide mechanical stability. Three applications of a linear stapler have been used to close the open ends of bowel in an everting fashion.

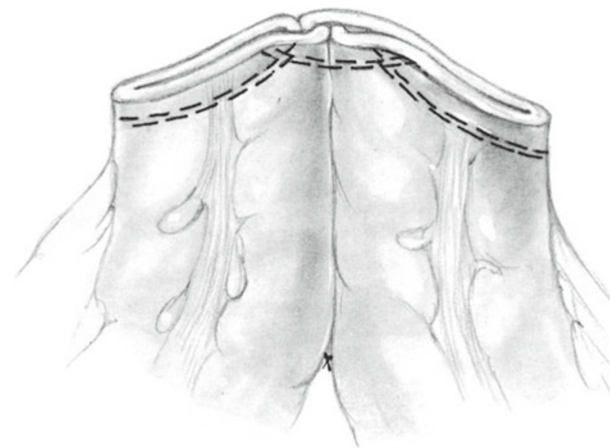


Fig. 5.2

Stapling in Eversion

Everted staple lines are commonly created when the linear stapler is used to complete an anastomosis or to close the end of a piece of bowel. Even when tissues are stapled in eversion, with mucosa facing mucosa, satisfactory healing takes place. This is in contrast to sutured everting anastomoses, which are generally weaker than inverting anastomoses.

Stapling Devices Used for Gastrointestinal Tract Anastomosis

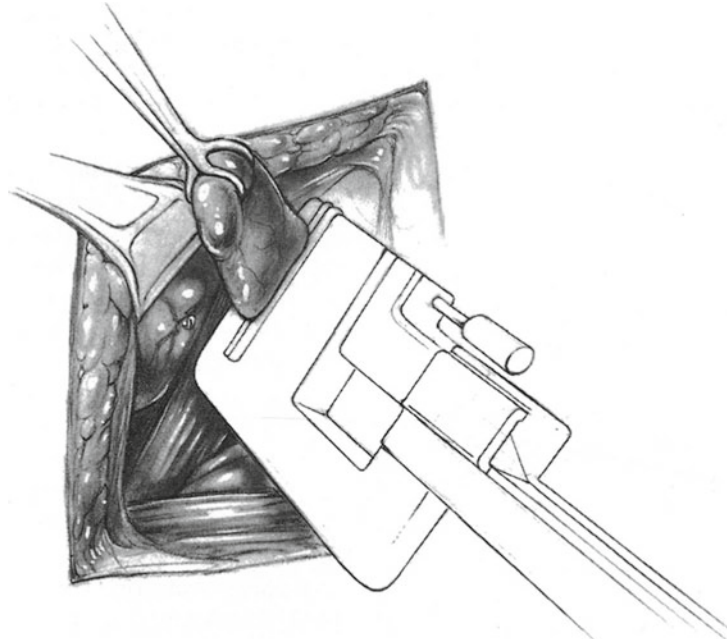
Linear Stapling Devices

The 55 mm linear stapler applies a doubled staggered row of staples approximately 55 mm long; similarly, the 90 mm linear stapler applies a doubled staggered row about 90 mm long. There is also a 30 mm stapler that is occasionally useful for extremely short suture lines.

Each device may be used with 3.5- or 4.8-mm staples, according to the principles described above. These devices are used to approximate the walls of the stomach or intestine in an everting fashion. They find application in closure of the duodenal stump, the gastric pouch during gastrectomy, and the end of the colon when a side-to-end coloproctostomy is performed.

Linear staplers use an aligning pin to ensure that the stapler cartridge meets the anvil accurately. This limits the length of bowel that can be stapled to a length that can be contained between the closed end of the device and the pin. For this reason, it is easier to use a cutting linear stapler (described below) when a long staple line must be produced. Figure 5.3 shows a linear stapler being used to close a Zenker's diverticulum prior to excision. Note that the tissue to be stapled is comfortably centered between the closed end

Fig. 5.3



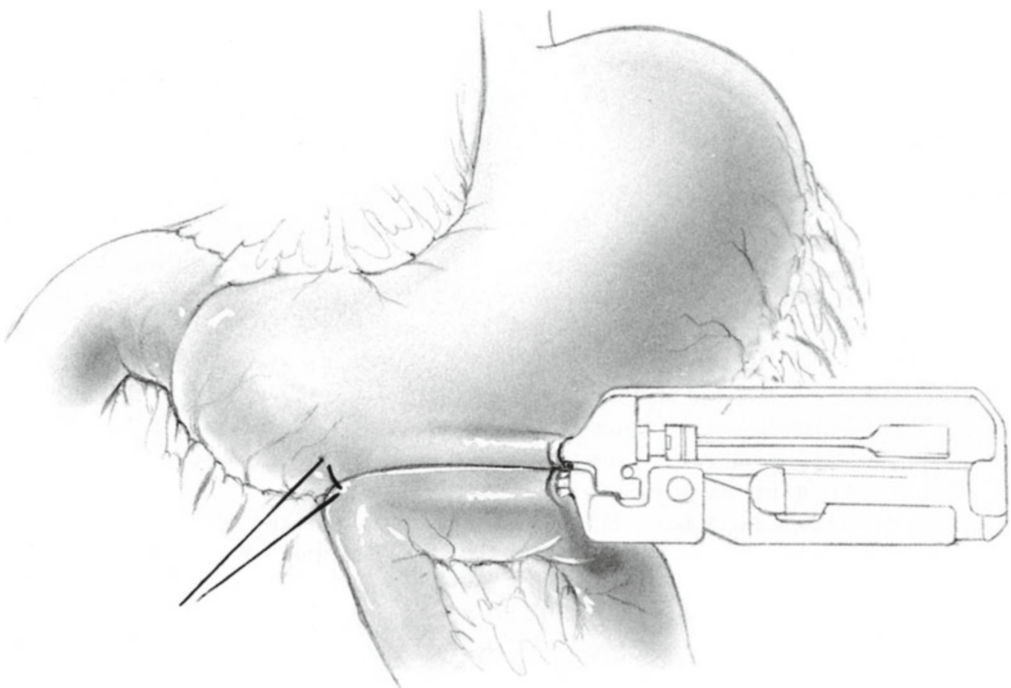


Fig. 5.4

of the stapler and the pin and that the stapler is longer than the desired staple line.

Linear Cutting Stapling Device

The linear cutting stapling device creates a stapled anastomosis with the tissues in inversion. It applies two double staggered rows of staples, while the knife in its assembly divides the tissue between the two double rows. It is used for side-to-side anastomoses (e.g., with gastrojejunostomy) and "functional end-to-end" anastomoses. It may also be used to divide the bowel prior to anastomosis. Figure 5.4 shows a linear cutting stapling device being used to join the stomach to the jejunum during a gastrojejunostomy.

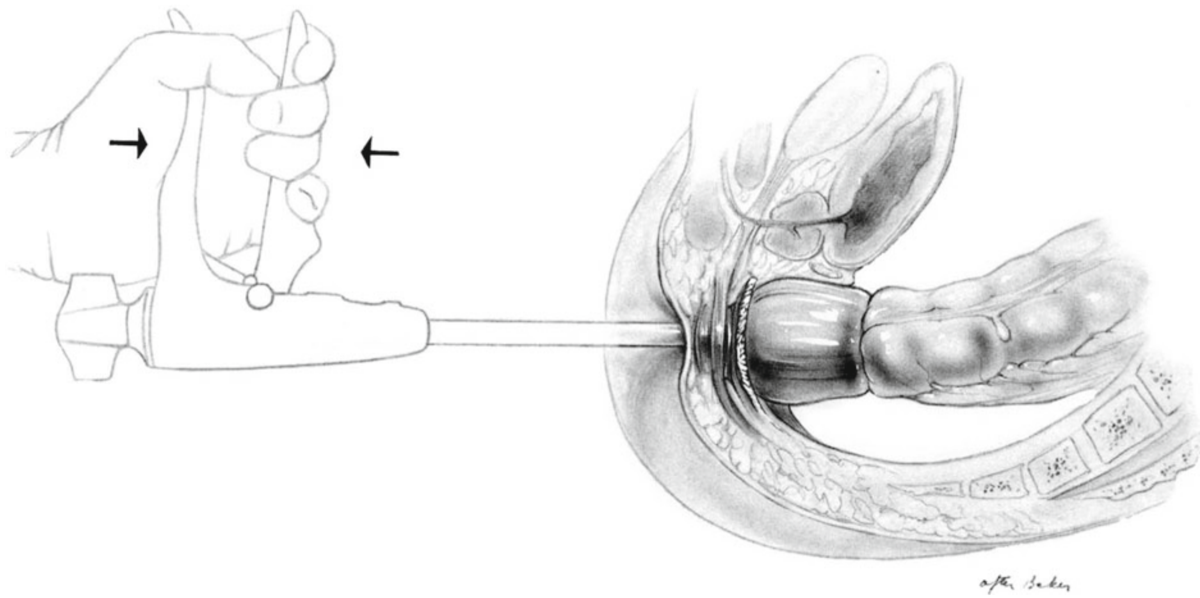


Fig. 5.5

Circular Stapling Device

The circular stapling device utilizes a circular anvil, a circular staple cartridge, and a circular knife to produce a double staggered row of staples that approximate two tubular structures in inversion while the knife cuts the tissue just inside the staple line. This creates an end-to-end anastomosis with a lumen ranging from 12 to 24 mm depending on the size of the device. The smaller sizes are rarely used. This stapler compresses tissues to a thickness of approximately 2.0 mm. Some circular stapling devices allow the surgeon to adjust the thickness within a range of 1.0–2.5 mm. When the device is inserted through the anal canal, it is ideally suited for a low colorectal anastomosis (Fig. 5.5). The circular stapler has also been used successfully for esophageal and gastroduodenal anastomoses.

Causes of Failure Following Stapled Anastomosis

Quality of the Tissues

The blood supply of the bowel to be anastomosed must be vigorous when staples are used, just as it must be for suturing. *Bowel that is not fit for suturing is not suitable for stapling*. Do not let the ease of inserting staples impair good judgment about the adequacy of tissue perfusion in the vicinity of any staple line. Always think of the blood supply.

When the linear cutting stapler is used to anastomose the jejunum to the back wall of a gastric pouch (see Fig. 33.44), at least 2.0–2.5 cm of gastric wall should be left between the linear cutting staple line and the closed end of the gastric pouch. This avoids a narrow ischemic strip of stomach and anastomotic failure.

Excessive compression of thickened tissues (e.g., gastric wall hypertrophied by chronic obstruction to a thickness of 6–8 mm) may produce a linear tear in the serosa adjacent to the stapling device. Seeing this, the surgeon should invert the staple line with a layer of seromuscular Lembert sutures; otherwise, the staple line should be excised and the closure accomplished entirely with sutures. Although tissue thickness rarely is a contraindication to the use of staples, failure by the surgeon to identify those cases in which the tissues are unsuitable for reliance on stapling may lead to serious complications.

Linear tension that exerts a distracting force against a sutured anastomosis certainly is detrimental. This tension is even more undesirable in the stapled anastomosis. One should assume that the fine wire in the staples tends to cut through tissues more readily than sutures, producing a leaking anastomosis. Reinforce points of expected tension (e.g., apex of a linear cutting staple line) with sutures.

Instrument Failure

The linear cutting stapling instrument may be misaligned, especially if it has been dropped on a ceramic floor and the two forks of the instrument diverge instead of remaining parallel. In this case the increased distance between the cartridge and the anvil prevents the staples at the distal end of the instrument from closing properly. As a precaution, *check the staple formation following completion of each anastomosis*.

In addition, when a reusable stapling device is used frequently, it should be test-fired once a month on a latex drain or a sheet of plastic to verify proper B formation (Fig. 5.1).

Partial failure of the knife assembly in the linear cutting stapling instrument occurs on rare occasions. When this happens the scalpel fails to make a complete incision between the two double rows of staples. If it is not detected by careful inspection, the resulting anastomosis has an extremely narrow lumen.

Complete failure of the staple cartridge to discharge staples has been known to happen. An inattentive surgeon may not notice it, as pressure alone may hold the bowel walls in apposition temporarily. A cartridge also fails to discharge staples if it has been spent and not replaced by a fresh cartridge before *each* application of the instrument.

Failure to wipe the excess spent staples from the anvil before inserting a fresh cartridge may result in poor apposition and difficult cutting. Check it before applying the stapler.

Human Error/Judgment

Do not place a staple line so it includes the mesentery of the bowel, as it may result in bleeding or intramural hematoma formation. Similarly, do not include mesenteric fat between the seromuscular layers of an anastomosis. Whenever the linear cutting stapling device is used on the gastric wall, carefully inspect the staple line for gastric bleeding. Transfix bleeding points with absorbable sutures. Occasionally an entire staple line in the stomach bleeds excessively. If it does, oversew the entire line with absorbable sutures inserted in the lumen of the stomach. Although it is preferable to insert sutures superficial to the staple line, there may not be sufficient tissue beyond the staples to accomplish it. On such occasions we have not had complications when 4-0 PG atraumatic sutures were inserted in the lumen of a linear cutting stapled anastomosis and were passed deep to the staples. These sutures must be tied with excessive tension. We have not observed significant bleeding following stapling in organs other than stomach. Minor bleeding may be controlled by cautious use of electrocautery.

When an excessive amount of tissue is bunched up in the crotch of the linear cutting stapler, firing the knife assembly may fail to incise the bowel between the two double rows of staples because the knife blade cannot penetrate the compressed tissue. As a result there is narrowing or absence of an anastomotic lumen. Every linear cutting staple line must be inspected for completeness and hemostasis upon removing the instrument. If the incision between the staple lines has not been made by the stapler knife assembly, it should be accomplished with straight scissors. Although this type of stapler failure is rare, its possibility should not be overlooked.

Multiple Allis clamps should be applied to the walls of the intestine included in a linear staple line. This prevents the bowel from retracting from the jaws of the instrument as the tissue is being compressed. If the tissue should retract from the jaws of the instrument, obviously the stapled closure would fail.

If an anastomosis constructed by the stapling technique has a lumen that is too small, the lumen probably cannot dilate following the passage of stool or food as much as it would if interrupted sutures had been used. If a stapled stoma is made too small, the two staggered rows of staples may keep it that way permanently after the anastomosis has been constructed. Consequently, more attention should be paid to the size of the lumen when constructing a stapled anastomosis than when constructing one by sutures.

Avoid making a false intramural passage when inserting the forks of the cutting linear stapler into stab wounds of the intestine or stomach, as it would prevent formation of a proper anastomosis. Place each fork accurately in the lumen of the intestine or the stomach.

The segments of the bowel should be in a relaxed position when a stapling device is applied to them. If excessive tension is applied while the stapler is being fired, the tissue may be too thin for proper purchase by the staples.

Special Precautions

After completing a stapled anastomosis, always inspect the entire circumference meticulously to ascertain that each staple has been formed into an adequate B. Test the lumen by invaginating the bowel wall with the index finger. Any point at which two or more staple lines cross should be carefully checked for possible leakage. Inspect the serosa for possible cracks or tears. If there is any doubt about the integrity of a stapled anastomosis, oversew it with a layer of interrupted or continuous seromuscular Lembert sutures of 4-0 atraumatic PG. Although the need to oversew the staple line occurs in no more than 1–2 % of cases managed by a surgeon experienced in performing stapled anastomoses, oversewing can be an essential step in preventing leaks in some situations.

During the last step of a functional end-to-end anastomosis, the defect is closed with a linear stapling device. If the first two stapling lines (Fig. 5.6) are kept in perfect apposition during this maneuver, six rows of staples can be seen to come together at one point after the linear stapler is fired. We believe that such a point is weak and permits development of an anastomotic leak because the presence of many staples and excess tissue in one spot results in failure to close properly. Occasionally this situation is seen in the operating room when carefully inspecting the completed anastomosis. To prevent this weak point, we have modified our technique by deliberately avoiding perfect apposition of the first two staple

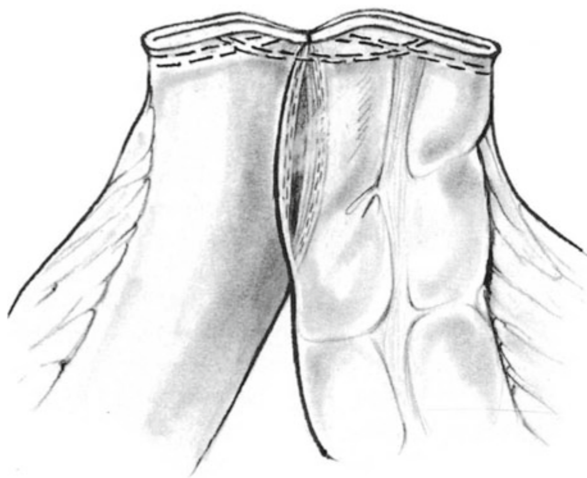


Fig. 5.6

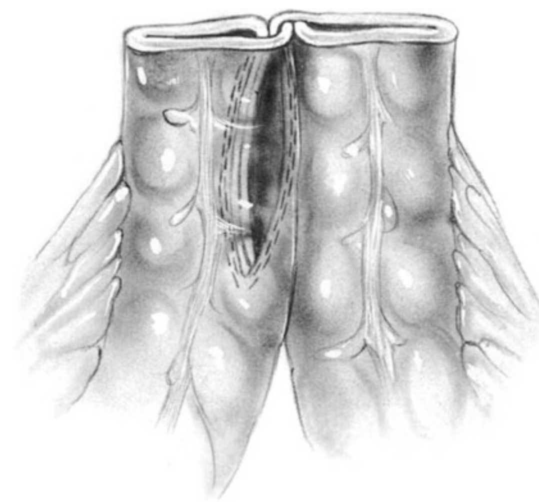


Fig. 5.7

lines to achieve more security (Fig. 5.7). A better way to avoid this problem is to use our modification of the functional end-to-end anastomosis, as illustrated in Figs. 51.35, 51.36, 51.37, and 51.38.

The many possible technical pitfalls of stapled low colorectal anastomoses are described in Chap. 53. Inserting the circular stapler anvil into the colon or esophagus is a problem when the lumen is too narrow to accommodate the anvil's diameter. The problem may result from muscle spasm or the use of a cartridge that is too large. Forceful dilatation may tear the coat of the colon or dilate the bowel to the point where it is too thin to hold staples firmly. The smallest available cartridges may result in an inadequate stoma size and should be used with care.

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6 Control of Bleeding

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Techniques for Achieving Hemostasis

Hemostat and Ligature

A hemostat of the proper length and design is a suitable instrument for occluding most bleeding vessels, followed by a ligature of a size compatible with the diameter of the vessel. As demanded by the situation, hemostats the size of a Halsted, Crile, Adson, Kelly, or Mixter may be indicated (see Chap. 11).

Polyglycolic (PG) ties are useful for most routine ligatures. Silk provides greater security when tying major vessels, such as the left gastric or inferior mesenteric artery. When the mesentery of the sigmoid colon is being divided during treatment of perforated diverticulitis, use 2-0 PG to ligate the vessels. If the splenic artery is being divided and ligated during resection of a pseudocyst of the pancreas, use a 2-0 ligature of Prolene.

Tying "In Continuity" with a Ligature Passer

When ligating large vessels such as the inferior mesenteric, ileocolic, or left gastric artery, it is convenient to pass a blunt-tipped right-angle Mixter clamp behind the vessel. The blunt tip of the clamp separates the adventitia of the artery from the surrounding tissue. Preferably, at least 1.5 cm of vessel is dissected free. When this has been done, use a ligature passer, which consists of a long hemostat holding the 2-0 silk ligature, to feed the thread into the jaws of the open Mixter clamp. Then draw the ligature behind the vessel and tie it. Pass the Mixter clamp behind the vessel again, feed a second ligature into its jaws, and ligate the distal portion of the vessel. Divide the vessel, leaving a 1 cm stump distal to the proximal tie and about 0.5 cm on the specimen side. Leaving a long stump of vessel distal to a single tie of 2-0 silk prevents the ligature from slipping off, even when it is subjected to the continuous pounding of arterial pulse waves. This type of ligation is sometimes called "tying in continuity" because the ties are placed before the vessel is divided.

Suture Ligature

Two simple ligatures of 2-0 silk placed about 3 mm apart, with a free 1 cm stump distal to the ligatures, ensure hemostasis when ligating the large arteries encountered during gastrointestinal surgery. If there is not a sufficient length of artery to meet these conditions, a 2-0 silk ligature supplemented by insertion of a transfixion suture ligature that pierces the wall of the artery 3 mm distal to the simple ligature is almost as good as a free 1 cm arterial stump. Pass the suture part of the way through the vessel wall rather than completely transfixing it. This maneuver avoids bleeding through the needle hole.

Another type of suture ligature is used in tissue into which a vessel has retracted. This problem may occur on the surface of the pancreas, where attempts to grasp a retracted vessel with hemostats can be much more traumatic than a small figure-of-eight suture of atraumatic 4-0 silk. The same figure-of-eight suture-ligature technique is valuable when a vessel has retracted into a mesentery thickened by obesity or Crohn's disease. Take care when using this technique to ensure that the vessel is actually secured; reinspect the region for hematoma formation (which would indicate that the vessel has continued to bleed and is not secured properly).

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Hemostatic Clips

Metallic hemostatic clips offer a secure, expedient method for obtaining hemostasis, provided the technique is properly applied. These clips are useful *only* when the *entire circumference* of a vessel is visible, preferably *before* the vessel has been lacerated. Applying a clip inaccurately often results in incomplete occlusion of the vessel and continued bleeding, following which the presence of the metal clip obstructs any hemostat or suture ligature in the same area. Attempts to remove the clip from a thin-walled vein may increase the rate of bleeding.

When clips are applied in an area where subsequent steps in the operation require blunt dissection or vigorous retraction, such as when performing a Kocher maneuver, the subsequent surgical maneuvers often dislodge the clips and lacerate the vessels, producing annoying hemorrhage. Hemostatic clips may similarly interfere with application of a stapling device.

It is futile to apply multiple clips in the general area from which blood is oozing in the hope it will somehow catch the bleeder. Again it must be emphasized that applying a clip is counterproductive unless a bleeding vessel can be clearly visualized.

In the absence of these contraindications, hemostatic clips speed dissection and allow secure control of bleeding vessels. An example is in the mediastinum during esophageal dissection or in the retroperitoneal area during colon resection.

Staplers

Laparoscopic surgeons are familiar with use of staplers, loaded with "vascular cartridges," for control of vessels too large to securely clip or ligate. These staplers are gradually making their way into common use during open surgery as well. They deposit three staggered rows of 2.5 mm staples and cut between, thus securing and dividing the vessels. They appear particularly useful for large diameter veins such as the adrenal vein during adrenalectomy or the splenic vein during splenectomy. As with any stapling device, it is essential that the surgeon be familiar with the particular stapler being used and that no clips are contained in the tissue to be stapled.

Electrocautery

With electrocautery a locally high current density is passed through the target tissues to achieve rapid tissue heating. Monopolar cautery devices allow the surgeon to cut or cauterize with a bladelike tip. The return current path is through a large grounding electrode placed on the patient's thigh or back. Two types of current are supplied by most electrocautery generators: cutting and coagulating. Cutting current is continuous-wave, high-frequency, relatively low-voltage current. It produces rapid tissue heating, which allows the blade of the cautery to cut through tissue like a scalpel. There is minimal hemostatic effect. Coagulating current is pulsed-waveform, low-frequency, high-voltage current that heats tissues slowly. The resulting protein coagulation seals small vessels.

Cautery is most effectively employed by grasping the bleeding vessel with forceps or a hemostat, elevating it slightly above surrounding tissue, and then touching the cautery blade to the instrument. The resulting coaptive coagulation seals the front and back wall of the collapsed vessel together. Small punctate bleeders may be secured by touching them directly with the tip of the cautery.

Bipolar cautery units generally have a forcepslike configuration that facilitates use of coaptive coagulation. It is less useful, however, for cutting.

Electrocautery is a valuable, rapid means to achieve hemostasis, provided certain contraindications are observed. Vessels that have an external diameter of more than 2–3 mm should not be secured with cautery. As with hemostatic clips, any tissue that will subsequently be subjected to blunt dissection or retraction may not be suitable for electrocautery, as the friction often wipes away the coagulum, causing bleeding to resume. Fat does not conduct electricity well, and extensive use of cautery in fatty tissues may result in excessive tissue destruction. Similarly, when many subcutaneous bleeding points are subjected to electrocoagulation, the extensive tissue insult may contribute to wound infection.

Ultrasonic Shears

Ultrasonic shears were initially introduced for minimal access surgery but are now available with shorter shanks for use during open surgery. These devices use ultrasound to heat and coagulate tissue in a coapted position. The tissue is then cut with the device or with scissors. Slightly larger vessels (e.g., short gastric vessels or vessels in the lateral rectal pedicles) may be secured with this device rather than with coaptive coagulation using electrocautery.

Physicochemical Methods

Gauze Pack

Physical application of a large, moist gauze pad has been employed for decades to control diffuse venous oozing. It enhances the clotting mechanism because pressure slows down the loss of blood, and the interstices of the gauze help form a framework for the deposition of fibrin. Unfortunately, after the gauze pack is removed, bleeding sometimes resumes. Packing has been lifesaving after major hepatic trauma or for persistent pelvic bleeding during abdominoperineal resection, particularly when the patient has become cold or developed a coagulopathy. Packs may be left in and removed after 24 h when the patient is stable and all hemostatic parameters have returned to normal (see Chap. 8).

Topical Hemostatic Agents

A variety of topical hemostatic agents are available in powder, sheet, and woven form. They vary in chemical formulation, but most are collagen or cellulose derivatives and act as a matrix and stimulant for clot formation; thus, the patient must be able to form clot for these agents to work. It is wise to remember the old axiom that *topical agents work best in a dry field*. In other words, these agents are adjuncts that help stop oozing but do not substitute for definitive hemostasis of individual bleeding vessels. References at the end give further details on specific agents.

Topical agents may be applied in a thin layer to an oozing surface, such as liver or spleen from which the capsule has been avulsed. An overlying gauze pad is then placed and pressure applied. When the pack is removed 10–15 min later, the topical hemostatic agent remains adherent to the surface, preventing disruption of the coagulum that is forming underneath. Choice of an agent is dictated in part by the physical geometry of the bleeding site (powders are best for irregular surfaces), availability, and surgeon preference.

Avitene (microfibrillar collagen) comes in powdered form to be sprinkled on a bleeding surface, or it can be applied with clean, dry forceps. Any moisture on instruments or gloves that come into contact with Avitene causes the Avitene to stick to the moist instrument rather than to the bleeding surface. If blood oozes through the layer of Avitene, another layer should be applied and pressure exerted over it. When flat surfaces of a denuded spleen or gallbladder bed are oozing, oxidized cellulose seems to be as effective as Avitene at one-twentieth the cost. Avitene is better for irregular surfaces because it is a powder. Microfibrillar collagen and oxidized cellulose are valuable when some portion of the splenic capsule has been avulsed during a vagotomy or splenic flexure mobilization.

Fibrin Sealant

Fibrin sealant is a hemostatic agent that mimics the final stage of blood coagulation. Fibrinogen and thrombin are combined at the bleeding site in the presence of calcium and in appropriate concentrations to produce an artificial coagulum. There is no current consensus on the usefulness of this agent in general surgical practice, although it is an area of active investigation. See references at the end for further information on these adjuncts.

Control of Hemorrhage

Temporary Control

During the course of operating, the equanimity of the surgeon is jarred occasionally by a sudden hemorrhage caused by inadvertent laceration of a large blood vessel. One should have in mind a sequence of steps to execute in such an event, aimed at temporary control of the bleeding in preparation for definitive steps later. The sequence should go something like the following:

1. *Finger pressure*. The simplest step, especially useful for controlling bleeding from an artery, is simple application of a fingertip to the bleeding point. In the case of a large vein, such as the axillary vein or vena cava, pinching the laceration between the thumb and index finger is sometimes effective. Notify the anesthesiologist that you are dealing with bleeding. Ascertain that the patient is fully resuscitated, that large-bore intravenous catheters are in place, and that blood and blood products are available. In the trauma situation, the use of defined protocols for blood product replacement has significantly helped avoid iatrogenic coagulopathy (see references at end).
2. *Elevation of the structure by placing the hand behind it*. If step 1 is not applicable, sometimes the left hand can be placed behind a structure such as the hepatoduodenal ligament to control bleeding from the cystic artery or the pancreas or behind the portal vein for bleeding in that area. This maneuver may bring temporary control.
3. *Compression by hand pressure or gauze-pad pressure*. Large lacerations of the liver may be temporarily controlled by compressing the liver between two hands while the patient is being resuscitated. Massive venous bleeding from the presacral space can be controlled by applying a large gauze pad.
4. *Satinsky clamp*. When direct pressure is not effective, a partially occluding Satinsky-type vascular clamp may be used to control the laceration of a large vessel.
5. *Proximal and distal control*. Sometimes even temporary control of hemorrhage is impossible without proximal and distal occlusion of the vessel, in some cases involving the aorta or vena cava. Preferably, vascular clamps are used; but in their absence, umbilical tape is a satisfactory temporary substitute. The aorta may even be clamped or occluded by pressure in a suprarenal position for 15–20 min if no other means of hemostasis is effective. This safe period may be lengthened if iced sterile saline is poured over the kidneys to reduce their metabolic requirements.

Definitive Control

Once hemorrhage has been temporarily controlled, the surgeon reassesses the strategic situation. The field is cleared of all instruments and hemostats not relevant to the major problem at hand. If additional exposure is needed, plans are outlined immediately to accomplish this by extending the incision or repositioning gauze pads or retractors. Optimal light and suction lines are put in place, and arrangements are made with the blood bank for adequate support of the patient. Additional personnel are recruited as necessary.

Assign someone to be "bookkeeper." This individual's only duty is to keep track of the volume of blood lost and the rate at which it is replaced, reporting this information to the operating surgeon at frequent intervals. Otherwise, the surgeon and anesthesiologist may become so involved with the task at hand they make inadequate provision for resuscitating the patient.

After all these steps have been completed and the patient's condition has stabilized, the surgeon can convert the measures for temporary control of hemorrhage to maneuvers to ensure permanent control. This step generally involves applying a partially occluding Satinsky-type clamp to the vessel or achieving proximal and distal control with vascular clamps, so the laceration can be sutured in a definitive fashion with a continuous suture of atraumatic Tevdek or Prolene. No surgeon should undertake to perform major surgery unless trained and experienced in suturing large arteries and veins.

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Management of the Contaminated Operation

7

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Infectious complications after surgery remain a major cause of morbidity and mortality in surgical patients. Bacteria are commonly present during surgical procedures, and the balance between bacterial presence and host defense is critically important in determining whether or not clinically significant infection will result. The degree of bacterial inoculum is thought to correlate with the risk of developing postoperative infection. Management of the contaminated operation presents the greatest clinical challenge.

Contaminated operations include intrinsically dirty procedures such as surgery for perforated ulcer, perforated diverticulitis, appendicitis, and dead bowel. They also include procedures in which unanticipated spillage occurs, for example, when bowel contents are spilled during lysis of adhesions or when the gallbladder is perforated during laparoscopic cholecystectomy (with resulting spillage of bile and stones).

Postoperative complications may include subcutaneous wound infection, fasciitis, abscess formation, enterocutaneous fistula, and systemic sepsis. Management should be directed toward minimizing the bacterial inoculum, addressing the patient's additional risk factors for infection and augmenting the patient's host defenses. This chapter reviews specific surgical strategies to address and potentially mitigate these risks.

Preoperative Considerations

Timing of Surgery

One of the most fundamental strategies is to consider whether the emergency contaminated operation can be converted into an elective operation performed later under more controlled circumstances. This has been extremely successful in the treatment of diverticular abscesses. The standard management of open surgical resection with drainage of the abscess, resection of the involved bowel, and Hartmann's procedure has largely been supplanted by percutaneous drainage of the abscess, treatment with antibiotics, and judicious assessment for possible delayed single-stage resection. Another example would be the management of perforated appendicitis with abscess – again often successfully managed with percutaneous drainage of the abscess and antibiotics. In both instances, the initial management has shifted from a primary surgical approach in a dirty field to judicious use of antibiotics and percutaneous drainage of the abscess.

Adequate Resuscitation of the Patient

Maximizing tissue perfusion and oxygen delivery forms the cornerstone of successful perioperative resuscitation. Two important principles are (1) restitution of adequate circulatory volume and (2) avoidance of peripheral vasoconstriction. Successful cardiopulmonary resuscitation ultimately results in higher PO_2 in injured tissue, which in turn results in increased bacterial resistance, collagen synthesis, and epithelialization.

Peripheral vasoconstriction is a clinically important contributor to poor oxygen supply in wounded tissue. Mediators of vasoconstriction include blood volume deficits, cold temperature, smoking (nicotine), and certain medications.

Perioperative hypothermia delays healing and predisposes patients to wound infections. Maintenance of perioperative normothermia is important for all surgical patients,

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but particularly so for patients undergoing emergency surgery for intra-abdominal sepsis.

Resuscitation should be determined not by fixed formulas but by specific goals (targets) for mixed venous oxygen saturation, central venous pressure, mean arterial pressure, and urine output.

Perioperative Parenteral Antibiotics

The use of perioperative parenteral antibiotics in contaminated operations is considered therapeutic rather than prophylactic. Start antibiotics as soon as a diagnosis of sepsis or a potentially septic focus is made. If spillage of enteric contents has caused unanticipated contamination during a routine operative procedure, adjust antibiotics accordingly.

Adjust these antibiotics in the operating room as dictated by the findings. In the postoperative period, assess the need for and appropriateness of antibiotic coverage every day as results of blood cultures, cultures of purulent material obtained at surgery, and the patient's clinical course dictate. Generally antibiotics are continued for 7–10 days after abdominal surgery for perforation or dead bowel.

Consider using prophylactic antifungal therapy when a gastrointestinal perforation is found.

Preoperative Imaging

CT scan with judicious use of contrast is the single most useful modality for evaluating patients before emergency abdominal surgery. If a discrete, contained abscess is found, consider parental antibiotics and percutaneous drainage rather than surgery.

Intraoperative Considerations

Supporting the Patient/Continuous Resuscitation

Continue goal-directed resuscitation in the operating room. Hypothermia during abdominal surgery has been associated with an increase in surgical wound infections. In animals, it has been shown to cause intraoperative and postoperative vasoconstriction with a resulting decrease in subcutaneous tissue oxygen tension. Decreased oxygen tension, in turn, results in decreased microbial defense and impaired immune function. Thus, attention has been directed to the effect of perioperative normothermia versus hypothermia and the incidence of surgical wound infection. Kutz et al. conducted a prospective double-blind randomized study in humans undergoing elective colorectal surgery and showed that patients who were normothermic during surgery experienced wound infections one-third as often as patients who were hypothermic during surgery.

Normothermia may be difficult to achieve in septic patients and patients with major trauma. Warming the operating room, warming all fluids, and using warming circuits in the anesthesia machine may all be required.

Finding and Isolating the Source

It is crucial to identify and eliminate the source of contamination. This may require closing a perforation, resecting a segment of bowel, or draining abscesses.

Sometimes the source is obvious from the history, physical examination, and preoperative imaging studies. Ruptured appendicitis with generalized peritonitis or a perforated duodenal ulcer would be examples of such situations. In other cases the source will be obvious only at surgery. In very rare and frustrating cases, free intra-abdominal air may prompt laparotomy, and no definite source is found (see the end of this section).

A long midline incision provides the best exposure to all quadrants of the abdomen. Carefully separate fibrinous adhesions between loops of bowel. The color, texture, content, and odor of peritoneal fluid will often give a definite clue as to the level of the perforation. Adhesions are often densest near the site of perforation. Copious irrigation with warm saline, removal of fibrin, and packing the abdomen in quadrants will allow identification of the source.

When, despite diligent search, no source is found, carefully evaluate the upper digestive tract by opening the lesser sac (to allow inspection of the back of the stomach). Fill the abdomen with warm saline and have the anesthesiologist inject air into the stomach via the gastric tube. Bubbles will be evident if there is a hole in the distal esophagus or stomach. Some surgeons use methylene blue dye for a similar purpose. Similarly carefully mobilize the sigmoid colon and look for a tiny diverticular perforation. When nothing is found, close the abdomen and continue antibiotics while awaiting results of cultures. Some surgeons will place closed suction drains near the most likely source, for example, near the sigmoid colon if occult diverticular perforation is suspected.

Surgical Technique: Does the Surgeon Make a Difference?

Studies have shown that when infection rates of individual surgeons are followed and the surgeons are provided with feedback regarding these data, their postoperative infection rates are reduced. Unfortunately, most such studies concern clean elective surgery where the anticipated wound infection rate is extremely low.

Meticulous surgical technique is an important principle that affects postoperative results, including the incidence of postoperative infections. Sharp dissection, gentle tissue manipulation, and adequate hemostasis have often been cited as important factors that constitute proper surgical technique. Although there are historical data that attempt to compare resistance of surgical wounds to infection based on the use of a steel knife versus electrocautery, few data support one technique or the other. Some attention has been also given to proper suture usage. The guiding message in this regard should be to limit suture use to a necessary minimum, avoiding undue tissue tension and strangulation.

Localizing Contamination

Adequate exposure with proper retraction is essential for conducting appropriate exploration of the contaminated field. Many surgeons drape off (isolate) the surgical incision by applying wet towels or gauze to the subcutaneous tissue, which minimizes contact with gross contamination but does not prevent bacterial strike-through. Use of a wound protector drape, such as the Alexis O Wound Protector/Retractor (Applied Medical, Rancho Santa Margarita, CA), may help keep tissues moist and isolate the subcutaneous fat from gross contamination. Such a drape is slipped into the open incision (Fig. 7.1) and then opened and spread out to cover the subcutaneous fat and musculoaponeurotic layers of the abdominal wall (Fig. 7.2).

Subtle behaviors in the operating room may also play a role in minimizing postoperative complications. Upon conclusion of the contaminated segment of the operation, change gown, gloves, and instruments prior to abdominal wall closure.

Wound Irrigation

Adequate intraoperative irrigation of the wound minimizes the bacterial inoculum and has been shown to decrease postoperative infection. It has long been customary to pour several liters of saline into the contaminated cavity during the contaminated portion of an operation and just prior to closing, although specific practices vary widely among surgeons. Frequent irrigation with 200 ml of saline followed by aspiration is a rational approach to washing out bacteria spilled into the field. Take care not to let the irrigation fluid spill over onto subcutaneous tissues. Experimental models have shown that the most important factor that determines wound infection during contaminated surgery is the number of bacteria present at the wound margins at the end of the operation. The effect of operative field irrigation on the incidence of deep wound/abscess formation is less clear.

The use of antibiotic agents in the irrigating solution is more controversial, although many surgeons routinely irrigate with antibiotic saline solutions. Irrigants have contained such antibiotics as a cephalosporin, an aminoglycoside, neomycin, and metronidazole. In addition to decreasing the

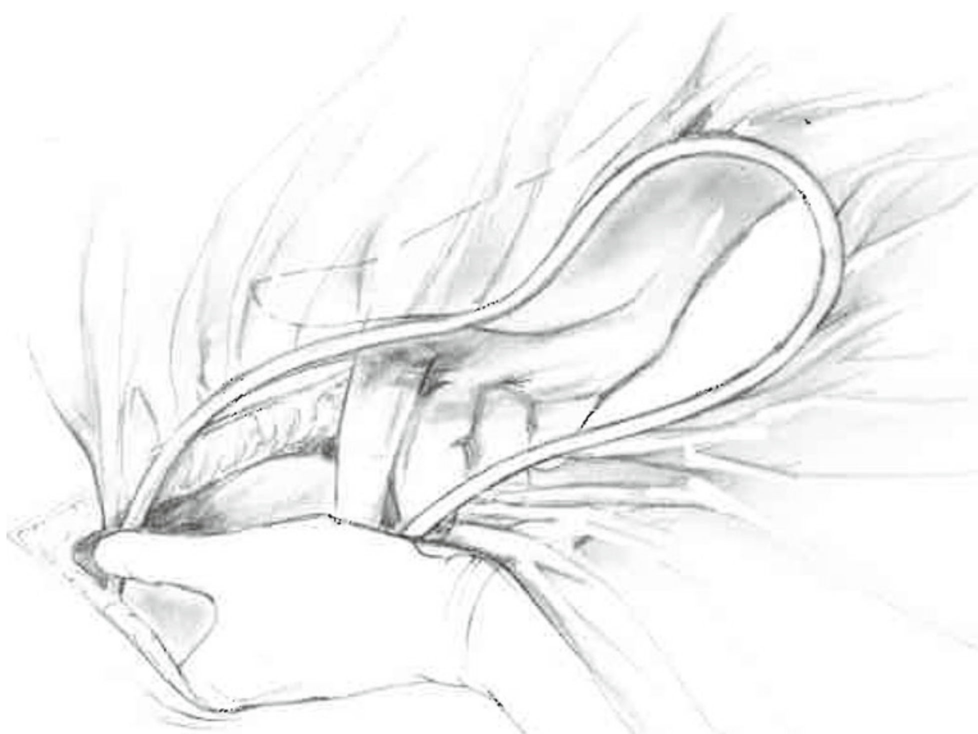

Fig. 7.1

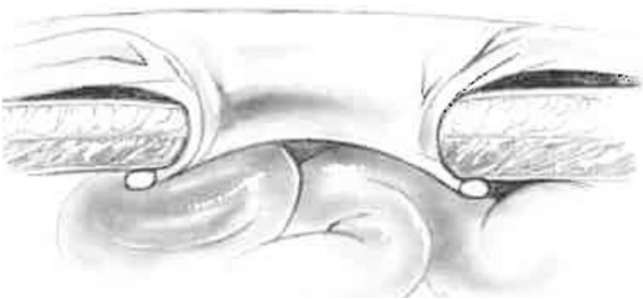

Fig. 7.2

bacterial inoculum, wound irrigation rinses the operative field of tissue debris and blood clots, which may be relevant to prevention of postoperative infection.

Other Considerations

Drains are used when a localized collection of pus (a well-formed abscess) is found or when there is concern over continuing contamination. See Chap. 10.

When the patient is unstable or reoperation is planned within a short period of time, consider damage control laparotomy (Chap. 8). Limit the initial operation to control of contamination and reserve any gastrointestinal reconstruction to a second procedure.

Local antibiotic therapy has received relatively little attention in the United States, with most of the available literature arising from European study groups. The application of local antibiotic therapy has the advantage of providing high concentrations of antibiotic to a well-defined area. On the other hand, once the wound is closed, it is not simple to reduce or remove the source of antibiotic.

Local antibiotic therapy has been supplied in the form of undiluted parenteral antibiotic powder, antibiotic beads, and antibiotic collagen sponges. The latter two methods are most popular. Antibiotic-containing collagen sponges appear to be most practical, as the collagen dissolves and does not require removal. The sponges are usually in the form of sheets and therefore can be used to cover large areas more accurately than the beads. Local antibiotic therapy has been utilized for orthopedic procedures, pilonidal surgery, colorectal procedures, and cardiovascular and vascular surgery.

Postoperative Considerations

Wound Closure

Primary wound closure during contaminated operations has been associated with a nearly 40 % wound sepsis rate. Thus, healing by secondary intention has been the tradition when dealing with wounds of highly contaminated operations. It is a well-accepted practice to leave the skin and subcutaneous tissue open after such operations to allow drainage. The main goal of such management is to prevent potentially devastating complications, such as fasciitis.

Delayed primary closure, within 4–6 postoperative days, results in fewer wound infections than primary closure after contaminated operations. Many surgeons believe that attempted delayed primary closure is a reasonable "compromise" between healing by secondary intention and primary closure. When successful, delayed primary closure avoids large wounds that require labor-intensive, potentially expensive care.

Wound Dressings

Wound dressings are a means to protect the wound and a mechanism for absorbing wound drainage. Wounds that are to heal by secondary intention or delayed primary closure require a wound dressing. Wet gauze should be applied to the subcutaneous tissue, covered with a dry pad, and then covered with occlusive tape. These dressings must be changed at least twice a day. To create a wet-to-dry dressing, the gauze is removed from the wound without soaking the gauze prior to removal. The wet-to-dry dressing mechanically helps debride the subcutaneous tissue of any debris that collects between dressing changes. On occasion, contaminated and infected abdominal operations require marsupialization, leaving the abdominal cavity open. In these cases dressing changes using sterile technique and optimal exposure must often take place in the operating room. They can also take place, with care, in the intensive care setting.

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8 Damage Control Laparotomy

Carol E.H. Scott-Conner

Damage control laparotomy is performed under dire situations, when a patient requires surgery but is too unstable to tolerate definitive operative repair. It was initially developed, and is still most commonly used, in the trauma situation. There are two major advantages: First, operative time is minimized by concentrating on control of injuries rather than definitive repair and, second, postoperative problems with abdominal compartment syndrome are avoided by leaving the abdomen open. Resuscitation continues after surgery and definitive repair can then be undertaken after the physiologic status of the patient has been optimized.

It is also applicable to other emergency situations, most notably operation for ischemic bowel. In this situation, a planned second-look operation provides the best opportunity for definitive repair.

The technique may be lifesaving but is associated with significant morbidity. Delayed abdominal closure is associated with an increased risk of enterocutaneous fistula formation. Ventral hernia formation is common, and most patients will require a subsequent operation for repair of their hernia.

Damage Control in Trauma

Always follow the basic principles of trauma surgery. These include warming the operating room, intravenous fluids, and ventilator circuit, having at least two large bore intravenous catheters in place and adequate (but not excessive) resuscitation with warmed crystalloid, and ensuring ready availability of blood and blood products (including activation of a massive transfusion protocol).

Prep and drape the entire abdomen, chest, neck, and groins. Prep wide, flank to flank, to allow for stomas and drains. Make a long laparotomy incision from xiphoid to pubis. Anticipate additional blood loss when the abdomen is entered and any venous tamponade is relieved. Eviscerate the bowel to gain better exposure to all quadrants. Rapidly evacuate the abdomen of blood and clots and pack it in quadrants.

Identify and control bleeding sites by packing solid organ injuries, repairing major vessels and ligating small ones. Control contamination from hollow viscus injuries with clamps, staples, or suture.

Massive intra-abdominal bleeding in blunt trauma commonly comes from spleen or liver, less commonly from kidney injuries, pelvic fractures, vascular injuries, mesenteric tears, or other sources. These injuries and some strategies for management in the damage control situation are discussed in the sections that follow.

Decision to Perform Damage Control

The decision to perform damage control rather than to pursue definitive repair of all injuries depends upon physiologic stability of patient, other injuries, and the nature of damage found on laparotomy. Physiologic criteria include acidosis, hypothermia, and coagulopathy. The approach outlined here works well for blunt trauma. It can be modified as needed in the case of penetrating trauma.

First, obtain temporary control of bleeding and allow anesthesia to catch up with blood loss. Next, determine how much surgery – in terms of additional blood loss as well as operative time – will be needed to attain definitive control. Major blunt liver trauma is best managed by packing; thus, the finding of significant hepatic injury will generally mandate

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damage control. Conversely, major splenic bleeding is easily and definitively managed by splenectomy. If prolonged resuscitation has caused significant bowel and retroperitoneal edema, abdominal compartment syndrome is a concern and damage control is more appropriate than primary abdominal closure.

Damage Control Management of Specific Injuries

Diaphragmatic injuries require repair at initial exploration. Rapid closure with a heavy running nonabsorbable suture provides hemostasis, prevents herniation of viscera, and facilitates liver packing. Without watertight closure of the diaphragm on the right, liver injuries may continue to bleed out a right-sided chest tube.

Splenic injuries are managed by rapid mobilization of the spleen and splenectomy. Take care not to injure colon, stomach, or tail of pancreas. There is no role for splenic repair in the setting of an unstable patient with multiple injuries. Pack the splenic bed with laparotomy pads, if necessary, to control oozing.

Have an assistant maintain bimanual compression of the liver to control bleeding as you mobilize the ligaments, including the falciform. Division of the falciform ligament makes it easier to pack the liver and helps prevent additional injuries caused by traction on the ligament. In less dire situations, finger fracture with direct control of bleeders and bile ducts provides definitive control. In the damage control situation, packing is the most common strategy. If the bleeding can be controlled by bimanual compression, packing should work. Packs must be placed in such a manner as to avoid compression on the inferior vena cava. This requires packing the right lobe against the retroperitoneum to the right of the cava. Elevate the abdominal wall and costal margin and place packs above the liver in such a way as to provide downward pressure on the right lobe. Many surgeons place a folded plastic drape directly on the liver and pack above this, to facilitate atraumatic removal of packs at second laparotomy. Have the anesthesiologist report any drop in blood pressure as you pack, and be prepared to adjust your packing to relieve inferior vena cava compression. Use only packs with radio-opaque markers. Avoid using surgical towels or other non-tagged items. Make careful note of the number of packs. If the patient will be transferred to another facility, write the number of packs on the abdominal wall in addition to sending records with the patient.

In dire situations, the Pringle maneuver will provide temporary vascular control (up to 1 h) unless bleeding is coming from the retrohepatic vena cava or major branches of the hepatic veins. Place a vascular clamp across the foramen of Winslow to occlude the hepatic artery and portal vein. Have the anesthesiologist note the time that the clamp is applied.

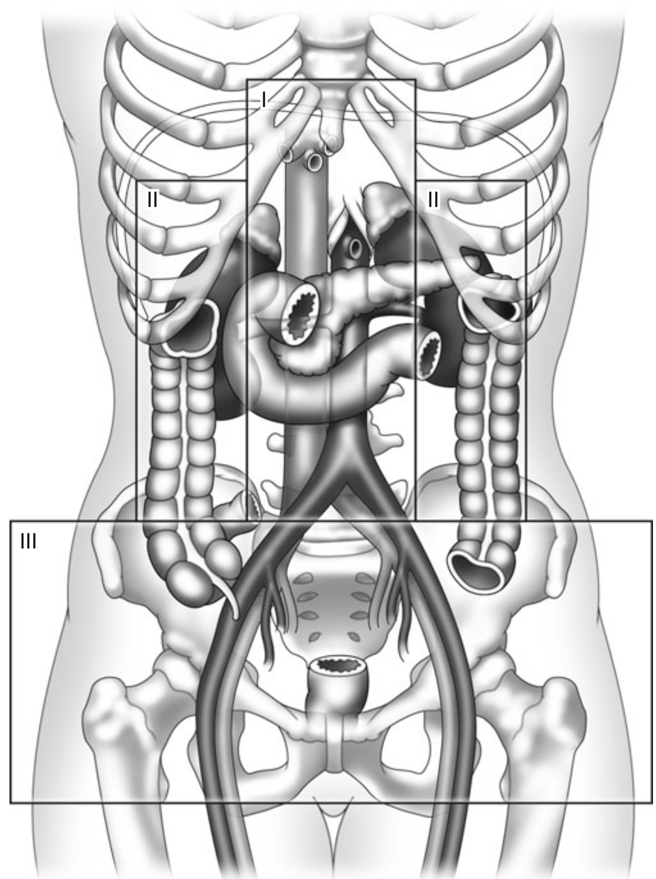

Fig. 8.1

Attain rapid control of hollow visceral injuries by closing the hole with a skin stapler or with sutures or by resection with gastrointestinal staplers. For temporary closure during exploration, Babcock clamps work well. Defer anastomosis or stoma formation until the patient is more stable.

The retroperitoneum is divided into three anatomic zones for trauma purposes. Zone I is the central zone (Fig. 8.1). It contains the duodenum, pancreas, aorta, and vena cava as well as many smaller named vessels such as the celiac, superior and inferior mesenteric arteries, and the renal vascular pedicles. Hematomas in this area must be explored to identify and manage injuries.

Zone II and III retroperitoneal hematomas are generally not explored in blunt trauma. Zone II includes the kidneys; all penetrating injuries are explored, and blunt injuries associated with pulsatile or expanding hematomas are explored as well. There is division of opinion as to whether central vascular control of the renal artery and vein should be obtained before the hematoma is opened.

It is especially important not to disrupt pelvic (zone III) hematomas associated with pelvic fractures, as the peritoneum provides vital tamponade of bleeding. Occasionally, the violence of the trauma will have disrupted the pelvic peritoneum, creating a hole into the pelvic hematoma with resulting bleeding into the abdomen. In these situations, packing is the best strategy. Zone III hematomas are explored in penetrating trauma due to risk of bladder or bowel injuries.

Damage Control in the Non-trauma Setting

Damage control concepts work nicely for situations where second-look laparotomy is planned; most commonly, this will be mesenteric ischemia. Rapid resection of grossly necrotic bowel coupled with correction of any correctable vascular lesions, with planned reoperation, maximizes the potential for bowel length salvage. At reoperation, additional bowel is resected if necessary and either stomas or anastomoses are constructed.

In contrast to the trauma situation, definitive abdominal closure can generally be obtained at second laparotomy, once the ischemic area has been dealt with.

Similarly, complicated peripancreatic sepsis where multiple operations or washouts will be required lends itself to damage control strategies. In these cases packing changes can be done in the intensive care unit. Enterocutaneous fistula and ventral hernia formation are common complications.

Temporary Abdominal Wall Closure

The original methods of temporary abdominal wall closure involved use of multiple towel clips to close skin only or suturing a prosthetic silo (including use of a sterile irrigation fluid bag opened up to form a flat sheet) to the fascia. Most of these have been abandoned in favor of a vacuum closure device. Such devices are commercially available or may be fabricated from materials available in the operating room. Vacuum closure controls drainage and facilitates nursing in the intensive care unit. The fascia will tend to retract but the closure itself does not damage the fascial edges (since no sutures are placed); it is fast and easy and provides maximum decompression.

Definitive closure and repair of subsequent ventral hernias frequently requires some form of component separation to reposition the retracted fascial edges.

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Mechanical Basics of Laparoscopic Surgery

9

Carol E.H. Scott-Conner

Flawless and smooth completion of laparoscopic surgical procedures requires complete understanding of equipment, techniques, and regional anatomy. This chapter details some of the basic principles common to all laparoscopic surgical procedures. It should be read and thoroughly understood as a background to the technical chapters that deal with specific surgical procedures.

Equipment and Supplies

A few minutes of thought and planning may save a lot of time once the operation begins. Ascertain that all needed equipment is present and in working order and that the room is properly set up *before* scrubbing. For most laparoscopic equipment and supplies, there is a choice of manufacturers. Apparently similar devices frequently have subtle points of difference when compared to other brands. Thus, it is crucial for surgeons to be familiar with the particular brands in use in their own hospitals.

A troubleshooting guide, such as the one produced by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), facilitates finding and fixing problems with the insufflator, the light source, the video equipment, cautery, suction, and other complex devices. Such a chart may be laminated and affixed to the laparoscopy cart for ready reference. This is particularly important when laparoscopy is performed during the evening or night shift (e.g., for acute appendicitis) with personnel who may not be familiar with the equipment and its setup.

Room Setup

The patient position and details of the room setup vary depending on the procedure to be performed. Laparoscopic surgery is extremely dependent on optimum patient and equipment position. Whereas during an *open* procedure the surgeon is free to move from side to side and vary his or her stance even from moment to moment to assume the ergonomically best position, the *laparoscopic* surgeon is limited by port placement. Think of the laparoscope as the surgeon's eyes and the two operating ports as the left and right hands. Although it is indeed possible to switch the laparoscope from one port to another, poorly positioned port sites limit visibility and access.

Plan the room setup so the surgeon can stand facing the quadrant containing the anticipated pathology. For example, laparoscopic cholecystectomy is comfortably performed by a surgeon standing to the patient's left, facing a monitor positioned at the patient's right shoulder (Fig. 9.1). Surgery

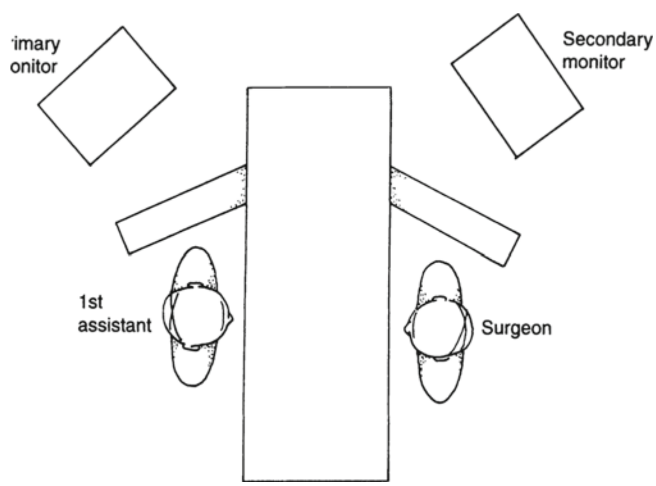

Fig. 9.1 (From Scott-Conner CEH (ed), The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer-Verlag, 1999, with permission)

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DOI 10.1007/978-1-4614-1393-6_9, © Springer Science+Business Media New York 2014

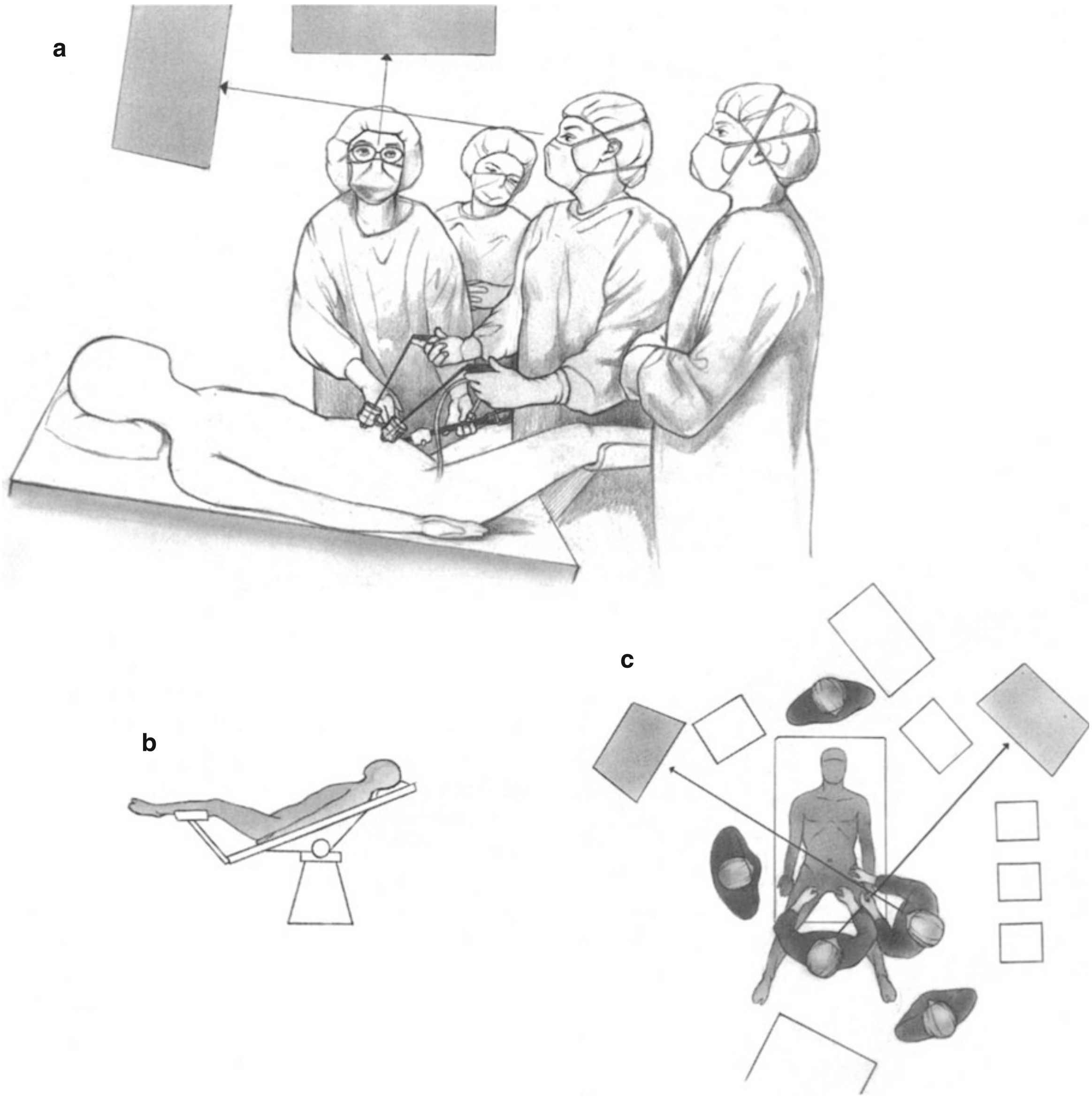

Fig. 9.2

around the esophageal hiatus is best performed with the patient in a modified lithotomy position, the surgeon standing behind the patient's legs, and the monitor at the left shoulder or head of the bed (Fig. 9.2). Even a relatively minor detail such as whether the arms are tucked at the side or placed out on arm boards becomes significant. In the technical chapters dealing with specific laparoscopic procedures, the important points relevant to each operation are explained. For now, suffice it to say that no detail is unimportant.

Choice of Laparoscope: Straight Versus Angled?

A straight (0°) laparoscope is easy to use and may be adequate for basic laparoscopic procedures in which the scope is easily brought to an en face view from a standard umbilical port site. The angled laparoscope allows the surgeon to view a structure from several viewpoints through a single trocar site and thus provides good flexibility. For some laparoscopic procedures, such as laparoscopic choledochotomy, Nissen fundoplication, and inguinal hernia repair, an angled laparoscope is virtually a necessity. Most commonly, laparoscopes with 30° or 45° angles are used.

The commonest error with an angled laparoscope is to point the angle *away* from the area of interest rather than *toward* it. It is easy for the neophyte camera holder to become confused unless a simple principle is kept in mind: Always remember that the angle of the laparoscope points away from the point of entry of the light handle (Fig. 9.3). Instruct the camera handler to hold the laparoscope cradled in the hand with the light cord between the thumb and forefinger. This comfortable and stable grip allows the camera holder easily to angle the scope to one side or the other by pronating or

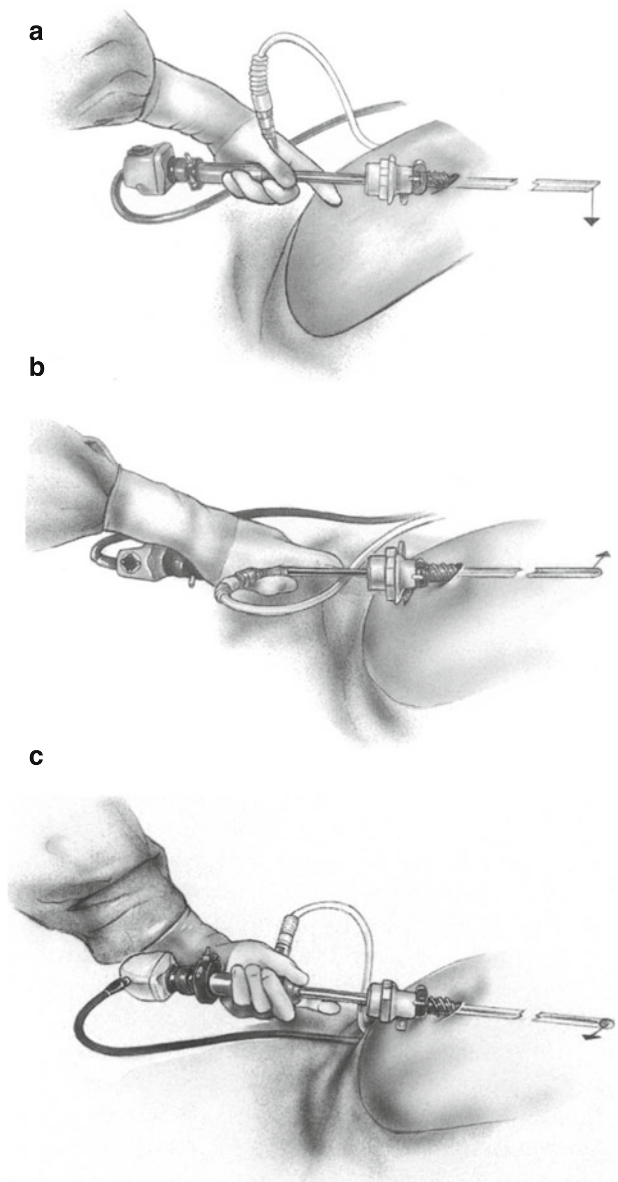

Fig. 9.3

supinating the wrist. If this causes the horizon to tilt noticeably, compensate by rotating the camera on the scope, if necessary.

Many experienced laparoscopic surgeons use an angled laparoscope (usually a 30° scope) as their standard scope. Become accustomed to an angled laparoscope by using it for laparoscopic cholecystectomy and note how it facilitates visualization of both sides of critical structures.

Choice of Initial Puncture Site

When planning trocar sites, particularly the initial puncture site, examine the abdomen for masses and scars from previous surgery and plan the location of the probable operative field. Think in terms of relative distance rather than fixed landmarks.

The umbilicus is a common site for primary entry and placement of the initial trocar. Use this site unless you have a specific reason to prefer an alternate position. Because the umbilicus represents the point where fascia and skin are adherent, entry is easy. The resulting scar is easily hidden in the skin creases around the umbilicus or is incorporated in a midline incision if conversion is required. The position of the umbilicus relative to the costal margin and symphysis pubis varies from one individual to another, particularly with increasing amounts of abdominal fat. Therefore, when considering this initial entry site for a particular patient, take note of how high or low the umbilicus is situated.

In the patient with a normally placed umbilicus, an infraumbilical "smile" incision works well for laparoscopic cholecystectomy. An obese patient with a low-lying umbilicus may require a supraumbilical "frown" incision or possibly a midline or right paramedian entry site placed even higher.

Alternate puncture sites include the subcostal region. Here, the costal arch provides counterpressure against which the Veress needle is easily passed into the abdomen. Subcostal entry sites are particularly useful for laparoscopic procedures done with the patient in the lateral position (e.g., laparoscopic splenectomy) or in the extremely obese patient.

Patient Preparation

An orogastric or nasogastric tube should be passed after induction of anesthesia to decompress the stomach. This maneuver minimizes the chance of inadvertent injury and significantly facilitates visualization. For laparoscopic procedures in the lower abdomen, catheter drainage of the bladder is needed. Monitoring devices should include end-tidal CO_2 measurement and pulse oximetry.

Creating Pneumoperitoneum

Closed Technique with Veress Needle

Begin with the operating table at a comfortable height for working on the anterior abdominal wall. Place the patient in 10–15° Trendelenburg position. Estimate the distance between the abdominal wall and the abdominal aorta by palpating the aorta. In a thin patient, this distance may be only 3 cm. Make a 1-cm incision at the chosen entry site and deepen the incision to expose the anterior rectus fascia. This is most easily done by spreading with a hemostat. The incision must be large enough to accept the 10-/11-mm trocar if a 10-mm laparoscope is being used. It is better to err on the side of slightly larger, as a small incision causes the trocar sheath to catch at the skin level.

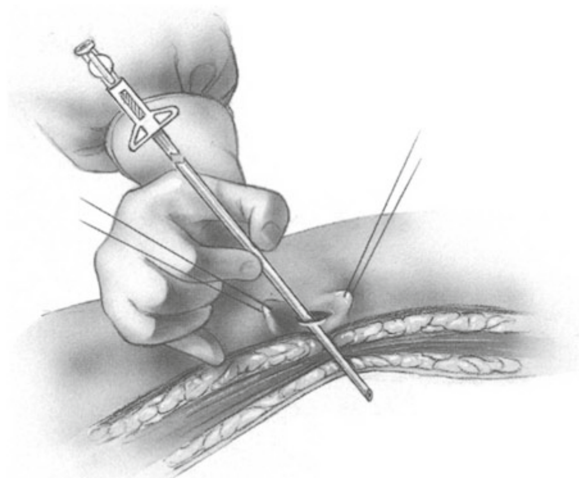

Fig. 9.4

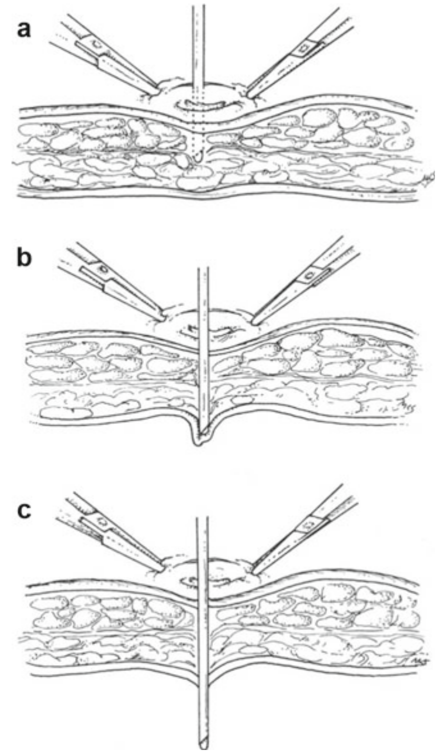

Fig. 9.5 (From Scott-Conner CEH (ed), The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer-Verlag, 1999, with permission)

Expose the fascia for a distance of about 10 mm in a vertical direction. If the subcutaneous fat is thick and it is difficult to visualize the fascia, apply a Kocher clamp to the underside of the umbilicus and pull up. The umbilicus is adherent to the fascia, and this traction pulls the fascia into view. Then apply a Kocher clamp to the lower margin of the exposed fascia and elevate the clamp in an anterior direction to increase the distance between the abdominal wall and the great vessels.

Now grasp the Veress needle between thumb and forefinger (Fig. 9.4) and hold it like a dart. After the tip of the needle has been inserted into the abdominal wall, place one drop of saline in the hub of the needle. Aim the needle roughly in the direction of the sacral promontory. As the needle passes through the abdominal wall, one should feel a pop as it passes through the fascia and another when it penetrates the peritoneum (Fig. 9.5). At this point, the drop of saline in the hub should be drawn into the peritoneal cavity owing to the negative pressure that exists in the peritoneal cavity with traction upward on the abdominal wall. Confirm this by placing another drop of saline in the hub of the needle and then elevating the abdominal wall to create more negative pressure. If the drop of fluid is not drawn into the peritoneal cavity, readjust the position of the needle. If this move is unsuccessful, withdraw the needle and reinsert it. When the needle appears to be in the proper position, perform a confirmatory test by attaching a syringe containing 10 ml of saline in the hub of the needle and inject the saline into the abdominal cavity. Then attempt to aspirate the fluid. If the needle is in the peritoneal cavity, no fluid is aspirated. If turbid fluid is aspirated, suspect that the needle has entered bowel. If blood returns, remove the needle and promptly insert a Hasson cannula as described below and insert the laparoscope to inspect the abdominal cavity for vascular injury.

Assuming that the Veress needle has entered the abdominal cavity uneventfully, attach the tube leading to the CO_2 insufflator. Begin at low flow or regulate the inflow to a rate of 1 L/min. The initial reading in the gauge measuring intra-abdominal pressure should be 5–10 mmHg if the needle is in the free peritoneal cavity. After 3–4 L of gas has been injected into the peritoneal cavity, percuss the four quadrants of the abdomen to confirm that the gas is being evenly distributed. This confirms proper needle placement. Increase the flow rate until the intra-abdominal pressure has reached 15 mmHg. At this stage, remove the Veress needle and insert the trocar cannula into the previous umbilical incision. Direct this device in the direction of the sacral promontory and exert gradual pressure with no sudden motions until it has penetrated the abdominal cavity. Then connect the insufflation device to the cannula and continue insufflation to maintain the desired intra-abdominal pressure. This initial cannula should have a diameter of 10–11 mm for the standard 10-mm laparoscope.

Open Technique with Hasson Cannula

The Hasson cannula is designed to be inserted under direct vision through a minilaparotomy incision. It is thus the method of choice in the previously operated abdomen when a scar encroaches on the proposed insufflation site. Some surgeons use this method preferentially for all cases.

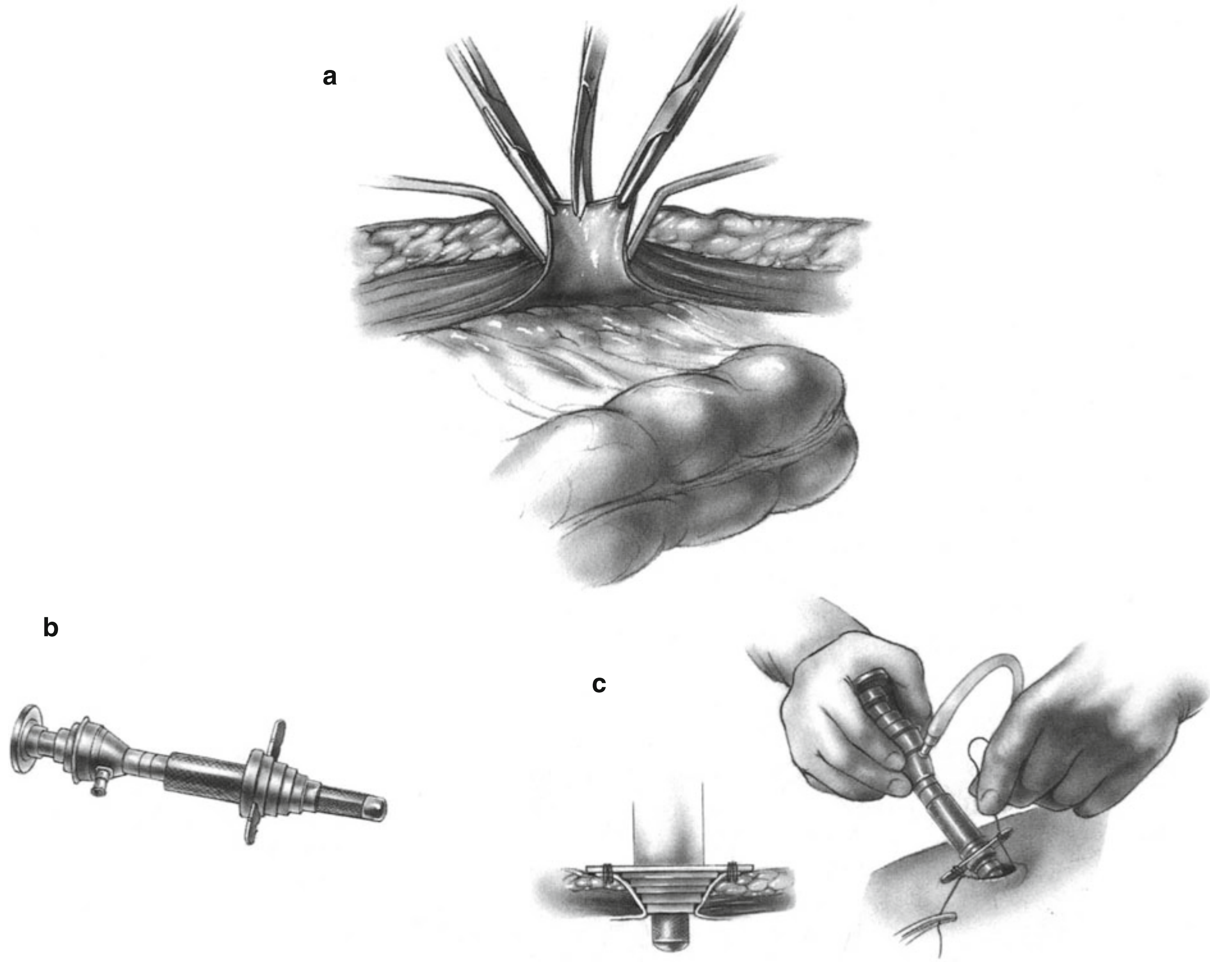

Fig. 9.6

Make a vertical 2- to 3-cm incision in the umbilicus and adjacent subumbilical area with a scalpel. Then identify the rectus fascia in the midline. Make a scalpel incision through the fascial layer and identify the peritoneum. Insert the index finger and carefully explore the undersurface of the fascia for adherent bowel. Open the peritoneum under direct vision with a scalpel. The commonest error is to make the incision too small. The peritoneal incision should comfortably admit the surgeon's index finger, and the skin incision should allow easy visualization of the peritoneum. After visual and finger exploration ascertains that the abdominal cavity has been entered, insert the Hasson cannula under direct vision (Fig. 9.6). This cannula has an adjustable olive-shaped obturator that partially enters the small incision. Insert a heavy PG suture, one on the left and another through the fascia on the right aspect of the incision. These sutures are used to anchor the cannula and at the end of the procedure to close the incision.

Attach each suture to the respective wing of the Hasson cannula, which firmly anchors the olive obturator in the incision and prevents loss of pneumoperitoneum. After this step has been accomplished, insufflate CO_2 as previously described. When the pressure reaches 12–15 mmHg, the telescope is inserted and the operation can begin.

Occasionally, there is difficulty or uncertainty about inserting the initial trocar cannula into the abdomen. In such cases, do not hesitate to abandon the blind steps of inserting the Veress needle or the trocar cannula and to switch to an open "minilaparotomy" for insertion of a Hasson cannula.

Management of Hypotension During Laparoscopy

When the patient deteriorates after induction of pneumoperitoneum, the safest immediate response is to withdraw any instruments into the trocars and release the pneumoperitoneum while seeking the cause of the problem. Among the possible causes are the following:

Interference with venous return. The increased intra-abdominal pressure is not always tolerated, especially in frail, elderly patients. Compounding the problem are the frequent use of reverse Trendelenburg position and relative hypovolemia due to bowel preparation or overnight fasting prior to surgery. Often the procedure can resume if additional volume is infused and the insufflator is set at a lower pressure. Some patients do not tolerate pneumoperitoneum, and the procedure must then be converted to an open laparotomy.

Hypercapnia. Cardiac dysrhythmias may be induced by CO_2 pneumoperitoneum, which may produce hypercapnia and occasionally hypoxia. A sudden increase in the end-tidal CO_2 level may indicate subcutaneous emphysema, preperitoneal trapping of CO_2, or injection of CO_2 into the liver by incorrect positioning of the Veress needle. Subcutaneous emphysema may be the result of an excessively high intra-abdominal pressure. Extraperitoneal CO_2 insufflation may progress to pneumomediastinum and subcutaneous emphysema. After checking all of these possibilities, the anesthesiologist can generally maintain the patient with hyperventilation. Gas embolus is rare if aspiration is performed before CO_2 is insufflated.

Tension pneumothorax. This should be suspected if unexpected hypotension occurs during the operation. It is particularly apt to occur during laparoscopic surgery in the vicinity of the esophageal hiatus.

Intra-abdominal or retroperitoneal bleeding. Bleeding related to trocar insertion is another cause of hypotension and should be suspected when no other cause is found. A quick survey of the abdomen with the laparoscope is indicated. Look for hematomas, especially arising in the retroperitoneum. If the laparoscopic search is not adequate, do not hesitate to make an emergency midline laparotomy incision, leaving all of the instruments and trocars in place. Explore the retroperitoneal area for damage to the great vessels, including the aorta, vena cava, and iliac vessels.

Secondary Trocar Placement

Place secondary trocars in accordance with the triangle rule: Think of the laparoscope (the surgeon's eyes) as being at the apex of an inverted isosceles triangle with the primary and secondary operating ports as the left and right hands, as shown in Fig. 9.7 for performance of laparoscopic Nissen fundoplication. Proper placement of these operating ports is crucial. For that reason inspect the abdomen with the laparoscope and, if necessary, insert one of the ports that will be used for retraction before placing the operating ports. For example, when setting up ports for a laparoscopic cholecystectomy, place the most lateral retracting port first. Then grasp the fundus of the gallbladder and try lifting it to get a feeling for the degree of mobility of the gallbladder and liver. Finally, place the two operating ports.

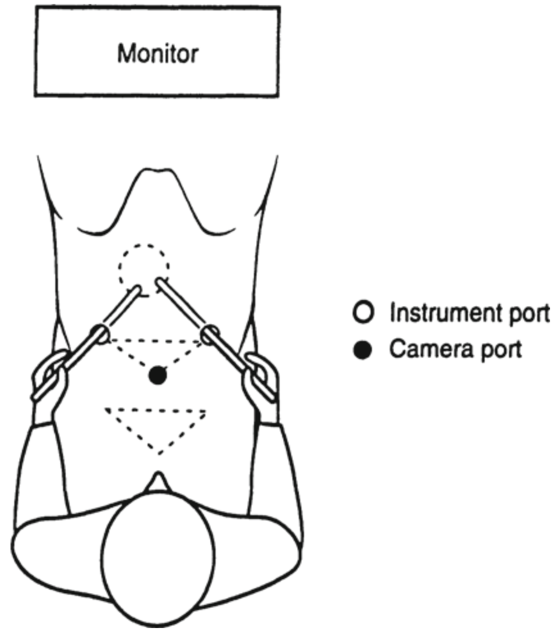

Fig. 9.7 (From Scott-Conner CEH (ed), The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer-Verlag, 1999, with permission)

Adopt a two-handed technique early in your laparoscopic career. This is the only way to become proficient with the maneuvers needed for laparoscopic suturing and knot tying. Instruments placed through the primary and secondary operating ports should intersect at the operative field at an angle of 60–90°. If you are uncertain, try out a contemplated trocar site by passing a long spinal needle through the insufflated abdominal wall into the field under direct vision and observe the position and angle at which it enters the operative field.

Additional trocars are frequently placed to allow retraction and assistance. Trocar diagrams given in textbooks, including this one, are just guidelines as each case is slightly different. If you are having difficulty, consider whether inserting another trocar for additional retraction or to substitute for an ill-placed port might help. It is generally necessary to leave the original trocar in place to avoid loss of the pneumoperitoneum.

Ergonomic Considerations

Once the ports have been placed, adjust the operating table and dim the overhead lights. The optimum table position allows the hands to be held at approximately elbow height with instruments in the trocars. Because laparoscopic instruments are longer than conventional instruments, it is generally necessary to lower the table. Adjust the position of the operating table to allow gravity to displace viscera (reverse Trendelenburg for upper abdominal surgery, Trendelenburg for lower abdominal surgery with the operative side rotated up). If lowering the table has made it impossible to position the patient optimally, raise the table and stand on a platform to compensate.

Laparoscopic Dissection and Hemostasis

Because even a small amount of bleeding absorbs light and obscures visualization, laparoscopic dissection places strong emphasis on careful hemostasis. For basic procedures such as laparoscopic cholecystectomy, monopolar hook cautery works well. The blunt back side of the hook may be used, cold, as a blunt dissector, and the hook then used to elevate, cauterize, and divide small structures. The back side of the hook may be used with cautery as a spatula cautery tip. The tip of the suction irrigator is also a useful dissecting tool. Curved "Maryland" dissectors, endoscopic right-angle clamps, and a variety of blunt graspers are used to stabilize and dissect in a manner analogous to that used for open surgery (Fig. 11.40).

For more extensive surgery, an ultrasonic scalpel or shears allow better hemostasis with less threat of damage to adjacent structures than cautery. Heat is generated by ultrasonic vibration of an active blade. Because this device works best when the active blade is placed against well-supported tissues, it is most commonly used with a slightly curved grasping tip. The tissue to be divided is grasped and gently compressed as the shears are activated. With the correct combination of ultrasonic power and compression, the tissue within the shears is first coagulated and then cut. A lower power setting, or less pressure on the tissue, produces more coagulation and slower cutting. Higher power and greater compression produce a cutting effect. The cutting speed is inversely proportional to the effectiveness of hemostasis. This instrument greatly facilitates advanced procedures such as Nissen fundoplication where sizable vessels (the short gastrics) must be divided.

Laparoscopic Suturing

Laparoscopic procedures that require suturing are considered advanced procedures; yet, the ability to place one or two sutures may enable the laparoscopic surgeon to avoid conversion to open surgery if a minor mishap occurs during basic laparoscopic procedures such as laparoscopic appendectomy. Every laparoscopic surgeon should have basic laparoscopic suturing and knot-tying skills. Practice suturing in a box trainer until you are facile.

Port placement is crucial for successful laparoscopic suturing. As previously mentioned, the primary and secondary ports should bring instrument tips together at an angle of 60–90° in the field. These ports should generally be at least 6 in. apart at the skin to avoid "dueling trocars," a situation where two trocars rub against and over or under each other at every movement.

Knots may be tied intracorporeally in a manner analogous to that used during open surgery or extracorporeally. Intracorporeal tying has the broadest range of applications and is briefly described here. For intracorporeal tying, the entire needle and suture are passed into the abdomen. The suture is cut short (generally around 10 cm): just long enough to be able to produce the loops required for intracorporeal knotting but short enough that the tail can be easily manipulated. Generally a pliable braided material such as silk or PG is used. The size of the suture must be appropriate to the intended purpose; for instance, during laparoscopic Nissen fundoplication, a heavier suture must be used to approximate the diaphragmatic crura than is used to anchor the fundoplication. Sutures for laparoscopic applications are ideally either dark or brightly fluorescent (rather than beige) to facilitate easy visualization.

Interrupted suturing requires that the laparoscopic surgeon be able to place a stitch accurately, pass it through tissue, and securely tie a knot. Tactile feedback is limited, and only visual cues are available. Two needle holders, each capable of securely grasping and holding a needle, are used. Needle holders with curved tips facilitate manipulation in the limited laparoscopic field. Load the needle forehand in the right-hand needle driver. Pass the needle through the tissue with a scooping motion. Following the curve of the needle requires a different set of motions than the simple supination used during open surgery. Watch the needle pass through the tissue and adjust your hand motions to pass it in a smooth, atraumatic fashion.

Grasp the needle with the left-hand needle holder and release the right. Pull the needle through the tissue with the left-hand needle holder.

Intracorporeal knots are placed and tied by the familiar "instrument-tying" method used during open surgery. The sequence of movements to create the first throw of a square knot is shown in Fig. 9.8. The second throw is shown in Fig. 9.9.

Continuous suturing is more rapid because only two knots are needed. Applications are limited, however.

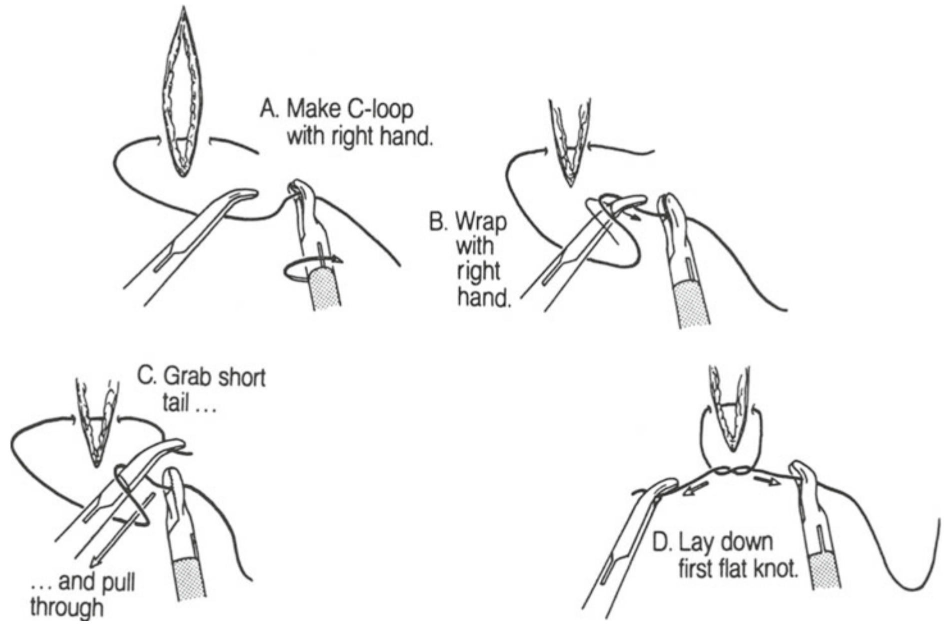

Fig. 9.8 (From Scott-Conner CEH (ed), The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer-Verlag, 1999, with permission)

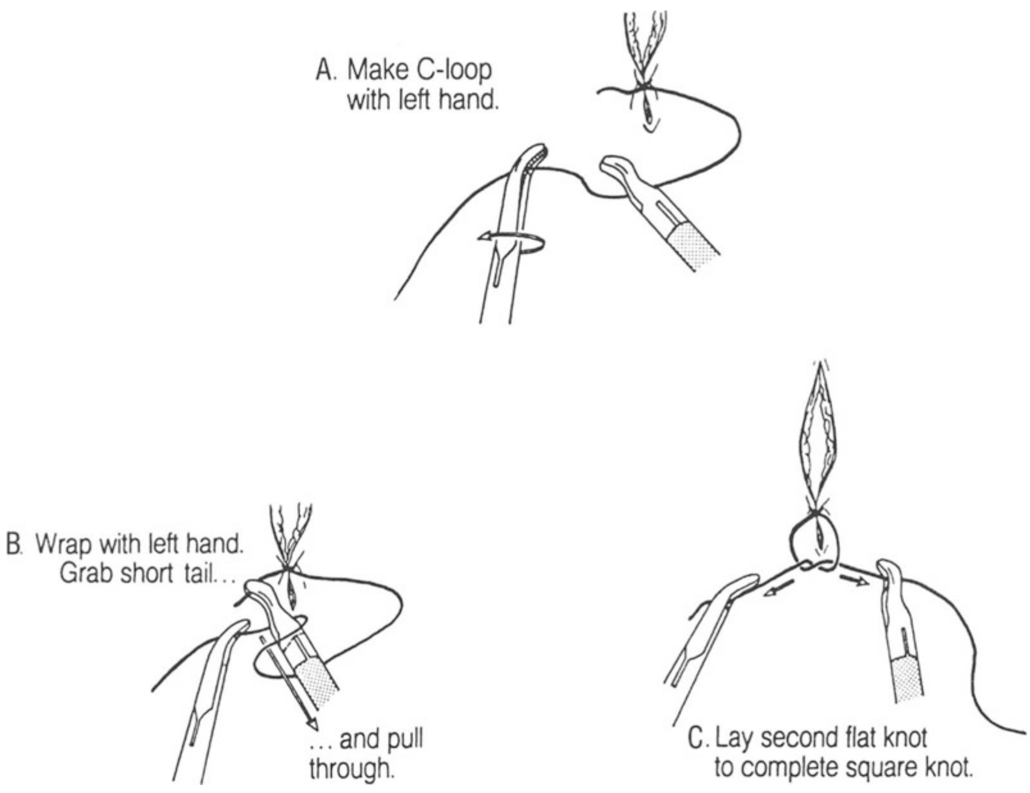

Fig. 9.9 (From Scott-Conner CEH (ed), The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer-Verlag, 1999, with permission)

Using a Pretied Suture Ligature

Pretied endoscopic suture ligatures are available and useful for simple applications (e.g., ligating a cystic duct if the clip closure appears tenuous). They are commonly loaded with chromic catgut because this material swells slightly as it absorbs water, rendering the knot even more secure. Pretied ligatures are best used to secure the stump of a structure that has already been divided or to ligate the base of an appendix. They are not applicable to the problem of applying a tie in continuity because you must be able to pass the loop over the structure to be ligated.

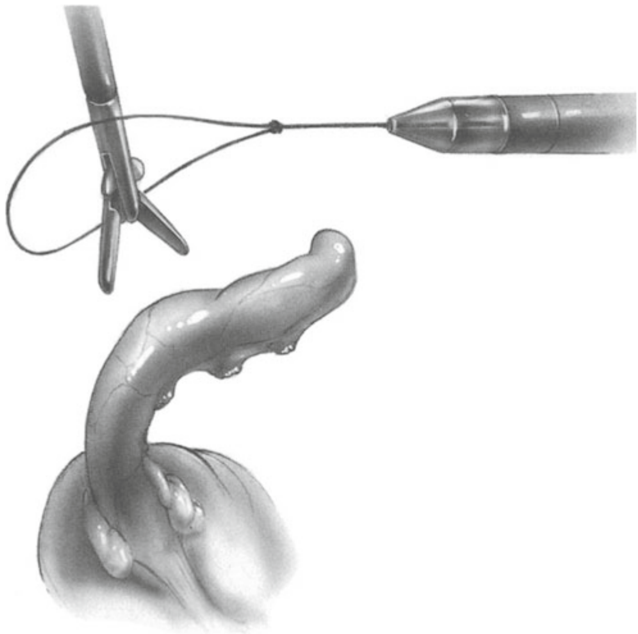

Fig. 9.10

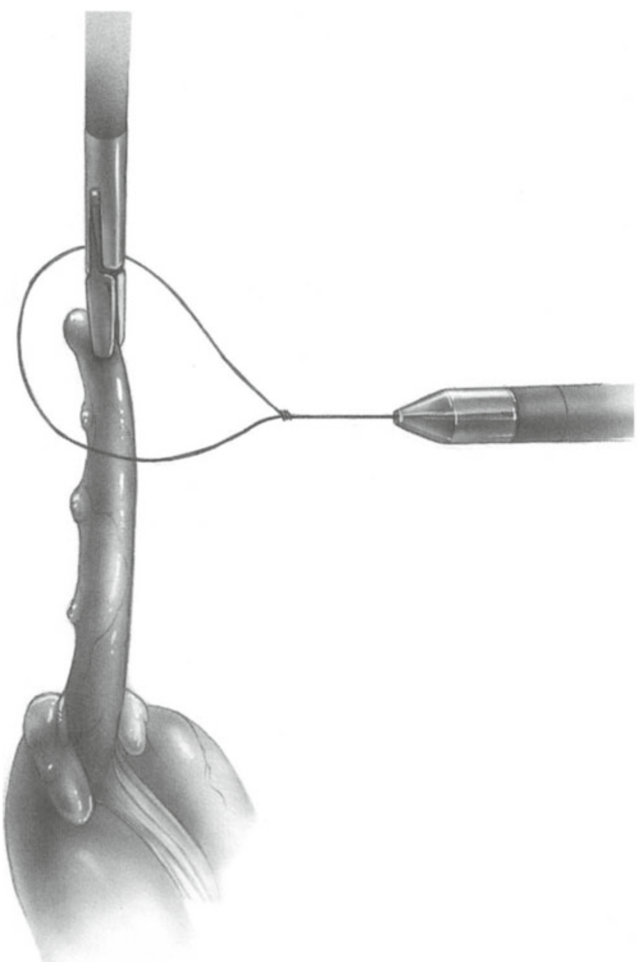

Fig. 9.11

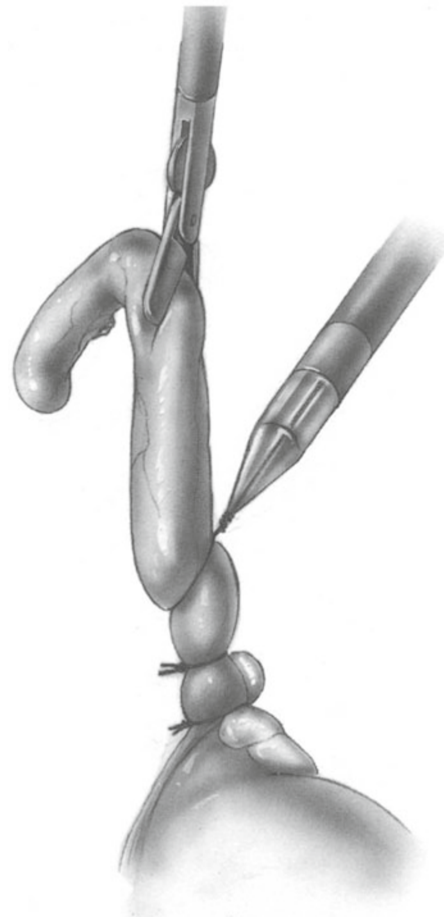

Fig. 9.12

To use a pretied endoscopic ligature, pass it into the field and slowly advance the loop. As the loop comes into contact with tissue, it absorbs water and softens, becoming limp and therefore much more difficult to handle. Avoid this problem by keeping the loop away from tissue until you are ready to close it. Pass a grasper through another port and pass it *through the loop* of the pretied ligature (Fig. 9.10). Ignore the loop and grasp the stump of the structure to be ligated (Fig. 9.11). Then slide the loop down the grasper until it encircles the stump. The loop is quite large, and drawing up on the tail to make the loop slightly smaller may facilitate this maneuver. Shorten the loop with care, as it is not possible to enlarge the loop again. Once the stump is surrounded, place the tip of the knot pusher against the base exactly where you want the knot to sit. Slowly tighten the loop while maintaining slight tension on the stump with the grasper (Fig. 9.12). Withdraw the knot pusher through the trocar and pass endoscopic scissors down to cut the ligature. As with all monofilament sutures, leave a tail of about 2 mm for security. Withdraw the grasper and inspect the ligated stump for security.

Laparoscopic Stapling

Laparoscopic stapling may be performed intra- or extracorporeally with the same staplers used during open surgery. Purely intracorporeal stapling is possible using an endoscopic linear cutting stapler that passes through a 12-mm port. This stapler may be used to secure the base of an appendix; then, loaded with smaller staples, it may be fired across the mesentery. It fires two triple rows of staples and cuts between them. The device is illustrated and its use described in Chap. 47.

Closing Trocar Sites

Any port site larger than 5 mm must be sutured closed to prevent hernia formation. Special suture passers are available to facilitate passing a suture through the skin incision at the trocar site and thence through all the layers of the abdominal wall and back out under direct vision. The suture is then tied at the level of the fascia to close the trocar site securely. These sutures are especially useful in obese patients.

Troubleshooting Equipment

Many hours of frustration can be avoided if laparoscopic surgeons take the time to become thoroughly familiar with the specific equipment in use in their particular operating suite. Adopt a standardized terminology for all the individual instruments you use so it is easy for the scrub person to pass you the specific grasper you need. Know where supplies and equipment are kept. A troubleshooting chart, such as that developed by SAGES, should be easily accessible.

Loss of Working Space

If visualization is difficult and the working space seems to be collapsing, feel the abdominal wall and check the pressure reading on the insufflator. If the abdominal wall is tense and flat and the insufflator pressure readings are normal or high, the problem is likely to be inadequate muscle relaxation. Instruct the anesthesiologist to correct the situation.

Conversely, a loose, limp, flaccid abdominal wall and low insufflator pressures mean inadequate CO_2. This may be due to an empty cannister, a dislodged insufflator line, or leaks in the system.

Avoiding Complications

Although each procedure has its unique complications, there are a set of problems shared by all laparoscopic operations. They are briefly considered here.

Hypercarbia from absorption of CO_2 gas is prevented by hyperventilation and vigilance on the part of the anesthesiologist. An occasional patient does not tolerate the physiologic stress of pneumoperitoneum, and conversion to open surgery may be needed.

Gas embolus is signaled by a sudden jump in end-tidal CO_2 followed by a rapid fall as cardiac output goes to zero. This rare complication is avoided by aspirating to check for blood before insufflating CO_2 through the Veress needle and employing special precautions during procedures (e.g., hepatic resection) where venous sinusoids are cut.

Bleeding from the abdominal wall is a common, annoying complication of trocar site placement. Blood may run down the instruments or laparoscope to obscure the view during surgery or cause hematoma or hemoperitoneum after surgery is complete. Avoid this situation by making the lower abdominal trocar sites lateral to the border of the rectus sheath (to avoid the inferior epigastric vessels), by avoiding umbilical puncture sites in cirrhotic patients (to avoid entering the dilated veins of a caput medusae), and by inspecting trocar sites as the last step before withdrawing the laparoscope. Generally such bleeding can be controlled by sutures through the abdominal wall.

Visceral or vascular injury during Veress needle or trocar placement is avoided by following the guidelines for Veress needle placement outlined in the previous sections. Place secondary trocars under direct vision. If visceral or vascular injury is suspected, leave the Veress needle or trocar in situ as you convert to a formal laparotomy. This may tamponade any bleeding and greatly facilitates finding the site of injury.

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Rational Use of Drains

10

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Purpose of Drains

Drains permit purulent material, blood, serum, lymph, bile, pancreatic juice, and intestinal contents to escape from the body. They form a walled-off passageway that leads from the source of infection or fluid buildup to the outside. This passageway, or tract, must persist for a period long enough to ensure complete evacuation of the collection, collapse of the cavity, and ultimately healing from the inside out.

In the presence of a discrete abscess, the need for and purpose of a drain is obvious and not controversial, as its therapeutic benefits are clear. In most other situations, the drain acts as a prophylactic instrument to prevent accumulation of undesirable products. Because it is a foreign body, the drain also has the paradoxical effect of potentiating infection. When and how a drain should be used for prophylactic purposes has long been a source of controversy. Controlled trials have significantly decreased the indications for "prophylactic" drainage; some are cited in the references at the end of the chapter.

Various Drains and Their Pros and Cons

Latex (Penrose) Drain

The Penrose drain is a soft latex drain of various dimensions. It has the shape of a flattened cylinder and is made of a thin, radiopaque sheet of rubber. It has the advantage of being inexpensive. It is also successful in encouraging fibrosis, so it forms a well-established tract within 8–10 days.

It has many disadvantages as well. This is a completely passive drain, and fluid exits around the drain by capillary action and gravity. Ideally, the drain is placed to create a dependent tract through which fluid escape may be aided by gravity. If the surgeon does not take pains to bring the drain out in a straight line, without wrinkles, stagnant pools of serum accumulate around the wrinkled areas of the drain. After the drain is removed, the patient may have a 24-h increase in temperature of as much as 1 °C. More fundamentally, the passive latex drain does not empty a cavity; it simply permits secretions to overflow from the abdomen to the outside. It is not particularly effective in evacuating oozing blood before a clot forms. There is no method by which the depth of the wound can be irrigated with this type of drain as there is when a tube or sump type is used.

Finally, the most important objection to the latex drain arises from the fact that it requires a 1- to 2-cm stab wound in the abdominal wall, which permits retrograde passage of pathogenic bacteria down into the drain tract. It also creates a sizable fascial opening that may be the site of subsequent hernia formation.

Penrose drains are also used for retraction, for example, when the esophagus is retracted during hiatal hernia repair.

Polyethylene or Rubber Tube Drain

These are also passive drains, but are tubular and more rigid than the Penrose drain. Both polyethylene and rubber tube drains establish tracts to the outside, as they are mildly irritating and stimulate adhesion formation. They effectively evacuate air and serum from the pleural cavity and bile from the common bile duct (so a chest tube, or a T-tube, would be examples of such drains). Drainage tract infection following the use of tube drains is rare for the reasons discussed below.

Among the disadvantages of rubber and polyethylene tubes is that they become clogged with clotted serum or

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blood unless they are large. Large tubes, however, are unsuitable for placement deep in the abdominal cavity for a period of more than a few days, as there is considerable danger of erosion through an adjacent segment of intestine, resulting in an intestinal fistula. These drains are, therefore, primarily used in selected applications such as pleural space drainage and biliary tract drainage as noted above.

Silicone Tube Drain

Silicone or Silastic tubes are less reactive than are other types of drain. They are less prone to become plugged as a result of clotting serum. Because of the soft texture of silicone, erosion into the intestine is uncommon.

A disadvantage of silicone drains is their lack of reactivity; hence, there is minimal fibrous tract formation. This lesson was learned when Silastic T-tubes were (briefly) used in the common bile duct, and their removal often resulted in bile peritonitis because a firm fibrous channel had not been established between the bile duct and the outside.

Sump Suction Drains

Generally constructed of silicone or polyethylene tubing, sump drains must be attached to a source of continuous suction. They effectively evacuate blood and serum, especially if suction is instituted in the operating room so the blood is evacuated before it clots. The sump allows (generally filtered) room air to enter as suction is applied, much as a sump nasogastric tube continuously aspirates air. This air intake channel can also be used for instillation of an antibiotic solution when indicated. If used regularly, fluid instillation prevents obstruction of the drain due to coagulation of serum or secretions. Drainage tract infections with sumps are uncommon even though unsterile, bacteria-laden air is drawn into the depths of the patient's wound by the continuous suction. A major disadvantage of sump drains is the requirement that the patient be attached permanently to a suction device, thereby impairing mobility. These drains are predominately used for very difficult abscesses, such as those associated with peripancreatic sepsis, where other drains tend to stop working.

Closed Suction Drain

These are the commonest drains used in current practice. The closed suction drain consists of one or two multiperforated silicone or polyethylene catheters attached to a sterile plastic container, the source of continuous suction. It is a closed system; and the catheters are brought out through puncture wounds. These drains have replaced other drains for most applications. Patient mobility is unimpaired, as the plastic container is easily attached to the patient's attire. The depths of the wound can be irrigated with an antibiotic solution by disconnecting the catheter from the suction device and instilling the medication with a sterile syringe.

Closed suction drains are commonly used in a clean field, such as at axillary node dissection sites to prevent seroma formation. They should be removed as soon as possible to prevent bacterial entry.

Some closed suction drains contain multiple perforations. In time, tissues are sucked into the fenestrations, and tissue ingrowth may even occur. This makes removal difficult (occasionally to the point of requiring relaparotomy), and most surgeons are reluctant to leave a fenestrated closed suction drain in the abdomen for more than 10 days. Fluted (channel-type) suction drains are also available and avoid this potential complication.

Gauze Packing

When a gauze pack is inserted into an abscess cavity and is brought to the outside, the gauze, in effect, serves as a drain. Unless the packing is changed frequently, this system has the disadvantage of potentiating sepsis by providing a foreign body that protects bacteria from phagocytosis. Management of pancreatic abscesses by marsupialization and packing is an example of this technique. Daily dressing changes keep the packing fresh.

Prevention of Drainage Tract Infection

Retrograde transit of bacteria from the patient's skin down into the drainage tract is a source of postoperative sepsis and may even follow clean operations. When a polyethylene sump or a silicone closed suction catheter is brought through a puncture wound of the skin, it is easy to suture it in place and minimize or eliminate the to-and-fro motion that encourages bacteria to migrate down the drain tract. On the other hand, when a latex drain is brought out through a 1- to 2-cm stab wound in the abdominal wall, there is no possibility of eliminating the to-and-fro motion of the drain or retrograde passage of bacteria into the drainage tract. Consequently, when latex or gauze drains are required for an established abscess, the surgeon must accept the added risk of retrograde contamination with bacteria despite sterile technique when dressings are changed.

Management of Intraperitoneal Sepsis

When managing intraperitoneal sepsis, a distinction must be made between an isolated abscess (e.g., around the appendix) and multiple abscesses involving the intestines accompanied by generalized peritonitis. With the latter type of sepsis, the presence of fibrin and necrotic tissue prevents adequate phagocytosis and perpetuates sepsis.

When an abscess has developed rigid walls that do not collapse after evacuation of pus, large drains must be inserted to establish a reliable tract to the outside. Sometimes a rigid abscess cavity requires 2–5 weeks to fill with granulation tissue. It is not safe to remove the drains until injecting the abscess with an aqueous iodinated contrast medium has produced a radiograph demonstrating that the cavity is no longer significantly larger in diameter than the drainage tract. If this is not done, the abscess may rapidly recur. For rigid-walled abscesses of this type, several large latex drains should be inserted together with one or two sump drains. Some surgeons place an additional straight 10F catheter for intermittent instillation of dilute antibiotic solution. At least one drain is left in place until the sinogram shows that the abscess cavity has essentially disappeared. Care should be taken that none of the rigid drains comes into contact with the intestine or stomach, as intestinal fistulas can be a serious complication.

Percutaneous Drainage of Abdominal Abscesses with Computed Tomography or Ultrasound Guidance

Treatment of abdominal abscesses underwent a revolutionary change during the 1990s owing to the demonstrated efficacy of percutaneous drainage by the interventional radiologist. In the case of most abdominal abscesses, the skilled radiologist can find a safe route along which to insert a drainage catheter that evacuates the pus without a need to perform laparotomy for drainage. This technology is especially welcome in the critically ill patient who may not tolerate a major operation.

Other Indications and Methods of Drainage

Abscess

For abscesses of the extremities, trunk, or perirectal area, the important step is to unroof the abscess by making a cruciate incision so the tract does not close before all the pus has been evacuated. An unroofing procedure is adequate for superficial abscesses, and any type of temporary drain is sufficient. When the danger exists that the superficial portion of the tract might close before deep healing takes place, insertion of gauze packing is indicated. The packing is then changed often enough to keep it from blocking the egress of pus.

Blood and Serum

The presence of blood, serum, or fibrin in a perfectly sterile area is not dangerous to the patient, although the operative field is never completely sterile following any major operation. For this reason, postoperative puddles of blood or serum in combination with even a small number of bacteria can result in abscess formation because the red blood cell impairs antibacterial defenses. With the low colorectal anastomosis, accumulated serum or blood in the presacral space, together with secondary infection and abscess formation, may result in anastomotic breakdown. For these reasons, strenuous efforts should be exerted to eliminate bleeding during any abdominal operation. If these efforts must be supplemented by some type of drainage, the ideal method is to insert one or two multiperforated Silastic drains, which are brought out through puncture wounds in the abdominal wall and attached to a closed suction system.

Closed suction drainage is extremely effective following radical mastectomy or regional lymph node dissections of the neck, axilla, or groin. Small-diameter tubing is acceptable. This technique has also been employed successfully following abdominoperineal proctectomy with primary closure of the perineal floor and skin.

Bile

Because bile has an extremely low surface tension, it tends to leak through tiny defects in anastomoses or through needle holes. It is essentially harmless if a passageway to the outside is established. A sump drain or closed suction system works well for this purpose. Silastic tubes are contraindicated whenever formation of a fibrous tract to the outside for the bile is desirable, especially with use of a T-tube in the common bile duct, as previously noted.

Pancreatic Secretions

It is not dangerous for pure pancreatic juice to drain into the abdominal cavity, as is evident in patients who have pancreatic ascites or a fistula. If the pancreatic secretion is activated by the presence of bile, duodenal contents, or pus, however, trypsinogen is converted to trypsin and the adjacent tissues are subjected to a raging inflammatory reaction. Recently constructed adjacent anastomoses may be digested and destroyed. Eventually, hemorrhage from retroperitoneal blood vessels ensues.

Consequently, it is important to evacuate bile and pancreatic secretions completely, especially after pancreaticoduodenectomy. This is accomplished by inserting a long plastic catheter into the pancreatic duct in the tail of the pancreas. The catheter is brought through the segment of jejunum to which the duct is anastomosed. Then it is brought through a jejunostomy opening to an outside drainage bag. Unless the tube is accidentally displaced, it conveys all pancreatic secretions from the abdominal cavity. In addition, a suction catheter is inserted in the vicinity of the anastomosis, between the tail of the pancreas and the jejunum. Many surgeons routinely drain pancreatic staple lines or suture lines (e.g., after distal pancreatectomy or pancreaticojejunostomy) with closed suction drains.

Anastomosis

It makes little sense to place a drain down to a gastrointestinal anastomosis simply because the surgeon has some doubt about its integrity. If anastomotic breakdown occurs, the presence of a drain may not prevent generalized peritonitis. If the surgeon believes there is significant risk of anastomotic failure, the anastomosis should be taken apart and done over, or else both ends should be exteriorized and reconnected at a second-stage operation. The surgeon must not fall into the trap of fuzzy thinking, which would permit acceptance of an anastomosis that might be less than adequate, rather than reconstructing the anastomosis or eliminating it from this stage of the operation.

When treating Crohn's disease accompanied by extensive cellulitis, some surgeons believe the inflamed areas should be drained. In reality, cellulitis or contamination, such as might follow a perforated duodenal ulcer, does not benefit from drainage. It is well established that the peritoneal cavity as a whole cannot be drained.

If complete hemostasis cannot be achieved in the vicinity of an anastomosis, there may be some merit to inserting a silicone closed suction drain for a few days to prevent pooling of blood next to the anastomosis, provided the drain does not come into direct contact with the suture line. In truth, there is no substitute for excellent hemostasis.

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Illustrated Glossary of Surgical Instruments

11

Mohammad Khreiss and Jamal Hoballah

In order to work efficiently in the operating room, you must know the names generally associated with common instruments. This chapter provides an illustrated glossary of common instruments and their names. Every operating room suite has developed its own names for instruments. The names given to hemostatic clamps, in particular, vary considerably. Use this as a general guide and then learn the terms used in your own institutions. Instruments used during open surgery are shown first, followed by instruments used during laparoscopic surgery.

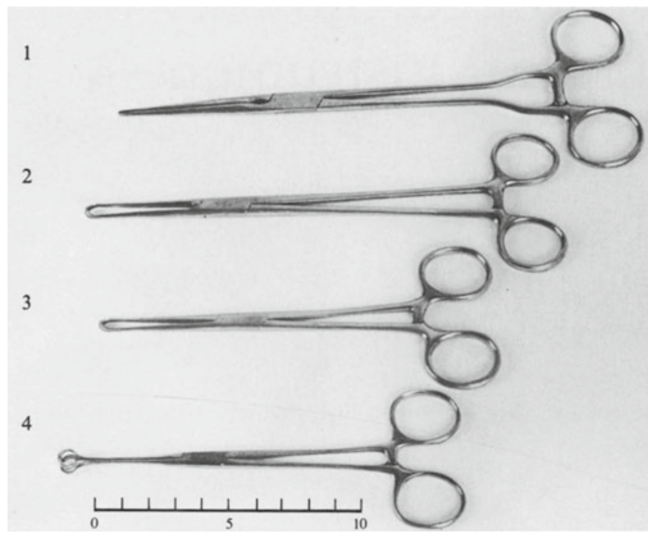

Fig. 11.1 Clamps: Allen (1), Allis (2, 3), Babcock (4)

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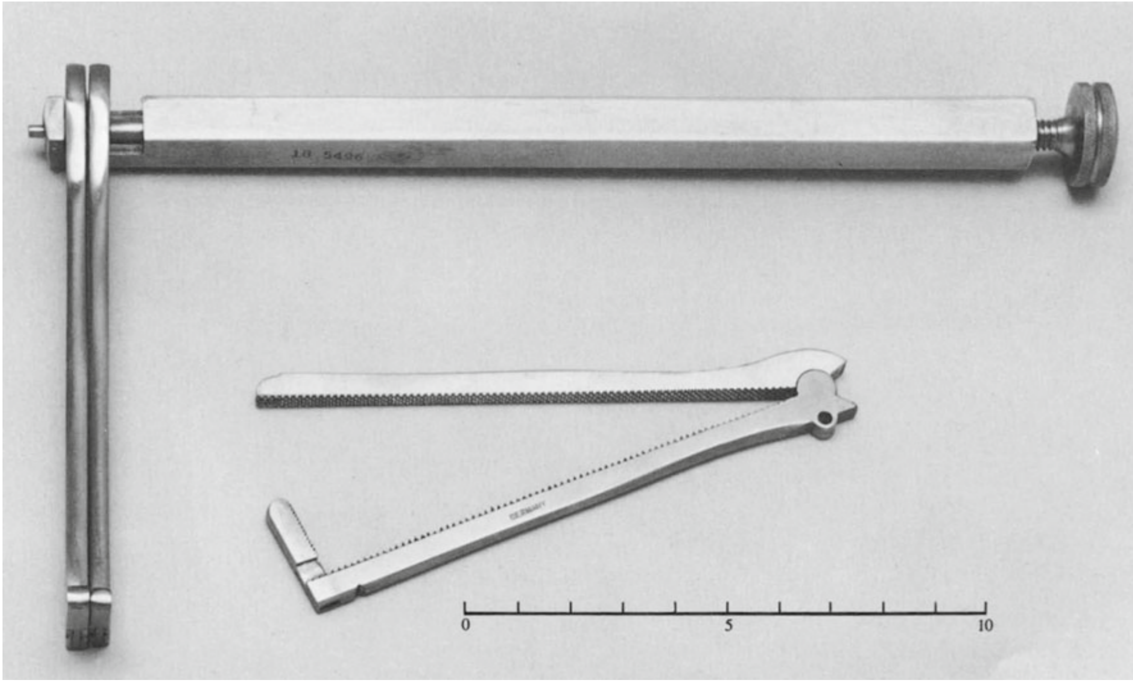

Fig. 11.2 Clamp: DeMartel (surgical legacy instrument)

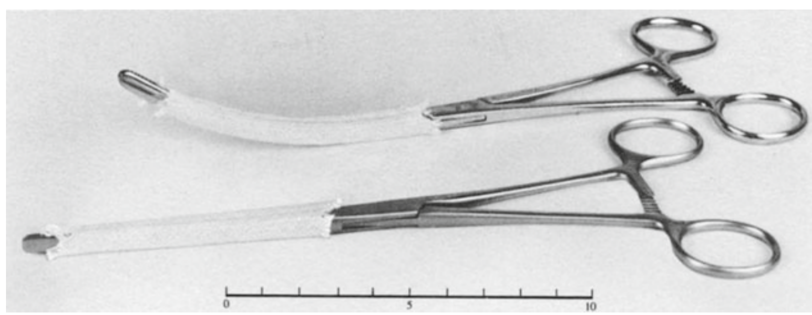

Fig. 11.3 Clamps: Doyen noncrushing intestinal, linen-shod

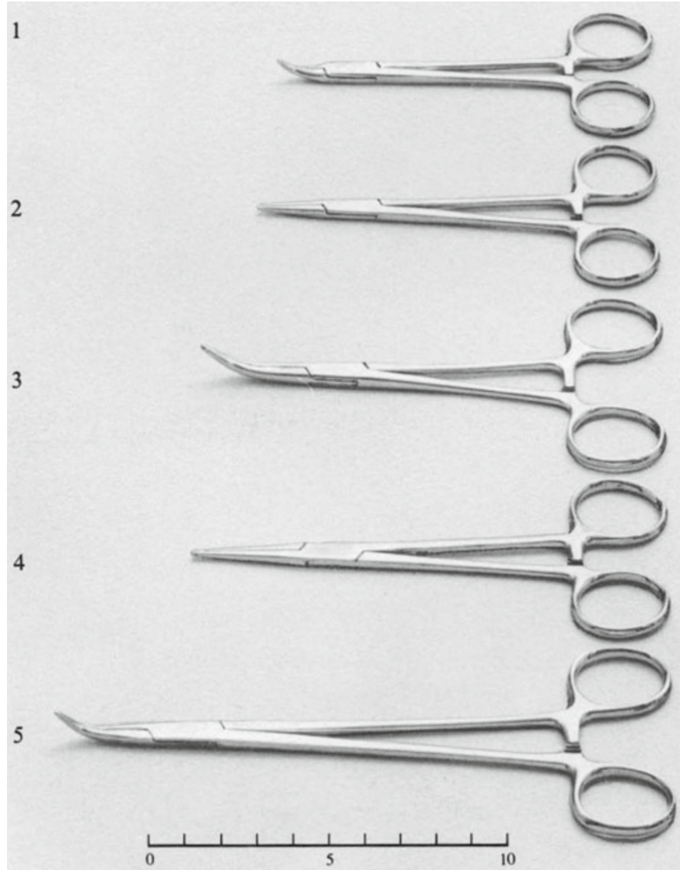

Fig. 11.4 Clamps, hemostatic: Halsted (1, 2); Crile (3, 4); Adson (tonsil) (5). Names of hemostatic clamps vary widely from institution to institution. The important characteristics are the length, the delicacy of the tips, curved versus straight (curved is more versatile), and whether the serrations extend all the way down to the hinge of the clamp

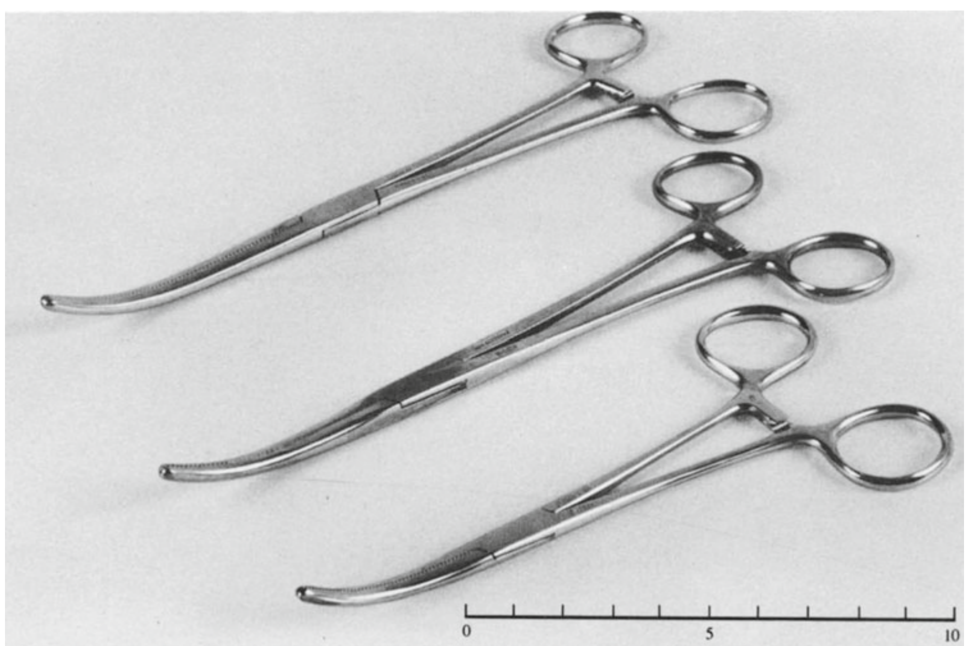

Fig. 11.5 Clamps, hemostatic: Kelly. This is generally a larger, courser clamp than those shown in Fig. 11.4

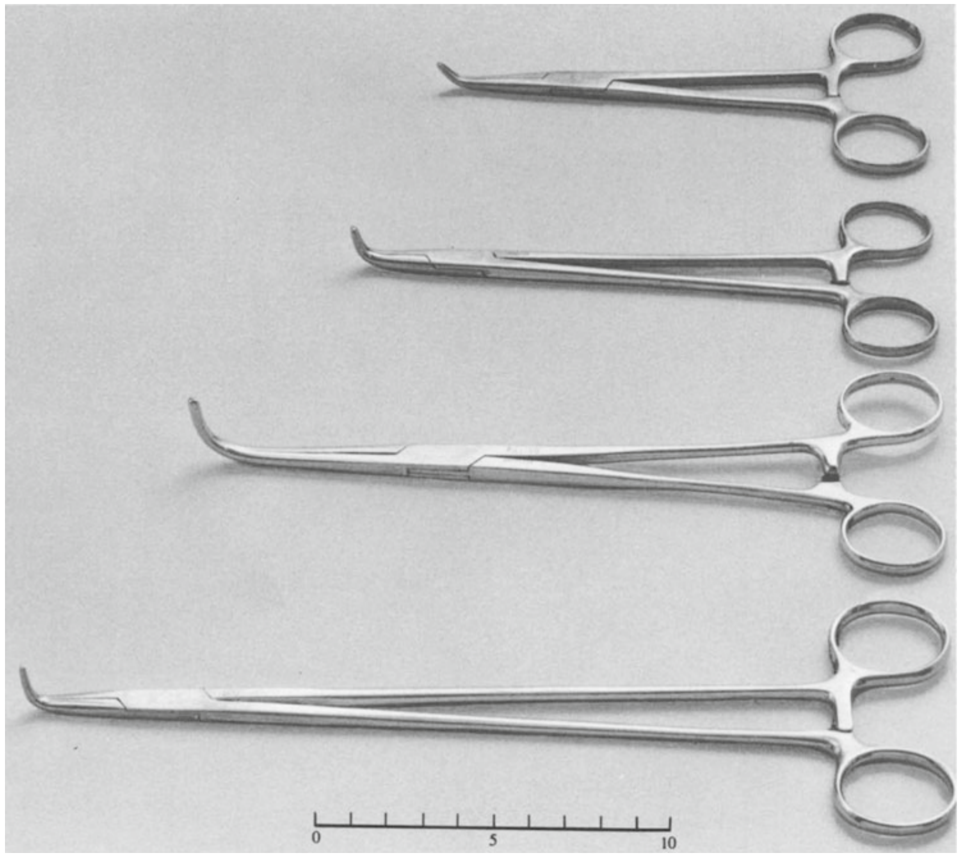

Fig. 11.6 Clamps, hemostatic: Mixter right angle

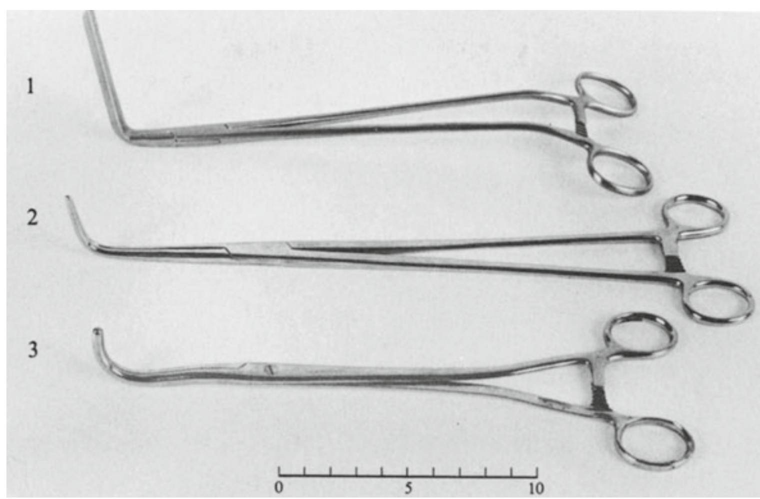

Fig. 11.7 Clamps: kidney, right angle (1); bronchus (2); Moynihan (3)

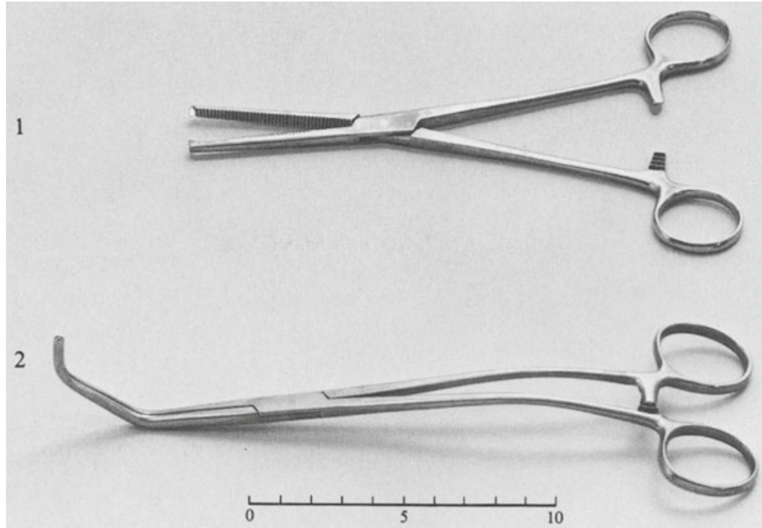

Fig. 11.8 Clamps: Kocher (1); Satinsky (2)

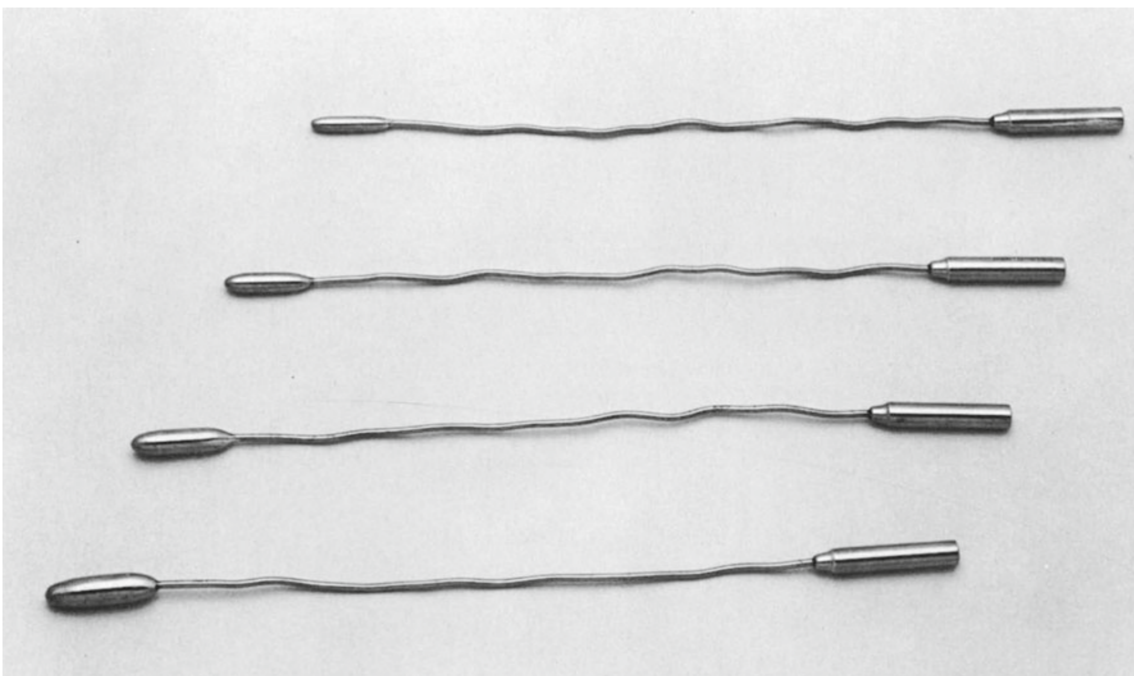

Fig. 11.9 Dilators, Bakes (surgical legacy instruments)

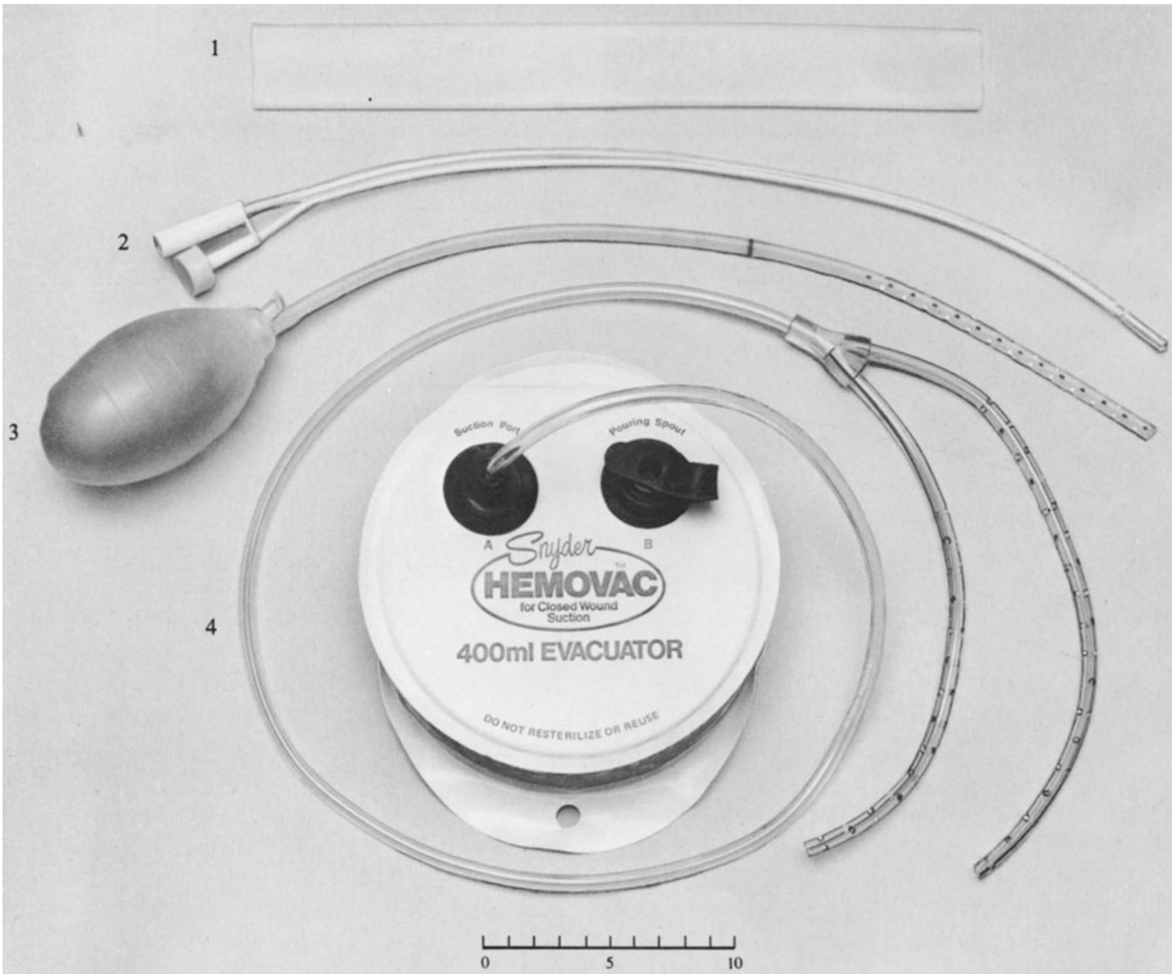

Fig. 11.10 Drains: latex (1); sump, Shiley (2); closed suction, Jackson-Pratt (3); Hemovac (4)

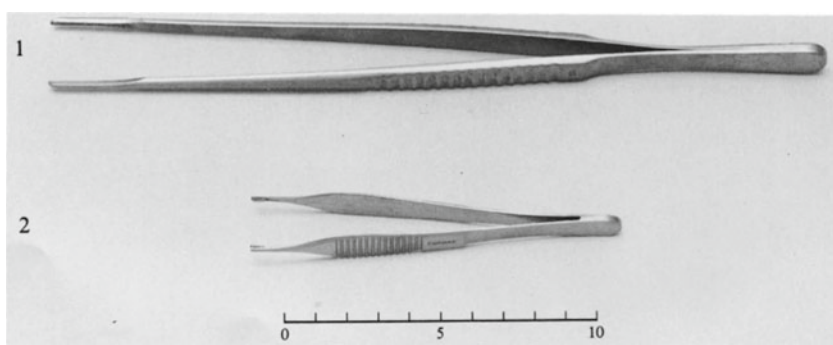

Fig. 11.11 Forceps: Debakey (1); Brown-Adson (2)

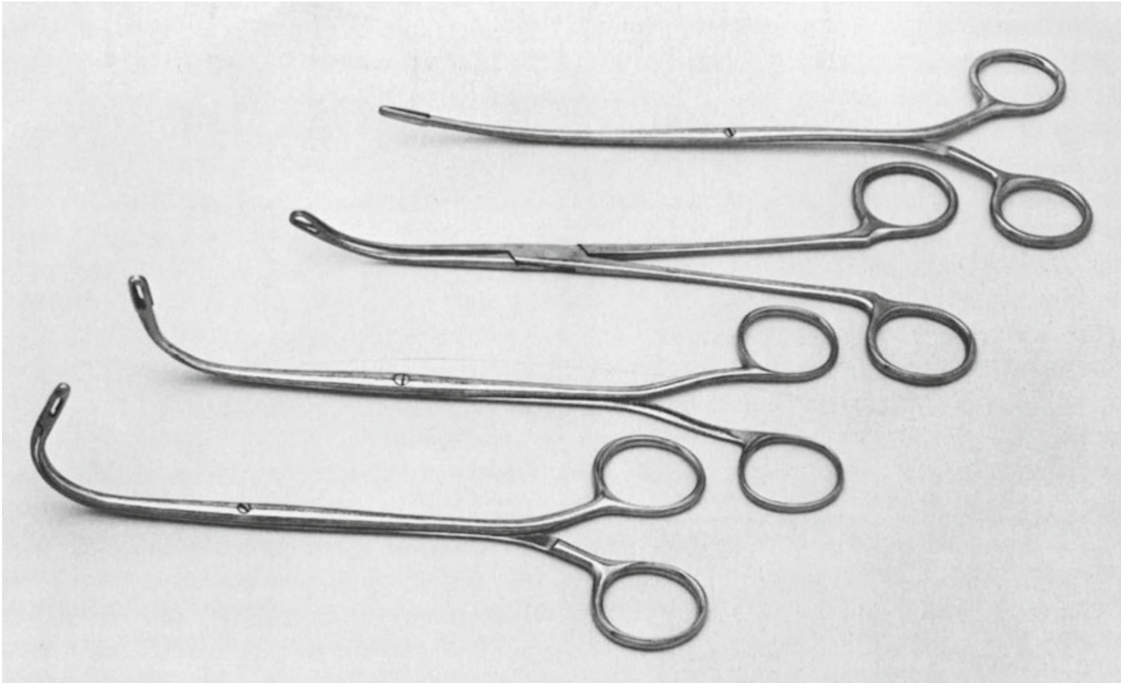

Fig. 11.12 Forceps: gallstone (Randall) (surgical legacy instruments)

1 2 3

Fig. 11.13 Knots: square (1); granny (2); surgeon's (3)

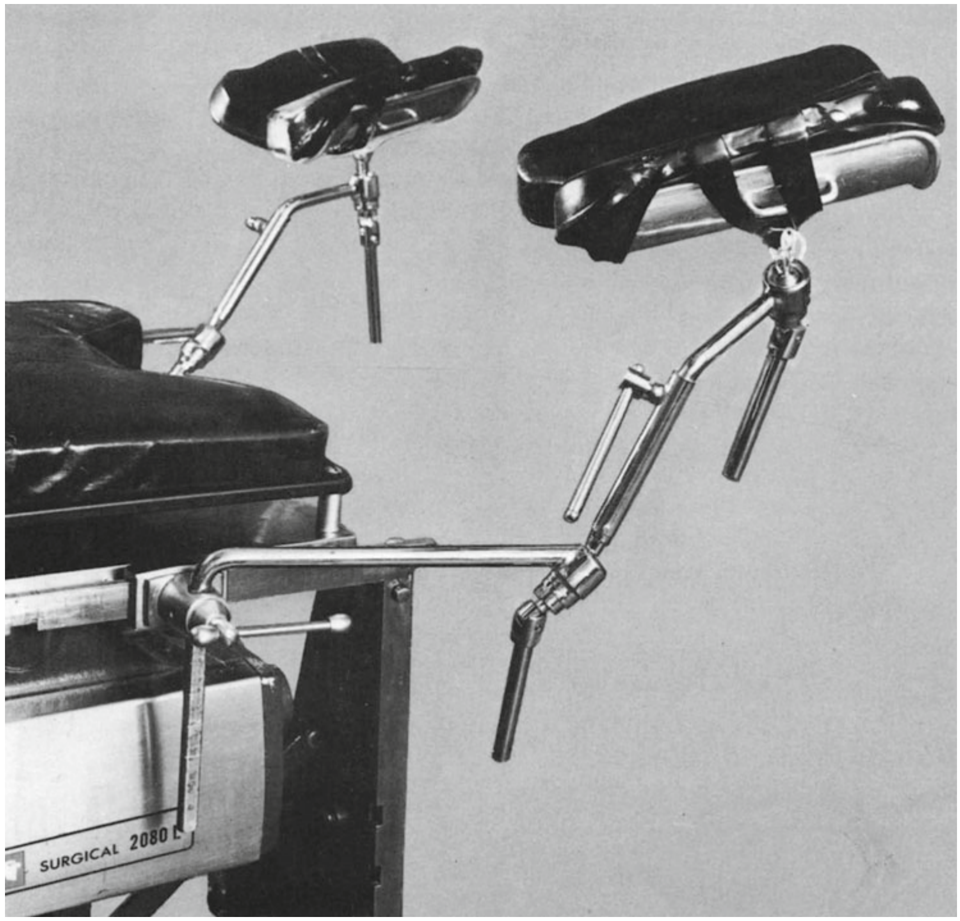

Fig. 11.14 Lloyd-Davies leg rests

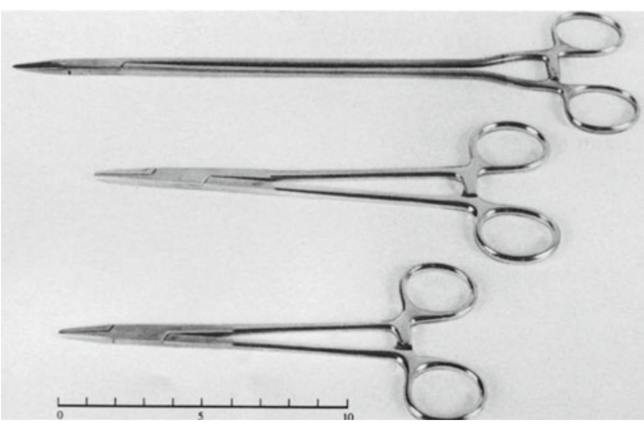

Fig. 11.15 Needle holders, straight

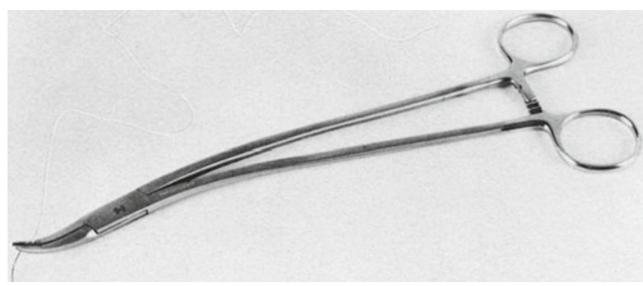

Fig. 11.16 Needle holder, Stratte. The curved tip and extra length are well suited to work deep in the pelvis

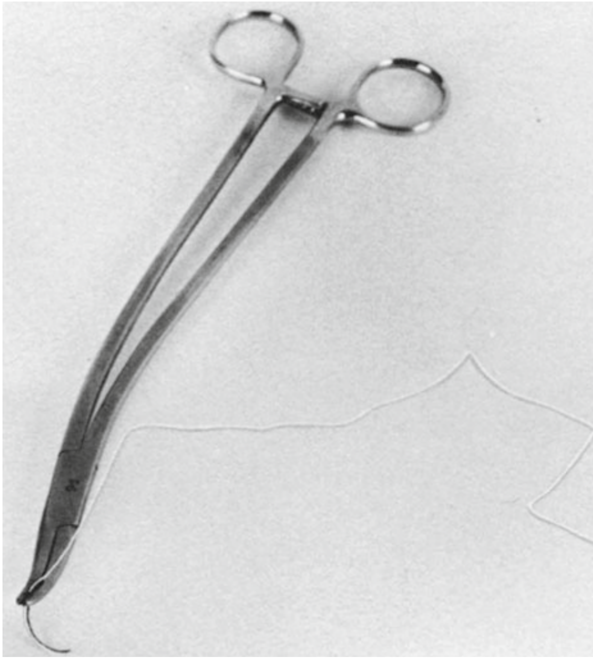

Fig. 11.17 Needle holder, Stratte, grasping an atraumatic suture

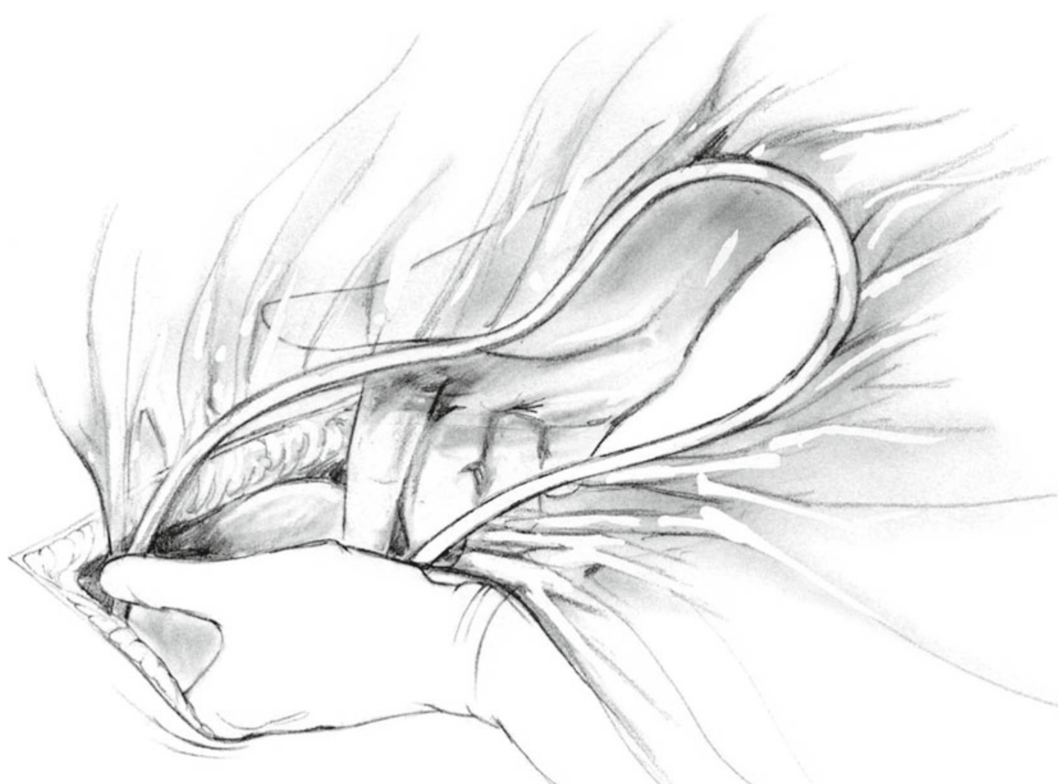

Fig. 11.18 Plastic drape being inserted

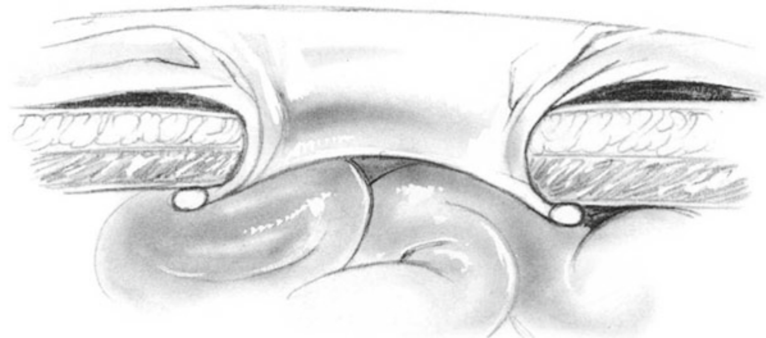

Fig. 11.19 Plastic drape in place

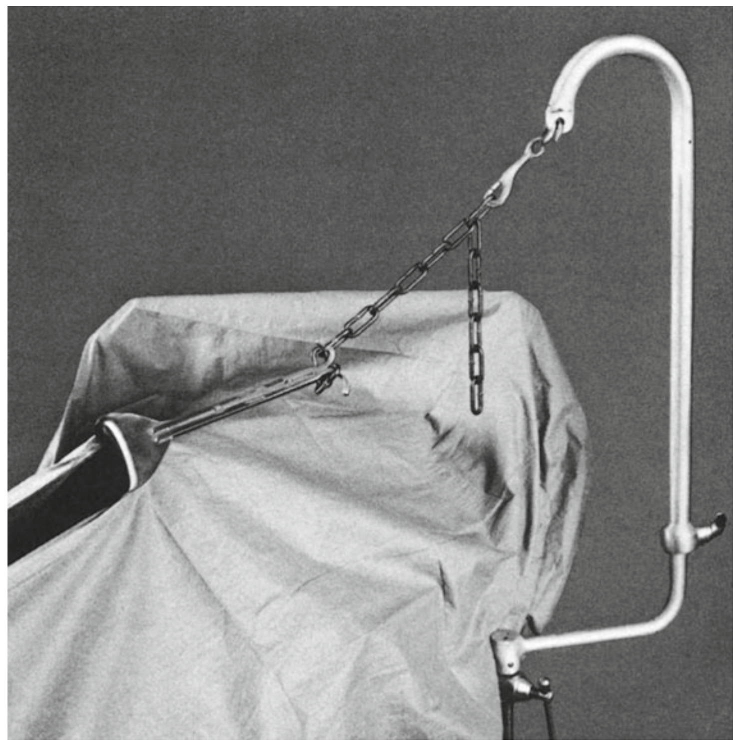

Fig. 11.20 Retractor: "chain"

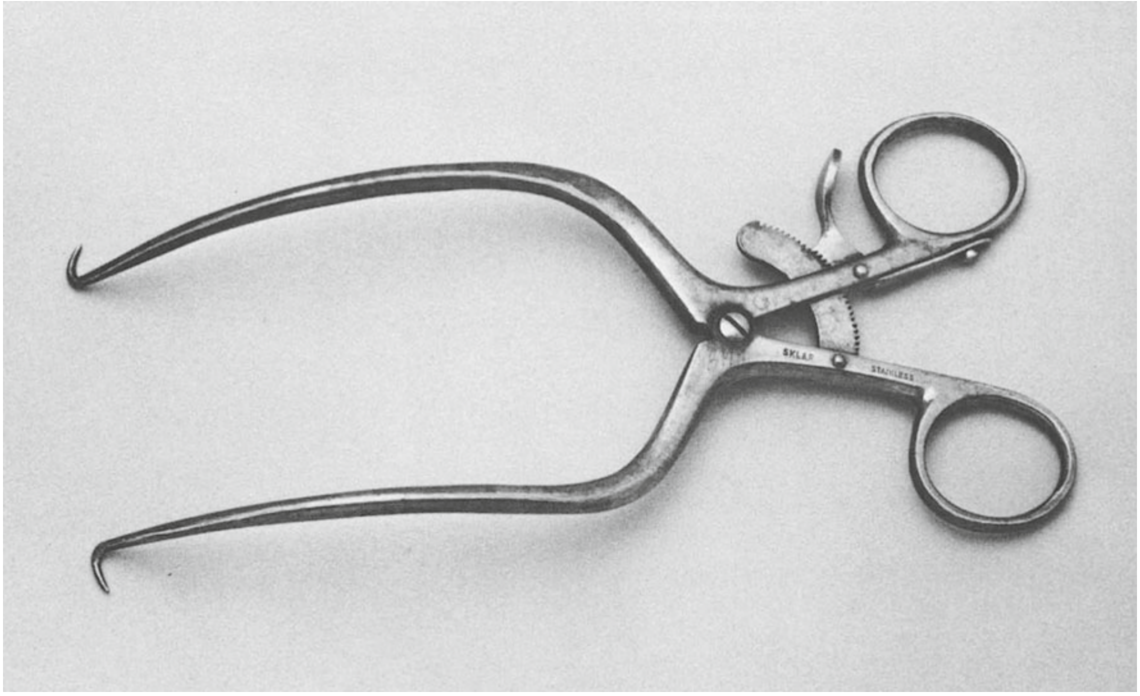

Fig. 11.21 Retractor, Gelpi

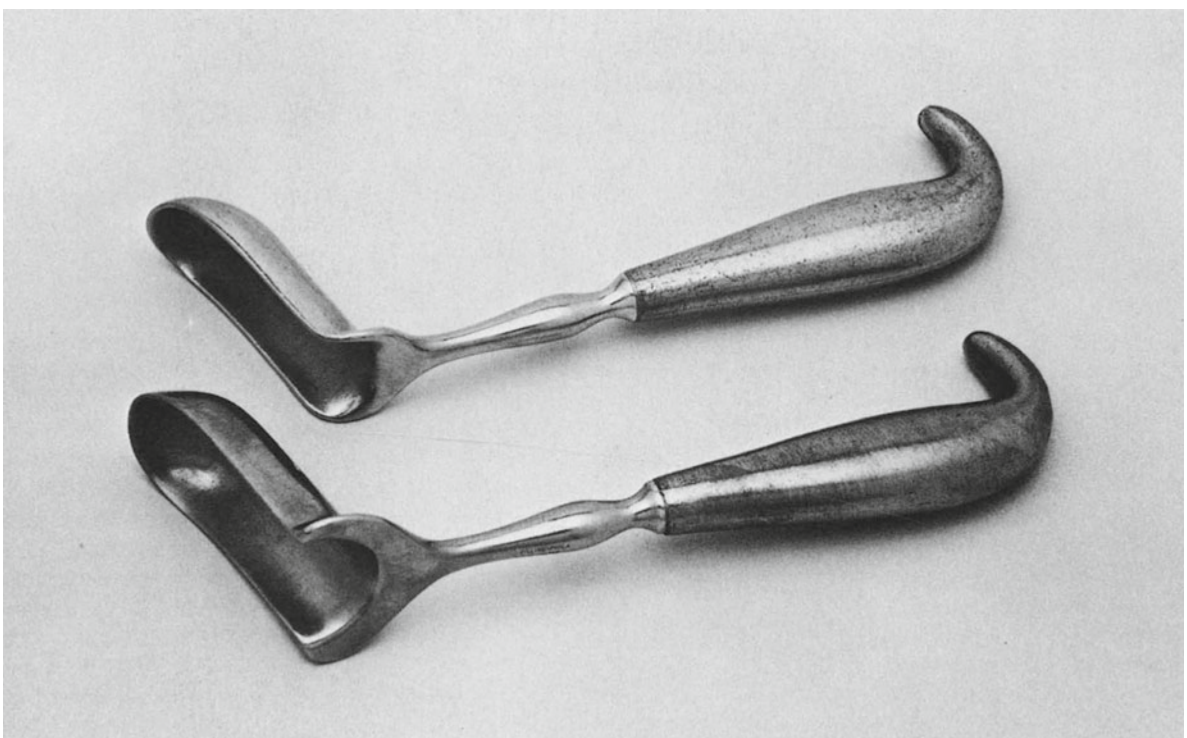

Fig. 11.22 Retractors, Hill-Ferguson

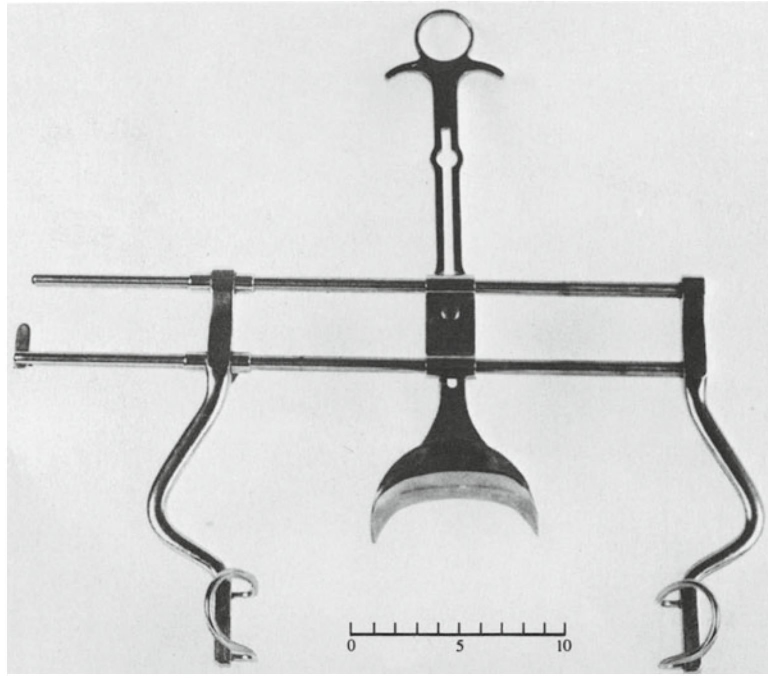

Fig. 11.23 Retractor, self retaining: Balfour

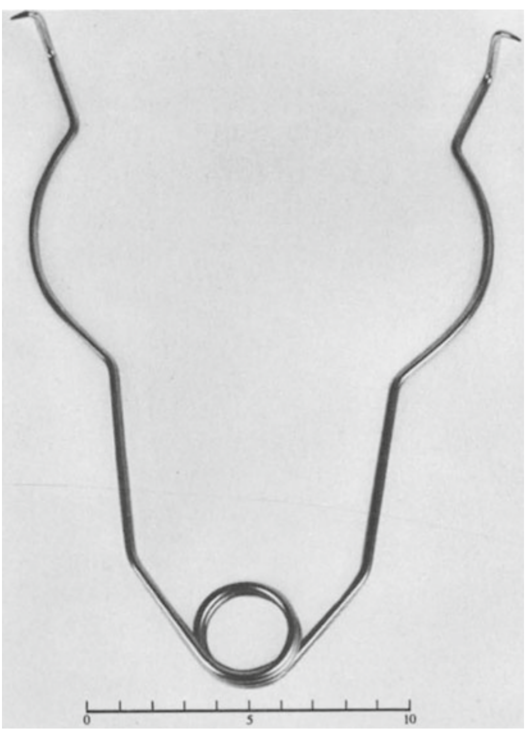

Fig. 11.24 Retractor, self retaining: Farr

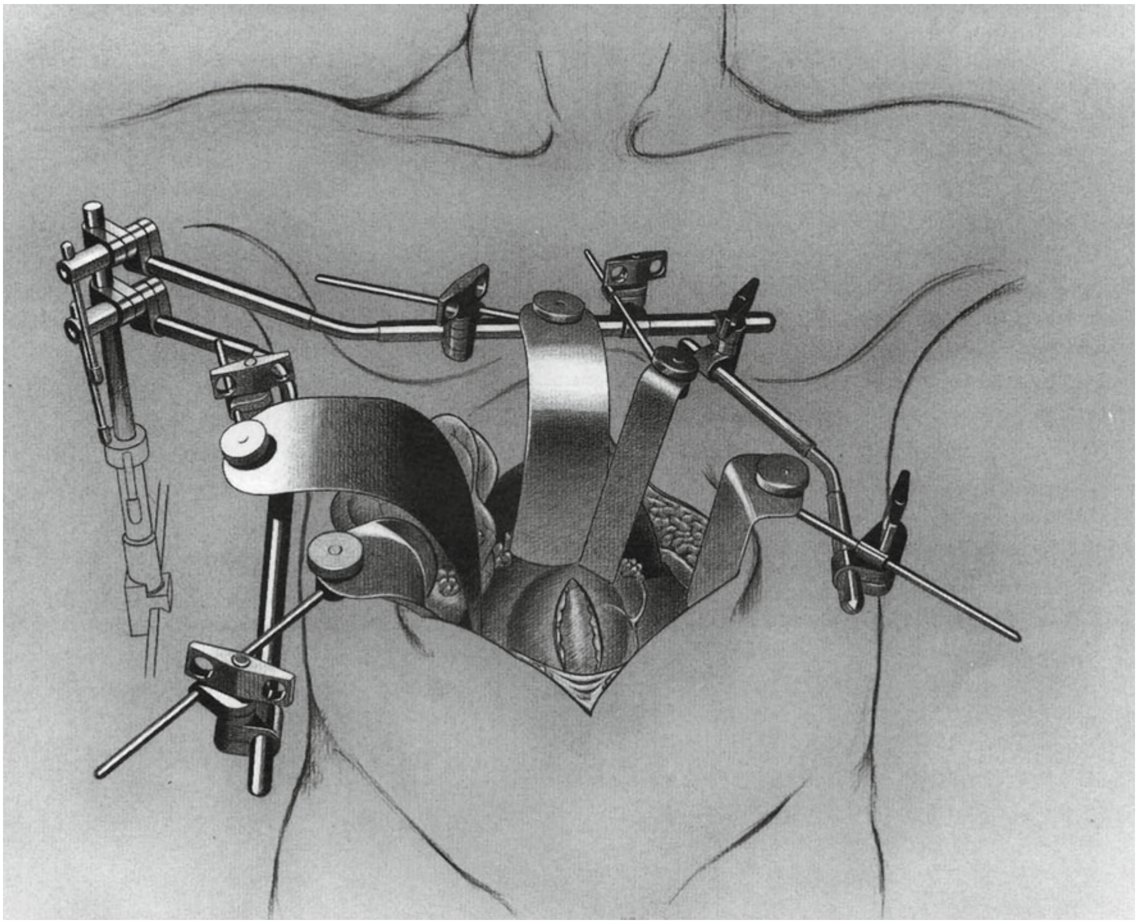

Fig. 11.25 Retractor, Thompson

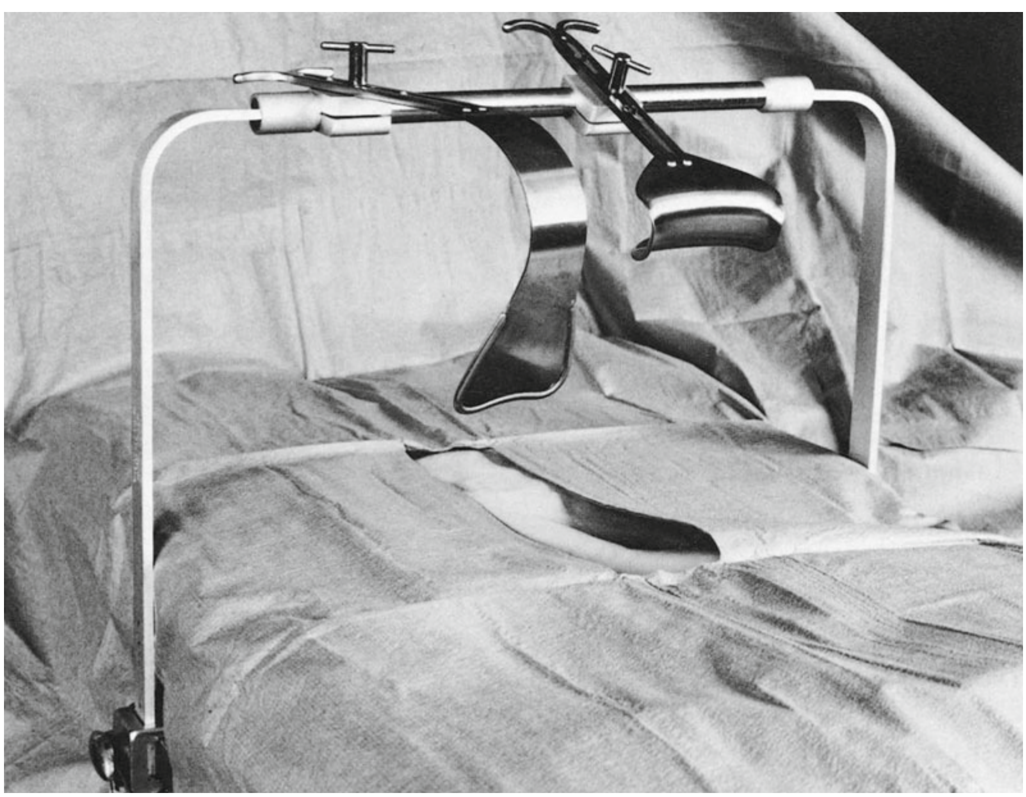

Fig. 11.26 Retractor, upper hand

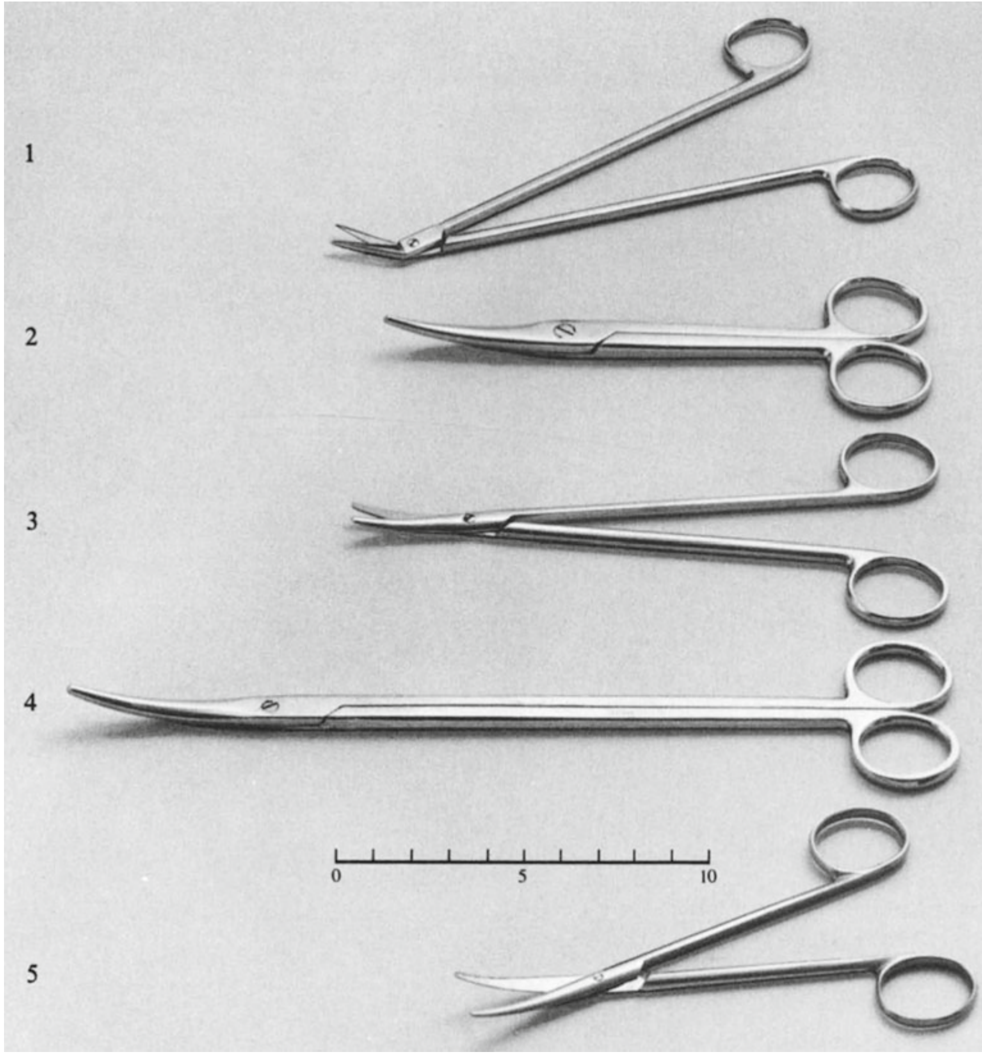

Fig. 11.27 Scissors: Potts (1); Mayo (2); Metzenbaum (3, 4, 5)

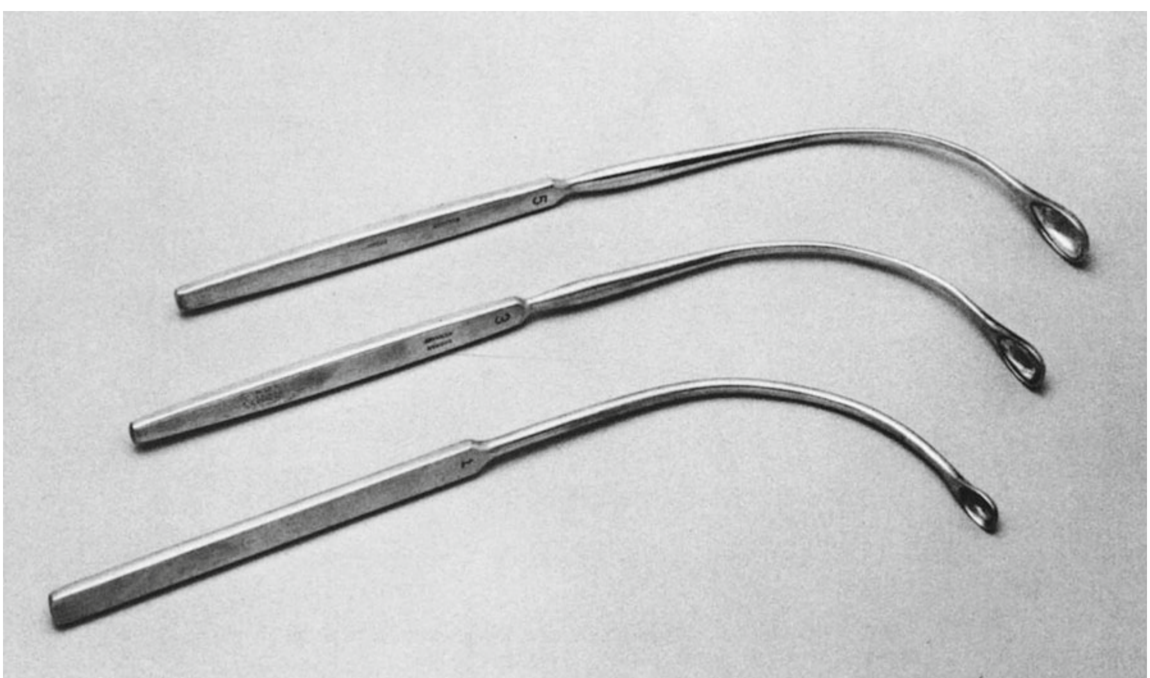

Fig. 11.28 Scoops, pituitary (surgical legacy instrument)

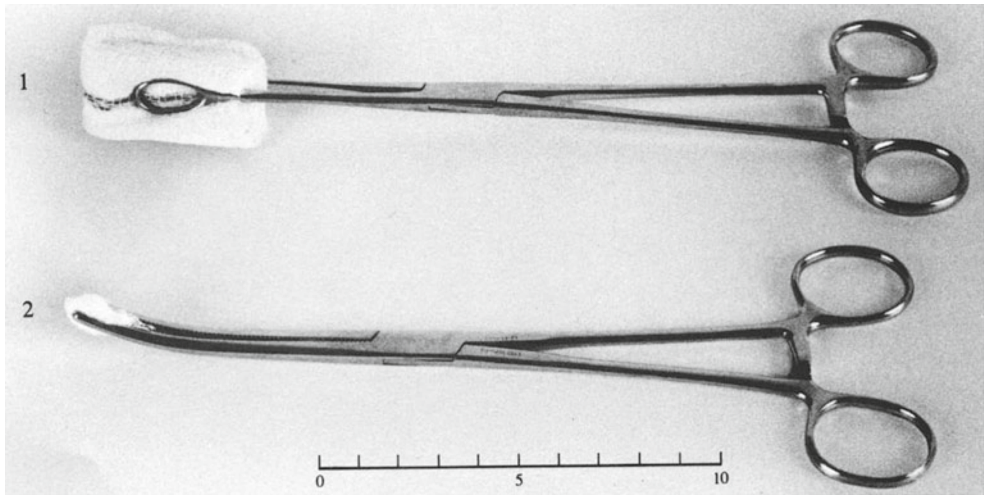

Fig. 11.29 Sponge holder with 10 × 10 cm gauze square (1); peanut sponge (Kuttner) dissector (2)

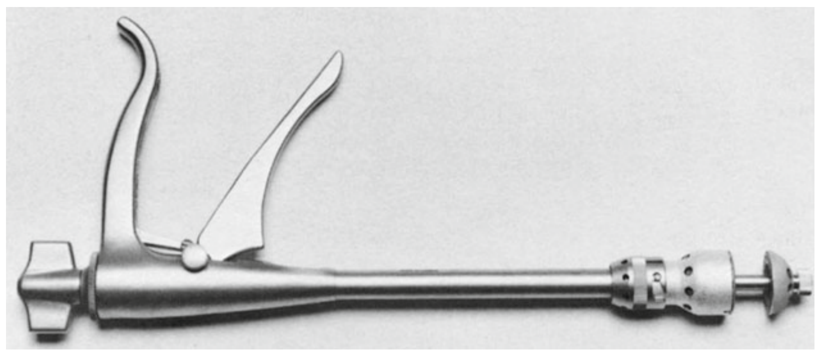

Fig. 11.30 Stapler, circular

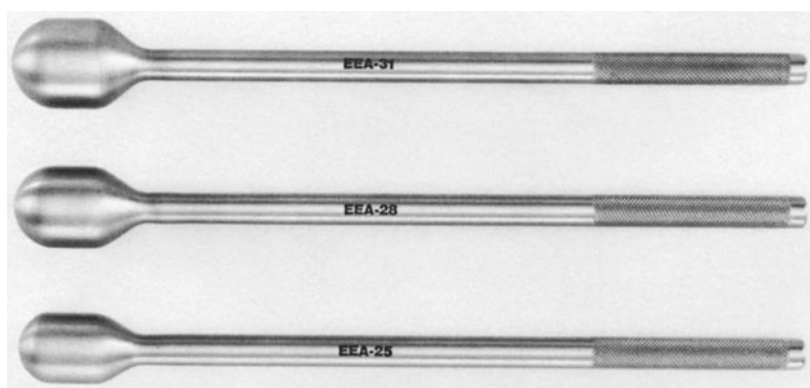

Fig. 11.31 Stapler, circular, sizers

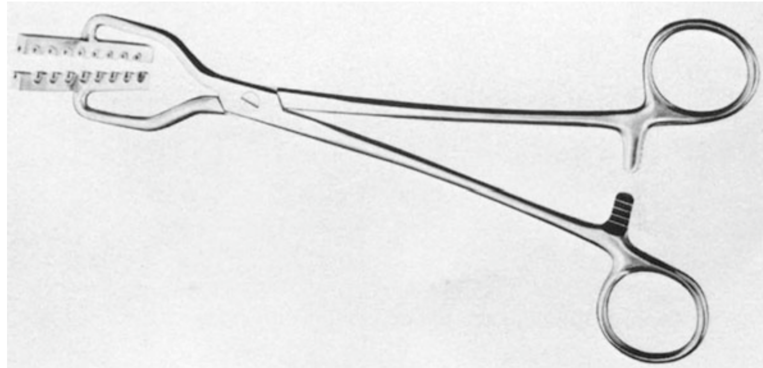

Fig. 11.32 Stapler, purse-string instrument for circular stapler

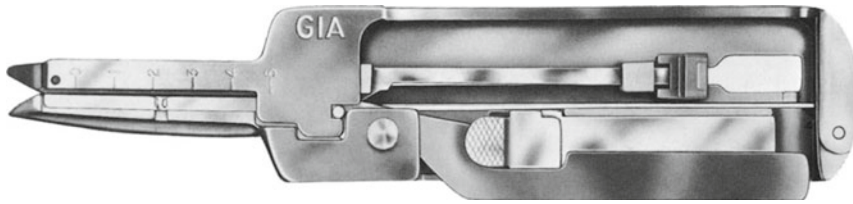

Fig. 11.33 Stapler, linear cutting

Fig. 11.34 Stapler, linear (55 mm)

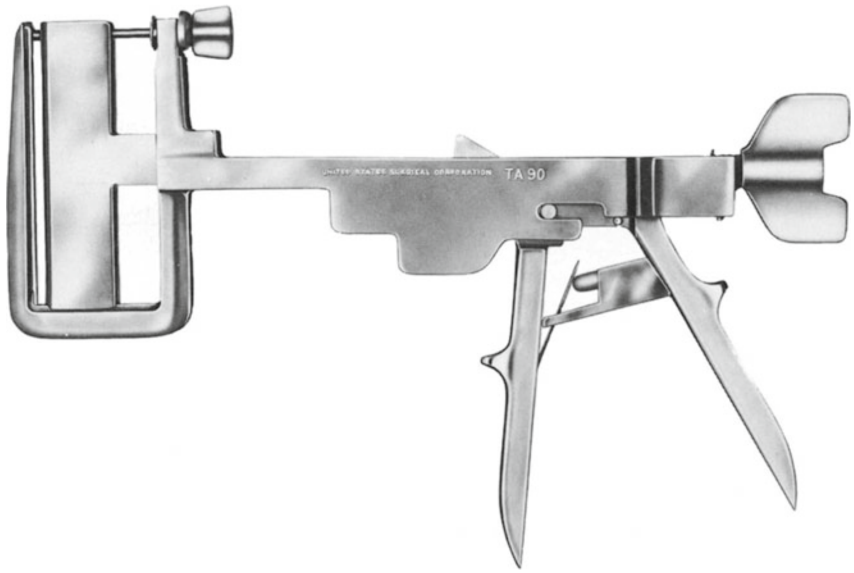

Fig. 11.35 Stapler, linear (90 mm)

Fig. 11.36 Stapler, skin

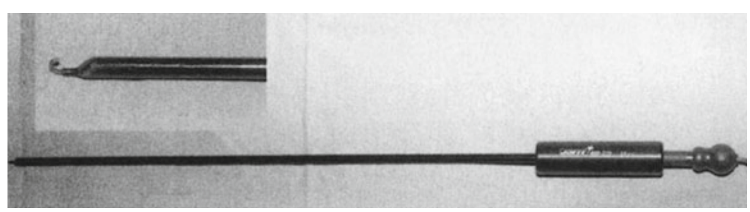

Fig. 11.37 Electrocautery, hook tip

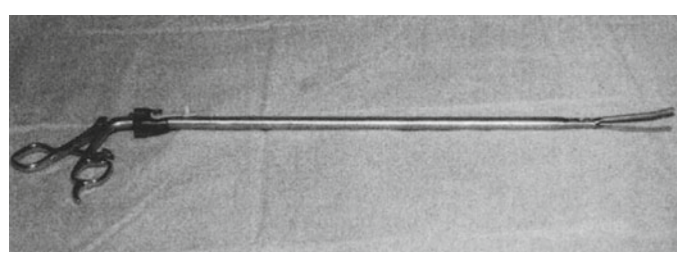

Fig. 11.38 Grasper, atraumatic

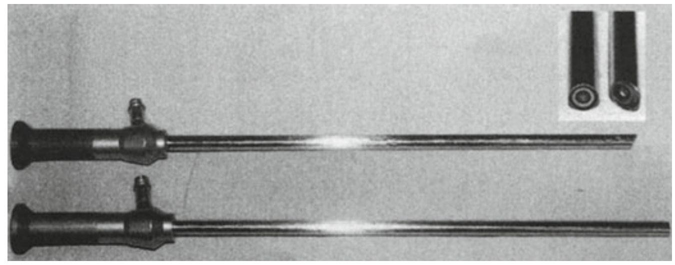

Fig. 11.39 Laparoscopes, straight and angled

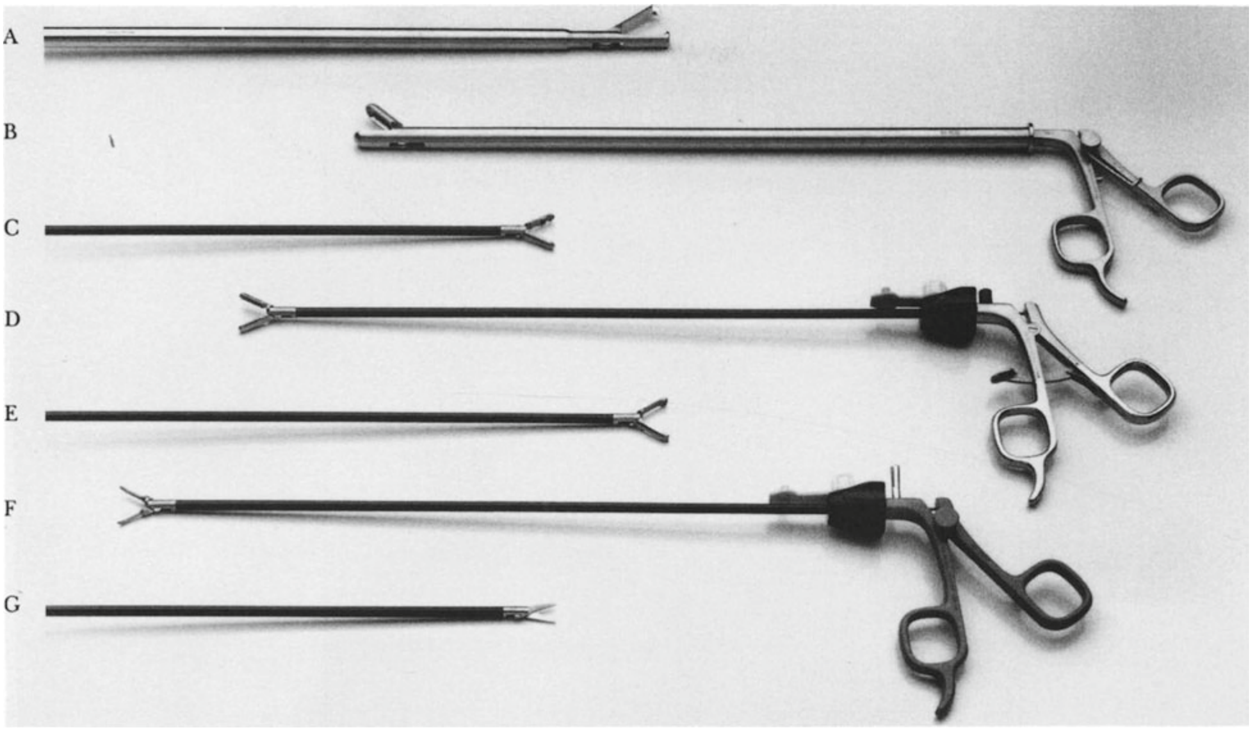

Fig. 11.40 Laparoscopic cholecystectomy instruments. (**a**) Claw to grasp and remove gallbladder from the abdominal cavity. (**b**) Large-mouth stone forceps. (**c**–**g**) Various shapes of grasping and dissecting forceps

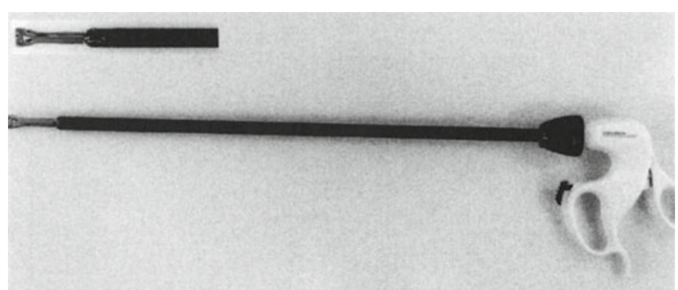

Fig. 11.41 Laparoscopic clamp, Babcock

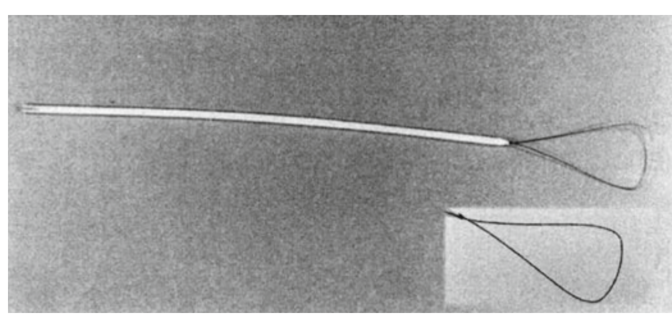

Fig. 11.42 Pretied laparoscopic suture ligature

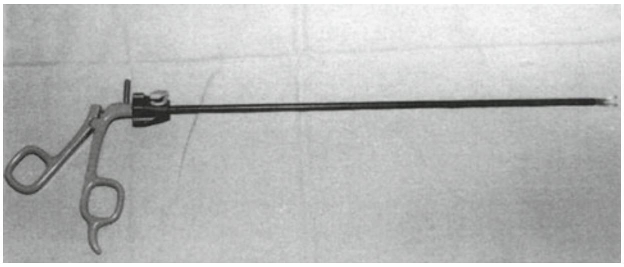

Fig. 11.43 Laparoscopic scissors, curved tip

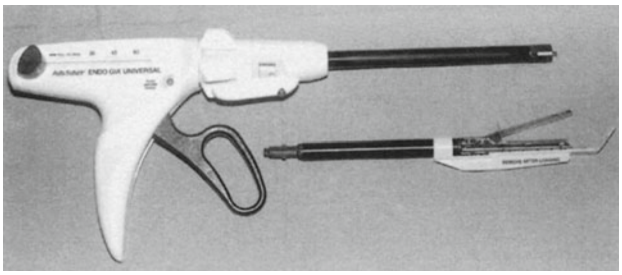

Fig. 11.44 Stapler, linear, cutting

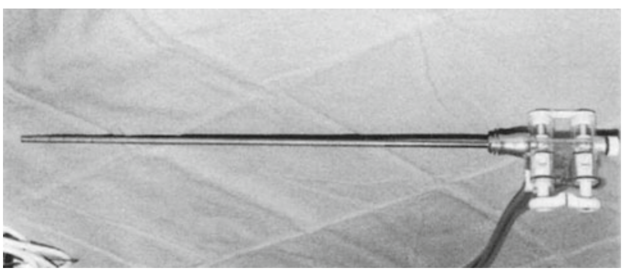

Fig. 11.45 Suction irrigator

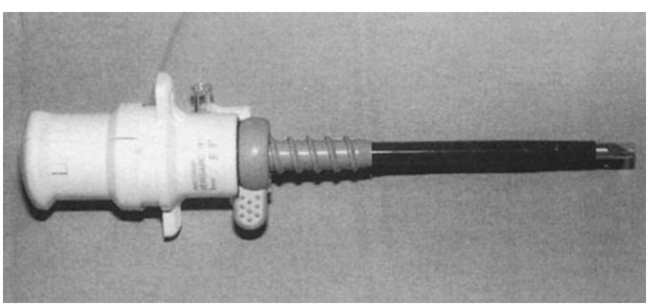

Fig. 11.46 Trocar, disposable, assembled

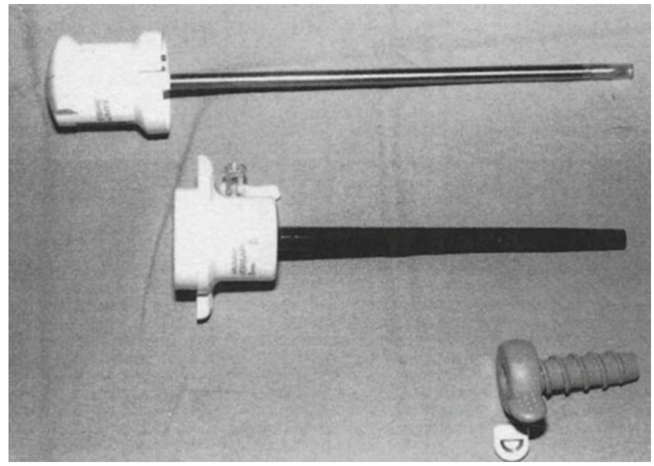

Fig. 11.47 Trocar, disposable, disassembled to show parts. The central trocar has a plastic safety sheath. The outer cannula has a port for insufflation. The grip screws into the skin and subcutaneous tissue to anchor the trocar

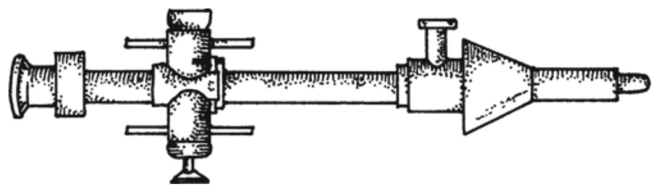

Fig. 11.48 Trocar, Hassan (From Scott-Conner CEH, editor. The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer; 1999, with permission)

Fig. 11.49 Ultrasonic shears, tip. The fixed blade is the active blade and becomes hot during use

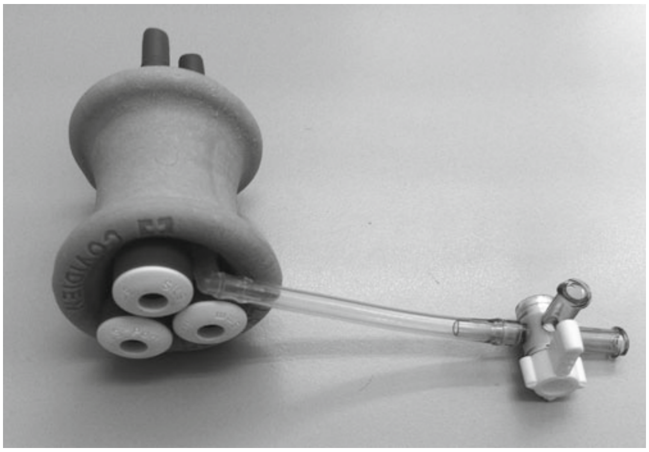

Fig. 11.50 Single port. This is a port designed to allow the surgeon to perform laparoscopic procedure through a single incision. It gives the surgeon the ability to use multiple instruments with maximal maneuverability through adjustable cannulas all within a low-profile malleable port

Fig. 11.51 Ultrasonic shears, tip

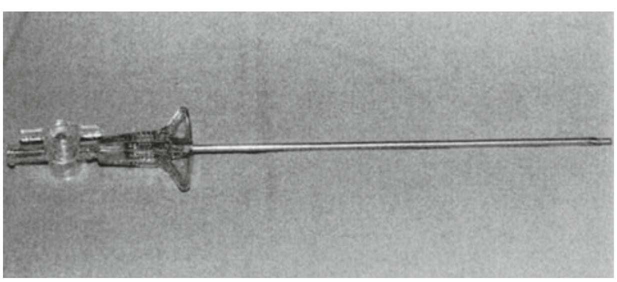

Fig. 11.52 Veress needle

Fig. 11.53 Ligasure™ (Covidien Corporation, Dublin, Ireland). This device seals vessels by a combination of pressure and monopolar electrocautery. It is available for open or laparoscopic use. This figure depicts an open instrument

12 The Operative Note

Jamal J. Hoballah

"No job is completed until the paper work is done." This cannot be more true than in healthcare—no surgical intervention can be considered completed until the operative note is done. The operative note is an essential part of the patient's medical care and records. It is part of the expected standard of care in all hospitals accredited by The Joint Commission or other international hospital accreditation organizations. Most hospitals delineate in their bylaws or policies and procedure manuals their expectations for prompt and accurate documentation of operative procedures. Many hospitals use a 24-h limit to have this note dictated. Not fulfilling such documentation represents a deviation from the standards of care.

The operative note is an integral part of the medical care provided to the patient and reflects the quality of care delivered. Its value may not be immediately apparent, particularly to the harried surgical resident. If the patient does well and does not require any further care for that problem, it may become a purely historical document. However, its value cannot be underestimated when a patient presents in the future needing additional related care at the same or another healthcare facility. Such need may arise when the original healthcare provider is no longer available and a different healthcare provider is going to assume care of that patient. Similarly if another operation becomes needed in the future, the pertinent details of what was performed during that operation cannot be undervalued.

Consider a patient with an aortic graft infection or aortoduodenal fistula. This patient will require an operation to correct the problem; and, like all reoperations in the same surgical field, the exact details of the original procedure become crucial. Thus, in the case cited, it is very important to know the location and configuration of the aortic anastomosis, whether it was performed using an end-to-end or end-to-side configuration. It is also crucial to know if the surgeon was able to place the aortic clamp in the usual infrarenal position or whether suprarenal clamping was necessary to allow for the construction of the proximal anastomosis. Such details are essential for the proper planning and selection of the most appropriate treatment option in the typically challenging reoperative situation. Trying to tackle this problem without knowing such details can further complicate the management of such patient resulting in a suboptimal outcome.

Similarly consider a patient with Crohn's disease requiring a second or third operation to manage yet another complication of the inflammatory bowel disease, where additional small bowel resection is anticipated. It is very important to know what was done or resected in the prior procedures and the length of the remaining small bowel to select the most appropriate surgical management.

Proper documentation is also necessary for ensuring payment for the procedure performed. The details will be necessary so that the appropriate CPT® (Current Procedural Terminology®) codes are submitted and charged. Such codes may vary depending on the extent of the procedure. For example, the coding for skin grafting will depend on the surface area covered. Similarly, reimbursement for stab phlebectomy of varicose veins will vary depending on whether the number of phlebectomy sites performed is greater or less than ten stabs.

For reimbursement purposes, the procedure must be indicated and must have been performed and clearly documented. "If it is not documented, it is not done." If it is not legible or understandable, then it can be viewed as not done. If the charts are audited for billing and the documentation does not reflect the billing submitted, the surgeon will be required to pay back what was not properly documented even if it was performed, along with whatever fines may be deemed necessary.

Proper documentation is also mandatory for risk management. Should an adverse event occur and the case is being reviewed for by a malpractice attorney, the operative note

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may be the surgeon's best ally or his worst foe depending on the documentation level. Adverse events can occur during an operation in the best of hands. Attempts at covering them or avoidance of describing them in the operative note and clarifying how they were managed can reflect negatively on the surgeon when the case is being reviewed. Consider a patient with hoarseness following a thyroidectomy or tongue deviation following a carotid endarterectomy. The operative note should indicate whether key structures were identified or spared such as the recurrent laryngeal nerve or the hypoglossal nerve.

The operative note follows a standard form and must include all of the essential information. It should be inclusive but not redundant or verbose. The following elements should be included in every operative note:

- The preoperative diagnosis
- The name of the procedure
- The postoperative diagnosis
- The indication for the procedure
- Clear description of the procedure
- Postoperative condition

(This will be discussed in the clear description of the procedure.) The *preoperative diagnosis* will reflect the medical condition for which the procedure is being performed. The *name of the procedure* will summarize what was done intraoperatively and is often used to guide coding and subsequent billing. The *postoperative diagnosis* will identify whether the operative findings were supportive or different from the preoperative diagnosis.

The *indication* section is a very essential part of the operative note as it will reflect the thinking process and frame of mind of the surgeon prior to the operation. It will clarify the justification for the operation that will be used if the case is being audited for billing issues or for malpractice litigation. It will also allow the surgeon to clarify the reasoning behind selecting one approach versus another. It should document that the case was discussed with the patient and that the procedure was explained to the patient along with its risks and benefits. It will further confirm that an informed consent was obtained and who were involved in the decision-making form the patient's side and family.

The *description of the procedure* is the crux of the operative note and should include several components. These components include the time-out, anesthesia type, monitoring lines, Foley catheters, position, prepping and draping, incision type, intraoperative findings, pertinent structures identified and protected, and the details of the procedure performed. The details of the procedure performed will include the anatomic location, specimen resected, viability of remnants, configuration of anastomoses, staples or hand sewn, any testing of anastomosis, placement of drains and tubes, and finally the closure technique.

The operative note should clearly indicate that a "time-out" was performed to confirm the patient identity, procedure, and correct site of surgery. It should clarify the position of the patient for the operation and clarify whether the positioning was performed according to the expected standards. The positioning will clarify how the arms were placed, whether cushion pads were used to support bony prominences and protect for any skin ulcerations or nerve compression or stretch in select positions.

The anesthesia used for the procedure should be clearly documented in the note along with the monitoring lines or catheters inserted. The method of prepping and draping is routinely included in the note. The next element is to clarify what type of incision and the location of the incision. The intraoperative findings are noted. It is very important to clarify and document the intraoperative findings in the operative note, especially if there were unexpected findings or if they caused a change in the procedure or the original planned intervention.

Always discuss and document whether important vulnerable structures were identified and protected, such as a recurrent laryngeal nerve during a thyroidectomy and a vagus or hypoglossal nerve during a carotid endarterectomy. The procedures performed should be clarified, and if any prosthesis was used, clear indications of the type and size of the prosthesis used should be documented, the conduct of any kind of dissection, the extent of the dissection, the steps until the completion of the procedure, and finally the closure of the incision. Finally it is also important to comment on the patient's condition upon the completion of the procedure. All these elements are very essential as they provide a clear documentation of the indication for what was performed and how it was conducted. Such documentation will allow other healthcare providers to care for this patient in the future if the patient care was transferred to another location or to another state or if the initial surgeon is no longer capable of providing care or if the patient wishes to switch to another healthcare provider. Such note will provide the necessary documents for billing and auditing purposes and for risk management.

It is a fine line between having a verbose and redundant operative note and a clear and to-the-point note that provides the needed information. Suppose you were to read the operative note two years after the surgery was performed. Would it provide sufficient level of detail that you could easily visualize what was done and why?

There are reports indicating that the use of templates may be helpful in some patients to avoid missing key important information in the management of these patients (DeOrio 2002). Having templates for dictations or to describe the operative notes allows the surgeon to use a systematic approach to the dictation that will not allow for missing any important information and could allow for better patient care (Elit et al. 2006). How to prepare an appropriate operative note was rarely taught or instructed to the budding surgical residents starting their surgical training. Such need was identified and addressed by a book entitled *Operative Dictations in General and Vascular Surgery*, coedited by Carol Scott-Conner and Jamal J Hoballah (2011), which has served as a companion to Chassin's textbook. This has been a very useful educational resource to the surgical residents in training as a quick guide prior to performing a surgical procedure or in preparation for the certifying part of the American Board of Surgery examination.

Finally it is very valuable that a surgeon keeps copies of his/her operative notes. The electronic medical records facilitate the ability of the surgeon to maintain soft copies of all his/her operative notes in an organized and manageable manner.

In summary the operative note is a solid reflection of the care provided. It is the responsibility of the surgeon to ensure that the essential elements of a surgical procedure are promptly documented in an accessible operative note.

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Part II

Esophagus

Concepts in Esophageal Surgery

13

Thomas H. Gouge

Advances in diagnostic studies, perioperative management, and the techniques of esophageal surgery have greatly reduced mortality, morbidity, and length of hospital stay. Multidisciplinary approaches have even begun to improve the long-term results of treatment for esophageal malignancy. Long-term survival following resection of a carcinoma of the esophagus is usually limited to those patients without regional spread whose tumors are confined to the wall of the esophagus. Successful esophageal surgery still requires knowledge of the anatomy and physiology of the esophagus and attention to the details of the operative technique.

Carcinoma of the Cardia Region

Resection of lesions of the distal esophagus and gastric cardia with esophagogastric anastomosis is no longer an operation with high mortality, significant complications, and intractable reflux esophagitis. Resection with an overall mortality of 2 % should be routine, and anastomotic leakage should be a rare event today. Operation without an intensive care unit stay, with early ambulation, return to oral intake within 48 h, and hospitalizations of 1 week are achievable even for patients over age 70 with either open or minimally invasive approaches. Continuing epidural analgesia with patient control after surgery has been an important advance. Although return of normal appetite and meal volume is slow, most patients have no dietary restrictions after the early narrowing of the anastomosis due to edema has resolved.

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Important concepts are resection with adequate margins of normal esophagus and stomach, resection of the fibroareolar tissue around the tumor to ensure local circumferential margins, and adequate lymphadenectomy for staging. The stomach must be well mobilized with preserved vascularity and esophagogastric continuity restored with an end-to-side or side-to-side anastomosis. The gastroepiploic arcade must be carefully preserved and the esophageal hiatus widened to prevent a tourniquet effect with obstruction to venous outflow. Properly performed, esophagogastrectomy is a safe operation with good symptomatic and nutritional results.

If a tumor extends into the stomach, a significant distance either along the lesser curvature or into the fundus, a significant proximal gastrectomy is necessary for adequate tumor margin. If resection of more than 50 % of the stomach is required for tumor margins or if the anastomosis is less than 10 cm from the pylorus, a total gastrectomy with Roux-en-Y esophagojejunostomy gives a much more satisfactory result. Intra-abdominal esophagogastric anastomoses near the pylorus leave too small a gastric remnant to construct a satisfactory end-to-side anastomosis. Such end-to-end anastomoses have a higher leak rate and severe problems with uncontrolled bile reflux esophagitis.

An abdominal and right chest approach can be used for lesions at any level of the thoracic esophagus, and transhiatal esophagectomy is an option for lesions in the distal 10 cm of the esophagus. The use of minimally invasive approaches utilizing laparoscopy and thoracoscopy have largely supplanted the left thoracoabdominal approach with the patient in the lateral position for tumors whose proximal extent on computed tomography is clearly below the carina. A combined minimally invasive operation is rapidly becoming the approach of choice. Although minimally invasive mobilization and resection can significantly increase the operating time, especially in the learning phase, it provides superb exposure without the increased morbidity of prolonged open surgery and it decreases blood loss. Minimally invasive techniques can refine both transhiatal and transthoracic surgery. I continue to prefer a left thoracoabdominal approach in the

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lateral position for bulky tumors of the distal esophagus and for salvage surgery when neoadjuvant therapy has failed to down stage a tumor. The direct visualization of both chest and abdomen is a great advantage for this palliative surgery, and anastomosis in the chest is easily accomplished.

Carcinoma of the Middle and Upper Esophagus

The operation of choice for lesions in the midthoracic esophagus is subtotal resection following full mobilization of the stomach. We routinely place a feeding jejunostomy as part of the abdominal phase. The anastomosis should be constructed with an end-to-side or side-to-side technique at the apex of the right chest or in the neck. A stapled anastomosis at the apex of the chest usually provides at least as much esophageal margin as a cervical anastomosis. The success rate of cervical anastomoses has been improved by the development of the semi-mechanical technique of anastomosis (Orringer et al. 2000). The same considerations of blood supply and lack of tension apply. Good vascularity ensured by preservation of the gastroepiploic arcade, enlargement of the hiatus to prevent compression, and wide mobilization of the stomach and duodenum to eliminate tension are essential to a satisfactory anastomosis. With appropriate preparation the operation can be done safely with resultant good digestive function and little or no reflux problems. The tumor must be staged as completely as possible prior to operation to ensure resectability because the surgeon cannot assess local fixation until after completion of the abdominal mobilization if the thoracic phase is done second. Bronchoscopy and endoscopic ultrasonography are the most accurate studies to determine the extent of invasion for these tumors. Doing the thoracic mobilization first has the advantage of evaluating the local condition early in the operation, and a minimally invasive approach with thoracoscopy decreases the need for position changes and the morbidity of thoracotomy so the substantial increase in operating time is not an issue.

I prefer dissection under direct vision (video assisted) for these lesions even though the same thing can be accomplished by the transhiatal approach. I use a transhiatal approach only for mid-esophageal lesions that are clearly confined to the wall of the esophagus to avoid injury to major vessels and the trachea. Wide resection around the esophagus is not as feasible in the mid- and upper esophagus as it is in the lower third and cardia because of the adjacent respiratory and vascular structures.

My preference has been for a high intrathoracic anastomosis when the location of the tumor permits rather than using a cervical anastomosis on principle in open surgery. The amount of esophagus resected with an anastomosis in the neck is minimally (if any) longer than for an anastomosis at the apex of the thorax. Although the trend has been toward anastomosis in the neck, with experience an intrathoracic anastomosis is no more difficult in minimally invasive surgery than in an open transthoracic operation. As the incidence of anastomotic failure of intrathoracic anastomoses has been reduced to an uncommon event, the previous arguments about safety have lost their force.

Anastomosis in the neck has a higher leak rate than intrathoracic anastomosis and introduces the problems of recurrent laryngeal nerve injury. As already mentioned, the use of the combined or semi-mechanical anastomosis in the neck may change this paradigm. With the use of a linear stapler for the back of the anastomosis and sutures for the front, cervical leaks are more likely to remain localized or drain anteriorly. If it does not drain exteriorly, a cervical leak can track caudad and cause thoracic mediastinitis. Cervical leaks have often caused strictures that require dilation and can be difficult to manage with circular anastomoses, but the problem seems less common with the combined technique. Cervical anastomosis has improved neither local recurrence nor long-term survival.

Unresectable Carcinoma

Patients whose lesions appear locally unresectable on initial evaluation by CT scan or ultrasonography should be treated with radiation and chemotherapy and then reevaluated for surgical treatment after completing the course of neoadjuvant therapy. For patients with significant invasion beyond the esophageal wall, a multimodality approach with radiation and chemotherapy has the potential to reduce significantly or even eliminate the tumor mass. Resection may be feasible for palliation or even with curative intent after such treatment.

Tumors that invade the aorta or the tracheobronchial tree must be approached with extreme caution. It is doubtful that heroic measures can prove more beneficial than a palliative approach and the chance of creating an unsalvageable situation is great.

How extensive a search one should do for distant metastases is both a practical and theoretical question. Distant metastases are not a contraindication to palliative resection of a locally resectable tumor, but they do preclude cure at the current level of knowledge. The patient's condition and the potential benefit must be carefully weighed when deciding whether to resect for palliation. A suitable patient is one whose tumor has caused obstruction or bleeding and who can easily withstand the operation. For such a patient, the ability to swallow can significantly enhance the quality of life. A palliative resection can be accomplished during a short hospitalization in appropriately selected patients.

Although it is feasible to interpose a colon segment between the proximal esophagus and the stomach for palliation of obstruction caused by an unresectable carcinoma, the operation has a high mortality rate and provides poor palliation for the short expected survival of such patients. The development of new techniques including endoscopic treatment with dilators, lasers, and stents provides a much more acceptable means of palliation.

Carcinoma of the Esophagus: Transhiatal or Transthoracic Approach

Each approach to resection of esophageal cancers has had strong proponents. Each also has advantages and disadvantages, and no series has demonstrated a clear superiority of one over the others. Although the left-sided approach I favor for certain distal lesions has been widely accepted, some have reported excessive mortality and leak rates. We have not had this experience, and others have also noted exceedingly low mortality and complication rates. Akiyama (1980), Ellis et al. (1983), and Mathiesen et al. (1988) have reported the same experience we have had with complications and mortality, both in the 2 % range and lower. With a large experience, Orringer and John (2008) results with transhiatal resections are similar. The minimally invasive and minimally invasive-assisted approaches are rapidly gaining adherents after the pioneering work by many surgeons around the world who championed the approach and demonstrated its equivalency and perhaps superiority. There is also intense interest in the use of robotic-assisted surgery, but it has yet to prove itself.

Each operative approach requires knowledge of the anatomy, appropriate staging and preparation of the patient, a well-orchestrated team approach in the operating room and afterward with meticulous and delicate surgical technique, careful anesthetic technique and monitoring, and devoted postoperative care to achieve comparable results.

Replacing or Bypassing the Esophagus: Stomach, Colon, or Jejunum

The stomach is the closest we have to the ideal esophageal replacement. When fully mobilized and based on the gastroepiploic arcades, the apex of the stomach reaches the nasopharynx. When the stomach is stretched out to reach the neck, it becomes a tubular organ of modest diameter, with the fundus at its apex and the site of the gastroesophageal junction one-third of the way down the lesser curvature side. Its arterial supply and venous drainage are reliable and difficult to compromise even if the lesser curvature arcades are divided to gain length. The stomach is thick walled and resistant to trauma when passed up to the neck by any route. Restoration of continuity to the esophagus or pharynx is straightforward and requires only a single anastomosis.

Although end-to-side anastomosis and creation of a partial antireflux "fundoplication" by wrapping or "ink welling" the anastomosis help decrease the amount of reflux, all patients with an esophagogastrostomy have abnormal gastroesophageal reflux. Significantly symptomatic reflux, however, is seen primarily with low anastomoses and rarely with higher anastomoses. Deprived of vagal innervation, the stomach is only a passive conduit, but its function is usually satisfactory. High anastomoses (in the neck or apex of the pleural space) help minimize the amount of reflux. I believe this improvement is on a purely mechanical basis. The complete vagotomy that occurs as part of an esophageal resection makes acid secretion minimal. Bile is the main culprit. A long, thin gastric tube helps minimize pooling in the intrathoracic stomach and facilitates emptying, thereby decreasing the amount of bile reflux. When the stomach is available, we have used it preferentially and reserved intestinal interposition for special circumstances. I have not had the opportunity to use gastric tube techniques and prefer other techniques in adults.

The use of the jejunum or colon to replace a resected segment of esophagus preserves a functioning stomach intact. Although less used today than previously, colon or jejunal interposition is an essential technique if the stomach is diseased or was previously resected. Most of the benign strictures formerly treated by short-segment colon interposition are now managed without resection. The colon is easily mobilized and can be supported on one of several major vascular pedicles and the marginal arcades. The transverse and descending colon based on the ascending branches of the left colic artery in isoperistaltic position is the appropriate size and length for substernal or intrathoracic interposition. The arterial supply of that segment is reliable and the venous pedicle short and less prone to kinking or twisting. Although sufficient length of colon can usually be achieved to reach the neck, use of the colon presents some special problems. The colon serves as a passive conduit and does not have effective peristalsis. Gastrocolic reflux occurs routinely, and the refluxate is slowly cleared, but the reflux is seldom symptomatic. The transit time for a bolus of food to pass into the stomach is invariably slow but variably symptomatic. Benign or malignant disease of the colon may preclude its use; and the mesenteric vascular arcade is variable, especially on the right. The interposed colon is also subject to venous infarction by trauma to the colon mesentery or compression at the hiatus.

The jejunum retains effective peristalsis when used to replace a segment of the esophagus. Short-segment jejunal interposition has been used effectively as a salvage operation to prevent reflux when multiple direct operations on the gastroesophageal junction for reflux esophagitis have failed. The shape of the jejunal mesentery limits the length of the interposition that can be achieved with a conventional technique. Without special techniques, the jejunum does not reach above the inferior pulmonary vein. Some of the limitations of jejunal interpositions have been solved by microvascular techniques, which allow either free transfer of jejunum to replace segments of the pharynx or proximal esophagus or interruption of the mesentery with a second proximal vascular anastomosis.

Even without microvascular techniques, the major objection to using jejunum or colon as an esophageal substitute has been the time involved in the additional dissection and the three required anastomoses. Mobilizing the bowel with careful preservation of both arterial and venous circulation can be difficult and time-consuming. Although experienced surgeons have reported excellent results with both colon and jejunum, higher mortality and morbidity rates are the rule. The higher complication rate for interposition operations likely reflects both the additional surgery required and the more complicated nature of the patients who require such an approach. When approaching a patient who needs an intestinal interposition, the surgeon must know as much as possible about the condition of the bowel and its vascular supply. Endoscopy, contrast studies, and vascular studies by angiography or magnetic resonance angiography should be performed and the bowel prepared both mechanically and with antibiotics in every case. The surgeon must have alternatives well thought-out if the originally selected segment of bowel is not usable or the adequacy of the blood supply is questionable.

Effective complete vagotomy is likely after any esophageal resection. Although it may not be necessary in more than a minority of cases, I do not hesitate to do a pyloromyotomy to facilitate gastric emptying. It is a simple maneuver if the patient does not have scarring from peptic disease. I have not found it harmful, and it avoids the need for balloon dilation or reoperation. Although a matter of judgment, a pyloromyotomy, or other drainage procedures should be done any time, the pyloroduodenal segment is within the hiatus when the stomach is pulled up. Although balloon dilation is usually sufficient, reoperation in this area is extremely difficult if it fails.

Hiatus Hernia and Reflux Disease

With the exception of traumatic diaphragmatic rupture, virtually all acquired diaphragmatic hernias enter the chest through the esophageal hiatus. Parahiatal hernia occurs but is a rare finding of no particular significance. On the other hand, it is essential for a surgeon to understand the difference between a sliding and a paraesophageal hiatus hernia and to differentiate them from posttraumatic hernias caused by blunt or penetrating trauma.

A sliding hiatus hernia may be thought of as a disease of the esophagus whose significance depends on the severity of associated gastroesophageal reflux and its consequences. A sliding hiatus hernia is sliding both in the anatomic sense (one wall of the hernia is made up of the visceral peritoneum covering the herniated stomach) and in the direction it herniates (the gastroesophageal junction migrates cephalad along the axis of the esophagus): hence the synonym axial hiatus hernia. The hiatus hernia must be reduced and the hiatus repaired as part of the operation to control reflux.

A paraesophageal hernia, also known as a rolling hiatus hernia, is best conceived as a disease of the diaphragm. In this case the gastroesophageal junction is in its normal position, and the stomach with the attached greater omentum and transverse colon herniates into the posterior mediastinum through an anterior widening of the hiatus. This hernia has a true sac of parietal peritoneum. The problems associated with paraesophageal hernias are the same as those with any abdominal wall hernia with the additional special problems of having the acid-secreting stomach involved. Patients with paraesophageal hernia are more often older and frequently have kyphoscoliosis. They usually do not have significant reflux but often have abnormal esophageal peristalsis. Many are entirely asymptomatic, and the diagnosis is suggested by the presence of a mediastinal air-fluid level on chest radiography. Unlike sliding hernias, all patients who have a significant paraesophageal hernia should undergo repair to avoid the mechanical complications of the hernia unless they are unfit candidates for general anesthesia. All symptomatic patients require surgical repair because this disease is caused by a mechanical problem for which there is no medical therapy. The essentials of the operation are reduction of the stomach and repair of the hiatus. Patients who do not have reflux do not benefit from an antireflux operation.

Complicating the matter is the combined hernia with features of both paraesophageal hernia and sliding hernia with reflux. These hernias are usually large and symptomatic. They should be repaired anatomically and to control reflux. They require an anatomic repair *and* an antireflux procedure.

Laparoscopy has become the standard approach for both antireflux surgery and for repair of paraesophageal hernias.

A posttraumatic hernia may involve any injured portion of the diaphragm. Deceleration injuries from blunt trauma usually involve the apex of the left hemidiaphragm. These hernias are usually large and are detected soon after injury from a fall or motor vehicle accident. Posttraumatic hernias involving penetrating trauma, on the other hand, can be small and may miss initial detection. Any atypical diaphragmatic hernia that appears to arise away from the hiatus should raise the suspicion of previous injury. Because these hernias do not have sacs, the abdominal contents are adherent to intrathoracic structures if time has passed between the time of injury and the time of repair. Consequently, all such hernias should be approached through the abdomen if repaired at the time of the injury and through the chest if operated late. Immediately after the trauma, the concern should be for the abdominal viscera; reduction should be a simple matter of traction. Late recognition of injury leads to incarceration of the viscera in the chest. The primary risk under these circumstances is injury to both the viscera and the lung. The abdominal contents are adherent to the edges of the diaphragmatic hernia, the lung, and the pleura and can much more safely be freed via the thoracic approach.

Complicated Paraesophageal Hiatus Hernia: Obstruction, Gastric Volvulus, and Strangulation

The patient with a large paraesophageal hernia may have a large portion of the stomach in the chest. As more and more stomach herniates, the fixed ends at the pylorus and the esophagogastric junction come close together, and volvulus becomes likely with intermittent obstruction. More complete volvulus leads to the rare but lethal complication of strangulation with necrosis and perforation. The development of a paraesophageal hernia after repair of any hiatal hernia is especially dangerous and unpredictable. It must be considered an incarceration with a high potential for complications. More commonly, patients develop gastric ulcer with bleeding or obstruction with pain. An incarcerated hernia usually causes severe substernal or epigastric pain, often with an inability to vomit because of obstruction at the esophagogastric junction. All patients with these symptoms should have surgery as soon as the diagnosis has been confirmed with a chest radiograph and contrast esophagram unless the obstruction can be relieved. It may be hazardous to insert a nasogastric tube for the same reason the patients cannot vomit. If the patient is vomiting, a tube can be passed safely, but in either case it should be inserted carefully with the distances measured out prior to insertion. Endoscopy or fluoroscopy should be used if there is any resistance to avoid perforation.

Surgical repair of a paraesophageal hernia should include resection of the sac, closure of the hiatus, and gastropexy either anteriorly or posteriorly. Anterior fixation of the anterior wall of the stomach to the abdominal wall with or without gastrostomy is straightforward if the esophagogastric junction is in normal position. The esophagogastric junction should be reduced and fixed in the abdomen if it has migrated cephalad. Posterior gastropexy as originally described by Hill (1967) works especially well under those circumstances.

Sliding Hiatus Hernia

The presence of a sliding hiatus hernia is not an indication for operation. An asymptomatic patient with a sliding hernia who has normal sphincter pressures and no significant reflux cannot be made better by either medical or surgical therapy. The patient without a hiatus hernia who has significant reflux and esophagitis may be greatly improved by medical therapy or operation. It is generally agreed that medical management is the treatment of choice for patients who have symptomatic reflux with minimal esophagitis. Surgery is most clearly indicated for patients with reflux that causes significant esophagitis and its complications of ulceration and stricture. Patients whose symptoms are completely relieved or greatly improved by modern medical management are also excellent candidates for surgery if their symptoms recur after the withdrawal of therapy (as is likely but not certain). Patients whose reflux symptoms cannot be controlled even by escalating doses of proton pump inhibitors should be carefully evaluated prior to operation to exclude other causes for their symptoms. Atypical symptoms not clearly related to reflux episodes are rarely improved by antireflux operations. The use of antireflux surgery for patients with Barrett's esophagus (columnar-lined esophagus with intestinal metaplasia) is still an unresolved issue at this time. Although Barrett's esophagus is clearly a premalignant lesion, it is less clear that it can be eliminated by antireflux surgery. Comparisons of medical and surgical treatment in controlled studies have proven the superiority of surgical control of reflux during every era of medical treatment: antacids, H_2 blockers, and proton pump inhibitors (Spechler 1992). Surgical control of reflux also has the advantage of controlling all the refluxate—duodenal as well as gastric—whereas medical therapy at best reduces only the amount of acid refluxed.

The minimal preoperative evaluation of a patient with gastroesophageal reflux disease (GERD) and classic symptoms should include esophagoscopy with biopsy to confirm the presence of esophagitis and a barium contrast foregut study. A timed esophageal pH study confirms the relation of symptoms to episodes of acid reflux. Manometry is useful for defining any abnormalities of sphincter location and pressure. It is also essential for pH-metry of any kind to place the probe at the proper place. Manometry can define the strength and regularity of the contractions of the body of the esophagus and can exclude defined motility disorders such as achalasia. It is not clear, however, how the surgeon can use manometric information to modify antireflux surgery. I have been able to plan antireflux surgery much more effectively by looking at the results of a standard barium meal, which clearly demonstrates the size and reducibility of the sliding hiatus hernia, the amount of shortening, and the effectiveness of peristalsis in the body of the esophagus, information that endoscopy does not provide.

Minimally invasive approaches can clearly replicate open antireflux surgery, and they have largely replaced open operations. The excellent short-term results with laparoscopy have now been confirmed by long-term results from many centers. With the availability of effective acid reduction, fewer patients have peptic stricture, severe ulceration, or dramatic shortening of the esophagus. I continue to recommend open operations to patients with peptic stricture, nonreducing hernias, or an esophagus shortened enough that the gastroesophageal junction never returns to the abdomen. But with increased experience, minimally invasive operations have been successfully used for increasing numbers of patients with reflux disease, and a laparoscopic approach by an experienced surgeon is an equally valid option.

Antireflux Operations

The multiple operations developed to prevent gastroesophageal reflux were developed empirically and only later validated. They have in common the principles of successful antireflux surgery, which seek to reproduce normal reflux control:

1. Reduce the gastroesophageal junction into the abdomen to restore the intra-abdominal segment of esophagus.
2. Narrow the esophageal hiatus posteriorly to increase the intra-abdominal length of esophagus and prevent the development of an iatrogenic paraesophageal hernia.
3. Restore the lower esophageal sphincter mechanism by creating a high-pressure zone in the distal esophagus with a fundoplication.

They differ in the degree of fundoplication, the method of fixation, and the approach required. Although known by the name of one or more of a technique's primary developers, it is preferable for the surgeon to define the operation by what is done than by the use of an eponym, as the current operation may little resemble the original description.

A complete (360°) fundoplication done by either the abdominal or thoracic approach is termed a Nissen-type operation (Donahue et al. 1985). Lesser degrees of anterior fundoplication follow the models of Hill (1967), Watson et al. (1991), or Dor et al. (1967), which can only be done by the abdominal approach, or that of Belsey (1976), which can only be done by the thoracic approach. Partial posterior fundoplication is termed a Toupet (1963) procedure. It can be done effectively only through the abdomen. All these operations can be done by minimally invasive and open techniques. Aye RW in "Current therapy in thoracic and cardiovascular surgery" has refined the minimally invasive Hill and Jamieson and Watson have proven the laparoscopic Dor (Chen et al. 2011).

Personal preference aside, the more complete the fundoplication, the more complete is control of reflux. The advantages of greater reflux control are offset by the more numerous postfundoplication symptoms created by a complete fundoplication. Fundoplication is associated with a reduced gastric reservoir and more rapid emptying of the stomach in addition to the abolition of both physiologic and pathologic reflux. The patient experiences postfundoplication symptoms as a result of these changes. Most patients have symptoms of early satiety, diarrhea, and increased flatus, which are usually mild and resolve over weeks to months. Some patients have a sensation of upper abdominal pressure or fullness, called the gas bloat syndrome. These symptoms are related to the changes created by the fundoplication and the habit of frequent swallowing or aerophagia common to refluxers. As the reflux resolves, the postfundoplication symptoms usually abate as well.

The inevitable results of surgery to control reflux must be distinguished from the consequences of surgery done incorrectly. Dysphagia and the inability to belch or vomit are often listed as postfundoplication symptoms. I believe they are most often the result of too long or too tight a fundoplication and are rarely seen with appropriate narrowing of the hiatal opening, full mobilization of the fundus with division of both the short gastric vessels and posterior gastropancreatic folds, and a floppy fundoplication. Whichever operation is chosen, the fundoplication should be kept to the physiologic length, and too tight a closure of the hiatus should be avoided to minimize the undesirable effects of the antireflux surgery. The most reproducible operation with the best combination of durability and reflux control is the complete, loose (floppy) fundoplication done with posterior crural closure and complete mobilization of the fundus.

Benign Reflux Stricture

The most important step when dealing with a stricture in a patient with reflux is to be certain that the stricture is benign. Most carcinomas of the cardia present with symptoms of obstruction. The possibility of Barrett's esophagus with malignancy must be considered, especially in white males over age 50 who have a long history of heartburn. If carcinoma can be excluded, the patient should undergo aggressive medical treatment with proton pump inhibitors and sequential dilation to at least 40 French prior to surgery. Almost all strictures regress with this treatment, and surgery is then greatly simplified. All patients who are good candidates for operation should undergo this initial treatment followed by antireflux surgery. Strictures that do not respond to acid reduction therapy and that cannot be dilated preoperatively with available techniques have a substantial chance of being malignant. When operating for such lesions, the surgeon must be prepared to resect the stricture, as for carcinoma. If the strictured esophagus splits open during aggressive dilation, resection is the only option. Some strictures that appear resistant to dilation dilate readily at operation with the esophagus mobilized. In my experience, all strictures not dilatable in the operating room or that split during operative dilation proved to be malignant.

The approach used when operating for stricture depends on the level of the stricture and the degree of esophageal shortening. In most cases with sliding hiatus hernia, the shortening is more apparent than real, and I would approach these from the abdomen. Mobilization through the hiatus allows the surgeon to have the stricture under vision when dilators of increasing size are passed through the mouth to dilate the stricture. After dilation, an ample length of intra-abdominal esophagus can ordinarily be restored. In the unusual case where mobilization does not allow reduction of the esophagogastric junction into the abdomen without tension, an esophageal lengthening procedure such as the standard Collis gastroplasty (Pearson et al. 1971) or the uncut Collis gastroplasty described by Demos (1984) can be used.

With long-standing reflux and columnar-lined esophagus, the stricture may be in the mid-esophagus and the shortening real. Such cases are best approached through the chest with plans for an esophageal lengthening procedure. The surgeon must always be prepared to resect the esophagus under these circumstances. The bowel should be prepared to allow for colon or jejunal interposition as well as gastric advancement in all cases when an esophageal lengthening operation is done.

Dilation is safest when it can be done with the esophagus completely mobilized using soft, tapered, mercury-filled, rubber (Maloney) bougies. With the stricture in hand, the surgeon can see and feel the stricture and dilator and can then guide the dilator precisely into the stricture and assess the pressure required to achieve dilation. Only when the esophagus is pliable and easily reducible after mobilization should transthoracic fundoplication alone be done. All other patients should have a Collis gastroplasty combined with fundoplication.

Intrathoracic fundoplication is a potentially dangerous condition. Incomplete intrathoracic fundoplication does not prevent reflux. A complete intrathoracic fundoplication is an incarcerated paraesophageal hernia and has all the associated complications of that condition including ulceration and perforation. The intra-abdominal segment of tubular esophagus should be restored in all cases, and the fundoplication should always be comfortably within the abdomen. Patients with these complications have advanced reflux disease and should always be treated with an effective fundoplication to control their reflux.

Failed Antireflux Operation

Secondary operations for reflux are a challenge at best and are associated with increased mortality and failure rates. After abdominal operation, the decisions to reoperate and by what technique can be very difficult. Following thoracic antireflux surgery an abdominal approach may provide relatively easy access for successful fundoplication provided the esophagus is not significantly shortened or adherent to the mediastinum. Likewise, following abdominal antireflux operations, a transthoracic approach has the advantage of going through a previously unoperated body cavity. In general this plan has merit, but the surgeon must be prepared to use the alternative approach of a thoracoabdominal operation or another type of surgery when dealing with this clinical problem. For the abdominal surgeon the secondary approach should be a diversion procedure (Fekete and Pateron 1992). Distal gastrectomy and Roux-en-Y gastrojejunostomy prevents reflux of either acid or bile into the esophagus if the defunctionalized limb is 40–50 cm long. This operation usually provides relief of symptoms at minimal surgical risk. Especially in poor risk patients, it has much to recommend it over extensive operations, such as thoracoabdominal reoperation with resection and interposition. If a resection has been done previously, a complete vagotomy can be correctly assumed. Even if vagal trunks remain, an adequate distal gastrectomy prevents marginal ulcer formation. The possibility of delayed gastric emptying following the Roux-en-Y reconstruction is a concern that has been overstated. An individualized decision based on the situation and the surgeon's expertise should be used because of the complex nature of the disease and the understandable lack of consensus among experts.

Pharyngoesophageal Diverticulum

Normal swallowing is an elegant, complex series of events coordinated by the swallowing center in the medulla. In the peristaltic sequence, both the upper and lower esophageal sphincters must relax to ensure proper timing to allow the bolus to pass. The upper esophageal sphincter—the cricopharyngeus muscle and the adjacent upper cervical esophagus—and the lower esophageal high-pressure zone are physiologic sphincters. They are in a state of contraction in the resting state and then relax on stimulation. A pharyngoesophageal (Zenker's) diverticulum develops in the posterior midline just above the cricopharyngeus muscle. The pathophysiology appears to be a lack of coordination in the relaxation of the upper sphincter with a resultant false diverticulum through the weak area of the distal pharyngeal constrictor. Whatever the cause, Zenker's diverticulum is a progressive disorder with no known medical treatment that should be corrected by surgery when diagnosed. The diverticulum almost always projects toward the left, so it is best approached through a left cervical incision. Although the operation can be performed under local anesthesia, with current technology, it is far better done under general anesthesia to control the airway and allow intubation of the esophagus. The operation is well tolerated in the elderly, poor risk patients who characteristically have this disease. Diverticulectomy is straightforward with the use of surgical staplers, and excising the diverticulum opens the plane of dissection for the cricopharyngeal myotomy. We have not seen any advantage to diverticulopexy and have not used the technique.

The size of the diverticulum is not predictive of the severity of the patient's symptomatology. Small diverticula can be associated with severe dysphagia. Both that and the average length of the upper sphincter of >3 cm make combining myotomy and diverticulectomy the most logical operation for both the more common Zenker's diverticula, which are easily diagnosed radiographically, and those rare patients with dysphagia caused by upper esophageal sphincter disorders and so-called cricopharyngeal achalasia, which are related to neurologic dysfunction and which must be proven by manometry. Minimally invasive and endoscopic techniques have also been developed to treat Zenker's diverticula. Collard (Gutschow et al. 2002) has reported modifications of staplers to divide the spur endoscopically with excellent results. The technique requires specialized equipment and experience to choose the appropriate candidates and is only suitable for the large diverticula that used to be seen more commonly.

Perforations and Anastomotic Leaks

"Conservative" Management

Left untreated, esophageal perforations are uniformly fatal. Expectant or nonoperative management of esophageal perforations is hardly "conservative." Although nonoperative treatment has a place in highly selected situations such as small perforations of the pharynx from endoscopy and clinically insignificant anastomotic leaks, its use must be confined to those settings in which the leak is proven to be small, contained or adequately drained, and minimally symptomatic with no sign of systemic sepsis. The posterior mediastinum has no compartments and poor defenses against the spread of infection. Perforation of the cervical esophagus can track through the mediastinum and into the retroperitoneum. A radiographically "small" thoracic perforation can cause a fulminant mediastinitis and lead to hydropneumothorax and empyema. Any pleural air or fluid is a contraindication to continued expectant management.

The essentials for treating perforations are:

1. Early identification of the perforation
2. Accurate localization of the site of perforation
3. Control of the airway and pulmonary decompression
4. Adequate drainage of the leak
5. Broad-spectrum antibiotic coverage
6. Supportive care
7. Operation for debridement and closure of the perforation whenever it is appropriate and possible

Adequate drainage can be accomplished surgically or by image-guided intervention. Adequate drainage implies that the drain goes to the site of the perforation and completely controls the leakage. Debridement of devitalized mediastinal tissues and decortication of the pleural space are necessary to restore pulmonary function and treat the infection.

The mixture of digestive enzymes and foreign material characteristic of traumatic and postemetic perforations creates a fertile ground for microbial growth. Antibiotic therapy should cover both aerobic and anaerobic bacteria as well as yeasts. Although proximal perforations contain mouth organisms generally sensitive to penicillin, the bacterial flora quickly changes to resemble that in the colon, so the antibiotic regimen appropriate for a colon perforation should be used. The esophagus also contains large numbers of yeast, especially *Candida* species, which become progressively more of a problem the longer the perforation is incompletely treated.

Supportive care must include adequate parenteral and/or enteral nutritional support. A feeding jejunostomy should be used in most cases.

Surgical Repair

Sutured or stapled repair alone is unwise unless the perforation occurs during operation, occurs in normal tissue, and can be immediately repaired. Even under those circumstances, buttress of the repair with viable tissue is a logical approach. Consideration should always be given to providing drainage of the repair. For all other circumstances, the surgeon should always buttress the repair with viable tissue and provide always adequate drainage (Richardson et al. 1985). Parietal pleura, intercostal muscle, pericardium, diaphragm, and stomach have all been used successfully; the choice depends on location and available tissue. Successful repair can still be achieved more than 48 h after perforation with a buttress of viable tissue as long as the esophagus was normal prior to perforation and there is no distal obstruction (Gouge et al. 1989). Proximal and distal tube decompression is a useful adjunct but not a substitute for an adequate repair.

When the esophagus is abnormal, resection is the best treatment. The resection can be done by a cervical approach combined with an abdominal and transhiatal or by a transthoracic approach. Primary anastomosis is unwise in this setting, and even cervical anastomoses should be used very selectively.

The most effective proximal esophageal diversion is total thoracic esophagectomy with end-cervical esophagostomy.

The esophagogastric junction should be closed, the stomach decompressed with a gastrostomy, and a jejunostomy inserted. Reconstruction with stomach or colon can follow at an appropriate interval. In the special case of perforation following balloon dilation for achalasia, a complete myotomy of the distal sphincter must be done along with the buttressed repair.

Esophageal Perforation at Various Anatomic Levels

Cervical Esophagus

The cervical esophagus may be perforated during endoscopy, during endotracheal intubation, by swallowing a foreign body, or by external trauma. Although endoscopic perforations of the pharynx can almost all be managed with antibiotics and usually do not need surgical drainage, cervical perforations below the cricopharyngeal sphincter are a much more serious matter. An esophageal perforation in this location may be several centimeters long, and prompt surgical exploration should be the rule. Exploration of the cervical esophagus is a simple procedure, and adequate drainage prevents spread of the contamination into the thoracic mediastinum. All patients who are febrile or have tenderness or swelling in the neck should undergo exploration and drainage of the retropharyngeal space. All cervical esophageal perforations should be repaired. Repair of pharyngeal perforations is usually neither feasible nor necessary.

Thoracic Esophagus

Perforation During Instrumentation: Dilator or Endoscope

Pain, crepitation, fever, leukocytosis, mediastinal emphysema, and pneumothorax or hydropneumothorax are evidence of esophageal perforation following instrumentation as under other circumstances, but these findings develop gradually over 12–24 h. When selecting the proper treatment for a patient with an iatrogenic perforation diagnosed within a few hours of the event, remember that the patient may look quite well during the first few hours only to collapse hours later with fulminant mediastinitis. Water-soluble contrast can define the presence and location of a perforation in almost most all cases, but the study cannot accurately define the size of the perforation or the extent of spread of contamination in the mediastinum. If the signs and symptoms suggest a perforation but the contrast study is negative, a follow-up study with computed tomography or repeat esophagram with high density barium should be used to confirm the absence of perforation. Flexible endoscopy has only a limited role. Although intact esophageal mucosa excludes perforation, if a perforation is present, insufflation can lead to tension pneumothorax. For that reason, flexible endoscopy should be used only after decompressive tube thoracostomy or negative contrast studies.

All patients with instrumental perforation should be treated by exploration and drainage. Closed tube thoracostomy is ineffective as definitive therapy. Buttressed repair or resection should be done depending on the esophageal pathology. Obstruction of the esophagus must be relieved if treatment is to be successful.

Barotrauma: Boerhaave's Syndrome and External Pressure

Postemetic perforations of the thoracic esophagus (Boerhaave's syndrome) are dangerous because they occur in a patient with a full stomach. Vomiting against a closed glottis floods the mediastinum with food, microbes, and digestive secretions. Rapidly developing, fulminant mediastinitis is the result and patients often present late for medical care. Diagnosis is often further delayed because esophageal perforation is not considered in the differential after the patient presents to the emergency department. Mediastinal emphysema on the chest radiograph is diagnostic and should lead to a water-soluble contrast study to confirm the diagnosis and location of the perforation even though the site of perforation is almost always in the distal esophagus and typically ruptures into the left pleura. In the absence of penetrating trauma, hydropneumothorax is diagnostic of esophageal perforation. With a blast injury from external pressure, the perforation may be anywhere in the esophagus.

After resuscitation, chest decompression, and control of the airway, thoracotomy for decortication, repair of the esophagus with a parietal pleural flap, and adequate drainage are almost always successful even if the delay to operation is more than 24 h. Although primary closure without leak is not achieved in every case, the fistula can be well controlled by the flap and drainage. Spontaneous closure usually occurs within weeks. After completion of the thoracic phase, a separate abdominal procedure (laparotomy or laparoscopy) to place a gastrostomy and jejunostomy should be done in all patients.

Anastomotic Leaks

Patients who develop a leak following a cervical anastomosis respond well to drainage as long as the interposition is viable. Although an anastomotic stricture may develop secondary to the leak, systemic or mediastinal sepsis is unusual and recovery is expected. These strictures usually respond to sequential dilations.

Anastomotic failure following intrathoracic anastomosis is a far more serious occurrence. Although most patients survive, their hospitalizations are usually long and complicated. Without prompt, adequate treatment, death from sepsis and organ failure is probable. I believe that virtually all anastomotic leaks result from technical errors at operation. They are present but not clinically apparent early when the defect could be corrected by reoperation. The best time to check for leakage is in the operating room. In addition to inspection of the anastomosis, insufflation through the nasogastric tube distends the stomach and reveals gross defects in a stapled or sutured anastomosis. In the past, we conducted studies at 5–7 days, if at all, before allowing oral intake. I have been doing contrast studies on the first postoperative day if the patient is able to swallow and to safely go to the radiology suite. The study is done first with a small amount of water-soluble contrast and then with barium if the first part of the swallow shows no leak. If the study is normal, patients are allowed liquids immediately. If the study is equivocal, a CT scan is obtained to look for extraluminal contrast. If none is seen, I leave the chest tube in place to maintain the seal of the lung around the anastomosis and withhold oral intake until a repeat study is normal. Using this plan, we have seen very few leaks presenting late in the clinical course. If a leak is demonstrated very early, the patient can be returned to the operating room for repair with a viable tissue buttress and wide drainage before extensive tissue reaction and infection limit the chance of success. Even if the leak is not completely sealed, the resulting lateral fistula is well controlled and closes spontaneously. If a jejunostomy was not done at the original operation, it should be done at this time.

If a leak is recognized late, reoperation should be done as soon as the patient can be prepared for anesthesia. Debridement, decortication, and closure can be attempted if the defect is small; but the realistic goal is control of sepsis and creation of a controlled fistula. Endoscopically placed stents can be a very effective adjunct in these circumstances. Antibacterial and antifungal therapy is essential under these circumstances. Enteral feeding by jejunostomy is a necessary part of management.

Nonoperative treatment is a tenable plan only if strict criteria are met (Cameron et al. 1979). The leak must be an insignificant radiographic finding. It must be a small, localized sinus that drains completely back into the lumen and does not involve the pleural space. The presence of pneumothorax or significant effusion mandates exploration, as does any sign of systemic toxicity. Contrast-enhanced computed tomography is essential to confirm that the sinus is behaving like a diverticulum that will resolve by itself. Broad-spectrum antibiotics and parenteral or enteral nutrition should be used until healing is confirmed by a contrast study. Oral intake should await proof that no leak is present.

In the catastrophic situation of complete anastomotic dehiscence or necrosis of the interposition, the source of sepsis must be completely eliminated to avoid death from multiple organ failure. All nonviable tissue must be resected. Decortication and wide pleural drainage help the antibacterial and antifungal therapy clear the sepsis. The anastomosis should be resected and the esophagus exteriorized as an end esophagostomy. The stomach should be returned to the abdomen, closed, and drained with a gastrostomy. Reconstruction usually requires colon interposition and can be done at an appropriate time.

Occult perforation is a problem during esophageal surgery, especially with minimally invasive approaches. For this reason, testing for leaks should be done in the operating room and early postoperatively day in all patients who undergo resection, myotomy, and fundoplication.

Achalasia

Achalasia, an acquired disease of unknown etiology, is characterized by denervation pathology. The ganglion cells of the myenteric plexus are lost, and the patient develops a hypertonic, non-relaxing distal esophageal sphincter with an aperistaltic body of the esophagus. The esophagus progressively dilates and then elongates. In the long term, patients with achalasia have an increased risk of epidermoid carcinoma. Their nutrition is usually well preserved, and patients typically present with a long history of slow eating and dysphagia to liquids more than solids that is not progressive. All treatment modalities rely on ablation of the lower esophageal sphincter mechanism to allow more normal but passive emptying of the esophagus. In all cases, the striated muscle proximal to the esophagus retains its normal size and contraction. The methodologies available today include temporary paralysis of the muscle of the sphincter with botulinum toxin, disruption of the muscle by balloon dilation, and surgical myotomy. Botulinum injection has had a predictably transient effect. The only difference between surgical and balloon myotomy is that the modified Heller myotomy is more controlled and more effective than the balloon procedure. The availability of minimally invasive surgical approaches has largely rendered balloon myotomy irrelevant. Because of the possibility of perforation, all patients with balloon disruption of the sphincter should have surgical backup, and all should have follow-up contrast studies as soon as possible to exclude perforation.

All patients should be studied with radiography, manometry, and endoscopy to confirm the diagnosis and to exclude other causes of pseudoachalasia in even the most typical cases. When the diagnostic combination of an aperistaltic body of the esophagus with a non-relaxing distal sphincter is present, the surgeon must chose among the available surgical approaches. The sphincter can be approached to perform a myotomy from the left chest or from the abdomen. The surgeon may use either a minimally invasive or open technique with or without an antireflux fundoplication. The most important principle is to complete the division of the sphincter. Although a complete myotomy can be done by any of the approaches, only a myotomy done by an expert through a left thoracotomy can be done accurately enough to complete the myotomy and not have an unacceptable amount of reflux (Ellis et al. 1992). Approached by left thoracotomy, the pattern of vessels that mark the cephalad margin of the stomach can be identified as the lower limit of the sphincter and of the myotomy without disrupting the anatomy of the cardia. This anatomic landmark cannot be visualized adequately by thoracoscopy or through the abdomen. To do so by any of the other approaches, the myotomy must be carried down well onto the stomach, and the operation must include a partial circumference fundoplication to minimize reflux. At present, a laparoscopic myotomy with anterior, partial fundoplication is the operation most acceptable to patients and physicians and most easily done by many surgeons. The integrity of the mucosa must be ensured in the operating room and should be confirmed by a contrast study within 24 h to identify incomplete myotomy and exclude perforation. Perforations can be repaired primarily when identified in the operating room or early postoperatively. The repair should always be buttressed with viable tissue as with any perforation. The stomach is readily available for this purpose.

The morbidity associated with laparotomy is little different than that seen with laparoscopy for myotomy and fundoplication. The surgeon must exercise good judgment when choosing the approach best suited to the individual patient. Extensive previous abdominal surgery may make a laparotomy or thoracic approach a better choice for such a patient. Reoperative surgery for achalasia can be challenging. For patients with failed operations for achalasia and for end-stage disease with sigmoidization of the esophagus, resection with gastric interposition and esophagogastrostomy in the neck or at the apex of the right thorax is an effective, durable option.

Other Motility Disorders

Diverse motility disorders of the esophagus—diffuse esophageal spasm, corkscrew esophagus, nutcracker esophagus, and others—have been described. They are poorly understood disorders of the body of the esophagus that do not affect the distal sphincter. The various diseases can be diagnosed and distinguished from achalasia and reflux by motility and pH studies. In the past, there has been enthusiasm for surgical procedures such as long myotomy of the body of the esophagus, but the results are mediocre at best. Although there may be a place for long myotomy in carefully selected patients who have failed medical therapy, almost all these patients should be treated pharmacologically.

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Esophagectomy: Right Thoracotomy and Laparotomy

14

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Carcinoma of the esophagus

Preoperative Preparation

Address any nutritional deficiencies.

Perform preoperative esophagoscopy and biopsy.

Use computed tomography (CT) and other staging studies, including preoperative bronchoscopy, to detect invasion of the tracheobronchial tree.

Improve oral and dental hygiene, if necessary.

Insist on smoking cessation.

Conduct pulmonary function studies.

Preoperative chemotherapy and radiation therapy is appropriate in selected cases.

Pass a nasogastric tube before operation.

Administer perioperative antibiotics.

Pitfalls and Danger Points

Hemorrhage from aorta

Perforation of trachea or bronchus

Anastomotic leak

Anastomotic stenosis

Inadvertent interruption of gastroepiploic arcade on greater curvature of the stomach

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Operative Strategy

The right chest allows access to the upper esophagus with resection of associated lymphatic tissue. The stomach must be fully mobilized during the abdominal phase of the operation. With care to preserve the arterial supply and venous drainage, the stomach can be extended as far as the cervical esophagus. Anastomosis in the neck allows the greatest margin of safety if anastomotic leakage occurs.

Critical errors such as attempting to resect a tumor that has invaded adjacent structures (aorta, bronchus, trachea) can be avoided by accurate preoperative staging. Anastomotic leakage and postoperative stenosis may be minimized by adopting several techniques. Maintain the blood supply to the stomach by meticulous attention to the gastroepiploic arcade. *The esophageal hiatus must be enlarged sufficiently to prevent any element of venous compression*, *as obstruction of the venous circulation is as detrimental as arterial ischemia*. The end-to-side esophagogastric anastomosis described here has markedly reduced the incidence of anastomotic leaks in our experience (see Chap. 15).

Because the submucosal spread of esophageal carcinoma has been observed by microscopy to extend a considerable distance cephalad from the visible carcinoma, remove a 10-cm margin of apparently normal esophagus with the specimen. Check the upper limit of the specimen by frozen section examination. Ease of access to the proximal esophagus is one of the major advantages of this operative approach.

Documentation Basics

Coding for esophageal procedures is complex. Consult the most recent edition of the AMA's Current Procedural Terminology book for details (see references at the end). In general, it is important to document:

†Deceased

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DOI 10.1007/978-1-4614-1393-6_14, © Springer Science+Business Media New York 2014

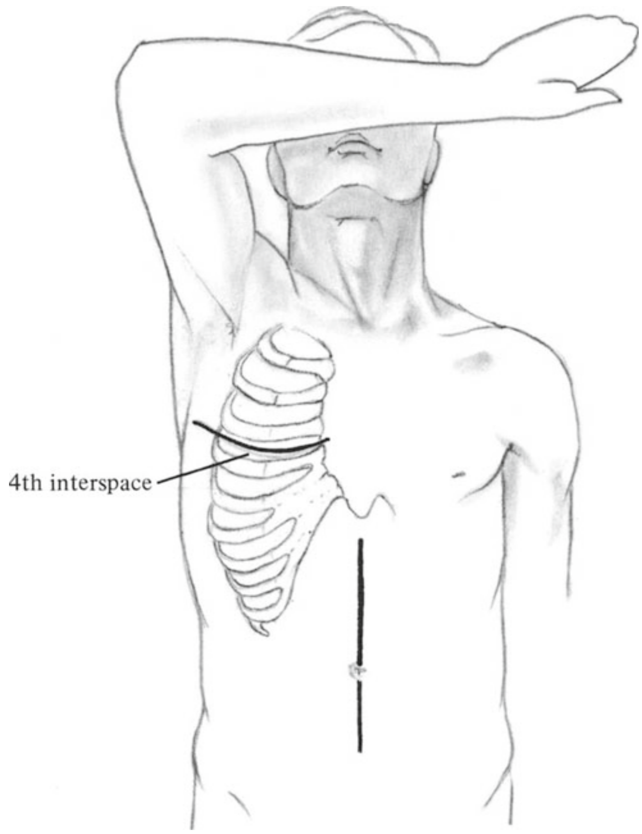

Fig. 14.1

- Findings
- Anastomosis in chest or in neck?
- Stapled or sewn?
- Pyloromyotomy or not?

Operative Technique

Incision and Position

Use a small sandbag to elevate the patient's right side 30°, with the right arm abducted and suspended from the "ether screen" cephalad to the surgical field. Turn the patient's head to the left in case the right cervical region has to be exposed for the esophagogastric anastomosis. Prepare the right neck, right hemithorax, and abdomen. Rotate the operating table slightly so the abdomen is parallel with the floor. After induction of one-lung endotracheal anesthesia, perform a midline upper abdominal incision for preliminary exploration of the liver and lower esophagus to help determine if resection should be attempted.

Then, in men, make an incision along the course of the fourth intercostal space from the sternum to the posterior axillary line (Fig. 14.1). In women, make the skin incision in the inframammary fold. Incise the pectoral and anterior serratus muscles with electrocautery along the fourth interspace (Figs. 14.2 and 14.3). Similarly incise the intercostal muscles along the upper border of the fifth rib. Identify the internal

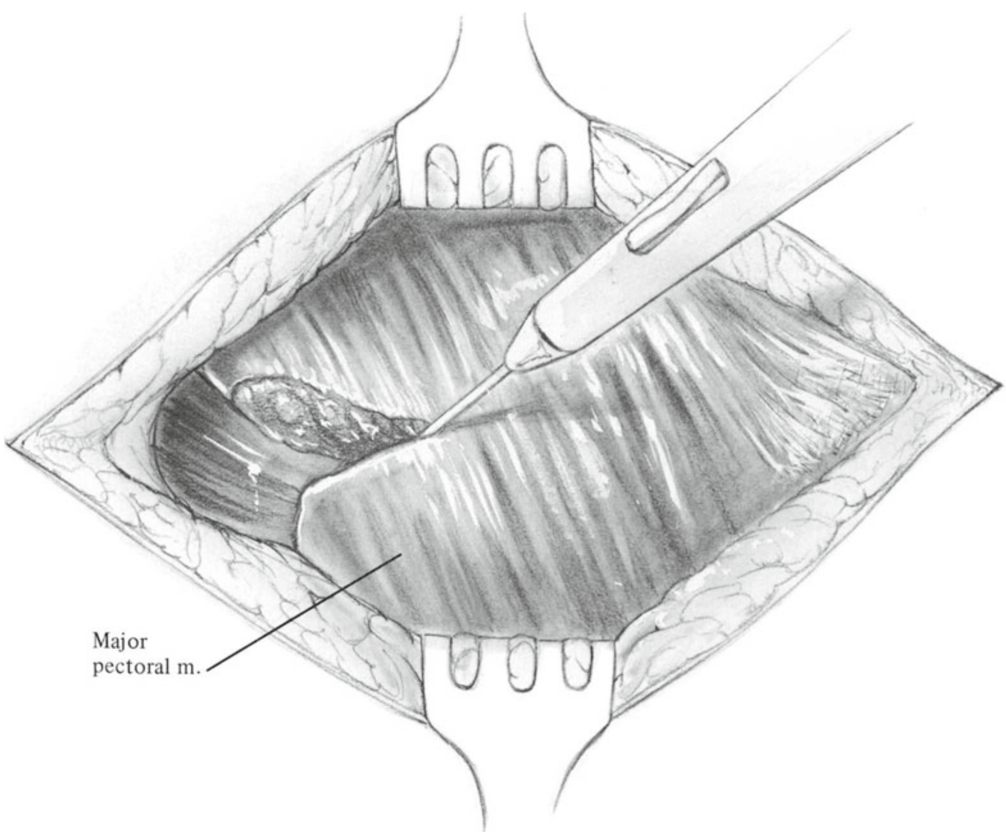

Fig. 14.2

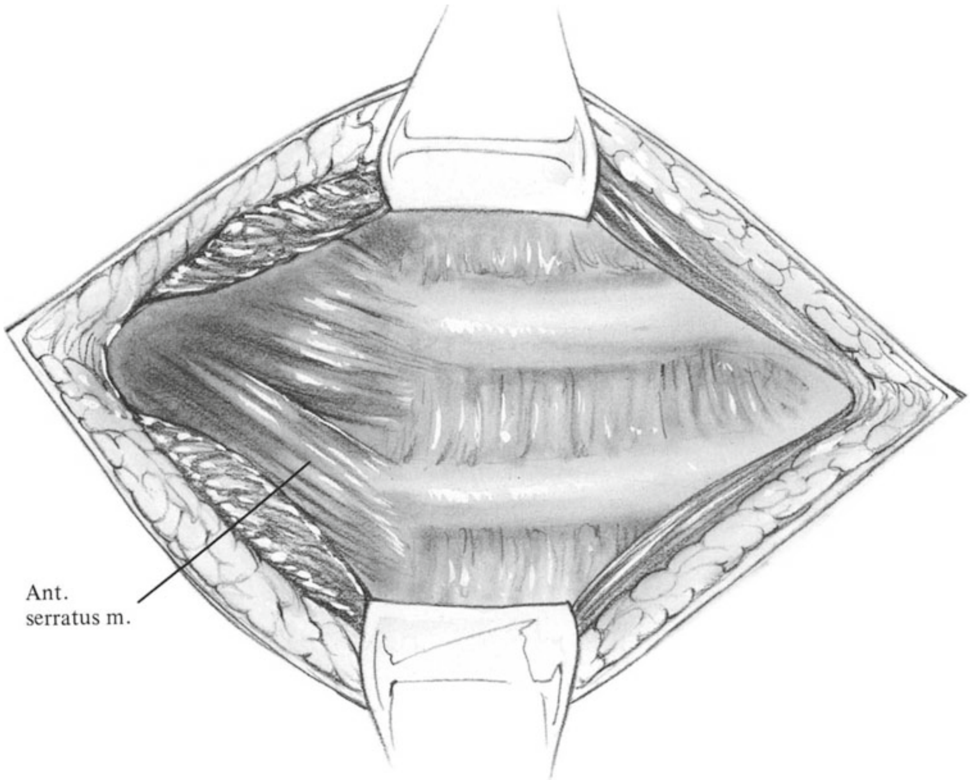

Fig. 14.3

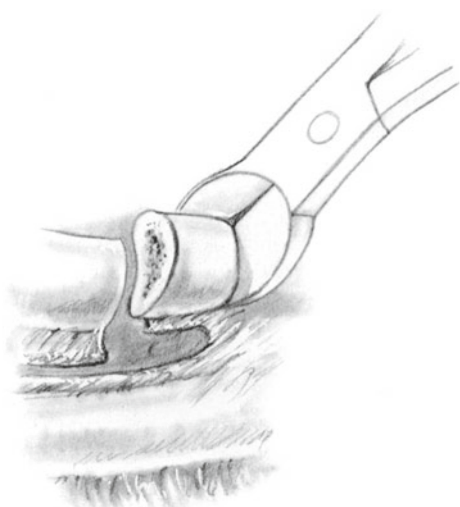

Fig. 14.4

mammary artery near the sternal margin, doubly ligate it, and divide it. Enter the pleura of the fourth intercostal space and then divide the cartilaginous portion of the fourth rib near its articulation with the sternum (Fig. 14.4). Clamp the neurovascular bundle, divide it, and ligate with 2-0 silk (Fig. 14.5).

Insert a Finochietto retractor over gauze pads and separate the ribs. If an additional costal cartilage requires division for adequate exposure, do not hesitate to perform this maneuver. Retract the lung anteriorly, cover it with gauze pads, and hold it with Harrington retractors.

Some surgeons prefer a posterolateral thoracotomy incision from the region of the paraspinal muscles to the sternum through the fourth or fifth interspace, but we have found the above exposure to be satisfactory. Using the anterior incision permits placing the patient in a position that is convenient for operating in the abdomen, the thorax, and even the neck, as necessary.

Mobilization of Esophagus

Make an incision in the mediastinal pleura, exposing the esophagus. Identify the azygous vein. Skeletonize, divide, and ligate it with 2-0 silk (Fig. 14.6). Encircle the esophagus with the index finger at a point away from the tumor. The dissection reveals several small arterial branches to the esophagus. Divide each branch between hemostatic clips. Wherever the pericardium or pleura is adherent to the tumor, excise patches of these structures and leave them attached to the specimen. Include adjacent mediastinal lymph nodes in the specimen. Dissect the esophagus from the apex of the chest to the diaphragmatic hiatus; this maneuver requires division of the proximal vagal trunks. To minimize spillage of tumor cells, ligate the lumen of the esophagus proximal and distal to the tumor, utilizing narrow umbilical tapes or a 55-mm linear surgical stapler.

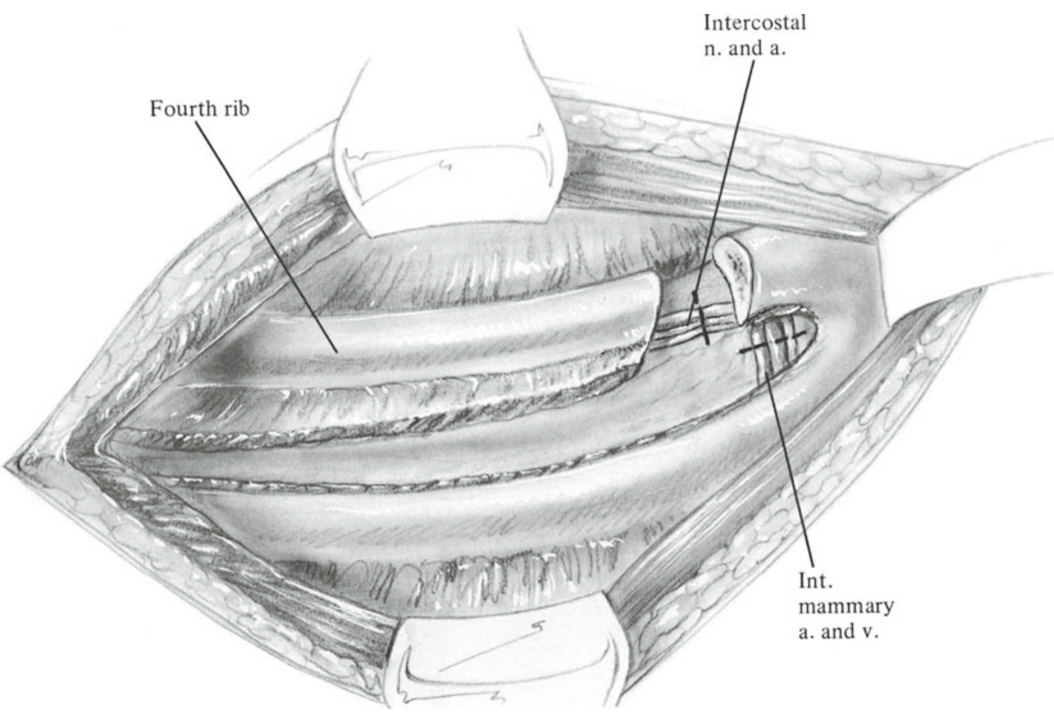

Fig. 14.5

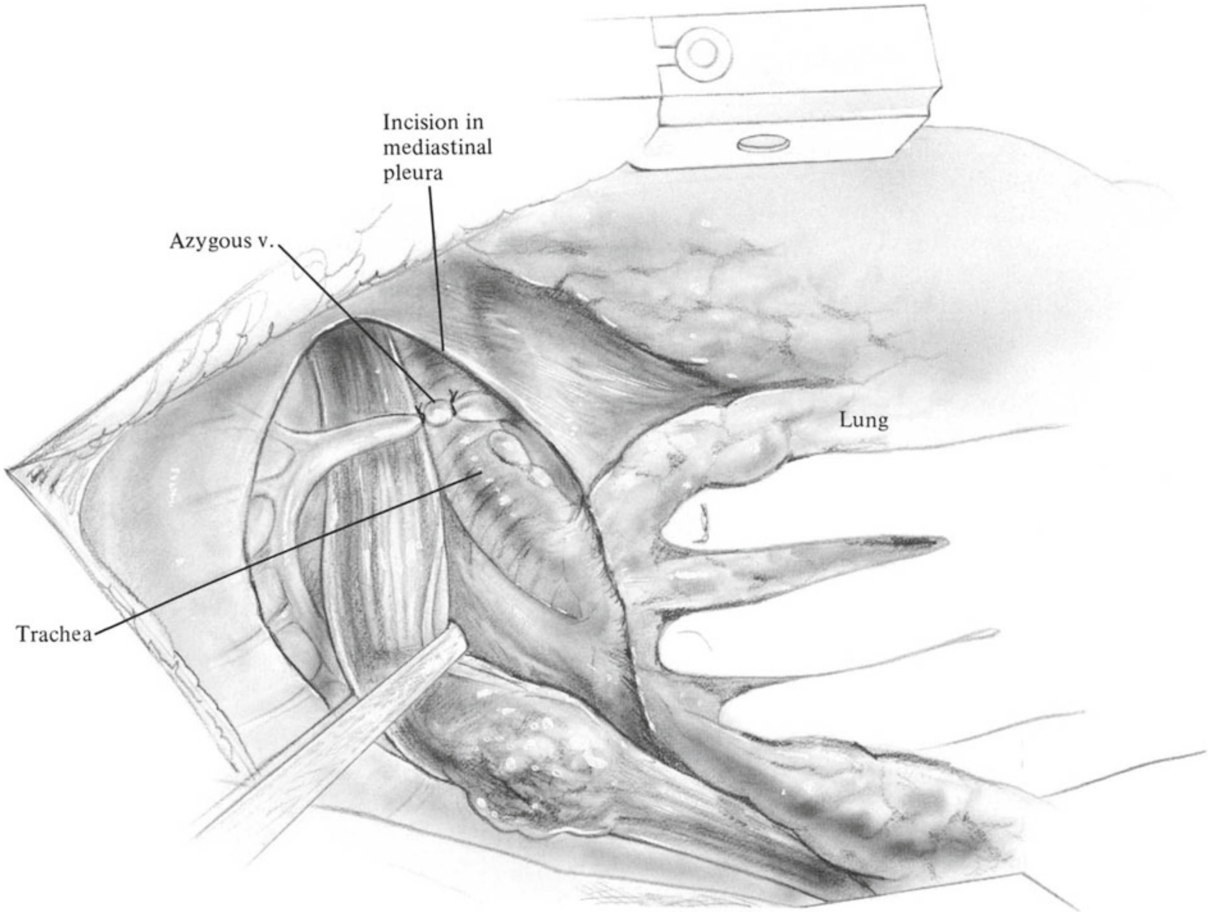

Fig. 14.6

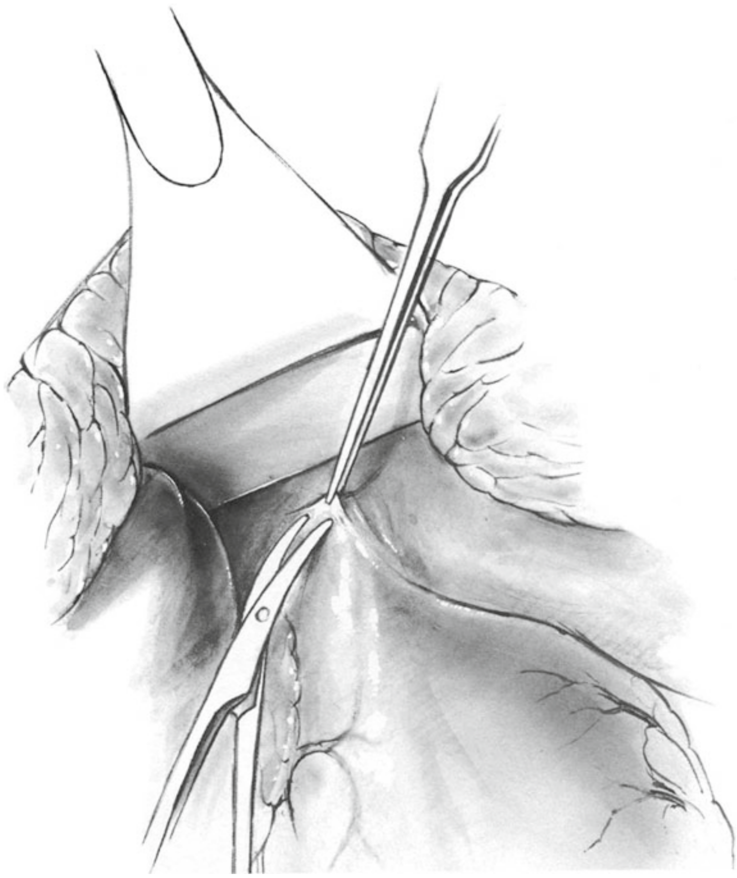

Fig. 14.7

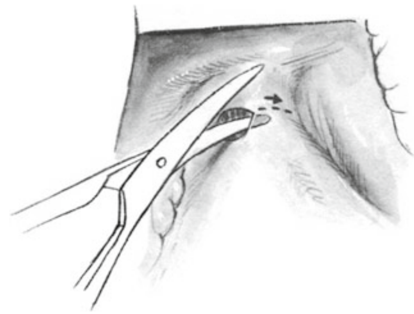

Fig. 14.8

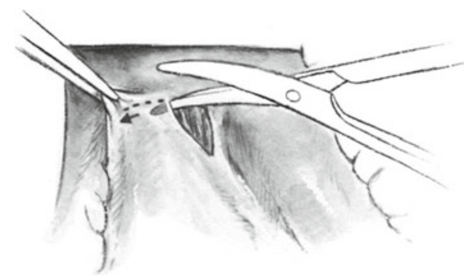

Fig. 14.9

Remove the Harrington retractors and gauze pads, permitting the right lung to expand. Cover the thoracic incision with a sterile towel.

Mobilization of Stomach

Expose the abdominal incision. Use a Thompson retractor to elevate the sternum. Elevate the left lobe of the liver in a cephalad direction with the Weinberg blade of the Thompson retractor and incise the peritoneum overlying the abdominal esophagus. Circumferentially mobilize the lower esophagus. Transect the vagal trunks and surrounding phrenoesophageal ligaments (Figs. 14.7, 14.8, and 14.9). The cephalad portion of the gastrohepatic ligament, generally containing an accessory left hepatic artery, should be doubly clamped, divided, and ligated with 2-0 silk or hemoclips (Fig. 14.10). Insert the left hand behind the esophagus and cardia of the stomach, elevate the gastrophrenic ligaments on the index finger, and transect them (Fig. 14.11). This dissection leads to the cephalad short gastric vessel; divide it between clamps and ligate it, along with the remaining short gastric vessels. The spleen need not be removed.

Divide and ligate the *left* gastroepiploic artery, but perform the remainder of the dissection *outside the gastroepiploic arcade*, *which must be kept intact and free of trauma*. This is accomplished by dividing the greater omentum serially between Kelly clamps, leaving 3–5 cm of omentum attached to the arcade as a margin of safety. Discontinue this dissection 6–8 cm proximal to the pylorus (Fig. 14.12).

With the greater curvature of the stomach elevated, use palpation to identify the origin of the left gastric artery at the celiac axis. The coronary vein is situated just caudal to the artery. Clear it and encircle it with a Mixter clamp. Then divide it between 2-0 silk ligatures. Skeletonize the left gastric artery (Fig. 14.13) so two 2-0 ligatures can be placed on the proximal portion of the artery and one on the specimen side. Transect the vessel and follow with an extensive Kocher maneuver.

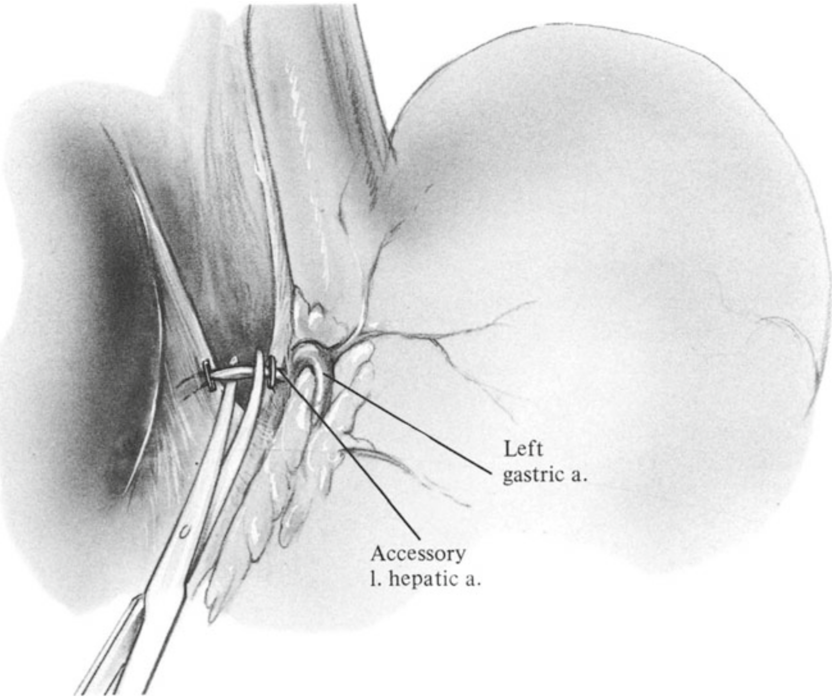

Fig. 14.10

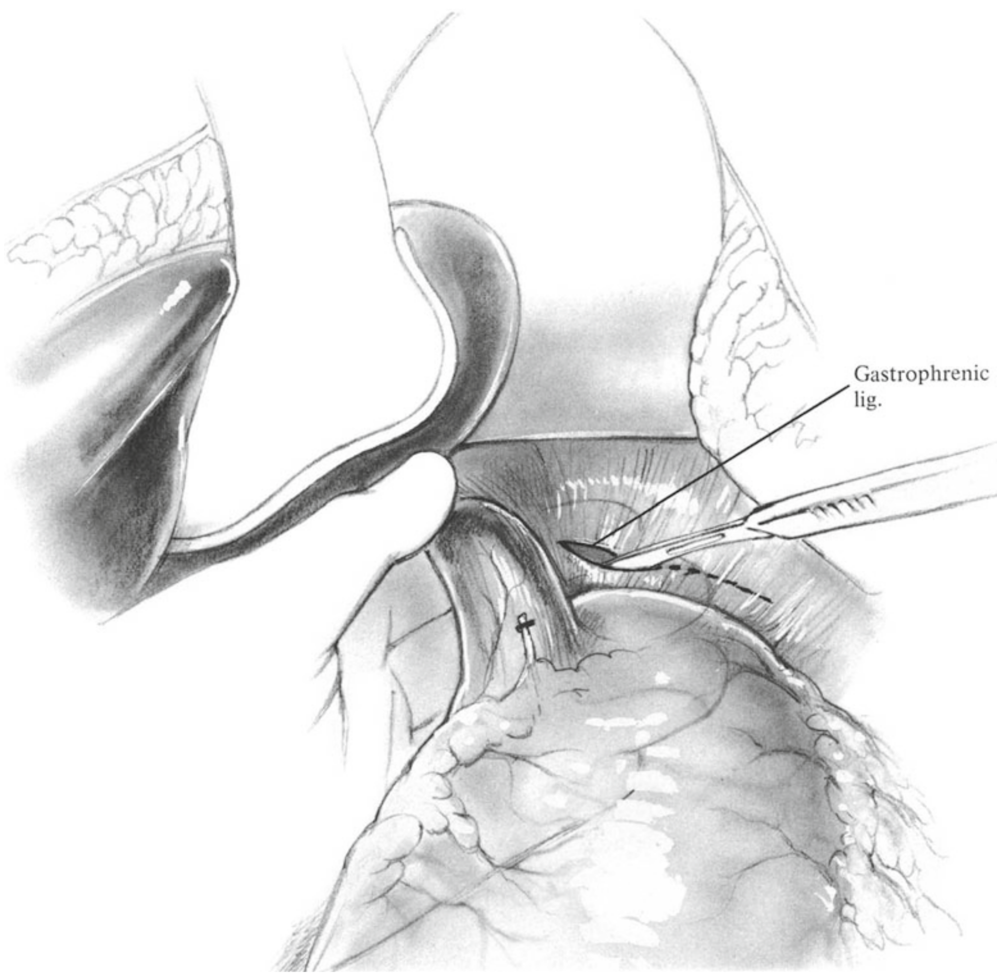

Fig. 14.11

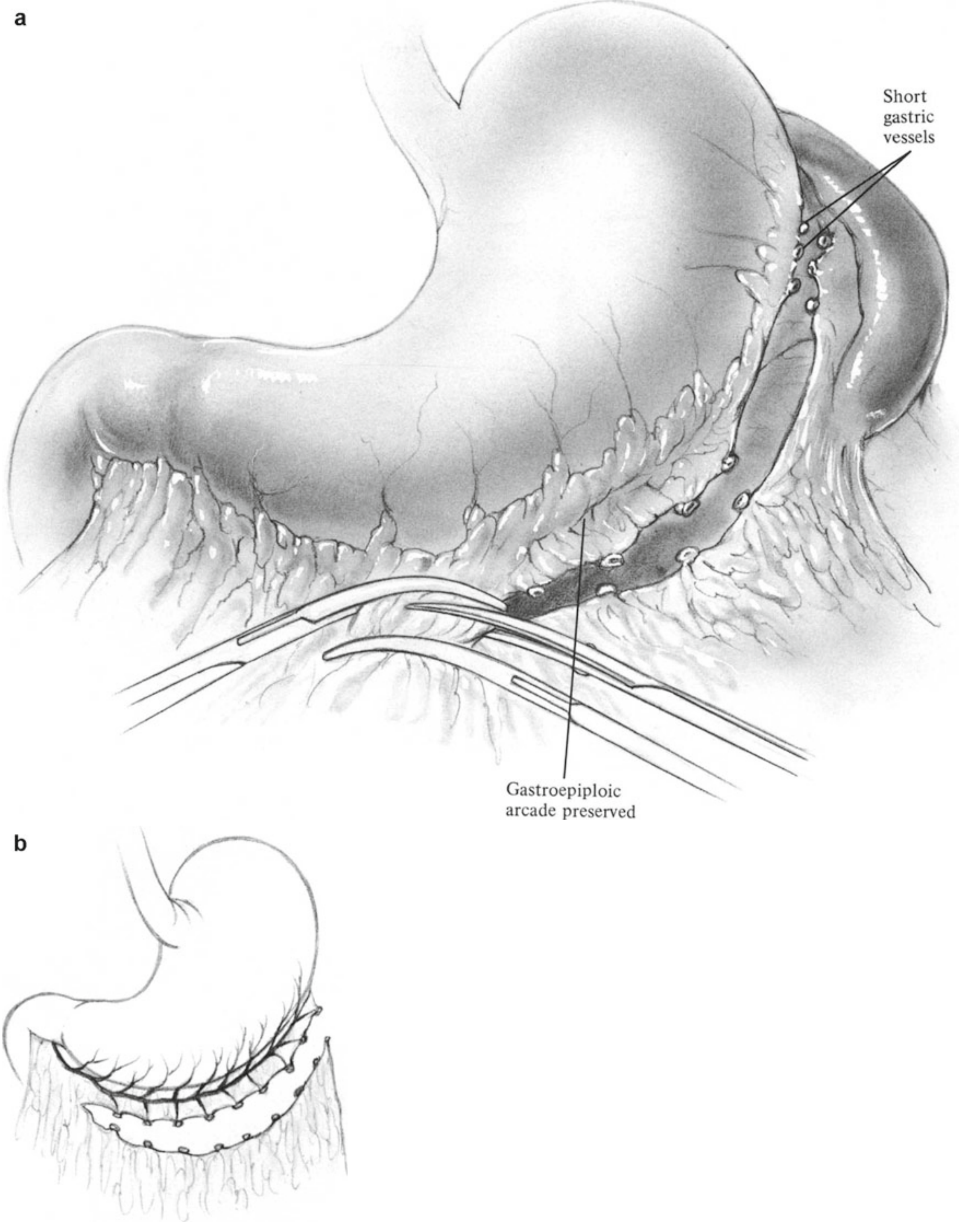

Fig. 14.12

Kocher Maneuver

Make an incision in the peritoneum lateral to the proximal duodenum (Fig. 14.14). Insert the left index finger behind the peritoneum and compress this tissue between fingertip and thumb, pushing retroperitoneal blood vessels and fat away. Incise the peritoneum on the index finger with scissors until the third portion of the duodenum is reached. Note that dividing the peritoneum alone is not sufficient to release the duodenum from its posterior attachments. There remains a ligamentous structure connecting the posterior duodenum to the region of Gerota's fascia. This ligamentous structure is

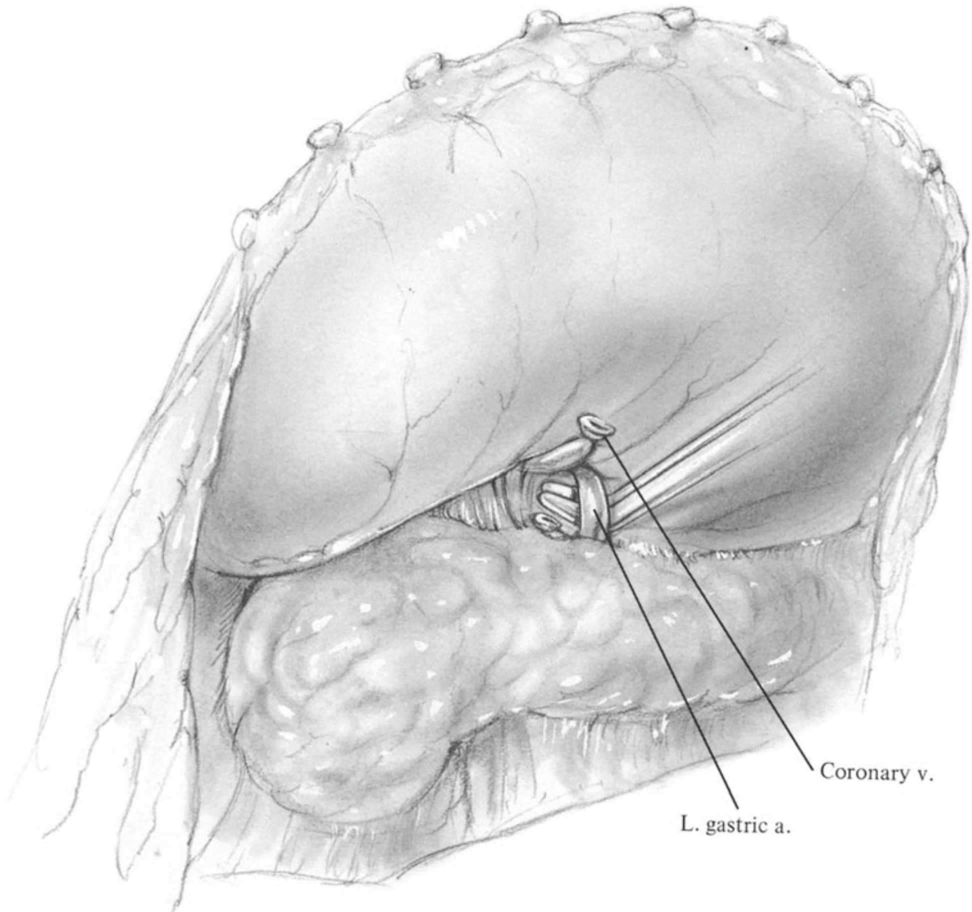

Fig. 14.13

Fig. 14.14

easily delineated by inserting the left index finger behind the pancreas. Move the finger laterally, exposing a lateral duodenal "ligament" behind the descending duodenum. Again, pinch the tissue between fingertip and thumb, which leaves vascular and fatty tissue behind, allowing this ligamentous structure to be divided. Incise it with Metzenbaum scissors (Fig. 14.15). Repeat this maneuver, going around the second and third portions of duodenum (behind the hepatic flexure); this leads to the point at which the superior mesenteric vein crosses over the duodenum. *Be careful*, as excessive traction with the index finger may tear this vessel.

For esophagogastric resection, the Kocher maneuver need not be continued much beyond the junction of the second and third portions of the duodenum. At this point the left hand is easily passed behind the head of the pancreas, which should

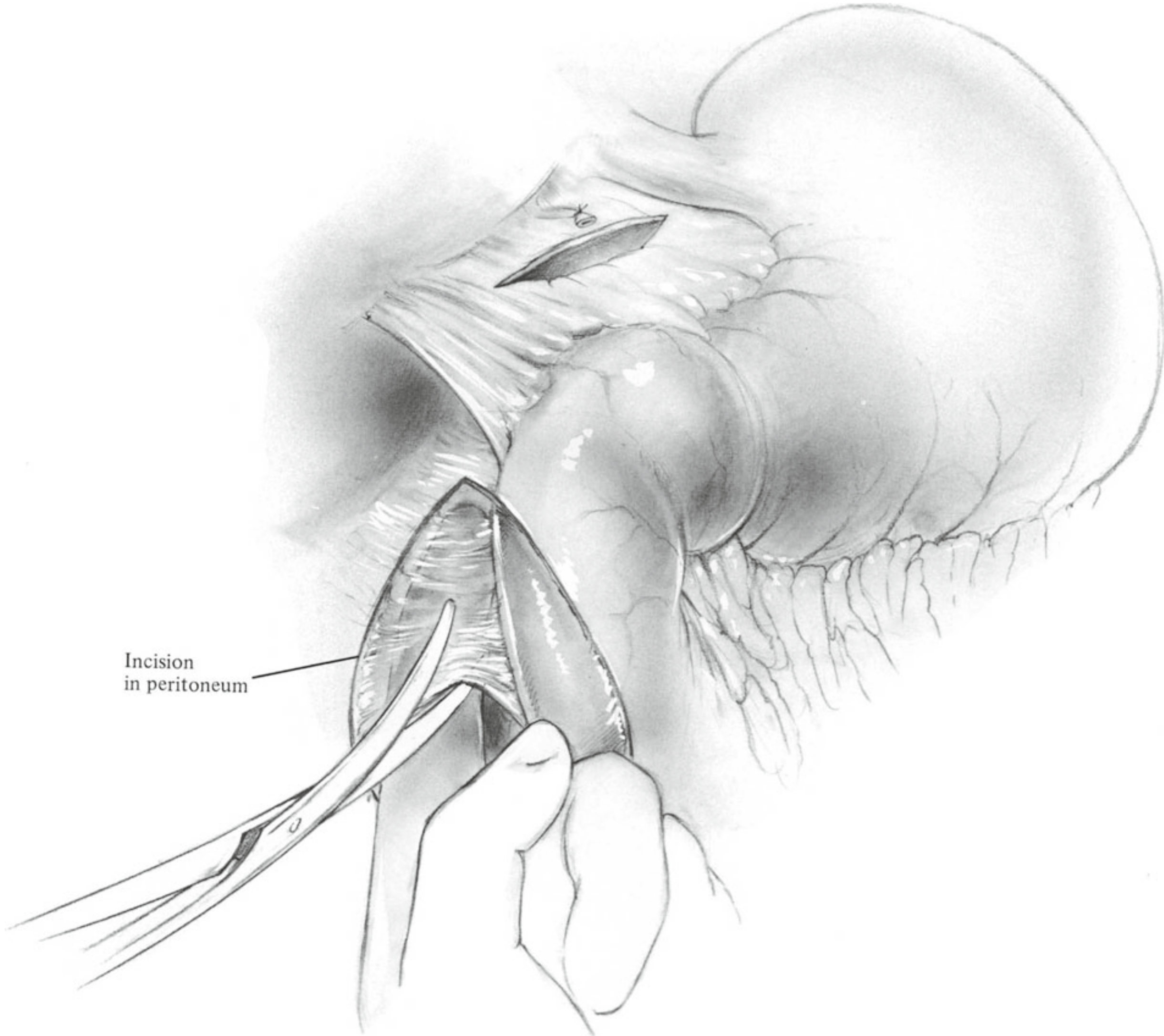

Fig. 14.15

be elevated from the renal capsule, vena cava, and aorta (Fig. 14.16). This permits the pyloroduodenal segment to be placed high in the abdomen, 8–10 cm from the esophageal hiatus, which in turn permits the gastric fundus to reach the thoracic apex, or neck, without tension.

Pyloromyotomy

Although in 80 % of patients' satisfactory results may be obtained without it, pyloromyotomy is generally performed at this point to prevent secondary operations for excessive gastric stasis due to vagotomy. Pyloromyotomy is accomplished by making a 1.5- to 2.0-cm incision across the anterior surface of the pyloric sphincter muscle (Figs. 14.17, 14.18, and 14.19). This maneuver is more difficult in an adult (who has only the normal thickness of muscle) than in an infant who suffers hypertrophic pyloric stenosis. Frequently, sharp dissection with a no. 15 scalpel blade must be done through most of the circular muscle. Separate the muscle fibers with a hemostat until the mucosa bulges out. This procedure may be expedited by invaginating the anterior gastric

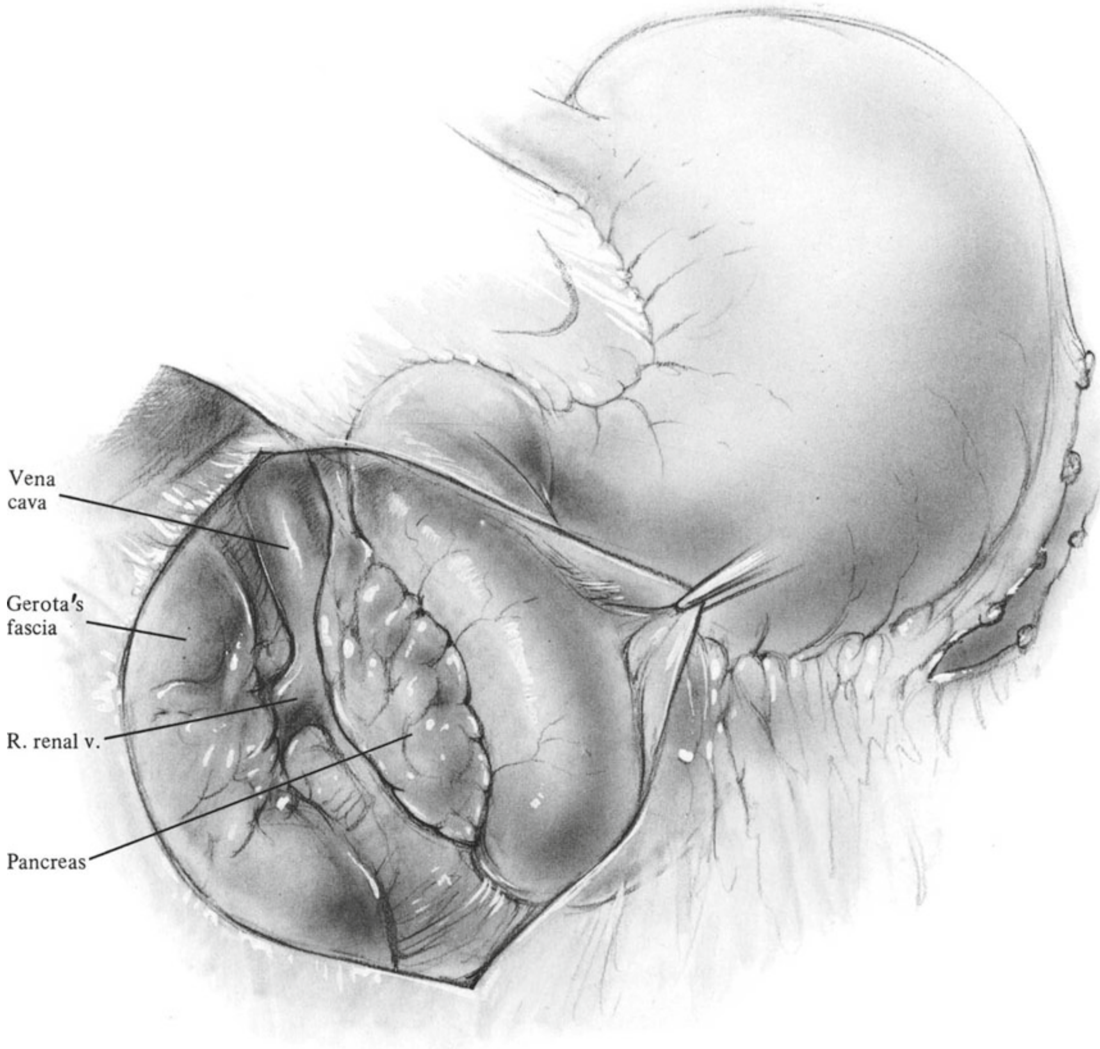

Fig. 14.16

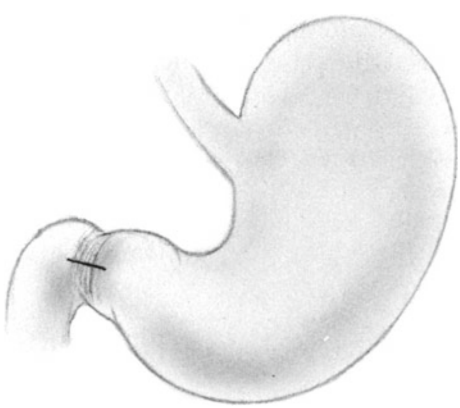

Fig. 14.17

wall into the pyloric sphincter with the index finger to divide the few remaining circular muscle fibers. Exercise care not to perforate the mucosa, which is prone to such injury at the duodenal end of the incision.

Advancement of Stomach into Right Chest

Divide the right crux of the diaphragm transversely using electrocautery (Fig. 14.20) and further dilate the esophageal hiatus manually. Advance the stomach into the right hemithorax, which should again be exposed by expanding the Finochietto retractor. There must be *no constriction of the veins* in the vascular pedicle of the stomach at the hiatus.

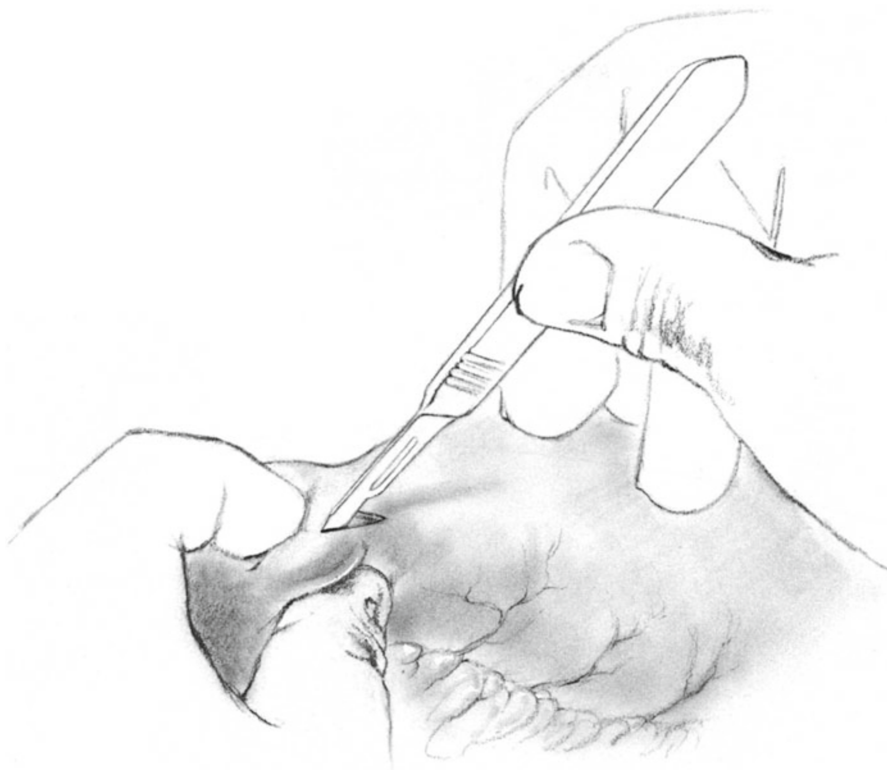

Fig. 14.18

Fig. 14.19

Suture the wall of stomach to the margins of the hiatus by means of interrupted 3-0 silk or Tevdek sutures spaced 2 cm apart to avoid postoperative herniation of bowel into the chest.

With the right lung collapsed, expose the esophagogastric junction in the right chest. When the esophageal carcinoma is located in the middle or upper esophagus, it is not necessary to remove the lesser curvature of the stomach and the celiac lymph nodes.

After clearing the areolar tissue and the fat pad from the region of the esophagocardiac junction, apply a 55-/4.8-mm linear stapler to the gastric side of this junction and fire the staples. Apply an Allen clamp to the esophagus, which should be transected flush with the stapler. Place a rubber glove over the divided esophagus and fix it in place with a narrow tape ligature. Lightly electrocoagulate the everted gastric mucosa and remove the stapling device (Fig. 14.21). It is not necessary to invert this stapled closure with a layer of sutures. The fundus of the stomach should now reach the apex of the thorax without tension. Take care to avoid twisting the stomach and its vascular pedicle.

Esophagogastric Anastomosis

Select a point on the proximal esophagus 10 cm above the tumor for the anastomosis. Before removing the specimen, insert the posterior layer of sutures to attach the posterior esophagus to the anterior seromuscular layer of the stomach at a point 6–7 cm from the cephalad end of the fundus

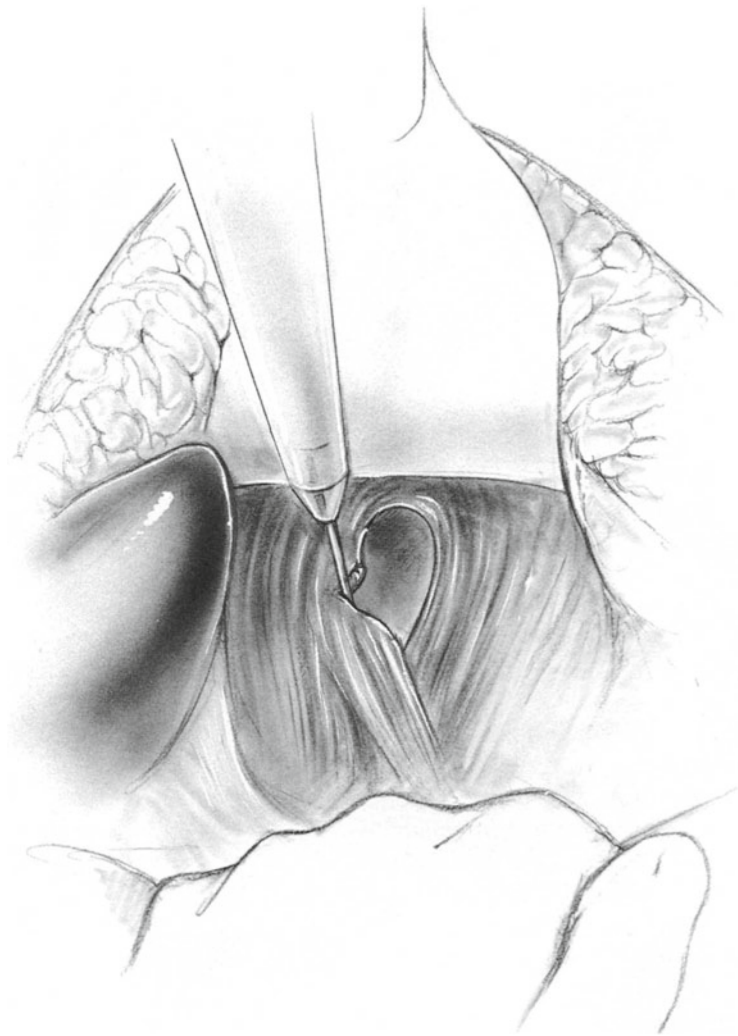

Fig. 14.20

(Fig. 14.22). The posterior layer should consist of about five interrupted atraumatic 4-0 silk Cushing sutures. Each bite should be 5 mm in width and deep enough to catch submucosa. The Stratte needle holder (see Fig. 11.16) may facilitate suture placement.

Transect the posterior wall of the esophagus with a scalpel at a point 6 mm beyond the first line of sutures. One can be certain that the esophageal mucosa has been transected when the nasogastric tube appears in the esophageal lumen. Now make a transverse incision in the stomach and control the bleeding points. This incision should be slightly longer than the diameter of the esophagus (Fig. 14.22).

Approximate the posterior mucosal layer by means of interrupted or continuous 5-0 atraumatic PG sutures, with the knots tied inside the lumen (Fig. 14.23). Then pass the nasogastric tube from the proximal esophagus through the anastomosis into the stomach.

Detach the specimen by dividing the anterior wall of the esophagus with scissors in such fashion as to leave the anterior wall of the esophagus 1 cm longer than the posterior wall (Fig. 14.24). This maneuver enlarges the stoma if the incision in the stomach is large enough to match that of the elliptical esophageal lumen.

Execute the anterior mucosal layer by means of interrupted sutures of 5-0 PG, with the knots tied inside the lumen thus inverting the mucosa (Fig. 14.25). Accomplish the second anterior layer by means of interrupted Cushing sutures of 4-0 silk (Fig. 14.26). Tie these sutures gently to approximate but not strangulate the tissue.

At this point some surgeons perform a Nissen fundoplication, which can be done if there is enough loose gastric wall to permit a wraparound without constricting the esophagus. Otherwise, a partial fundoplication may be accomplished by inserting several sutures between the outer walls of the esophagus and adjacent stomach. We have observed that even if fundoplication is not performed, few patients develop reflux esophagitis following this operation so long as end-to-side esophagogastric anastomosis has been accomplished 6 cm or more below the cephalad margin of the gastric remnant.

Surgeons who lack wide experience with this anastomosis might find it wise to inflate the gastric pouch to test the anastomosis for leakage. A solution of methylene blue is injected into the nasogastric tube by the anesthesiologist for this purpose.

As a final, essential step in this operation, tension on the anastomosis is prevented by tacking the fundus of the stomach to the prevertebral fascia and mediastinal pleura at the apex of the thorax. Use interrupted sutures of 3-0 silk or Tevdek for this purpose (Fig. 14.26). These sutures must not penetrate the lumen of the stomach, lest a gastropleural fistula result.

As soon as the specimen has been removed, examine the proximal end of the esophagus by frozen section to see if there has been submucosal extension of the cancer. If the pathologist detects tumor cells in the esophageal margin, more esophagus should be resected.

Stapled Esophagogastric Anastomosis

Stapling techniques for this anastomosis are described in Chap. 15.

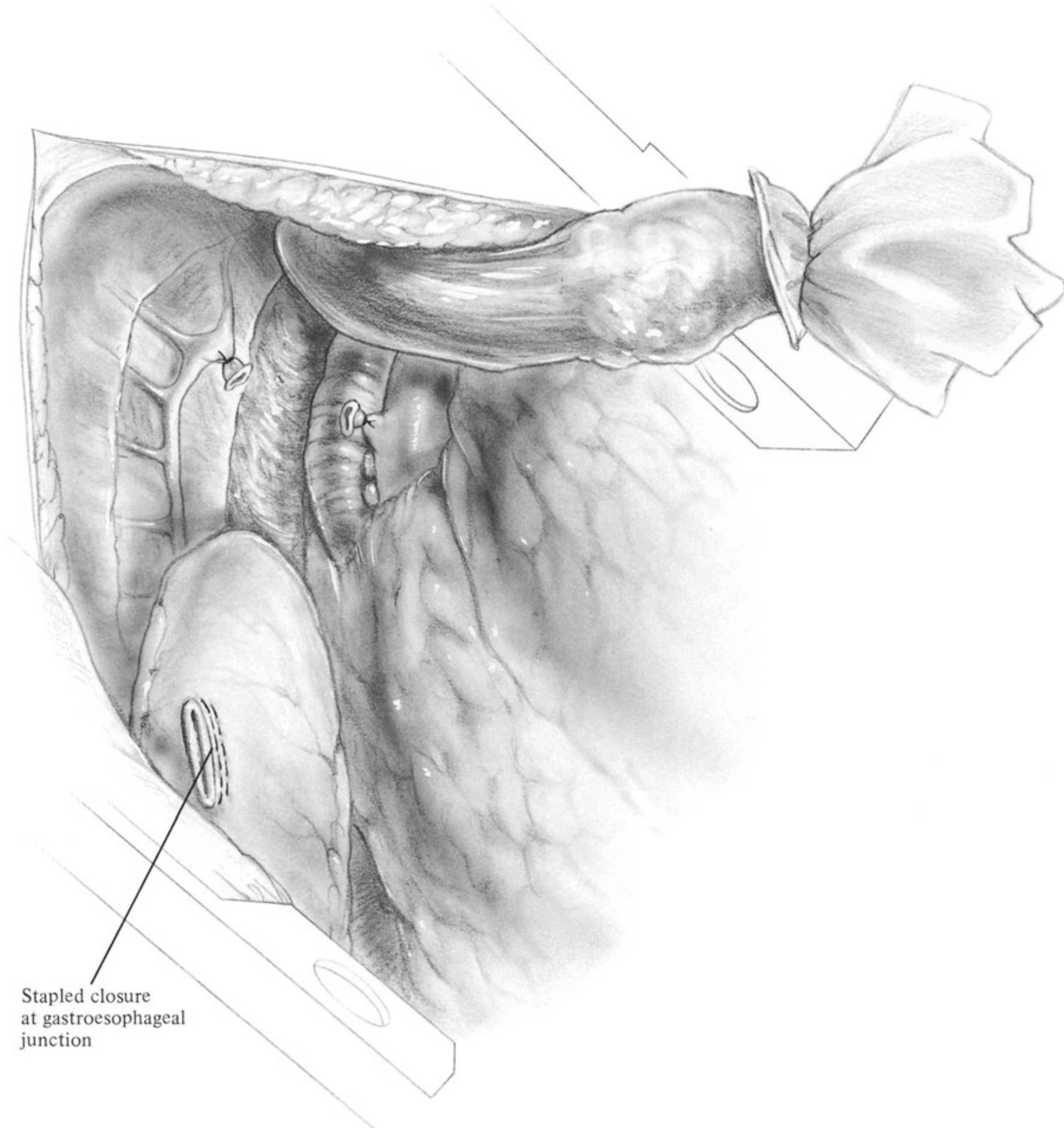

Fig. 14.21

Cervical Esophagogastric Anastomosis

When treating carcinoma of the mid-esophagus, it is often necessary to resect the entire thoracic esophagus to obtain a sufficient margin of normal tissue above the tumor. This requires esophagogastric reconstruction in the neck.

With the patient's head turned slightly to the left, make an oblique incision along the anterior border of the right sternomastoid muscle (Fig. 14.27). Carry the incision through the platysma. Identify (Fig. 14.28) and transect the omohyoid muscle. Retract the sternomastoid muscle and carotid sheath laterally and retract the prethyroid muscles medially, exposing the thyroid gland (Fig. 14.29). The middle thyroid vein, when present, should be doubly ligated and divided. Put traction on the areolar tissue between the gland and the carotid sheath by upward and medial displacement

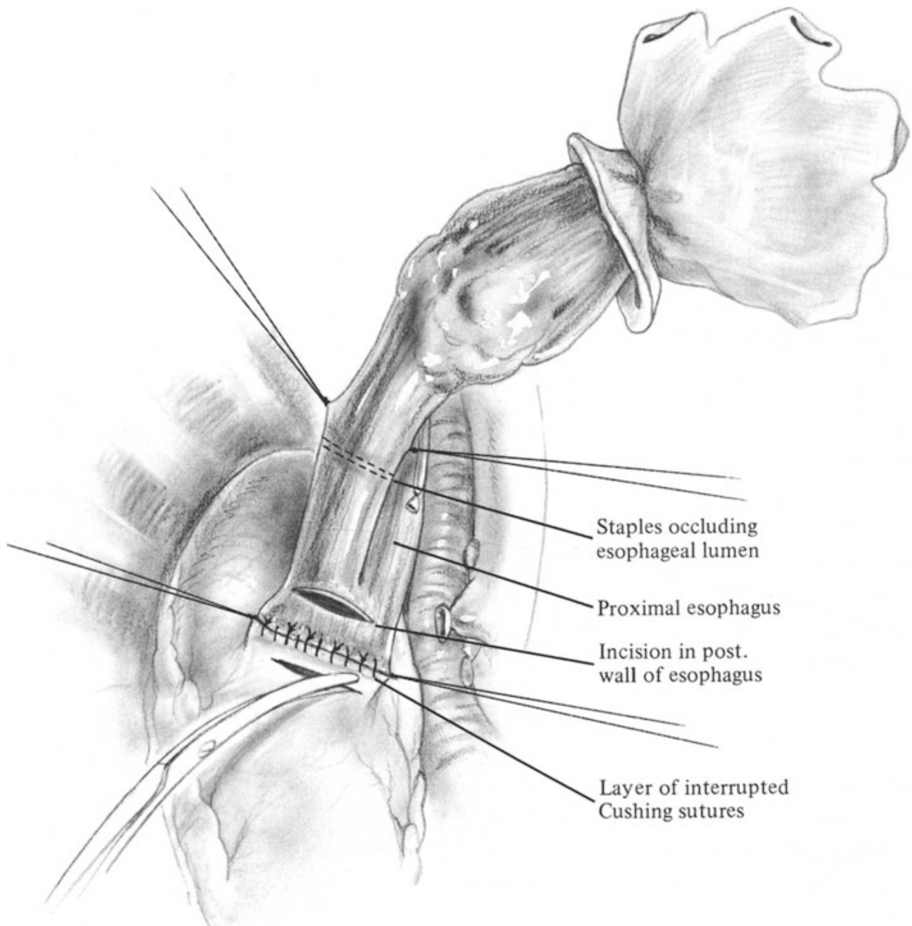

Fig. 14.22

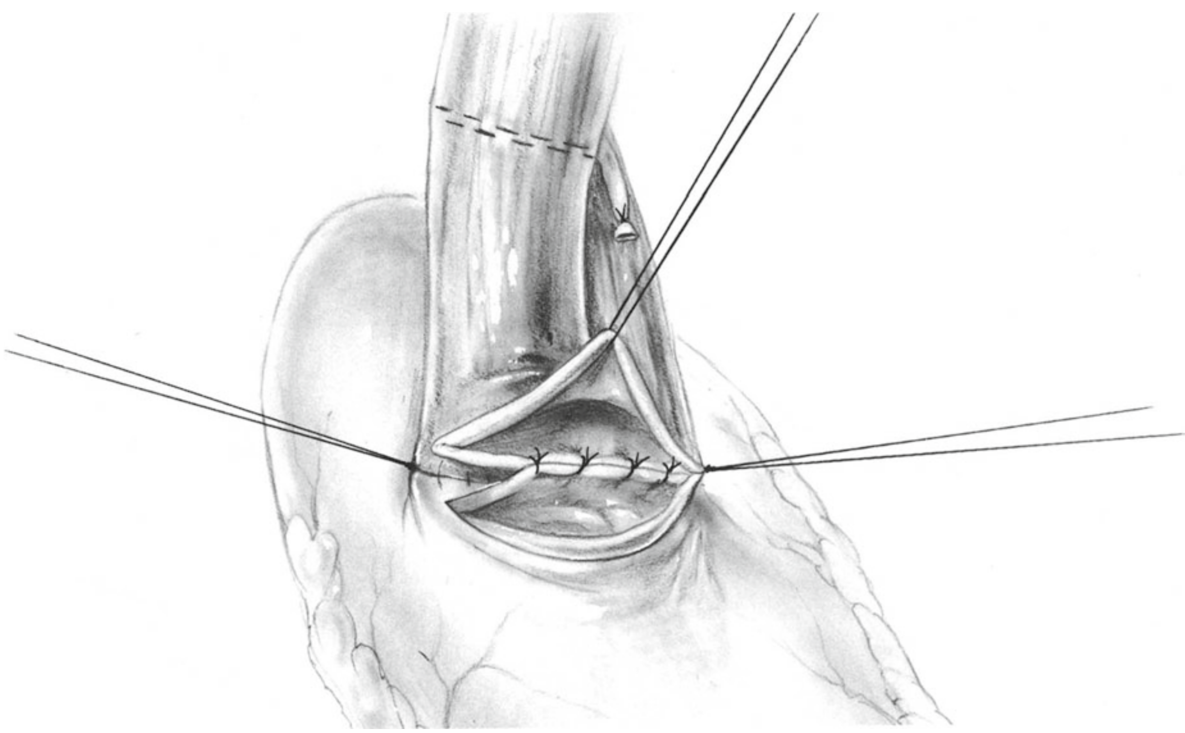

Fig. 14.23

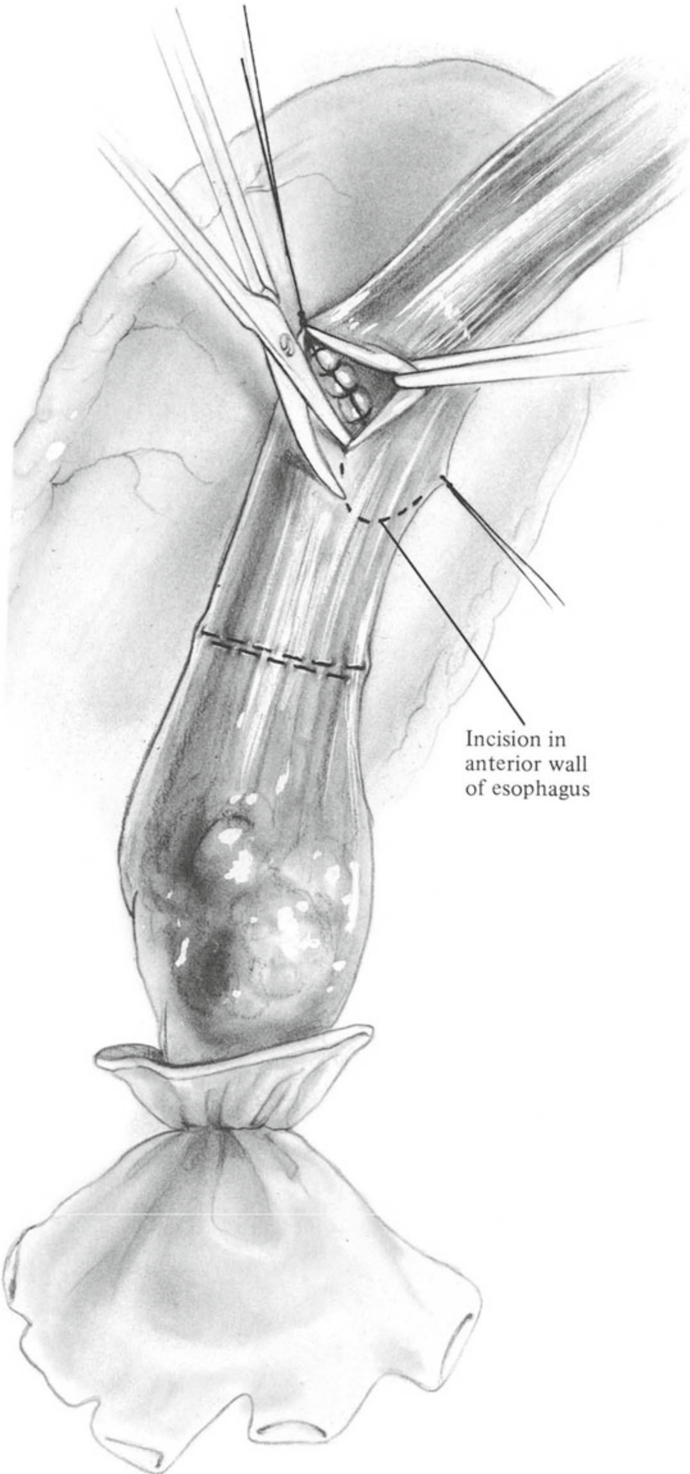

Fig. 14.24

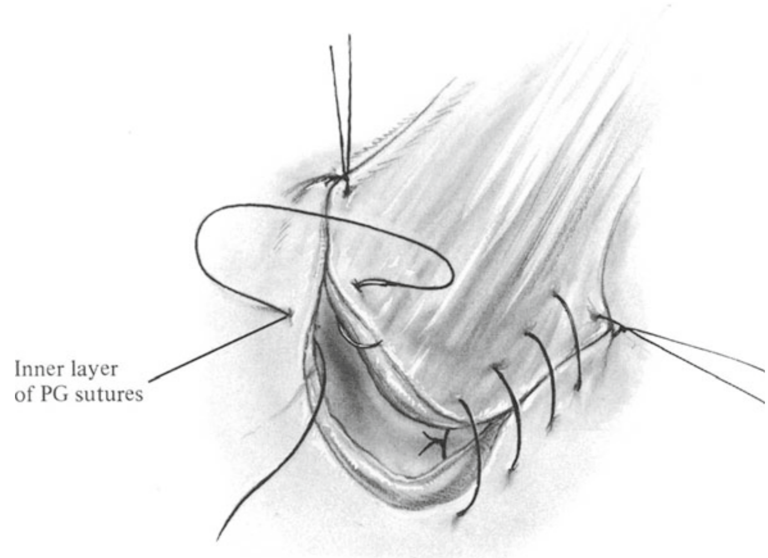

Fig. 14.25

of the thyroid. Excessive traction applied to the thyroid or larynx may injure the contralateral recurrent laryngeal nerve. Identify and skeletonize the inferior thyroid artery, which crosses the lower third of the surgical field in a transverse direction, by a Metzenbaum dissection toward the prevertebral fascia. Dissect it toward the thyroid gland until the recurrent laryngeal nerve can be seen. Then dissect the nerve upward to achieve thorough exposure, so it can be preserved (Fig. 14.29).

At this point the tracheoesophageal groove is seen, and the cervical esophagus can be encircled by the surgeon's index finger, which should be passed between the esophagus and the prevertebral fascia and then between the esophagus and trachea. The finger should stay close to the esophageal wall; otherwise the *left* recurrent laryngeal nerve may be avulsed during this dissection. Although the inferior thyroid artery generally must be ligated and divided before the esophagus is mobilized, in some cases its course is low enough in the neck so it can be preserved.

Because the thoracic esophagus has been dissected up to the thoracic inlet, it is a simple matter to transect the esophagus low in the neck. When the proper point of transection of the esophagus has been selected, apply a 55-mm linear stapler to the specimen side (Fig. 14.30) and transect the esophagus flush with the stapler. Remove the specimen through the thoracic incision.

Now pass the fundus of the stomach (which has already been passed into the thorax) through the thoracic inlet into the cervical region. The fundus should reach the hypopharynx without tension. Anchor it to the prevertebral fascia with several 3-0 silk sutures. Then construct an end-to-side anastomosis by the same technique described above (Figs. 14.25, 14.26, 14.31, and 14.32).

Lavage the operative site with an antibiotic solution and initiate wound closure by inserting a layer of interrupted 4-0 PG sutures, approximating the anterior border of the

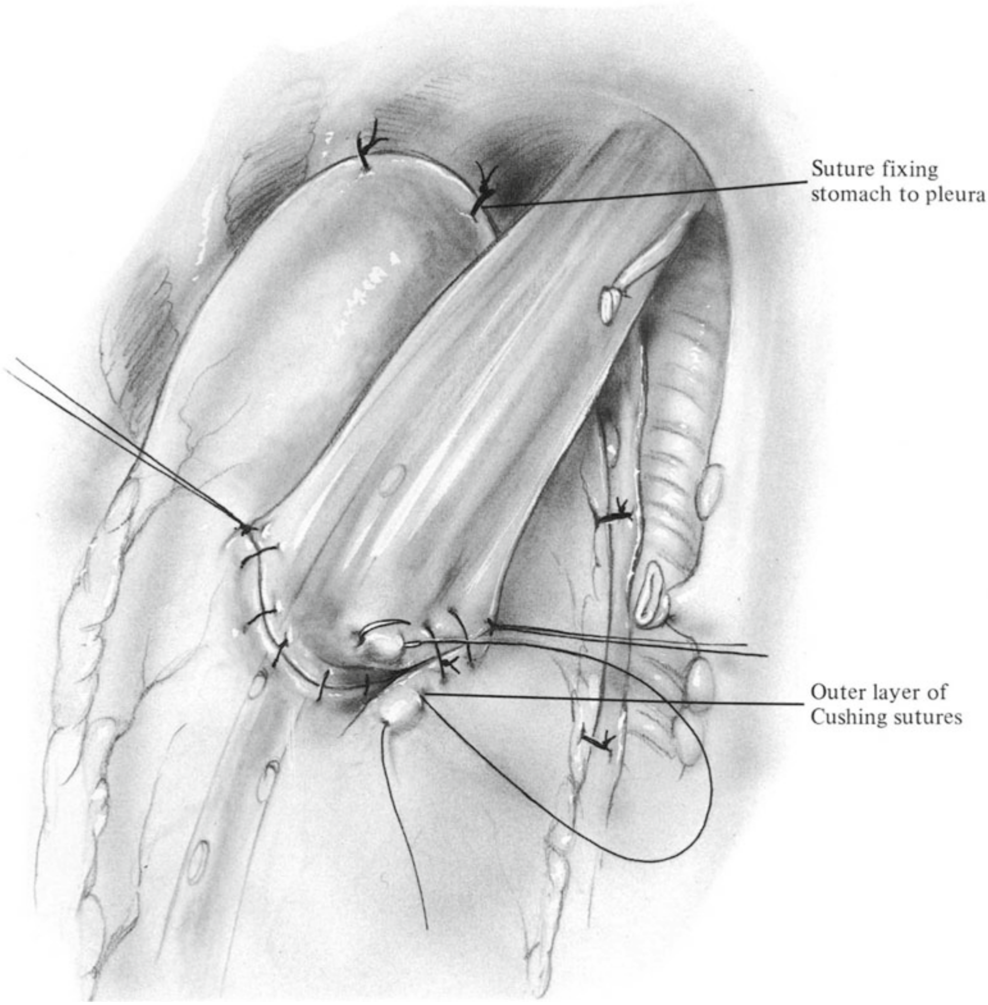

Fig. 14.26

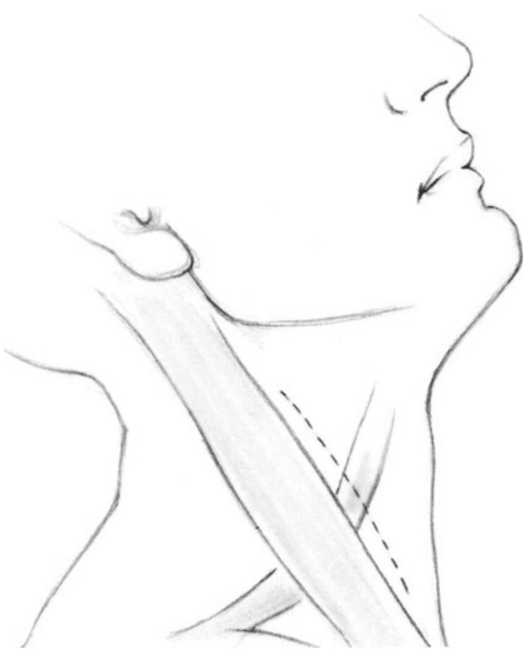

Fig. 14.27

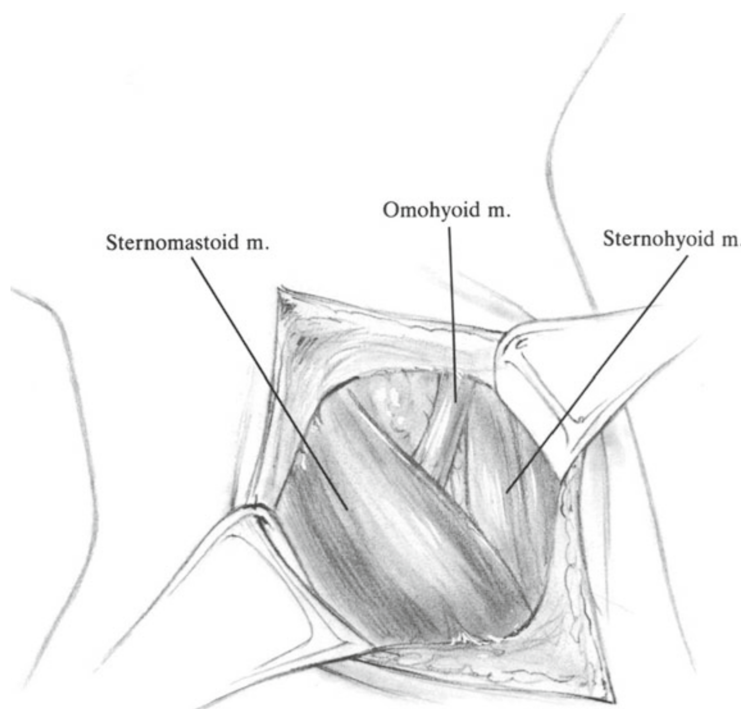

Fig. 14.28

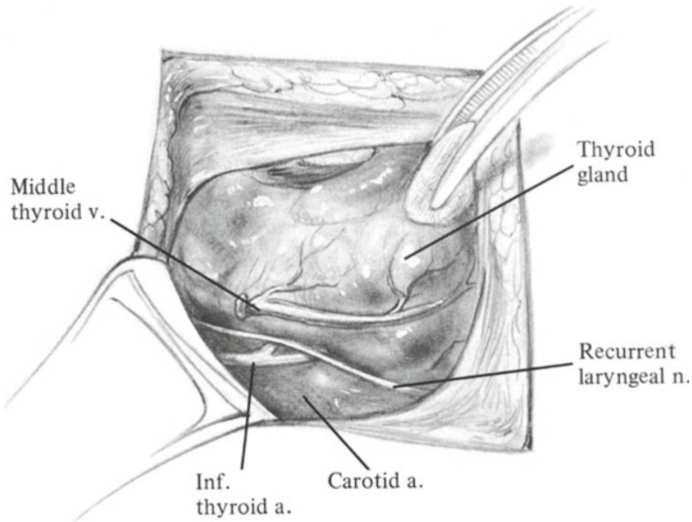

Fig. 14.29

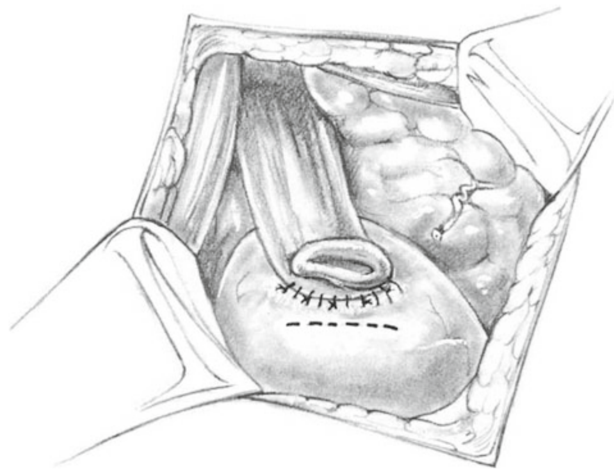

Fig. 14.31

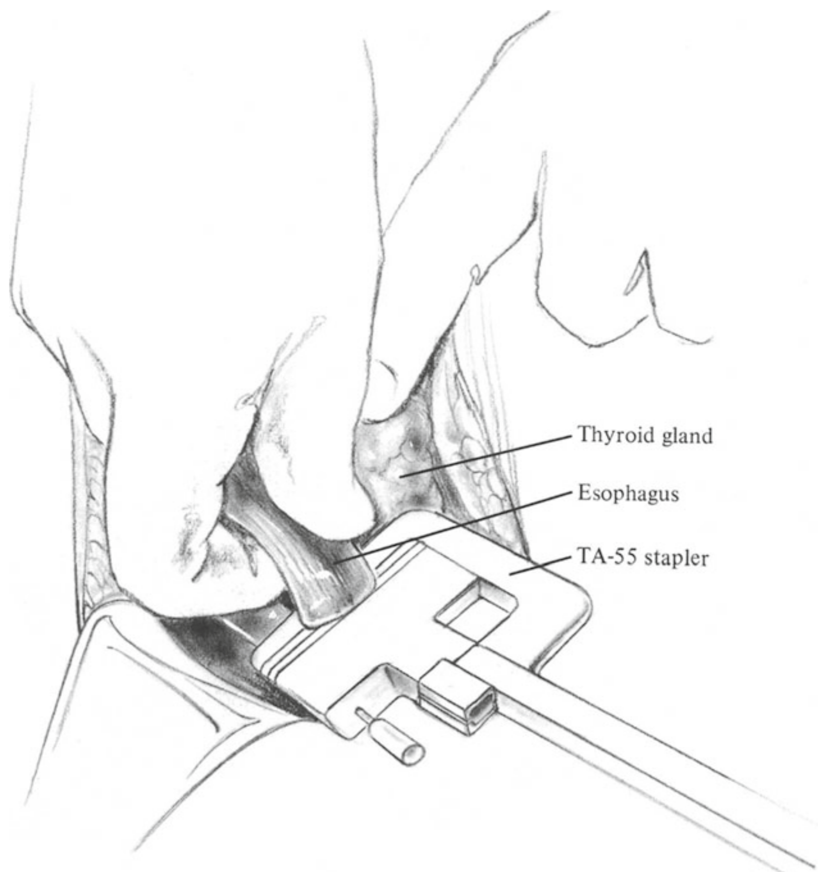

Fig. 14.30

sternomastoid to the prethyroid strap muscles. Several similar sutures may be used loosely to approximate the platysma. Close the skin, generally by means of a continuous 4-0 PG subcuticular suture, leaving sufficient space to bring a latex drain out from the prevertebral region through the lower pole of the incision.

Closure

Insert a 36F chest tube through a stab wound in the ninth intercostal space, and use 4-0 absorbable sutures to secure the catheter to the posterior pleura in the upper thorax. After thoroughly irrigating the thoracic and abdominal cavities with an antibiotic solution, approximate the ribs with four or five interrupted pericostal sutures of no. 1 PDS and approximate the serratus and pectoral muscles in layers by means of continuous 2-0 atraumatic PG (Figs. 14.33 and 14.34). Close the skin with continuous 3-0 nylon or subcuticular 4-0 PG.

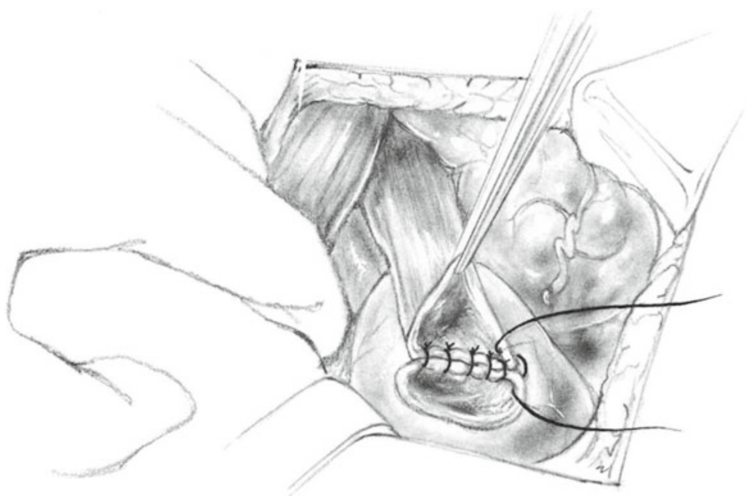

Fig. 14.32

Consider inserting a needle-catheter feeding jejunostomy. Close the abdominal wall in the usual fashion by means of interrupted no. 1 PDS sutures.

Postoperative Care

Keep the nasogastric tube on low suction for 4–5 days. Permit nothing by mouth until a contrast study has demonstrated integrity of the anastomosis.

Obtain an esophagram with water-soluble contrast followed by thin barium on the seventh postoperative day. If no leak is demonstrated, the patient is given a liquid diet, which is advanced to a full diet within 3–5 days.

Attach the chest tube to underwater suction drainage for 4–5 days. Follow the routine steps for managing a postoperative thoracotomy patient, including frequent determinations of arterial blood gases and pH. Tracheal suction is used with caution to avoid possible trauma to the anastomosis. Ventilatory support is employed when necessary. Continue prophylactic antibiotics until removal of the chest tube. Use the needle-catheter jejunostomy for enteral alimentation beginning promptly after surgery.

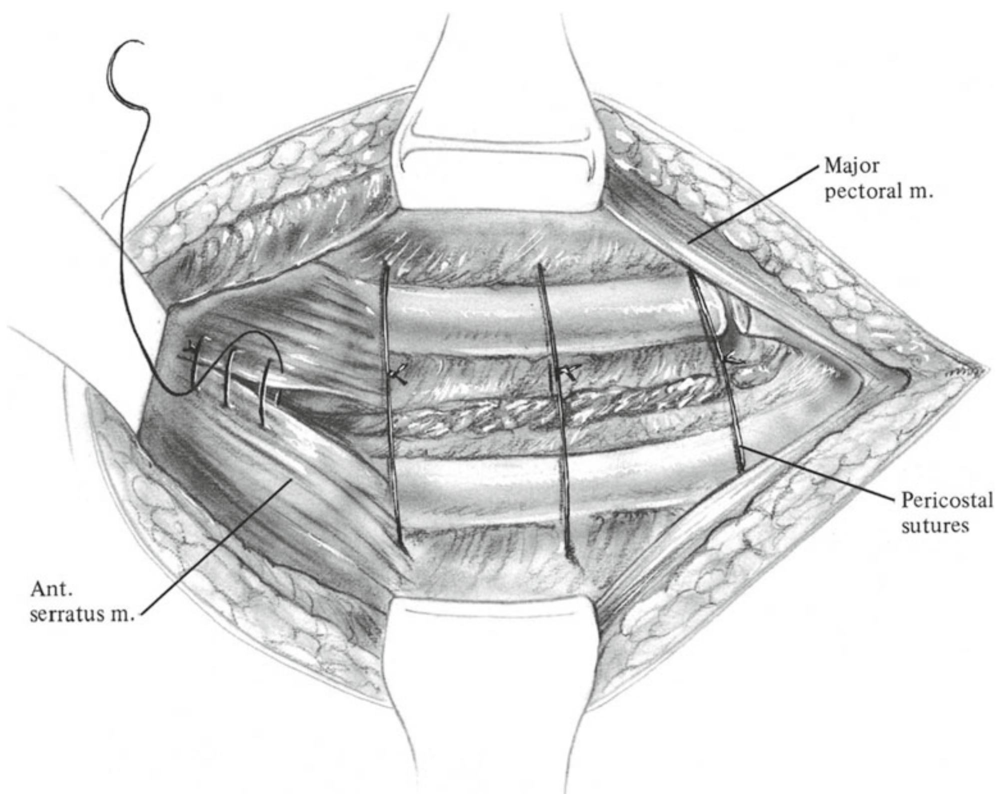

Fig. 14.33

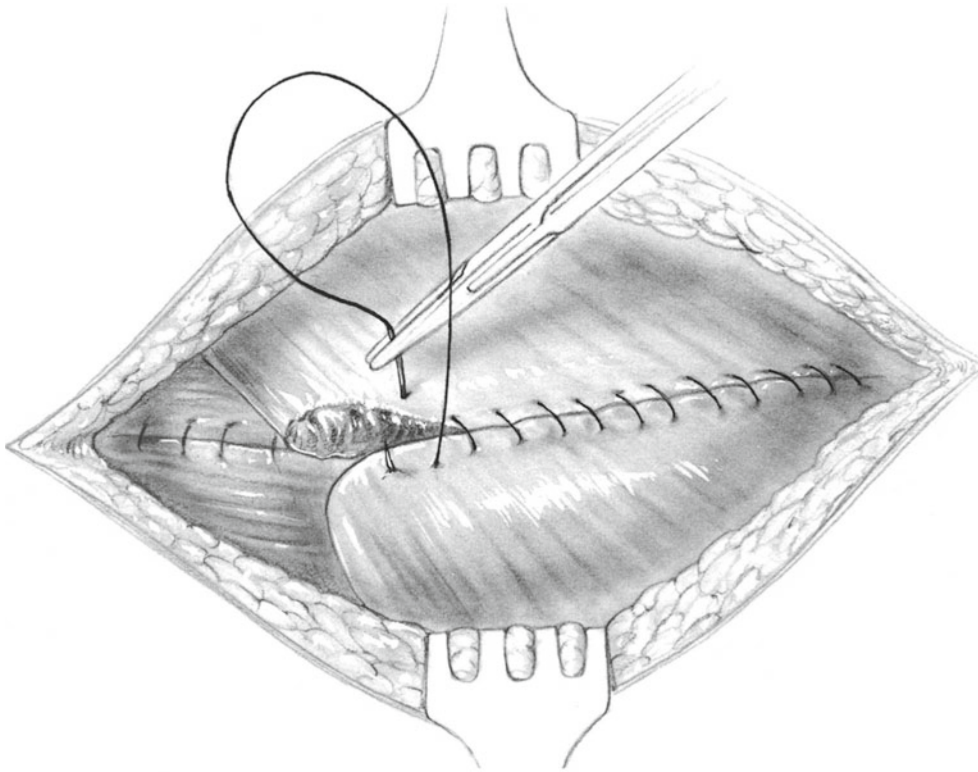

Fig. 14.34

Complications

Anastomotic leaks. Anastomotic leaks constitute by far the most important complication of this operation, but they are *preventable if proper surgical technique is used*. Although minor contained leaks may be treated nonoperatively, most leaks require operative drainage, diversion, repair, or a combination of these maneuvers (see Chap. 27).

Abscesses. A subphrenic or subhepatic abscess may follow an operation for an ulcerated malignancy because a necrotic gastric tumor often harbors virulent organisms. The incidence of this complication can be reduced by administering prophylactic antibiotics before and during the operation. Treatment is by computed tomography (CT)-directed or surgical drainage.

Pulmonary problems. Pulmonary complications were common in the past, but their incidence has been minimized by proper postoperative pulmonary care. Adequate pain control may require epidural analgesia.

Cardiac arrhythmias. Cardiac failure and arrhythmia are not uncommon in patients who are in their seventh or eighth decade of life. Generally, with careful monitoring and early detection, these complications can be easily managed. Hemodynamic monitoring may be helpful.

Stenosis. In the absence of recurrent mediastinal cancer, stenosis of the anastomosis has not occurred in any of the cases Chassin managed and reported. When this complication does occur, repeated passage of Maloney bougies may reverse the condition.

Further Reading

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15 Esophagogastrectomy: Left Thoracoabdominal Approach

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Carcinoma of the distal esophagus or proximal stomach
Distal esophageal stricture

Preoperative Preparation

See Chap. 14.

Pitfalls and Danger Points

Anastomotic failure

Ischemia of gastric pouch. Pay meticulous attention to preserving the entire arcade of the right gastroepiploic artery and vein along the greater curvature of the stomach.

Hemorrhage. Occasionally, the left gastric artery is embedded in tumor via invasion from metastatic lymph nodes. Unless this vessel can be identified, transecting the artery through the tumor may produce hemorrhage that is difficult to control.

Pancreas. Trauma to the tail of the pancreas may cause a pancreatic fistula or acute hemorrhagic pancreatitis.

Sepsis. Some malignancies in the proximal portion of the stomach are ulcerated and bulky with areas of necrosis that contain virulent bacteria. These bacteria may produce postoperative subhepatic or subphrenic abscesses via operative contamination even without anastomotic leakage. Both enteral and parenteral antibiotics that cover colon flora should be used.

Inadequate cancer operation. Because gastric and esophageal malignancies can spread submucosally for some distance without being visible, frozen section studies of both proximal and distal margins of the excision are helpful.

Paralysis of the diaphragm. The diaphragm should be divided around the periphery to preserve phrenic innervation and prevent paralysis.

Operative Strategy

Objectives of Esophagogastrectomy

With operations done for cure, the objective is wide removal of the primary tumor, along with a 6- to 10-cm margin of normal esophagus in a proximal direction and a 6-cm margin of normal stomach below. Even if the stomach is not involved, when the tumor is situated low in the esophagus the proximal lesser curvature of the stomach should be included to remove the left gastric artery at its origin and the celiac lymph nodes. Splenectomy and removal of the lymph nodes at the splenic hilus may be required for large lesions of the proximal stomach and fundus. Any suspicious nodes along the superior border of the pancreas should also be removed.

Thoracoabdominal Incision with Preservation of Phrenic Nerve Function

When gastric cancer encroaches on the gastroesophageal junction, operations done by abdominal incision exclusively are contraindicated for several reasons. In the first place, this anastomosis frequently requires the surgeon's hand and the needle holder to be in an awkward position and may result in leakage. Furthermore, the abdominal incision makes it difficult to perform wide excision of possible areas of invasion of the

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distal esophagus. We have seen some upper gastric lesions that extended into the esophagus as far as 10 cm.

The left thoracoabdominal incision, we have found, is both safe and efficacious. It is easy to divide all the muscles of the thoracic cage rapidly by electrocautery. Even patients in their 80s have tolerated this incision well when given adequate postoperative support. Epidural anesthesia minimizes pain and allows early mobilization.

Positioning the patient in the full lateral position with an incision through the fifth or sixth intercostal space gives wide exposure to the mediastinum, left pleural space, and left upper quadrant of the abdomen.

The diaphragm should *not* be incised radially from the costal margin to the esophageal hiatus because it would transect the phrenic nerve and paralyze the left diaphragm. Many patients who require gastric surgery for cancer are aged and have limited pulmonary reserve; moreover, because atelectasis is a common postoperative complication, it is better to make a circumferential incision in the periphery of the diaphragm to preserve phrenic and intercostal nerve function and normal diaphragmatic motion.

Postoperative pain at the site of the divided costal margin is allegedly common following a thoracoabdominal incision. In our experience proper resuturing of the costal margin with monofilament steel wire results in solid healing of this area. Neither pain nor costochondritis has been a problem.

Anastomotic Leakage

Delicacy and precision of anastomotic technique and adequate exposure are important for preventing anastomotic leaks. If a gastric or lower esophageal lesion has spread up the lower esophagus for a distance of more than 6–8 cm, the esophagogastric anastomosis should not be constructed high up under the aortic arch as it is a hazardous technique. Instead, 1-cm posterior segments of two additional ribs are resected if necessary to give more proximal exposure, and the esophagus is liberated behind the arch of the aorta and passed out to an intrapleural, supraaortic position. This exposure permits the anastomosis to be done in a manner less traumatic to the tissues than an anastomosis constructed high up under the aortic arch. Otherwise, the surgeon's hand and wrist are situated in an awkward position, which makes smooth manipulation of instruments difficult. Jerky suturing motions produce small tears in the esophagus, especially in the posterior layer, where access is difficult.

End-to-End Versus End-to-Side Anastomosis

We showed that the end-to-end esophagogastric anastomosis carries with it a much higher rate of leakage and a higher mortality rate than the end-to-side variety (Chassin 1978). Explanations for the increased complication rate following end-to-end esophagogastrostomy are not difficult to find.

1. It is necessary to close a portion of the end of the stomach because of the disparity between the lumen of the stomach and that of the esophagus. This increases the technical difficulty of doing the end-to-end anastomosis (Fig. 15.1a, b).
2. The blood supply of the gastric pouch at its proximal margin is inferior to that at the site of the end-to-side anastomosis.
3. Inserting the posterior layer of esophagogastric sutures may be difficult. Traction must be applied to the esophagus to improve exposure, and the surgeon's hand and the needle holder may have to assume positions that are awkward for efficient, atraumatic suturing, which produces imperfections in the suture line.
4. As seen in Fig. 15.2a, protection from posterior leakage is achieved in the end-to-side cases by the buttress effect of a 6- to 7-cm segment of gastric wall behind the esophagus. In end-to-end operations, however, there is no second line of defense against technical error.

a

b

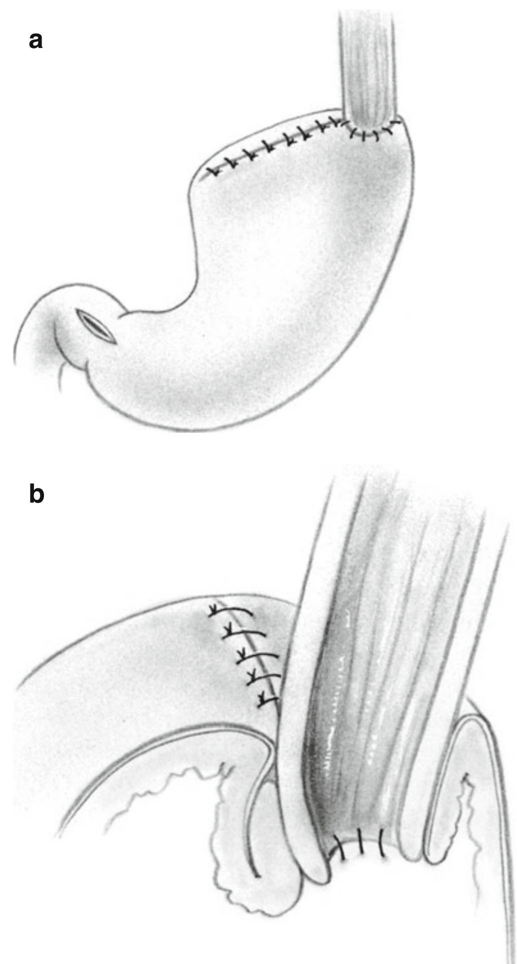


Fig. 15.1

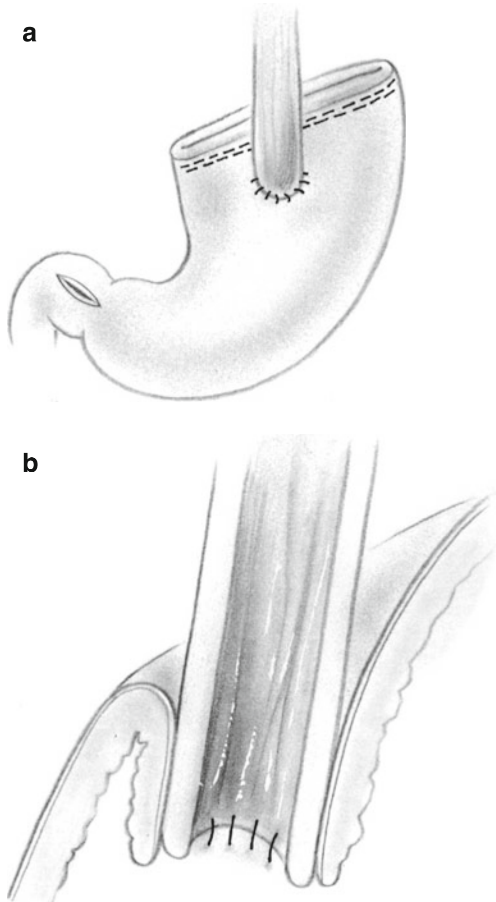


Fig. 15.2

5. Although the anterior layer of the end-to-end or the end-to-side esophagogastrostomy is much easier to construct without technical defects than the posterior layer, even here the end-to-side version offers advantages. Figure 15.2b illustrates how the anterior wall of the esophagus invaginates into the stomach for additional protection. If this were attempted with an end-to-end anastomosis, the large inverted cuff would produce stenosis at the stoma (Fig. 15.1b).

Additional protection against leakage from the anterior aspect of the end-to-side anastomosis can be achieved by performing a Nissen fundoplication around the anastomosis. This also helps prevent postoperative gastroesophageal reflux, but it requires the presence of a large gastric pouch and cannot be performed, unless modified, when the proximal stomach has been resected.

Avoiding Postoperative Reflux Esophagitis

Another serious drawback of an end-to-end esophagogastric anastomosis is the occurrence of reflux esophagitis in patients who achieve long-term survival. It can be avoided by implanting the end of the esophagus end-to-side into the stomach at least 6 cm beyond the proximal margin of the gastric pouch. This type of construction functions as a valve, probably because air in the gastric pouch behind the distal esophagus and above the esophagogastric anastomosis compresses the overlying esophagus. This is fortunate, as there is rarely enough remaining stomach to fashion an adequate "fundoplication" when the gastric fundus has been resected.

When the anastomosis is performed by the stapling method, the anastomosis should still be a comfortable distance from the proximal end of the gastric interposition for the same reason as elaborated for the sutured anastomosis.

Efficacy of Stapling Techniques for the Esophagogastric Anastomosis

We have developed a stapling technique for end-to-side esophagogastrostomy that can be done swiftly with an extremely low leak rate (Chassin 1978). After a long, sometimes complicated dissection, an accurate anastomosis that takes only 2–3 min of operating time constitutes a welcome epilogue, especially when treating poor-risk patients. Whereas 28-mm and 31-mm circular stapling cartridges produce a good anastomosis, use of the 25-mm cartridge results in a high incidence of anastomotic postoperative strictures requiring dilatation.

Postoperative Sepsis

To prevent postoperative sepsis, meticulously avoid spillage of the gastric content, which can contaminate the subhepatic or subcutaneous space. Any instruments that come into contact with the lumen of the stomach or esophagus should be treated as dirty and the area walled off wherever possible. During the operation intravenous antibiotics that cover a spectrum from lower mouth to skin to enteric organisms should be given at appropriate intervals to ensure that body fluid and tissue levels are maintained.

Documentation Basics

Coding for esophageal procedures is complex. Consult the most recent edition of the AMA's Current Procedural Terminology book for details (see references at the end). In general, it is important to document:

- Findings
- Extent of resection
- Stapled or sutured anastomosis?
- Pyloromyotomy or not?

Fig. 15.3

Operative Technique

Incision and Position

Endobronchial (double-lumen) one-lung anesthesia permits atraumatic collapse of the left lung during the esophageal dissection. It is far preferable to advancing an endotracheal tube down the right mainstream bronchus.

With the aid of sandbags and wide adhesive tape across the patient's hips and left shoulder, elevate the patient's left side to a 60–90° angle. Place the right arm straight on an arm board. Pad the patient's left arm and suspend it in a forward position (Fig. 15.3).

Begin the incision at the umbilicus and continue it up the midline about halfway to the xiphoid, or use an oblique incision parallel to the right costal margin midway between the xiphoid and umbilicus. Explore the abdomen. The presence of metastasis of moderate degree to the celiac lymph nodes or to the liver does not constitute a contraindication to resection.

Redirect the incision to cross the costal margin into the sixth intercostal space and continue to it the region of the erector spinae muscle near the tip of the scapula. After the skin incision has been completed, use the coagulating current to divide the latissimus dorsi muscle in as caudal a location as possible (Fig. 15.4). The index fingers of both the

Fig. 15.4

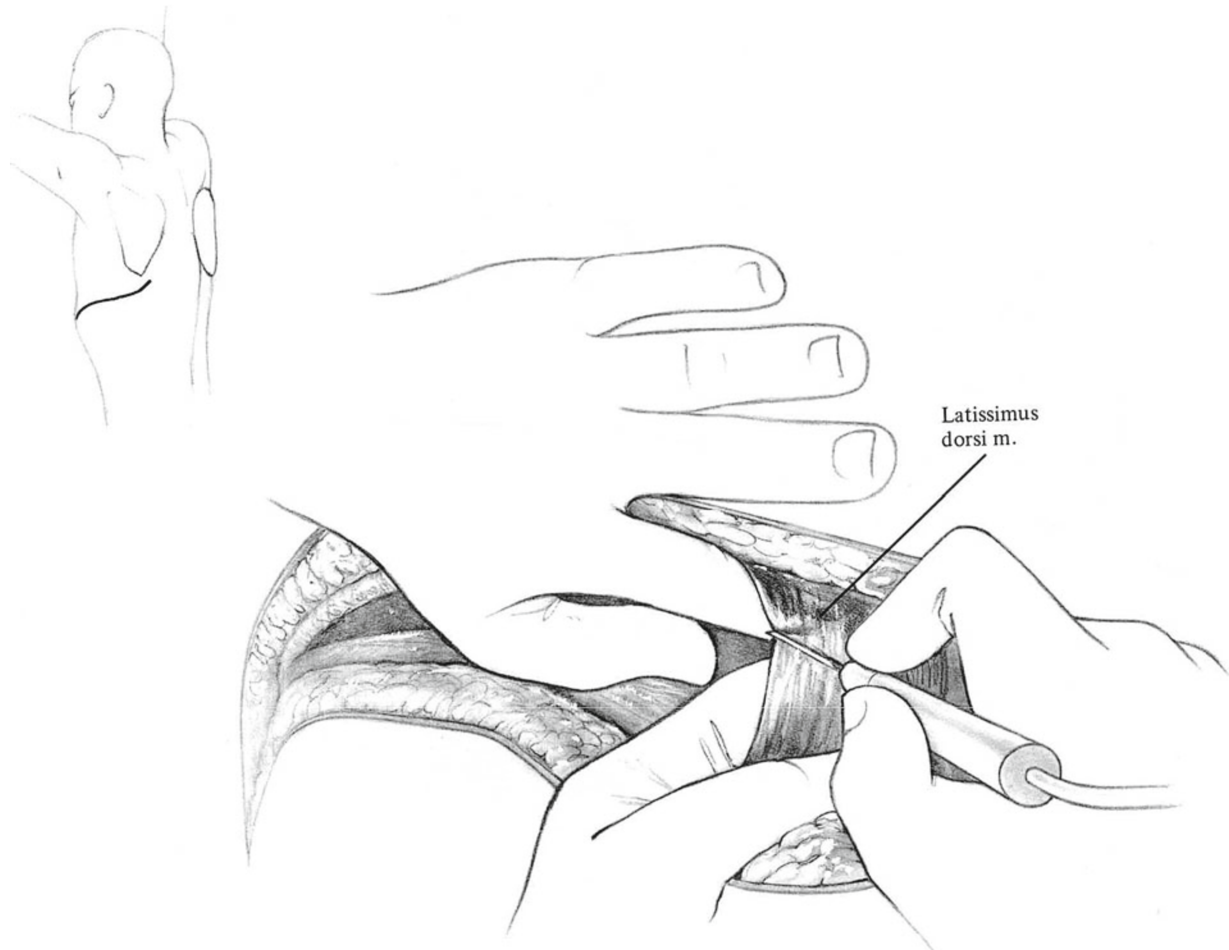


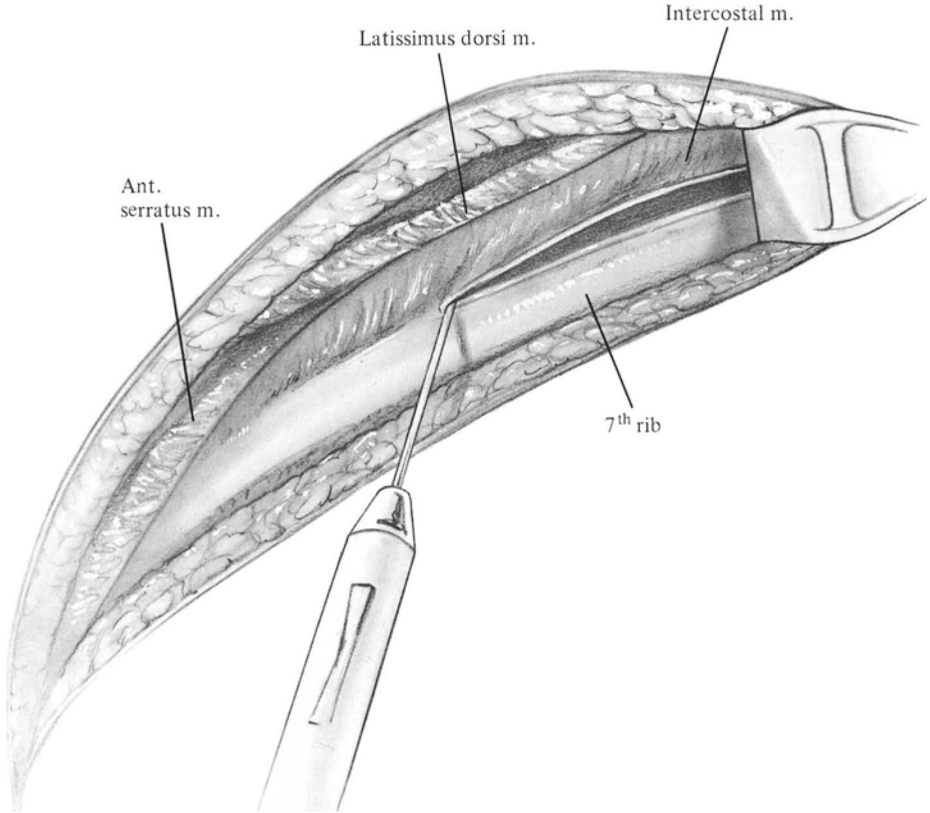
Fig. 15.5

surgeon and first assistant should be inserted side by side underneath the latissimus muscle while the electrocautery divides the muscle (Fig. 15.5). Divide the anterior serratus muscle in a similar fashion. The rhomboid muscles medial to the scapula need not be divided unless a supraaortic dissection proves necessary.

Next retract the scapula in a cephalad direction and count down the interspaces from the first rib to confirm the location of the sixth interspace. Divide the intercostal musculature by electrocautery along the superior surface of the seventh rib and enter the pleura (Fig. 15.6). Divide the costal margin where it is a wide plate with a scalpel, heavy scissors, or rib cutter. Divide the internal mammary artery, deep and slightly lateral to the costal margin, ligate or electrocoagulate it (Fig. 15.7).

Incise the diaphragm in a circumferential fashion (Figs. 15.7 and 15.8) along a line 3–4 cm from its insertion into the rib cage. Use electrocautery for this incision, which should extend laterally about 15 cm from the divided costal margin. Spread the intercostal incision by inserting a mechanical retractor. Use of a multiarm retraction system without a mechanical advantage allows retraction of the lung, diaphragm, and liver for both the thoracic and abdominal phases of the operation, and it avoids fracturing the ribs.

Fig. 15.6



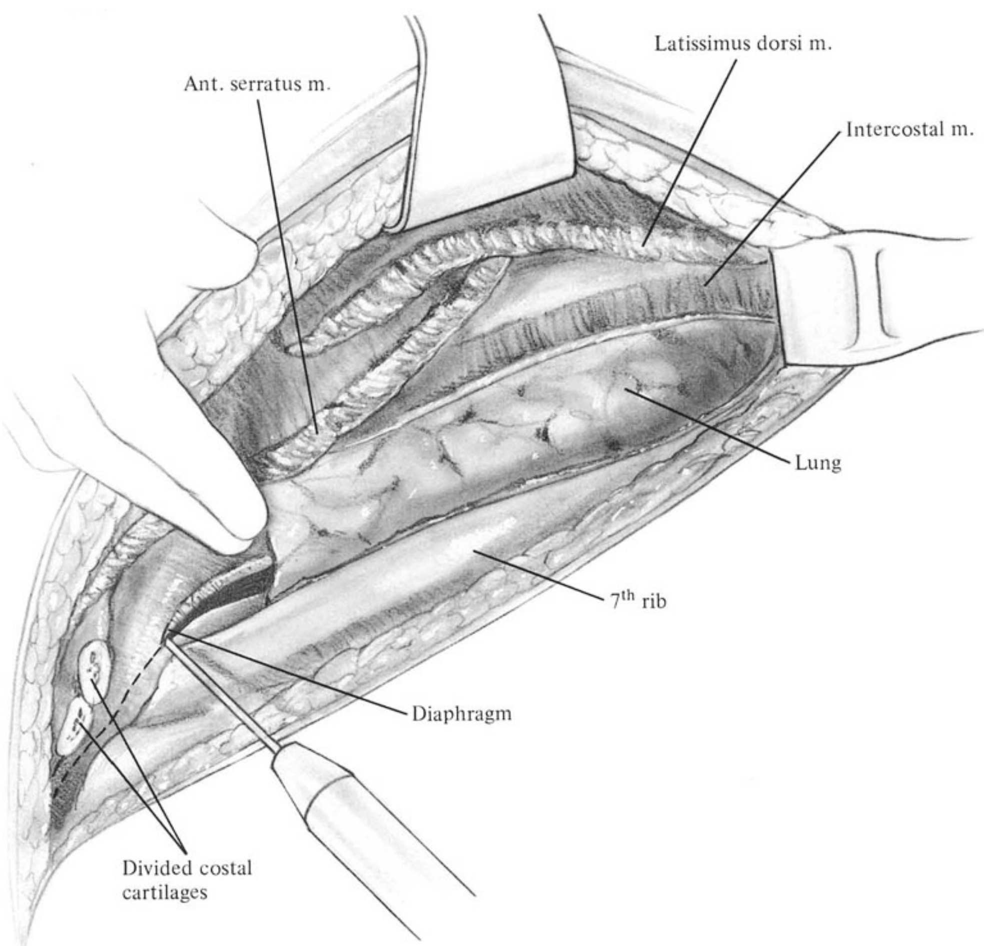
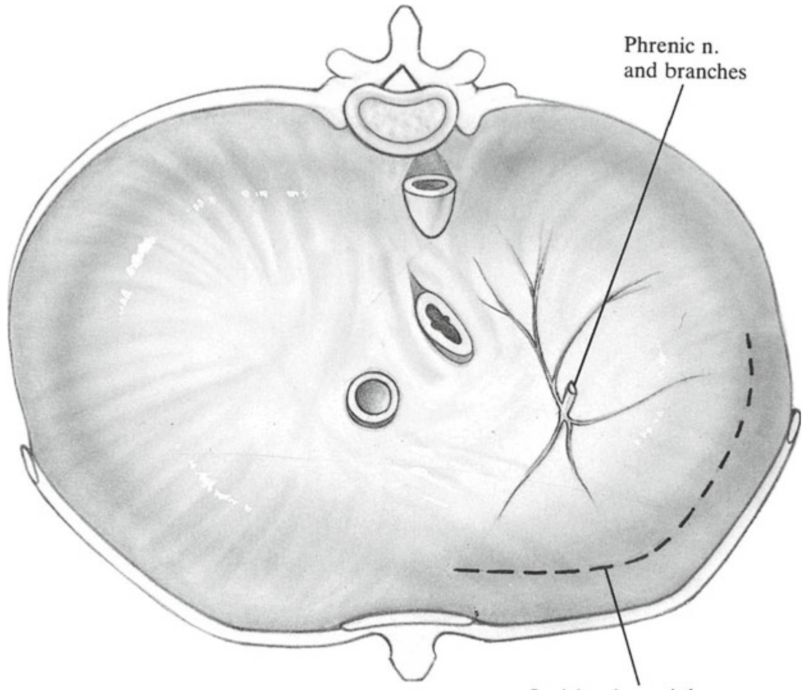


Fig. 15.7

Fig. 15.8



Liberation of Esophagus

Divide the inferior pulmonary ligament with electrocautery or long Metzenbaum scissors, progressing in a cephalad direction until the inferior pulmonary vein has been reached. Collapse the lung, cover it with moist gauze pads, and retract it in a cephalad and anterior direction with Harrington retractors.

Incise the mediastinal pleura from the aorta to the hiatus, beginning at a point above the tumor (Fig. 15.9). Encircle the esophagus first with the index finger and then with a latex drain (Fig. 15.10). Divide the vagus nerves as they approach the esophagus from the hilus of the lung. Dissect the tumor and the attached vagus nerves away from the mediastinal structures. If the pleura of the right thoracic cavity or pericardium has been invaded by tumor, include it in the resection. Dissection of the esophagus should free this organ from the arch of the aorta down to the hiatus, including all the periesophageal areolar tissue. Generally, only two or three arterial branches of the descending aorta join the esophagus. They should be occluded by hemostatic clips and divided. Use an umbilical tape ligature or a 55-/3.5-mm linear stapler to occlude the lumen of the proximal esophagus (above the tumor) to prevent cephalad migration of tumor cells (Fig. 15.11). The esophagus may be divided at this time and reflected into the abdomen once hiatal mobilization is complete, or it may be delayed until the stomach is mobilized.

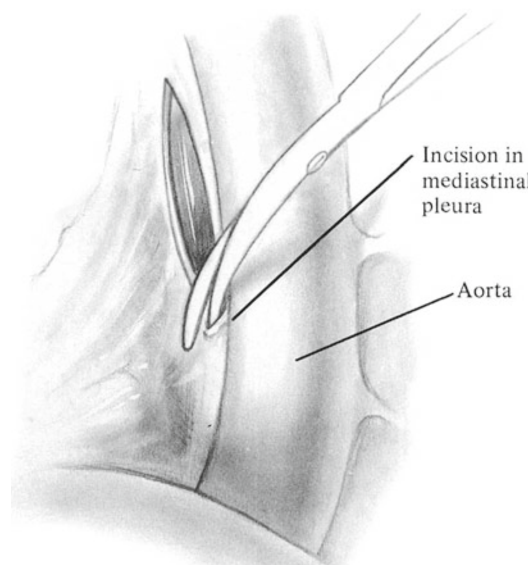
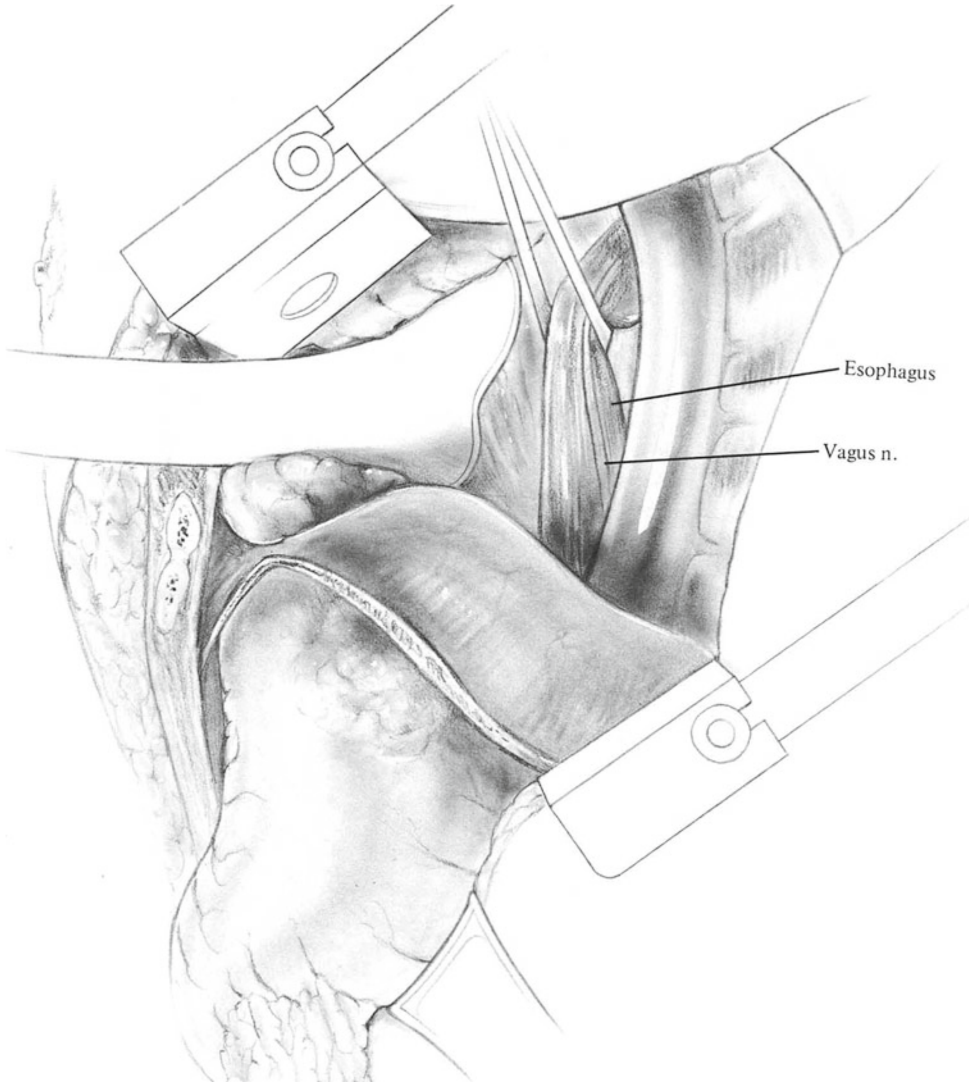


Fig. 15.9

Fig. 15.10



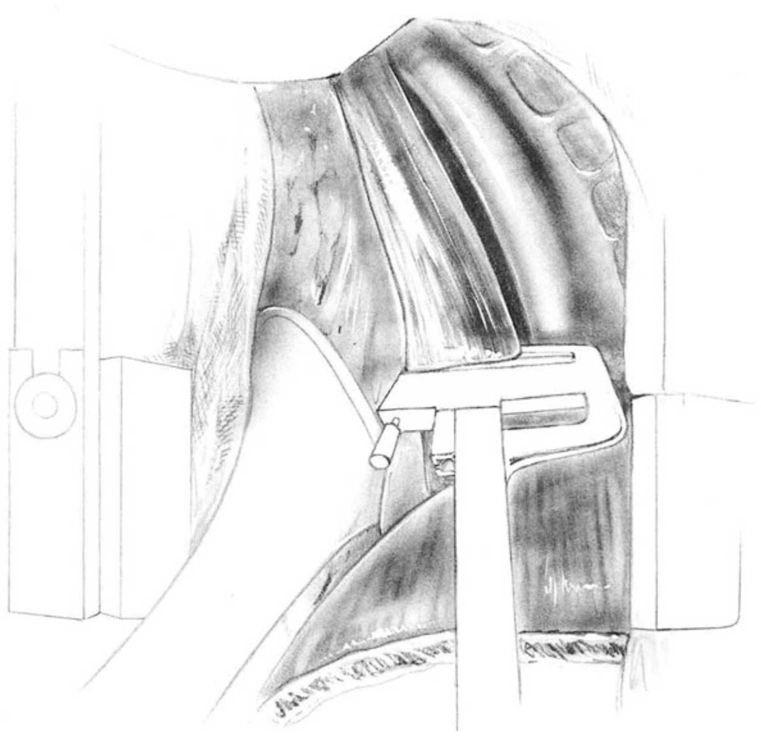


Fig. 15.11

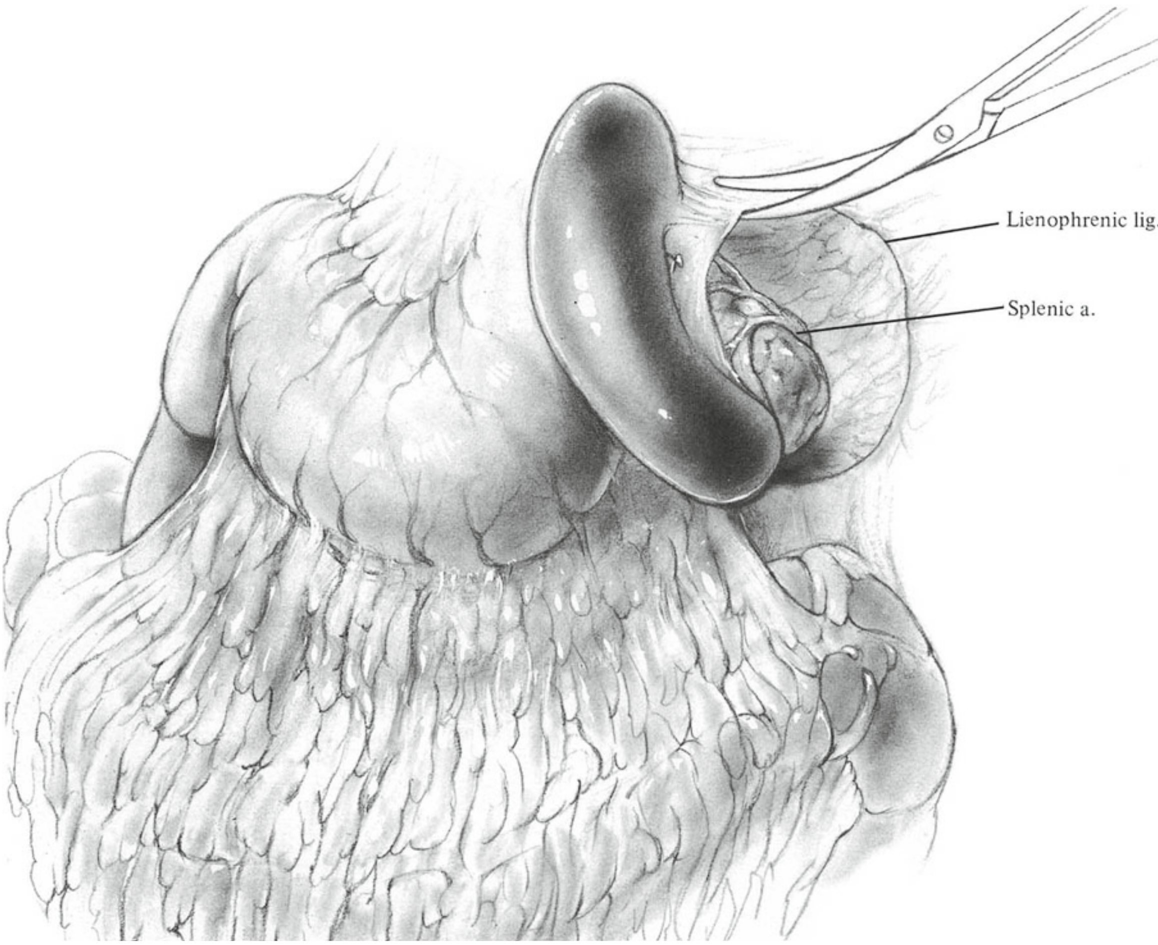


Fig. 15.12

Splenectomy

If the proximity of the carcinoma makes splenectomy necessary, retract the spleen medially and divide the lienophrenic ligament (Fig. 15.12). Gently elevate the spleen and the tail of the pancreas from the retroperitoneal tissues by finger dissection. Divide the lienocolic ligament. Identify the splenic artery and vein on the posterior surface of the splenic hilus. Each should be divided and ligated with 2-0 silk. It may be convenient to remove the spleen as a separate specimen after dividing each of the short gastric vessels. Do this on the anterior aspect of the stomach to visualize the greater curvature accurately, thereby avoiding any possibility of trauma to the stomach. If splenectomy is not necessary, enter the lesser sac through the avascular space above the left gastroepiploic vessels and individually control and divide the short gastric vessels.

Gastric Mobilization

The gastroepiploic arcade along the greater curvature of the stomach *must be preserved with compulsive attention to detail*, as the inadvertent occlusion of this vessel in a clamp or ligature results in ischemia of the gastric pouch and anastomotic leakage. Working from above down, divide the left gastroepiploic vessels and open the lesser sac to identify the gastroepiploic arcades from both front and back. Be sure always to *leave 3–5 cm of redundant omentum attached* to the vascular arcade. Identify the plane separating the colon mesentery from the gastroepiploic arcade. Continue the dissection to a point 6–8 cm cephalad to the pylorus (Fig. 15.13a, b). The greater curvature now should be elevated. Complete posterior mobilization of the stomach by incising the avascular attachments that connect the back wall of the stomach to the posterior parietal peritoneum overlying the pancreas (gastropancreatic folds) and continue the dissection to the pylorus. Carefully preserve the subpyloric vessels (right gastroepiploic and right gastric).

Identify the celiac axis by palpating the origins of the splenic, hepatic, and left gastric arteries. Dissect lymphatic and areolar tissues away from the celiac axis toward the specimen. Skeletonize the coronary vein and divide and ligate it with 2-0 silk. Immediately cephalad to this structure is the left gastric artery, which should be doubly ligated with

2-0 silk and divided (Fig. 15.14a, b). Incise the gastrohepatic ligament near its attachment to the liver (Fig. 15.15). An accessory left hepatic artery generally can be found in the cephalad portion of the gastrohepatic ligament. Divide the artery and ligate it with 2-0 silk; then divide the remainder of the ligament and the peritoneum overlying the esophagus.

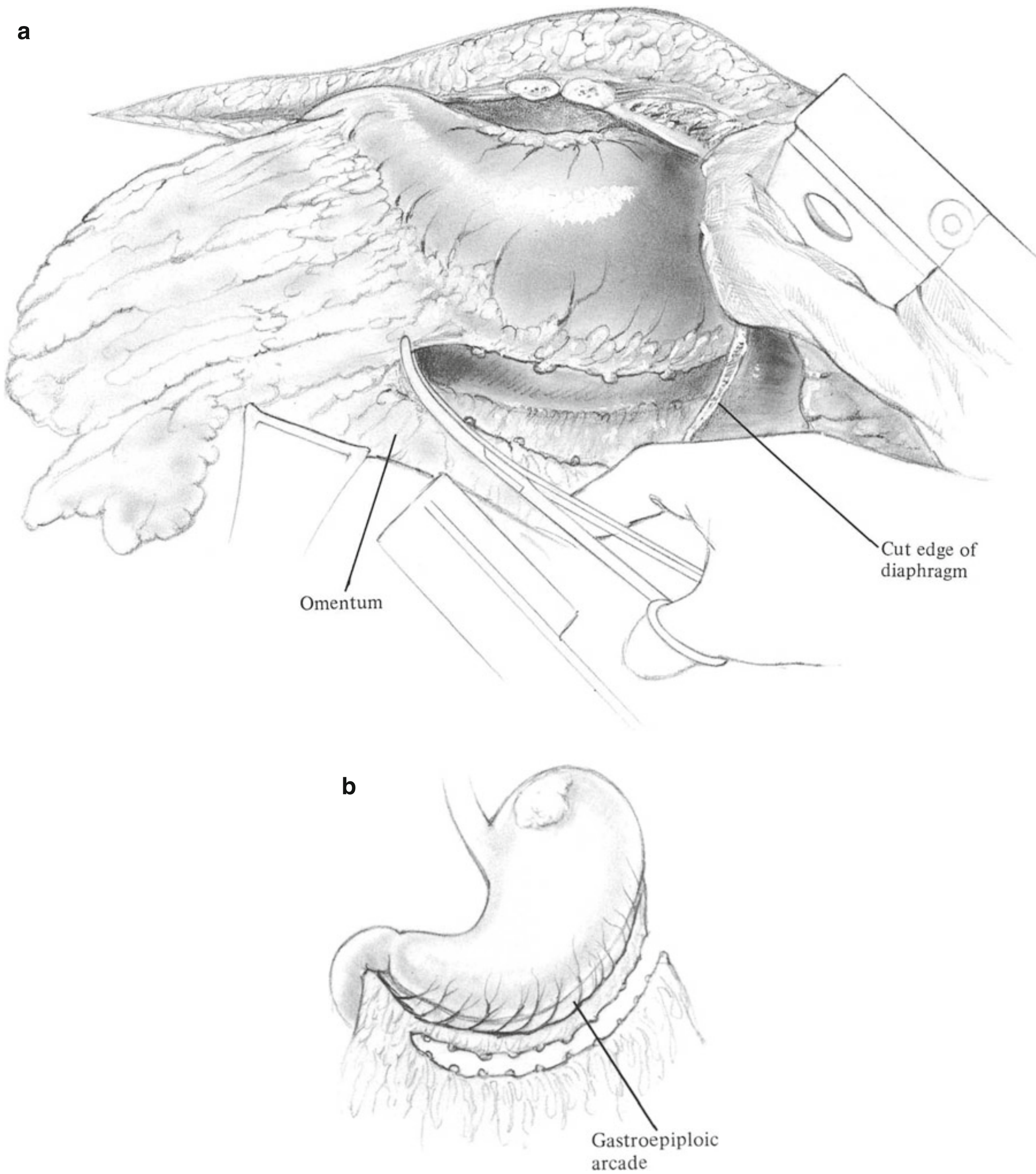


Fig. 15.13

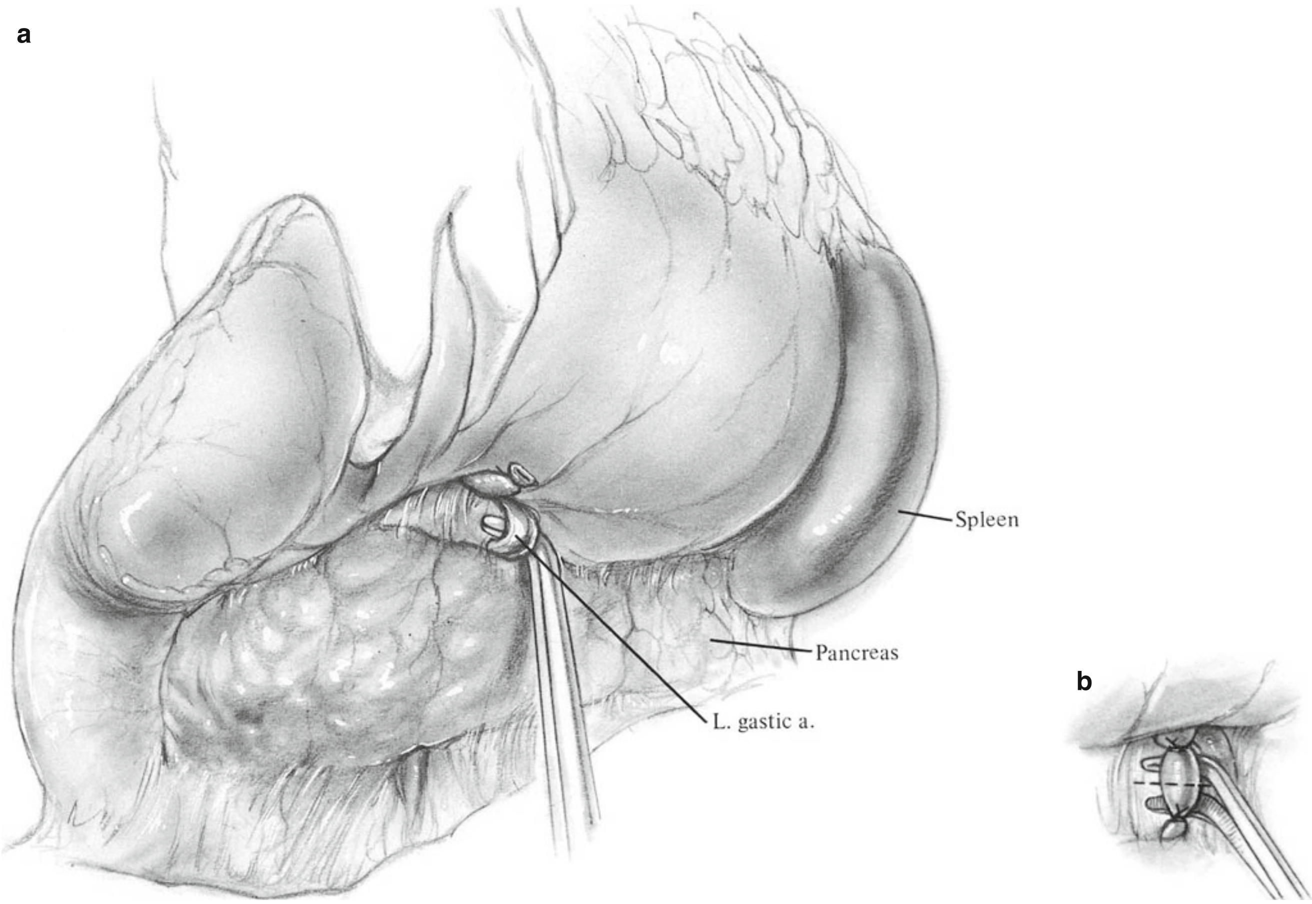


Fig. 15.14

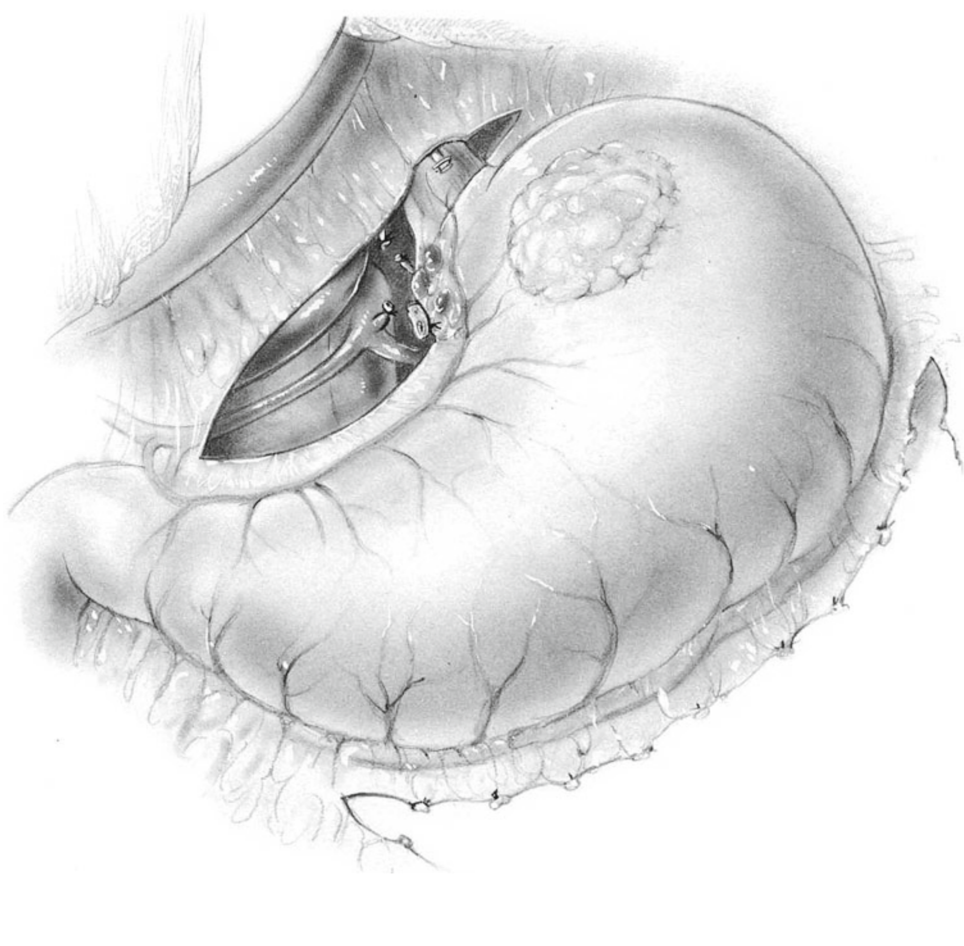


Fig. 15.15

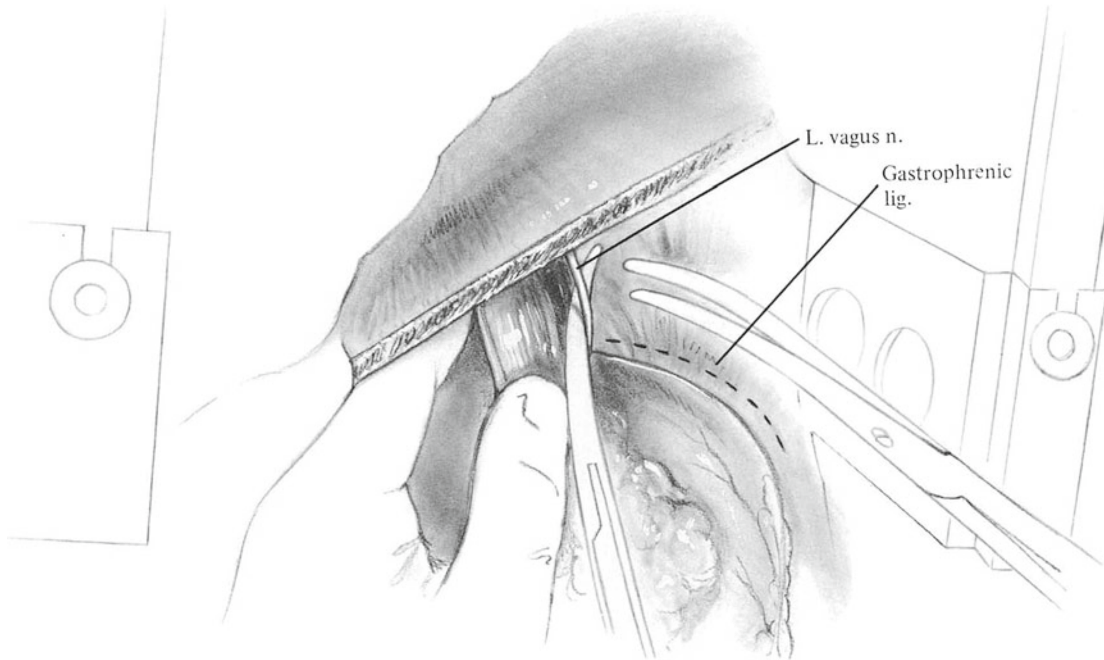


Fig. 15.16

Hiatal Dissection

A gastrophrenic ligament attaches the posterior aspect of the gastric fundus to the posterior diaphragm. Divide the ligament using the left index finger as a guide. If tumor has encroached on the hiatus, leave crural musculature attached to the tumor and divide it from the surrounding diaphragm with electrocautery. This may require division and ligature of the inferior phrenic artery. Divide the vagus nerves just below the hiatus (Fig. 15.16) and divide the phrenoesophageal ligaments; this frees the esophagus and stomach from the arch of the aorta down to the duodenum.

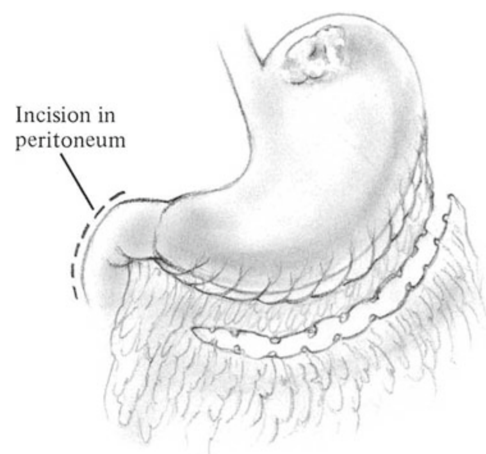
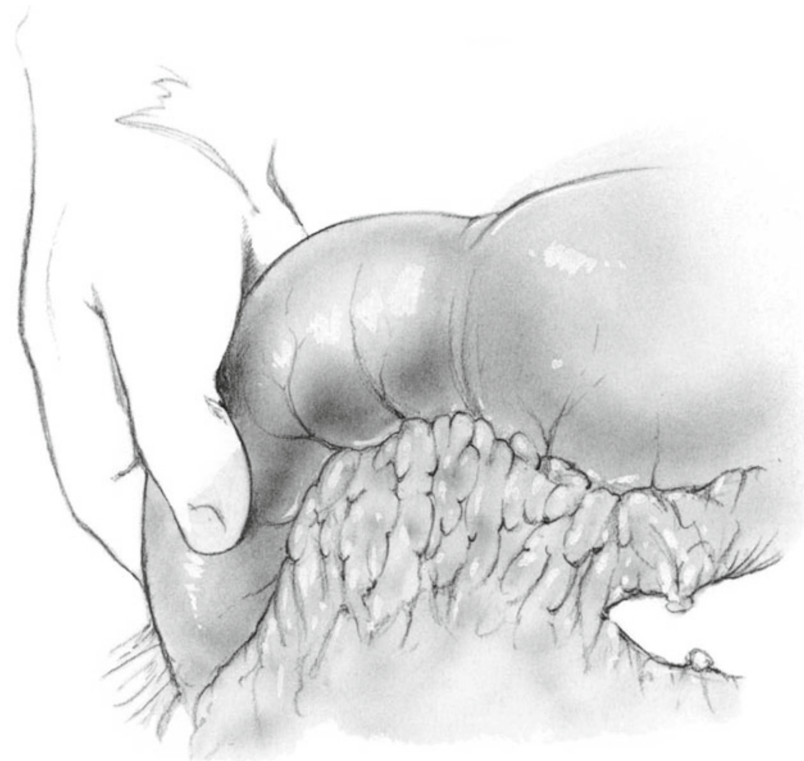


Fig. 15.17

Kocher Maneuver

To achieve maximum upward mobility of the gastric pouch, divide the avascular lateral duodenal ligament and pass a hand behind the duodenum and the head of the pancreas (Figs. 15.17 and 15.18). If necessary, continue this Kocher maneuver along the duodenum as far distally as the superior mesenteric vein (see Figs. 14.15 and 14.16). Additional freedom of the mobilized stomach can be achieved by dividing the attachments of the greater omentum to the duodenum beyond the right gastroepiploic vessels.

Fig. 15.18



Pyloromyotomy

Perform a pyloromyotomy as described in Chap. 14 (see Figs. 14.17, 14.18, and 14.19).

Transection of Stomach and Esophagus

To treat a primary tumor of the lower esophagus, apply either a long linear cutting stapler or a 90-mm linear stapler (loaded with 4.8-mm staples) in an oblique fashion to remove the stump of the left gastric artery, the celiac lymph nodes on the lesser curvature of the stomach, and 5–6 cm of the greater curvature.

To treat lesions of the proximal stomach, which is the operation illustrated in Figs. 15.19a, b, apply the stapler so 5–6 cm of normal stomach distal to the lesion is removed. *Ascertain that the nasogastric tube has been withdrawn* and divide the stomach with a long linear cutting stapler or with two 90-mm linear staplers applied in a parallel fashion. Make an incision with the scalpel flush with the stapler attached to the residual gastric pouch. If two 90-mm linear staplers are not available, the first stapler should be applied to the stomach, fired, and then reapplied 1 cm lower on the gastric wall. The transection should be made flush with the stapler on the gastric pouch. Control individual bleeding vessels with electrocautery after removing the device. This staple line should be oversewn with fine inverting sutures. The gastric wall is of variable thickness, and we have seen isolated leakage from this staple line when it was not reinforced. If multiple applications of the cutting stapler were required, a running 4-0 polypropylene Lembert suture conveniently reinforces the staple line without excess inversion.

In a previous step the esophageal lumen proximal to the tumor was occluded with a row of staples (Fig. 15.11). If the esophagus has not yet been divided, transect it now 8–10 cm proximal to the tumor and remove the specimen (Fig. 15.20). Submit the proximal and distal margins of the specimen to frozen section examination. Clean the lumen of the proximal esophagus with a suction device (Fig. 15.21).

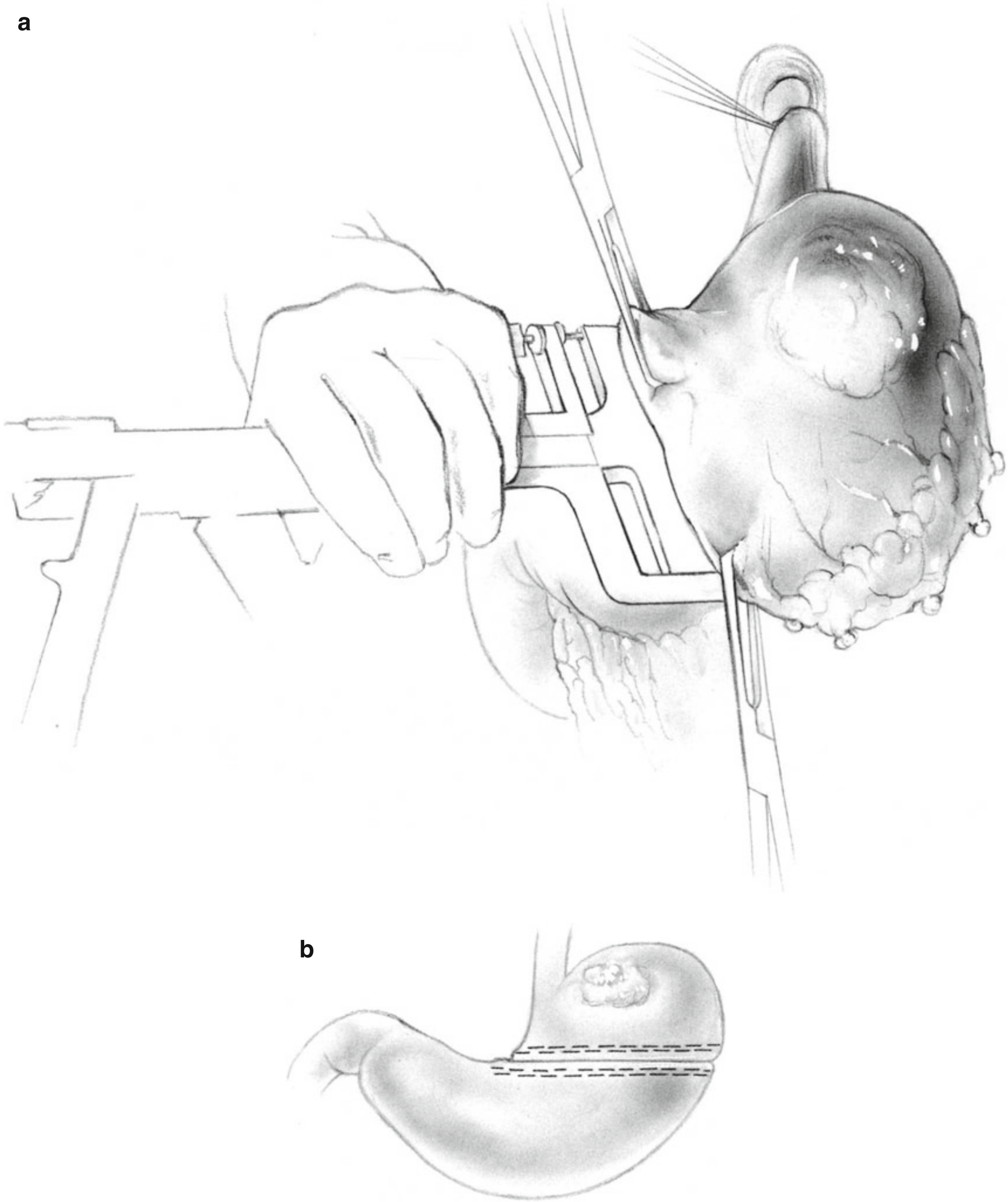


Fig. 15.19

Fig. 15.20

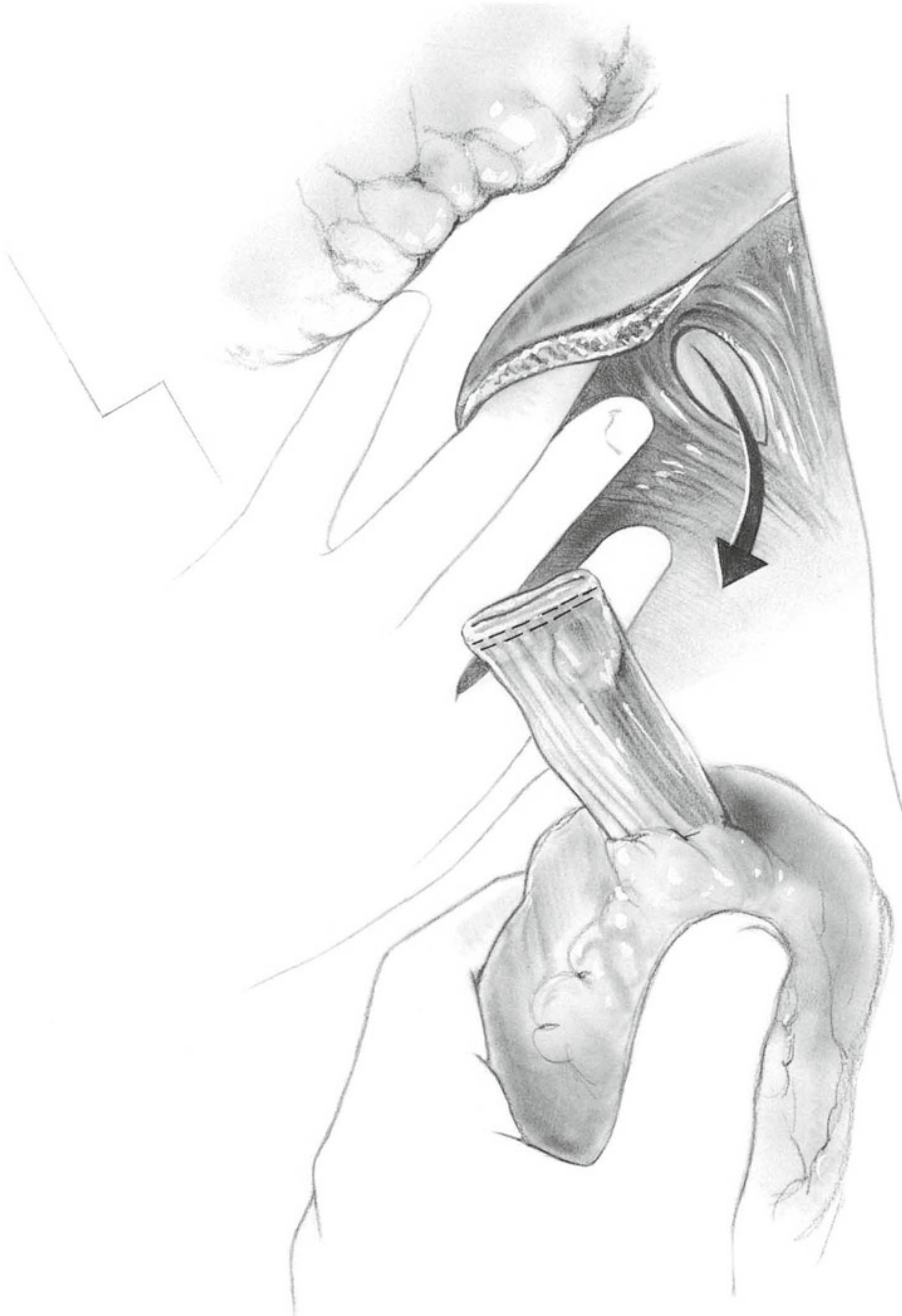


Fig. 15.21

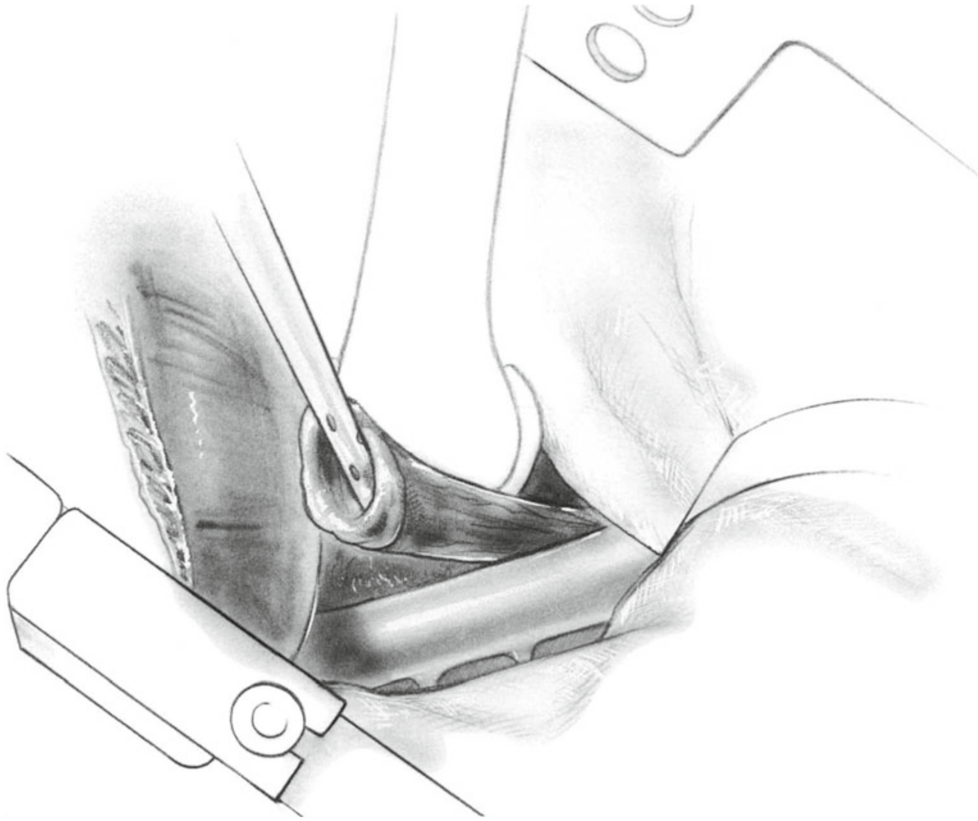
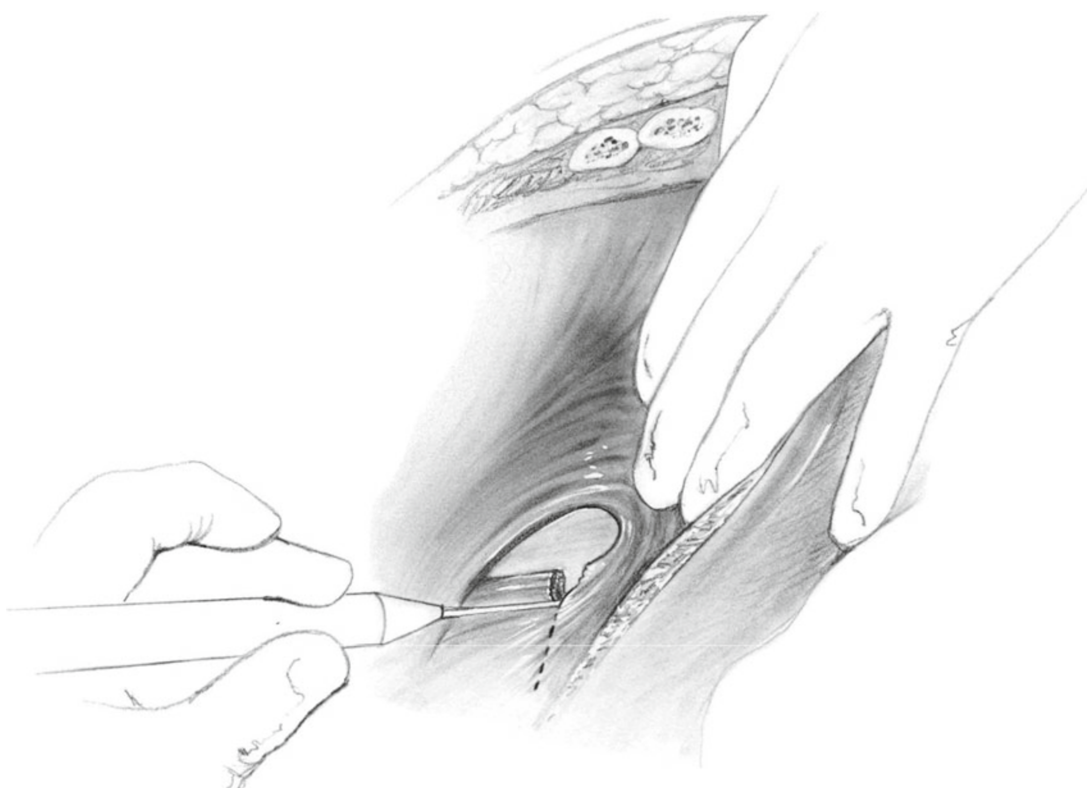


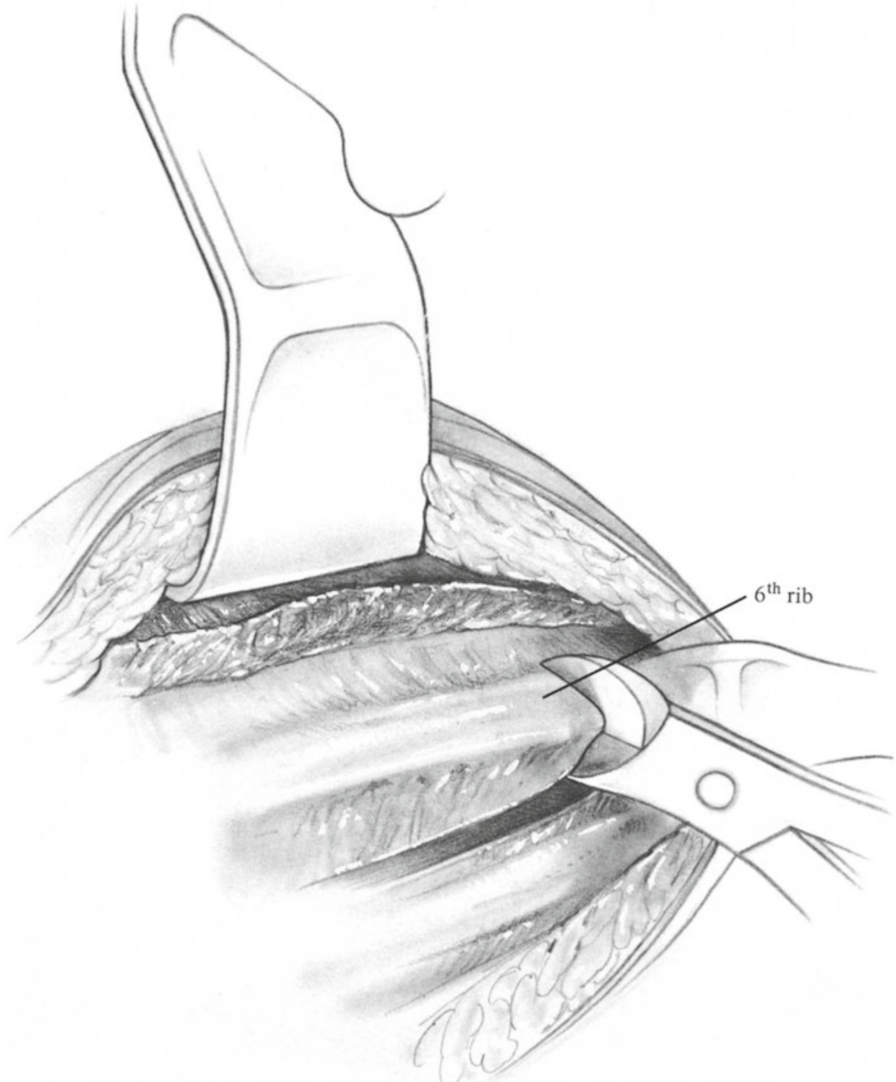
Fig. 15.22



Enlargement of Hiatus

Enlarging the hiatus is rarely necessary if the crura have been skeletonized as described by division of the phrenoesophageal ligament. If the hiatus appears tight, make a transverse incision by electrocautery in the left branch of the crux (Fig. 15.22). The incision should be of sufficient magnitude to allow the gastric pouch to pass into the mediastinum *without constriction* of its venous circulation.

Fig. 15.23



Enlargement of Thoracic Incision if Supraaortic Anastomosis Is Necessary

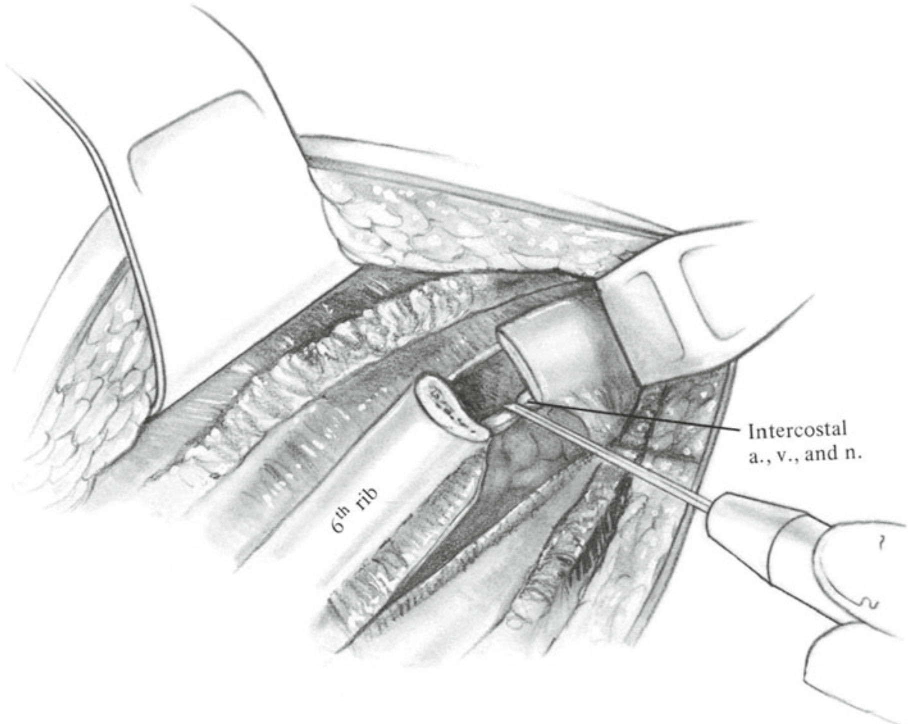
A properly fashioned end-to-side esophagogastric anastomosis requires the presence of 6–8 cm of esophagus below the aortic arch. If there is not 6–8 cm of esophagus below the aortic arch, the surgeon should not hesitate to enlarge the thoracic incision so the esophagus can be passed behind the arch into a supraaortic position. This makes the anastomosis far simpler and safer to perform and requires only a few minutes to accomplish.

Move to a position on the left side of the patient. Extend the skin incision up from the tip of the scapula in a cephalad direction between the scapula and the spine. With electrocautery divide the rhomboid and trapezium muscles medial to the scapula. Retract the scapula in a cephalad direction and free the erector spinal muscle from the necks of the sixth and fifth ribs. Free a short (1 cm) segment of the sixth (and often of the fifth) rib of its surrounding periosteum and excise it (Fig. 15.23). Divide and ligate or electrocoagulate the intercostal nerves with their accompanying vessels (Fig. 15.24). Reinsert the Finochietto or other mechanical retractor (Fig. 15.25). If the exposure is still inadequate, a segment of the fourth rib may also be excised, but this is rarely necessary.

Enter the space between the anterior wall of the esophagus and the aortic arch with the index finger (Figs. 15.26a, b, c). There are no vascular attachments in this area. The index finger emerges cephalad to the aortic arch behind the mediastinal pleura. Incise the mediastinal pleura on the index finger, making a window extending along the anterior surface of the esophagus up to the thoracic inlet. Now dissect the esophagus free of all its attachments to the mediastinum in the vicinity of the aortic arch. Avoid damage to the left recurrent laryngeal nerve, the thoracic duct, and the left vagus nerve located medial to the esophagus above the aortic arch. One or two vessels may have to be divided between hemostatic clips.

Deliver the esophagus from behind the aortic arch up through the window in the pleura between the left carotid and subclavian arteries (Fig. 15.27). If the space between the

Fig. 15.24



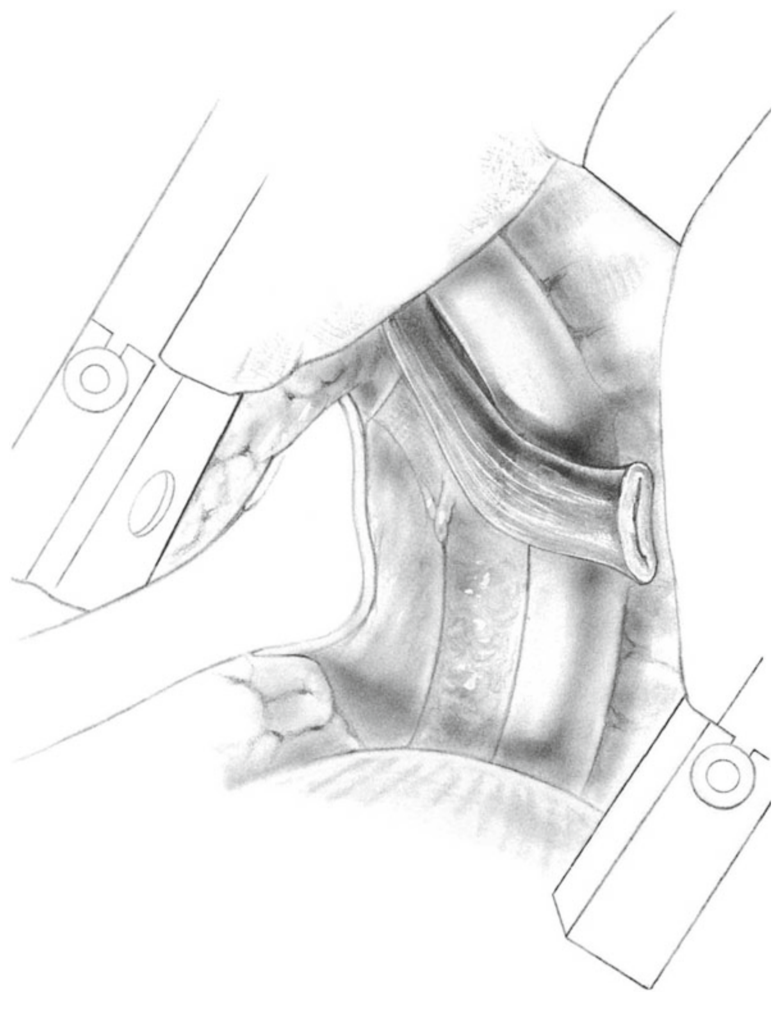


Fig. 15.25

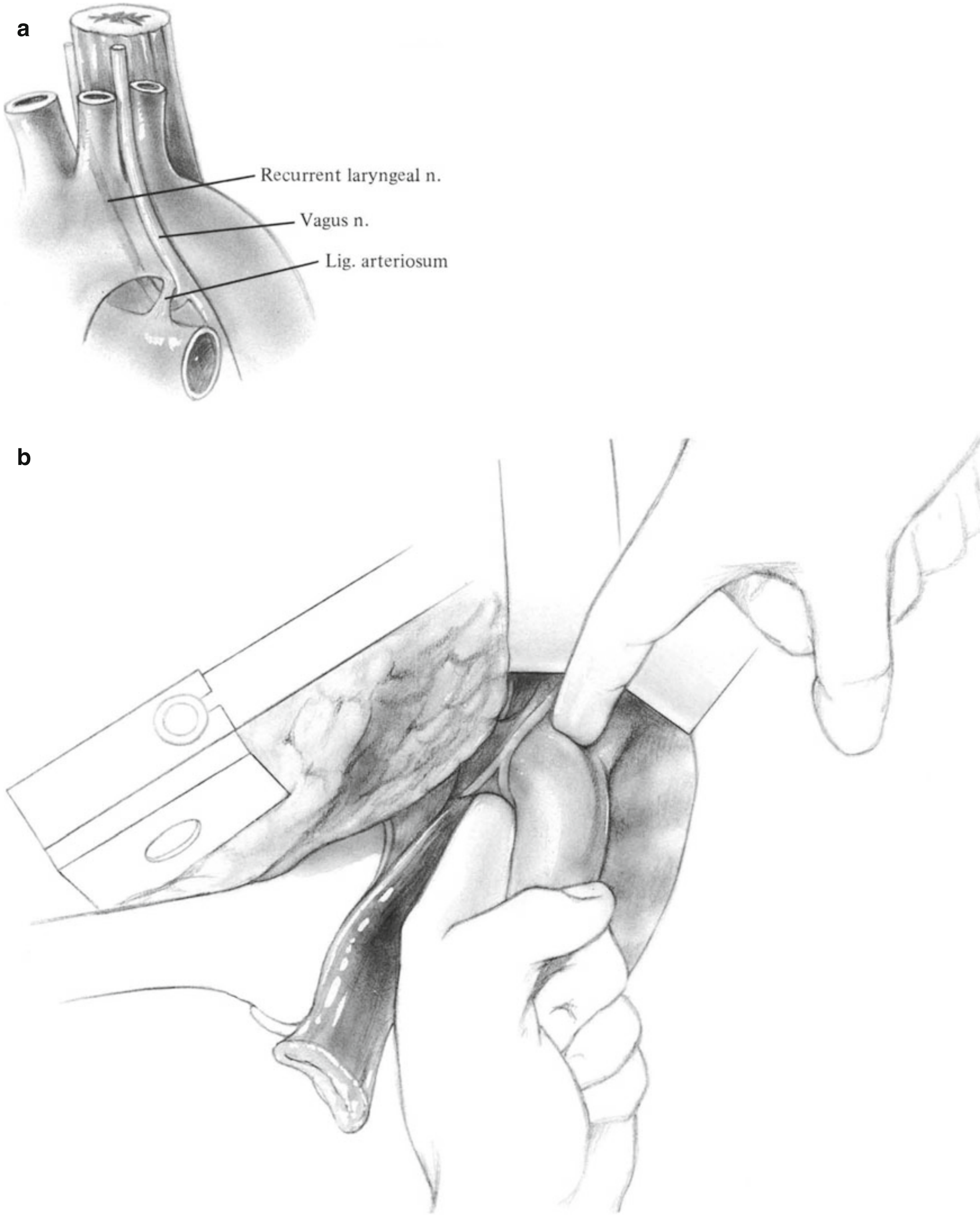
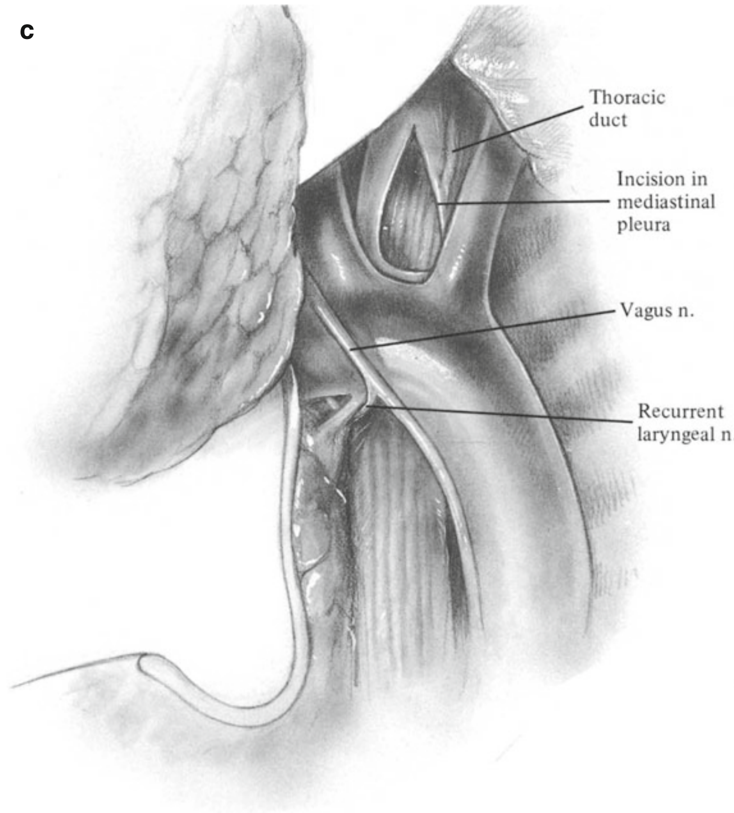


Fig. 15.26

Fig. 15.26 (continued)



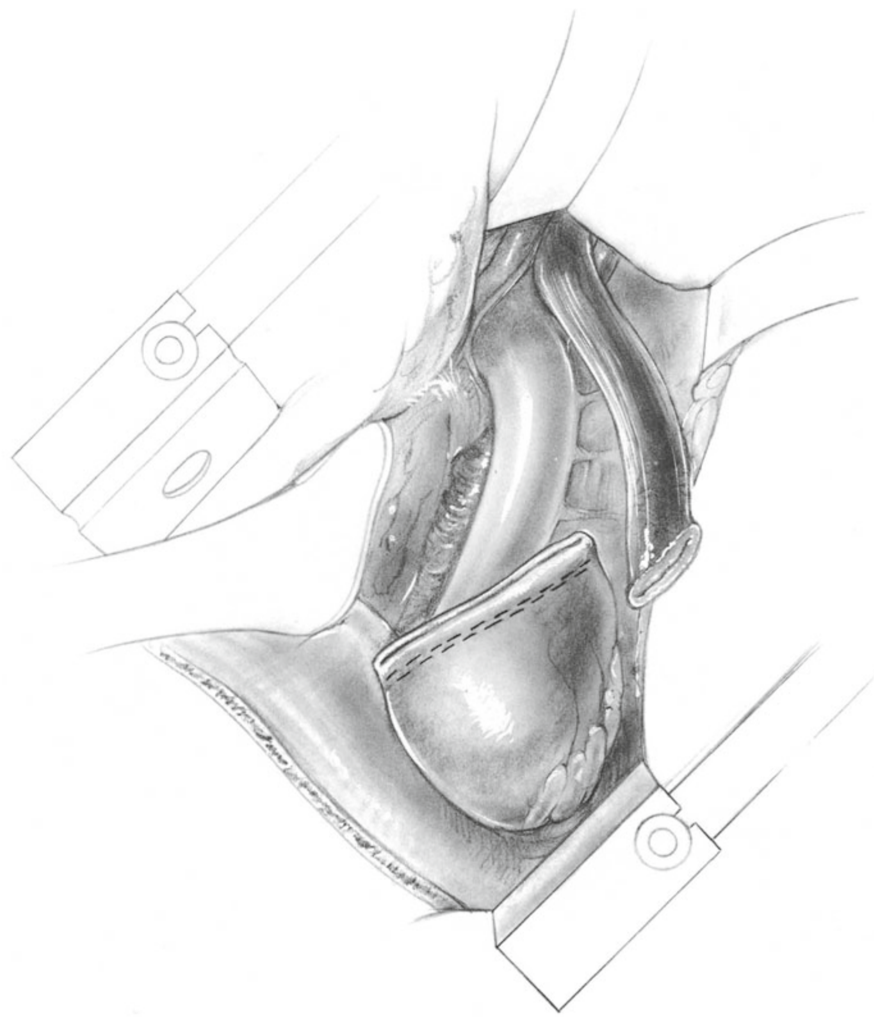


Fig. 15.27

carotid and subclavian arteries is narrow, bring the esophagus out through a pleural incision lateral to the subclavian artery.

The esophagogastric anastomosis, as described below, should be constructed in a position lateral and anterior to the aortic arch. Exposure for the anastomosis in this location is excellent. Bring the esophagus down over the anterior wall of the stomach for a sutured anastomosis. An overlap of 6–7 cm is desirable. If the esophageal dissection has been carried out without undue trauma, the esophageal segment has an excellent blood supply even though its distal 10 cm has been liberated from its bed in the mediastinum. The anastomosis can readily be performed as high as the apex of the thorax by this method, and a level of resection comparable to that achieved by adding a cervical incision can often be used. Use of the circular stapling technique to perform the anastomosis high in the chest is an excellent alternative to sutured intrathoracic or cervical anastomosis. For this technique, the stomach is placed in front of the esophagus for the end-to-side anastomosis.

Esophagogastric Anastomosis, Suture Technique

The technique for sutured esophagogastric anastomosis is described and illustrated in Chap. 14.

Esophagogastric Anastomosis, Stapling Technique (Surgical Legacy Technique)

In 1978, Chassin described a linear stapling technique for esophagogastric anastomosis. Although circular staplers are more commonly used currently, this method is still occasionally useful and applicable when other methods are difficult. It involves attaching the posterior aspect of the distal esophagus to the anterior wall of the stomach. It requires an overlap to enable 7–8 cm of the esophagus to lie freely over the front of the stomach. If a 7- to 8-cm overlap is not available, this stapling technique is contraindicated.

Make a stab wound, 1.5 cm long, on the anterior wall of the gastric pouch at a point 7–8 cm from the cephalad margin of the stomach (Fig. 15.28). Insert one fork of the cutting linear stapler through the stab wound into the stomach and the other fork into the open end of the overlying esophagus (Fig. 15.29). Insert the stapling device to a depth of 3.5–4.0 cm. Fire and remove the stapling device. This step leaves both the end of the esophagus and a large opening in the stomach unclosed (Fig. 15.30). The posterior layer of the anastomosis has already been accomplished by the stapling device. Complete the anastomosis in an everting fashion by triangulation with two applications of the 55-mm linear stapler. To facilitate this step, insert a 4-0 temporary guy suture through the full thickness of the anterior esophageal wall at its midpoint, carry the suture through the center of the remaining opening in the gastric wall (Fig. 15.31), and tie the suture. Apply Allis clamps to approximate the everted walls of the esophagus and stomach. Apply the first Allis clamp just behind termination of the first staple line on the medial side. Hold the suture and the Allis clamps so the linear stapler can be applied just underneath the clamps and the suture (Fig. 15.32). Tighten and fire the stapling device. Excise the esophageal and gastric tissues flush with the stapling device with Mayo scissors. Leave the guy suture intact.

Use an identical procedure to approximate the lateral side of the esophagogastric defect. Apply additional Allis clamps. Then place the 55-mm linear stapling device into position deep to the Allis clamps and the previously placed guy suture. Close and fire the stapler and remove the redundant tissue with Mayo scissors (Fig. 15.33). It is essential that a small portion of the lateral termination of the stapled anastomosis be included in the final linear staple line. Include the guy suture also in this last application of the linear stapler. These measures eliminate any possibility of leaving a gap between the various staple lines. Test the integrity of the anastomosis by inserting a sterile solution of methylene blue through the nasogastric tube into the gastric pouch. The appearance of the completed stapled anastomosis is shown in Fig. 15.34.

Whether a Nissen fundoplication is to be constructed following this anastomosis depends on the judgment of the surgeon and the availability of loose gastric wall. In some cases partial fundoplication can be done.

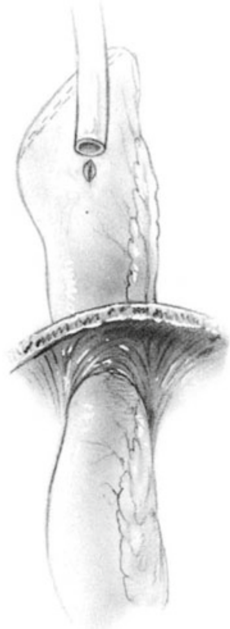


Fig. 15.28

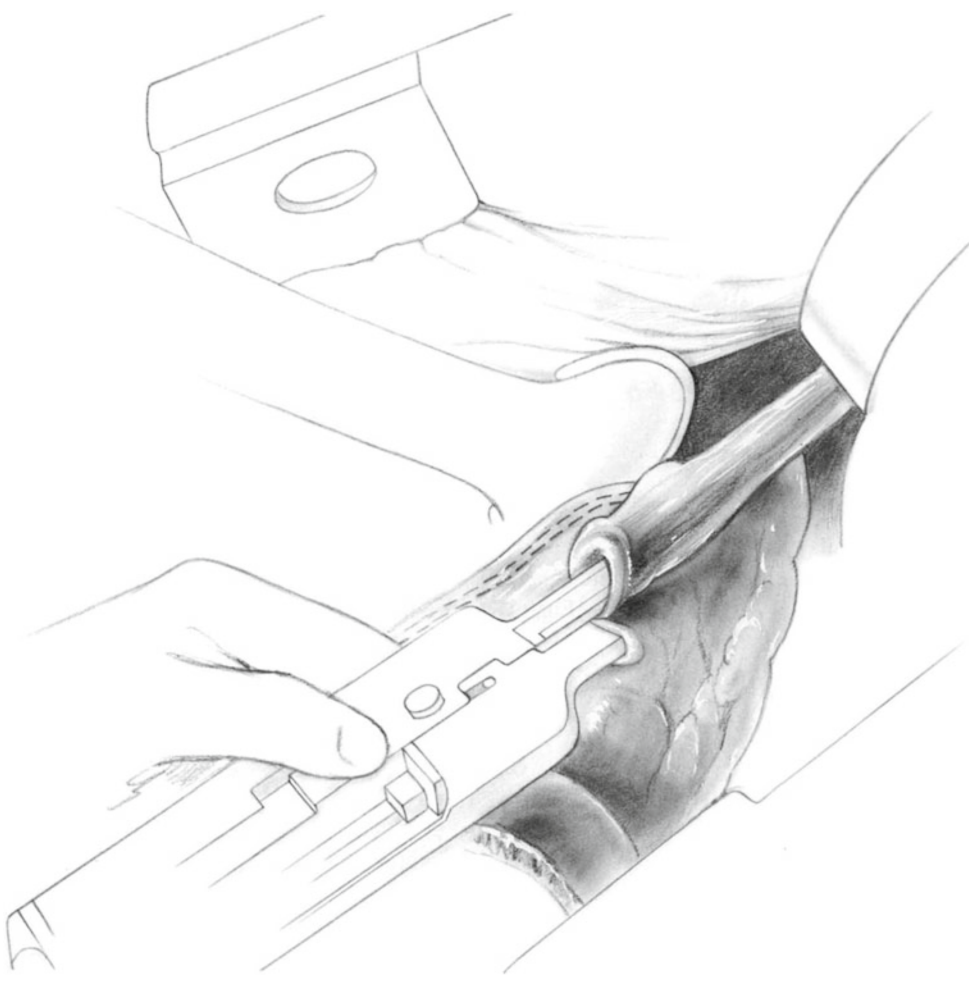
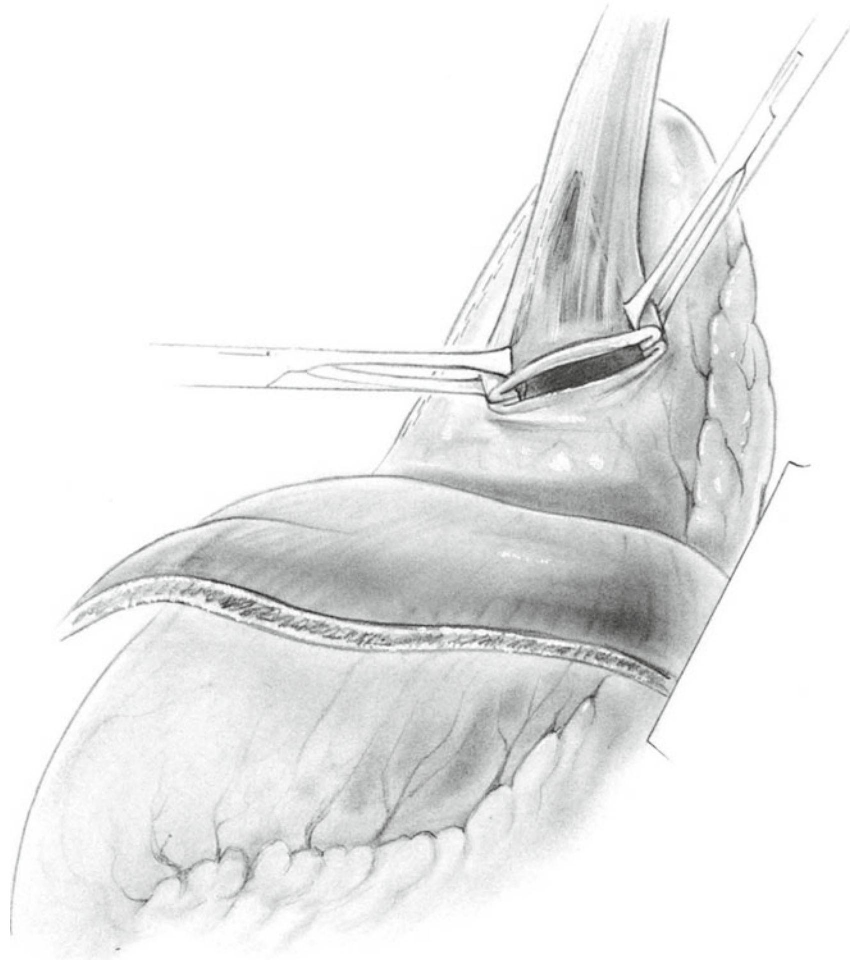


Fig. 15.29

Fig. 15.30



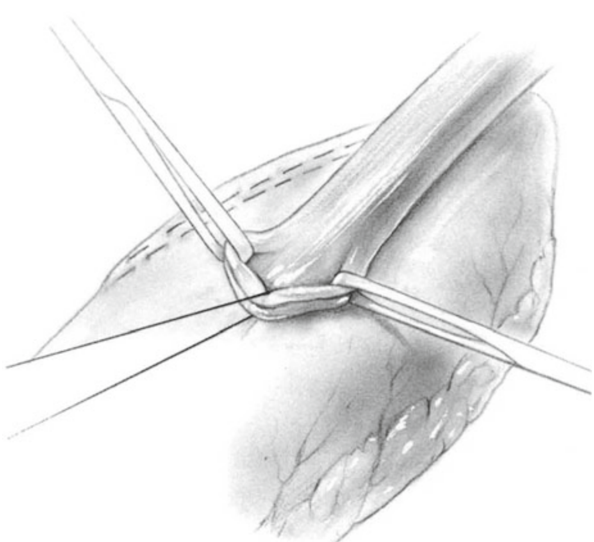


Fig. 15.31

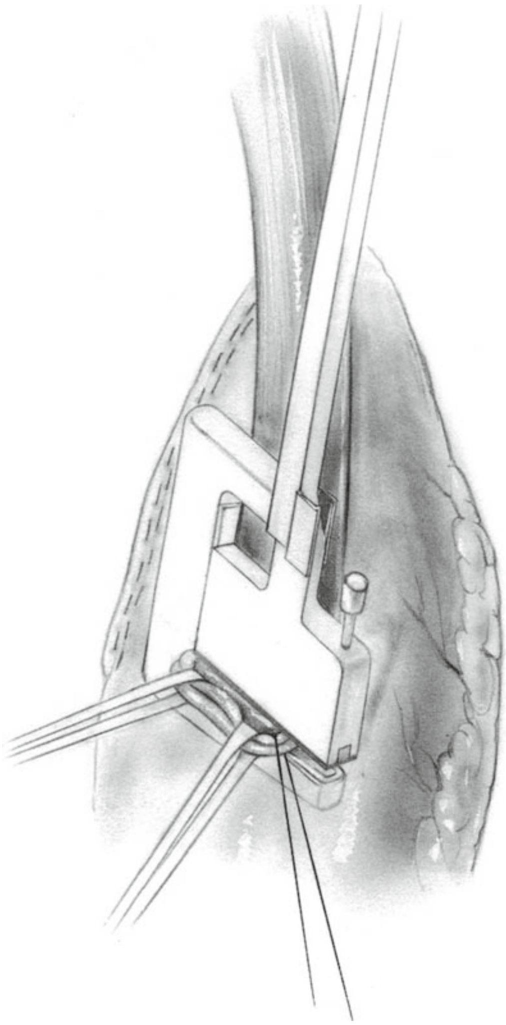


Fig. 15.32

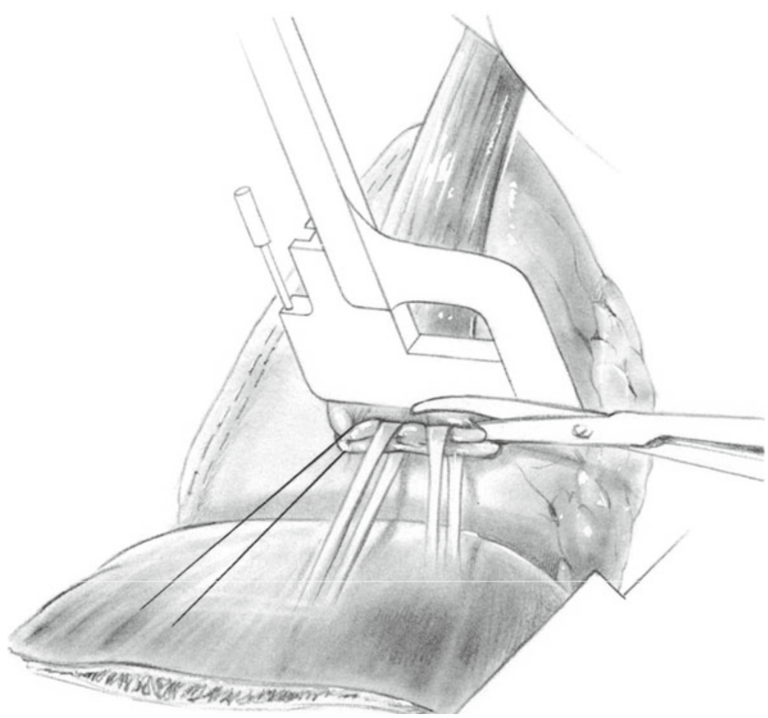


Fig. 15.33

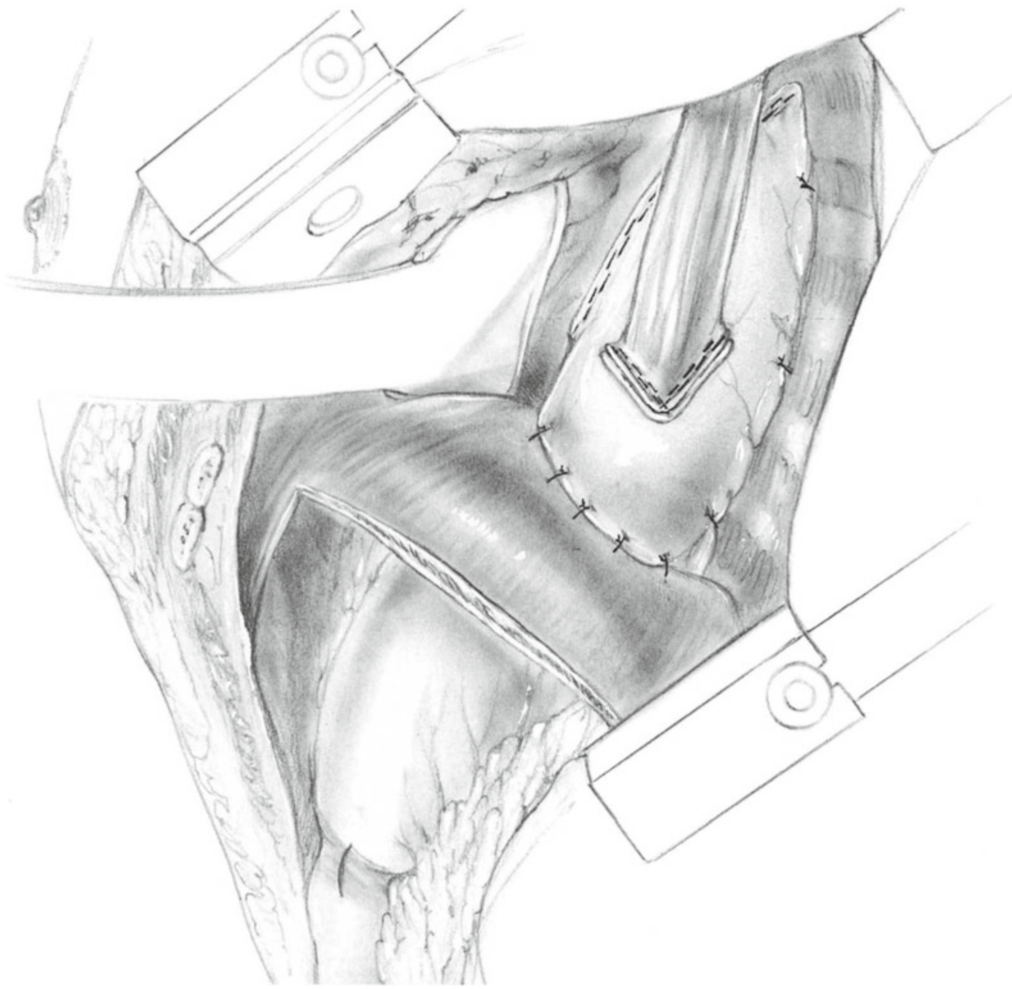


Fig. 15.34

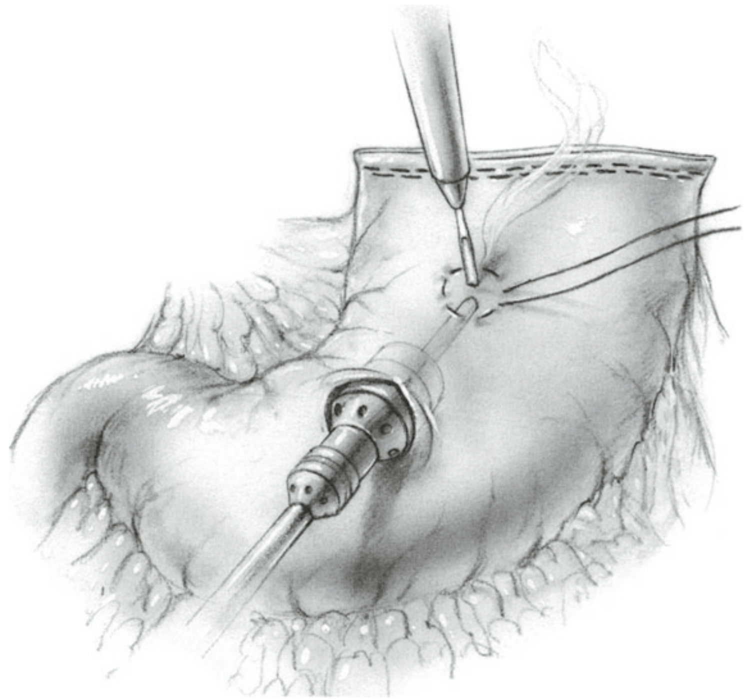
Esophagogastric Anastomosis Performed by Circular Stapling Technique

The circular stapling technique is especially suitable for patients in whom the lumen of the esophagus is large enough to admit a 28- or 31-mm circular stapling device. The esophageal lumen can be measured by attempting to insert sizers (which come in 25-, 28-, and 31-mm sizes). It is dangerous to stretch the esophagus with these sizers, because it can result in one or more longitudinal tears of the mucosa and submucosa. Gentle dilatation with a Foley catheter balloon is the safest way to achieve lumen of adequate size for anastomosis. Use a 16-F Foley catheter with a 5-cc balloon attached to a 20-cc syringe filled with saline. Insert the Foley catheter well above the site for anastomosis and inflate the balloon in 2.5-cc increments. Withdraw the inflated balloon slowly after each inflation. A 28-mm circular staple can almost always be inserted with ease (use the largest size that can be inserted easily). Place four long Allis clamps or guy sutures equidistant around the circumference of the esophagus to maintain a wide lumen and minimize difficulty with insertion of the stapler head.

If a tear is detected, resect an additional segment of the esophagus to remove the laceration. If the tear is not detected and a stapled anastomosis is constructed, postoperative leakage is a potentially dangerous complication.

Next, insert the 25-mm sizer and then the 28-mm sizer. If the 28-mm sizer passes easily, the circular stapling technique is a good one. If only the 25-mm sizer can be inserted, there is danger of postoperative stenosis when this size staple cartridge is used. Although this type of stenosis frequently responds well to postoperative dilatation, we prefer to utilize the alternative technique described above (Figs. 15.28, 15.29, 15.30, 15.31, 15.32, 15.33, and 15.34), which corrects for the narrow esophagus without requiring postoperative dilatation. Use a purse-string suture to tighten the esophagus around the shaft of the stapler. After inserting a 28- or 31-mm sizer, place one or two purse-string sutures of 0 or 2-0 Prolene, making certain to include the mucosa and the muscularis in each bite.

Fig. 15.35



The anastomosis can be done to the anterior or posterior wall of the stomach. We generally prefer to use the posterior wall if the anastomosis is high in the chest, as it allows an easy anterior hemifundoplication.

Make a 3-cm linear incision somewhere in the antrum of the gastric pouch utilizing electrocautery. Through this opening in the anterior wall of the gastric pouch, insert the cartridge of a circular stapling device after having removed the anvil.

Then choose a point 5–6 cm from the proximal cut end of the gastric pouch and use the spike of the stapler to puncture it. Advance the shaft as far as it will go and then insert a small purse-string suture of 2-0 Prolene around the shaft. Alternatively, place the purse-string suture first; then make a stab wound in the middle of it (Fig. 15.35) and permit the shaft of the circular stapler to emerge from the stab wound. Tie the purse-string suture around the shaft. Remove the spike. Gently insert the anvil of the device into the open end of the esophagus. Draw the esophagus down over the anvil. When this has been accomplished, tie the purse-string suture around the instrument's shaft, fixing the esophagus in position (Fig. 15.36). Ensure that there is no axial rotation of the stomach. Now attach the anvil to the shaft of the device and approximate the anvil to the cartridge of the circular stapling device by turning the wing nut in a clockwise direction to the indicated tightness. Be certain that the purse-string suture fits snugly around the shaft and that it does not catch on grooves in the shaft. After this has been accomplished, fire the stapling device.

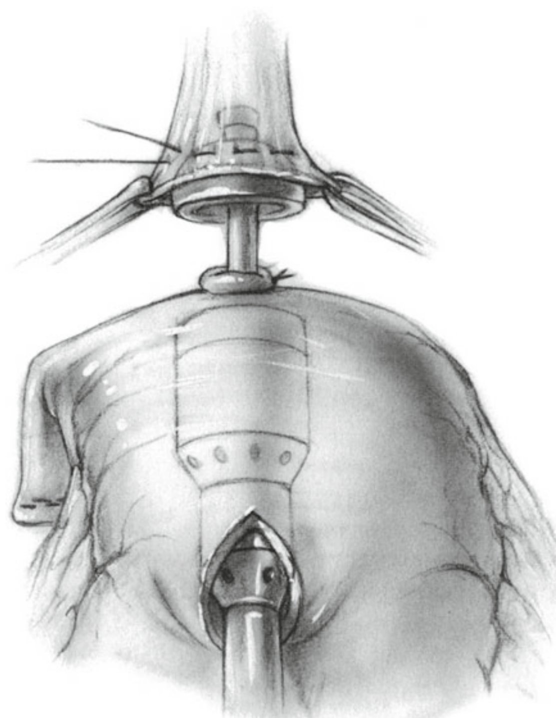


Fig. 15.36

Now rotate the wing nut the appropriate number of turns in a counterclockwise direction, gently disengage the anvil from the newly created anastomosis, and remove the entire device from the gastric pouch. Carefully inspect the newly

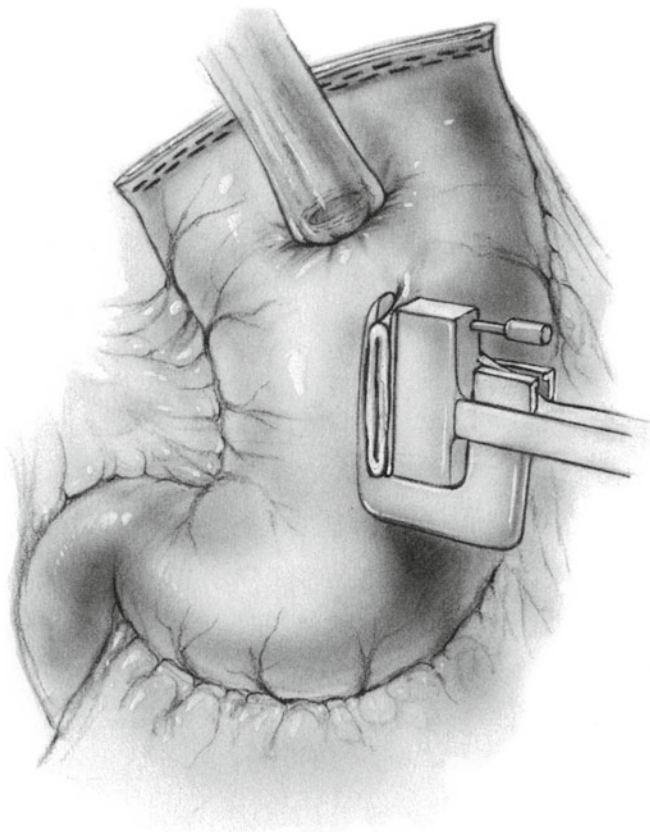


Fig. 15.37

constructed circular anastomosis between the open end of the esophagus and the gastric pouch to see that all the staples have fired and that the anastomosis is intact. Confirm this by inserting the index finger through the previously made gastrotomy incision and pass the finger into the esophagus, confirming the presence of an open lumen. Now apply Allis clamps to the gastrotomy incision on the anterior wall of the gastric pouch. Apply a linear stapling device for thick tissue (4.8 mm) and fire. Excise any redundant gastric tissue, remove the stapler, and lightly electrocoagulate bleeding vessels. Carefully inspect the staple line to be sure all of the staples have closed. Many surgeons oversew the gastrotomy incision with a layer of continuous or interrupted Lembert sutures of a nonabsorbable nature, although this step may not be essential if 4.8-mm staples are used (Fig. 15.37). Do not convert the linear gastrotomy to a transverse closure as you would for a pyloroplasty because it increases tension on the suture line.

Muehrcke and Donnelly reported four leaks from stapled gastrotomies in 195 patients undergoing esophageal resection using circular stapling instruments. A possible explanation for failure of the stapled gastrotomy closure to heal properly is the use of a 3.5-mm staple. In a stomach of normal thickness, using a small staple can produce a line of necrosis. We prefer that a 4.8-mm staple be used when closing the stomach. These authors found that there was a reduction in the leak rate from their gastrotomy closures if they oversewed the gastrotomy staple line with a continuous noninverting layer of 3-0 Mersilene. We have used a 4-0 polypropylene running, inverting seromuscular suture to cover the staple line and have seen leaks only .when this step was omitted.

Stabilizing the Gastric Pouch

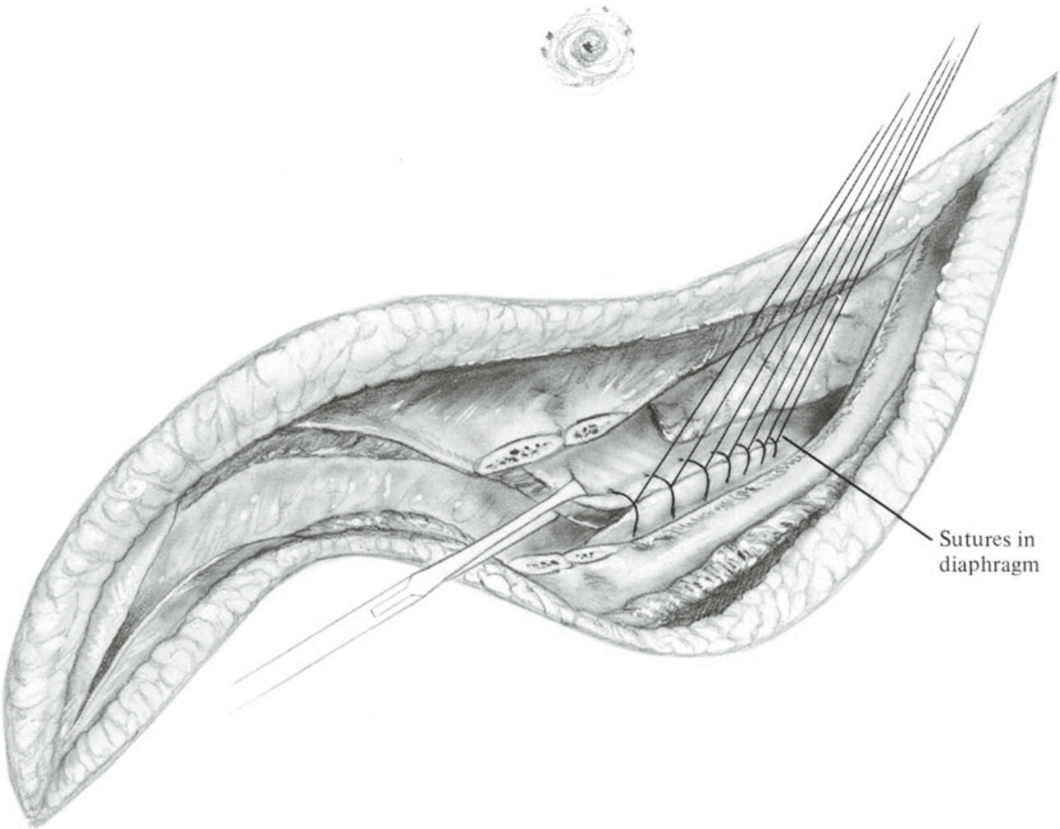
To prevent any gravity-induced tension on the anastomosis, the apex of the gastric pouch should be sutured to the mediastinal pleura or the prevertebral fascia with 2-0 or 3-0 nonabsorbable sutures. The gastric pouch should then be fixed to the enlarged diaphragmatic hiatus with interrupted 2-0 or 3-0 nonabsorbable sutures, which attach the gastric wall to the margins of the hiatus (Fig. 15.34). These sutures should be 2 cm apart and should not penetrate the gastric mucosa lest they induce a gastropleural fistula. Consider performing a jejunostomy for immediate postoperative enteral alimentation.

Closure

Irrigate the thoracic and abdominal cavities and close the incision in the diaphragm with interrupted sutures of 2-0 Tevdek or a running suture of 0 monofilament (Fig. 15.38). In either case, take fairly large (1 cm) bites, as dehiscence of this suture line can have serious consequences, such as herniation of small intestine into the chest. Do not try to complete this closure until the costal margin has been approximated to avoid tearing the diaphragm.

Excise approximately 1 cm of cartilage from the costal margin to improve apposition (Fig. 15.39). Close the incision in the costal margin with one or two sutures of monofilament stainless steel wire (Fig. 15.40). Either 2-0 or no. 5 wire may be used. Insert four or five pericostal sutures of no. 1 PDS to approximate the ribs (Fig. 15.41). Bring a 30-F chest tube through the ninth intercostal space in the anterior axillary line and carry it up to the level of the anastomosis. Place it under direct vision. If it does not sit comfortably, suture it to the parietal pleura posterior to the aorta using fine absorbable sutures. Inflate the lung to eliminate any atelectatic patches. If a significant number of air leaks from the lung are noted, pass a second chest catheter anterior to the lung up to the apex of the thorax. Tie the pericostal sutures and the final diaphragm sutures and close the muscles in two layers with a continuous 2-0 or 0 PG atraumatic synthetic absorbable suture in each (Figs. 15.42 and 15.43).

Fig. 15.38



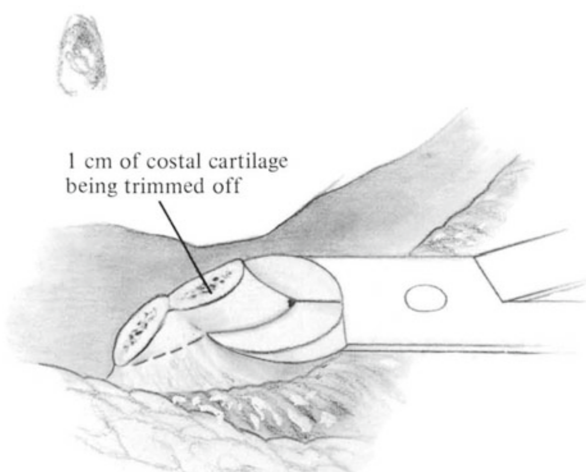
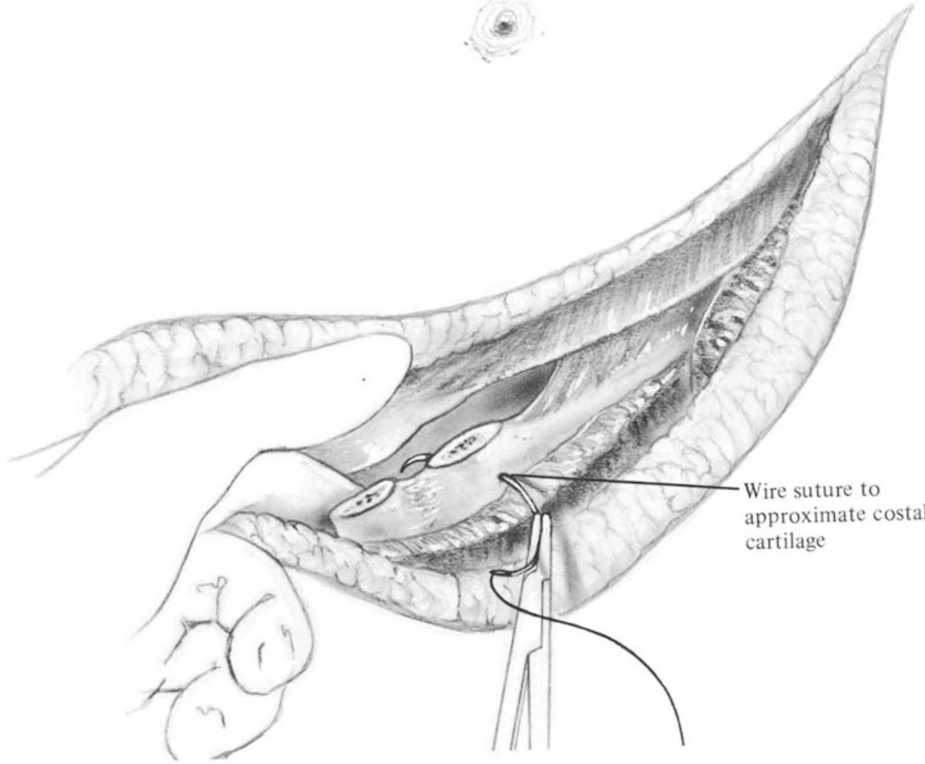


Fig. 15.39

Fig. 15.40



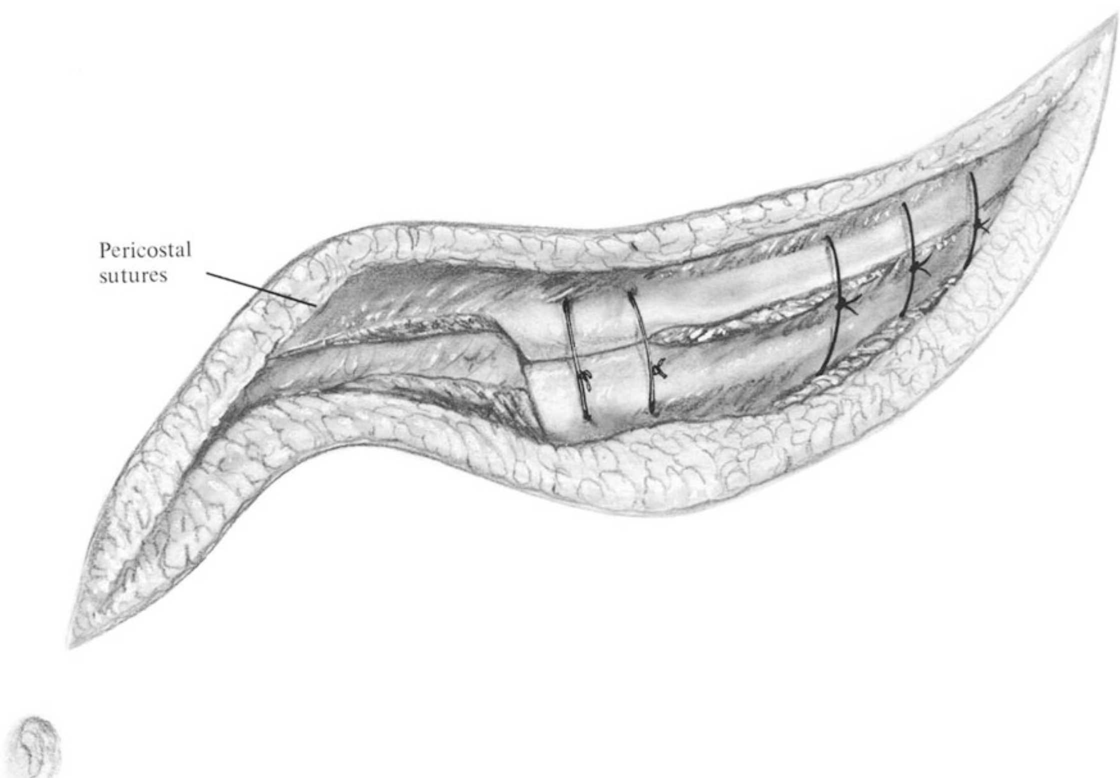


Fig. 15.41

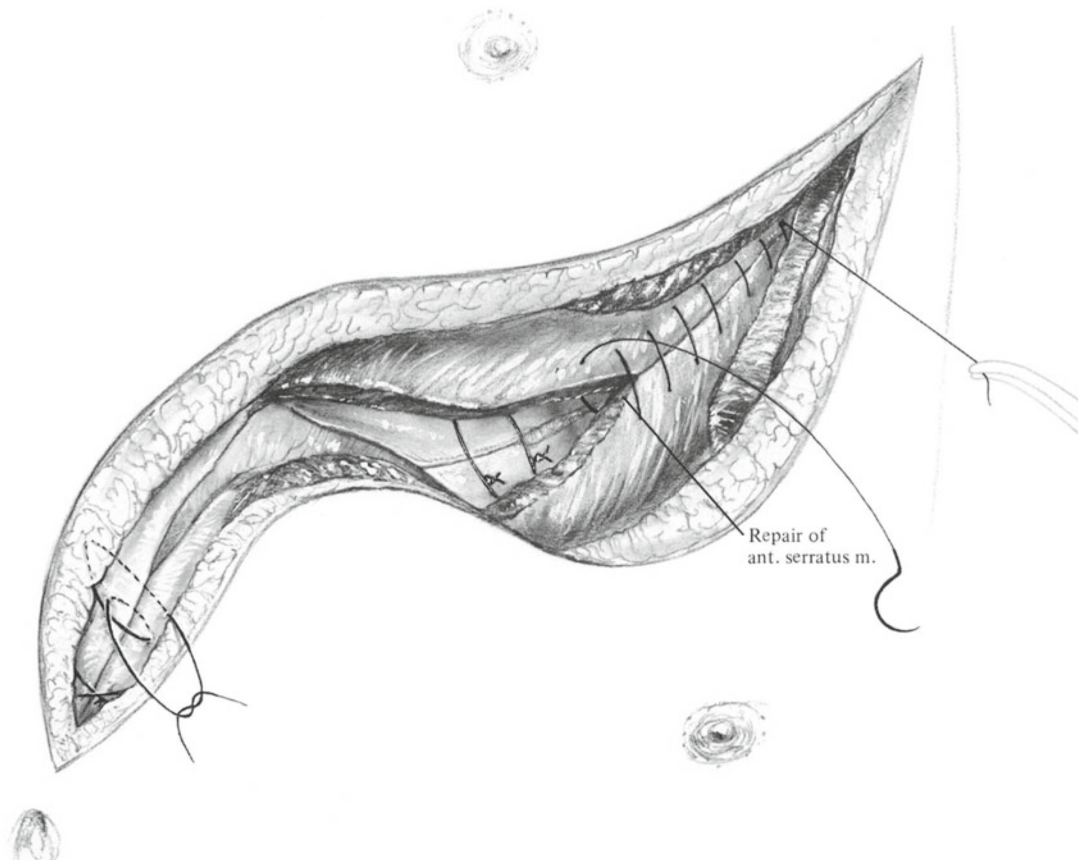


Fig. 15.42

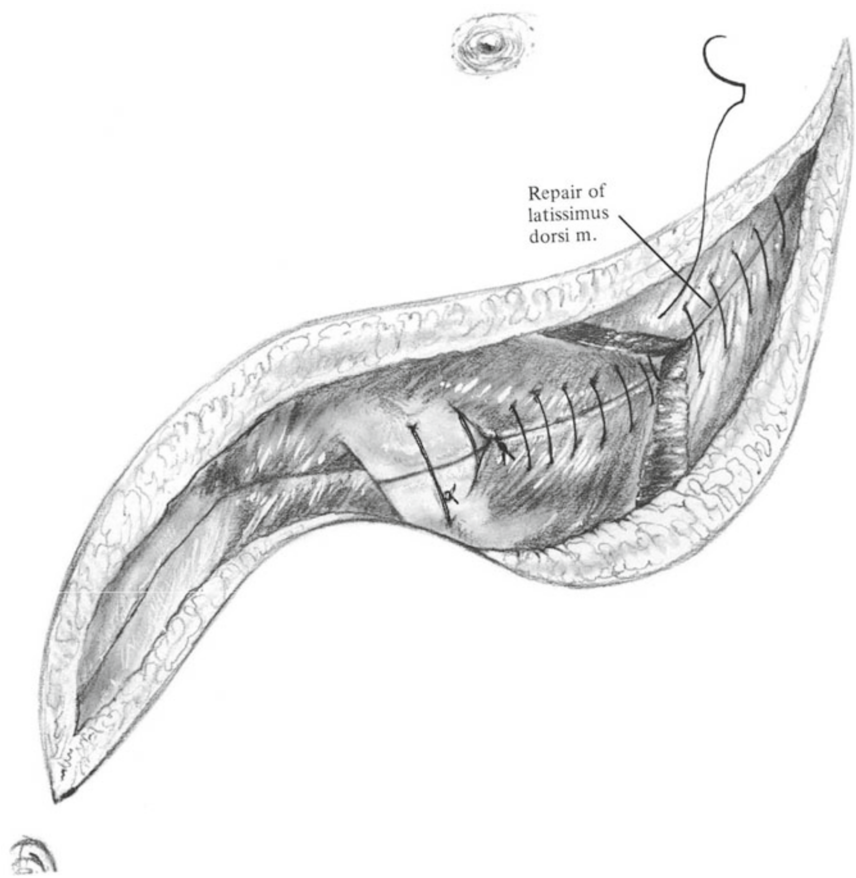


Fig. 15.43

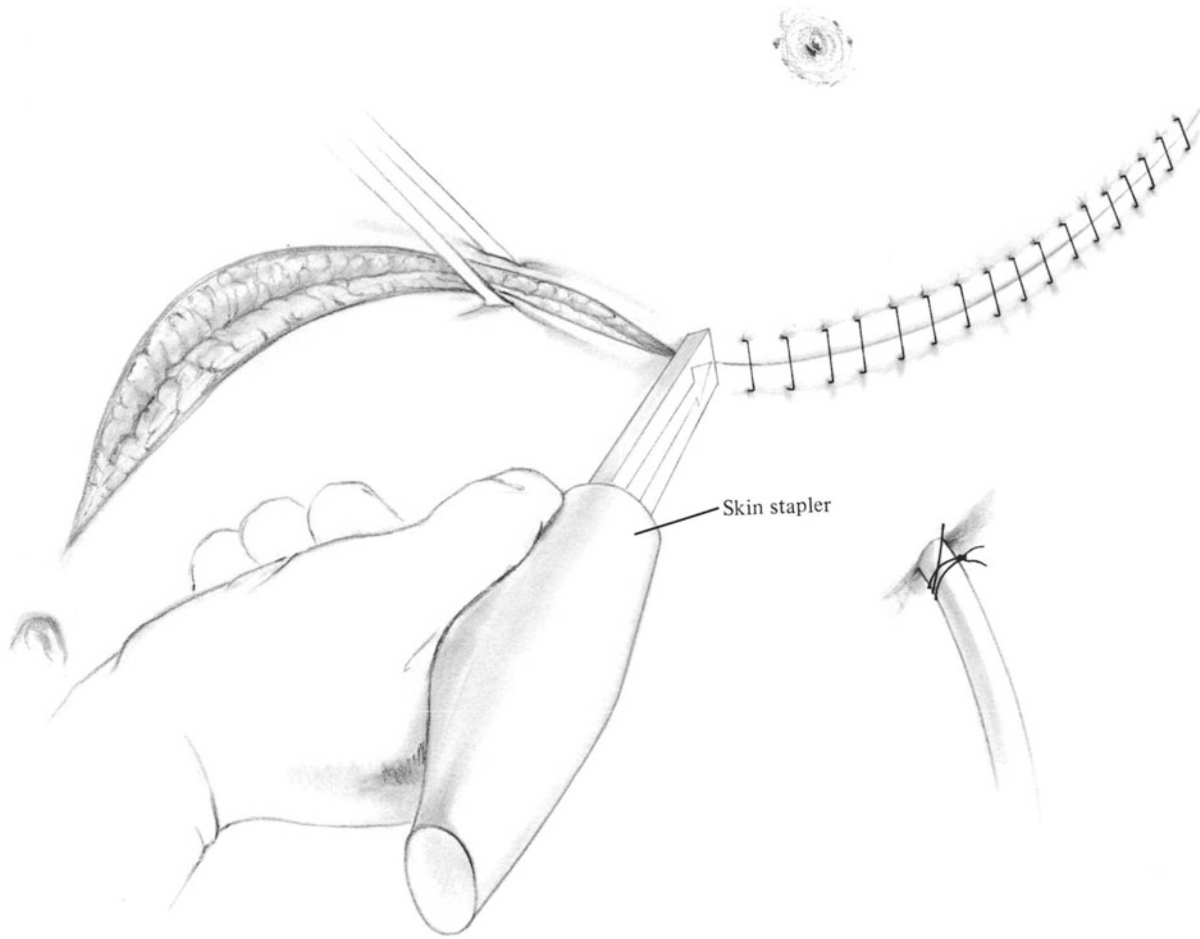


Fig. 15.44

Close the abdominal portion of the incision with interrupted no. 1 PDS Smead-Jones sutures as described in Chap. 3. The diaphragm is continuous with the endoabdominal fascia, and separate closure of this layer to meet the diaphragmatic closure facilitates closure of both diaphragm and abdominal wall. Use staples or a subcuticular suture to close the skin (Fig. 15.44). No drains should be needed in the abdominal cavity.

Postoperative Care

See Chap. 14.

Complications

See Chap. 14.

Further Reading

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Transshiatal Esophagectomy

16

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Carcinoma of the esophagus
Barrett's esophagus with severe dysplasia
Esophageal stricture
Achalasia
Perforation

Preoperative Preparation

See Chap. 14.
Prepare for possible massive blood loss during the blunt phase of the thoracic dissection.
Prepare a single-lumen endotracheal tube, not cut short.
Consider hemodynamic monitoring.

Pitfalls and Danger Points

Excessive bleeding
Laceration of membranous trachea
Injury to spleen
Hypotension during mediastinal dissection due to compression of the heart
Trauma to thoracic duct, chylothorax
Traction injury or laceration of the recurrent laryngeal nerve
Bowel herniation through a too large diaphragmatic hiatus
Undetected pneumothorax
Ischemia or trauma to tip of gastric tube in the neck inducing necrosis and sepsis
Anastomotic leak
Inadvertent laceration of right gastroepiploic artery

Operative Strategy

Although a large portion of this operation is accomplished by blunt dissection, there are five areas where dissection must be performed with consummate delicacy to avoid devastating complications.

1. *Membranous trachea*. A small linear laceration of the membranous trachea can be repaired by suturing. However, if a patch of the membranous trachea is avulsed while dissecting an esophageal cancer that has invaded the trachea, adequate repair may be impossible. In the absence of a malignancy in the area of the trachea, dissection of the esophagus away from the trachea should not be difficult if carried out in a gentle manner.
2. *Right gastroepiploic artery*. While dissecting the omentum away from the gastroepiploic artery, continually keep in mind that this vessel constitutes the major blood supply to the tip of the gastric tube to be constructed. In many areas this vessel is covered by omental fat so its exact location is not obvious to the naked eye. Consequently, when dividing the omentum, leave a few centimeters of omentum attached to the artery, as inadvertent division of this vessel makes the stomach useless as an esophageal substitute.
3. *Gastric tip*. Be aware that the gastroepiploic artery does not continue to the tip of the gastric tube. Beyond the termination of this artery, the blood supply to the gastric tip consists of intramural circulation. Although this circulation is *normally* adequate to sustain the healing process of the gastroesophageal anastomosis in the neck, *unneces-*

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sary trauma to this area can threaten this precarious anastomosis. Consequently, be aware throughout the operation that this tissue must be protected from rough handling. Even inserting a suture between the gastric tip and the prevertebral fascia in the neck has been reported to have caused focal necrosis of the stomach and a gastric fistula with vertebral osteomyelitis. If an anchoring stitch is considered necessary, use 5-0 PG suture material, do not place the suture too deeply, and do not tie a tight knot.

4. *Recurrent laryngeal nerve*. Aside from hoarseness, damage to the left recurrent laryngeal nerve during the cervical dissection can also result in swallowing difficulty and aspiration. Use the assistant's index finger rather than a rigid instrument to retract the trachea and the thyroid gland.
5. *Azygos vein*. Laceration or avulsion of the azygos vein results in massive hemorrhage that in most cases requires right thoracotomy for control. Avoid this by careful preoperative staging and careful dissection at the point where the azygos vein crosses the esophagus.

Documentation Basics

Coding for esophageal procedures is complex. Consult the most recent edition of the AMA's Current Procedural Terminology book for details (see references at the end). In general, it is important to document:

- Findings
- Stapled or sutured anastomosis?
- Pyloromyotomy or not?

Operative Technique

Place the patient in a supine position on the operating table and insert bilateral intravenous catheters and one intra-arterial catheter, which permit continuous monitoring of the patient's blood pressure. Both arms are padded and aligned alongside the body. If a central venous pressure or a Swan-Ganz catheter is to be used, insert it into the right internal jugular vein, as the left side of the neck is preserved for the esophagogastric anastomosis. Request that the anesthesiologist use a standard endotracheal tube of standard length that has not been shortened. If the membranous trachea is inadvertently lacerated, the anesthesiologist can then advance the tip of the endotracheal tube into the left main bronchus. After the balloon is inflated, this maneuver enables the anesthesiologist to control the patient's respiration while repair of the laceration is attempted. Place a small blanket roll under the upper thorax to keep the neck extended.

Turn the head to the right. Attach a self-retaining Thompson, Omni, or similar retractor to the operating table for later use (see Chap. 11).

Abdomen

Make a midline incision from the xyphoid to a point a few centimeters distal to the umbilicus, and enter the abdominal cavity. Check the stomach carefully to ascertain that it is indeed suitable for the development of a gastric tube that reaches up into the neck. Check the celiac lymph nodes for metastases. Liberate the left lobe of the liver by incising the triangular ligament. Expose the spleen and divide any adhesions that involve the capsule of the spleen, so the short gastric and left gastroepiploic vessels are easily identified. Insert the Weinberg blade of the Thompson retractor underneath the sternum and retract the liver in a cephalad direction, exposing the esophageal hiatus. Thereupon free the lower esophagus and divide the gastrophrenic ligament as described in Figs. 14.7, 14.8, 14.9, 14.10, and 14.11. Encircle the esophagus with the index finger and then with a 2 cm wide Penrose drain. Divide the right and left vagus nerves. Apply caudad traction to the esophagus via the Penrose drain and free up the lower esophagus by blunt dissection. If the tumor can be reached by digital palpation, ascertain that it is not fixed to the aorta or vertebral column. If it is fixed, transhiatal esophagectomy without thoracotomy is contraindicated. If not, expose the gastric cardia and then carefully divide and ligate each of the short gastric vessels as well as the left gastroepiploic artery.

Divide the greater omentum serially between Kelly clamps leaving 3–5 cm of omentum attached to the right gastroepiploic arcade to avoid injury to the gastroepiploic artery. Remember that this vessel will be the main blood supply to the gastric conduit (see Fig. 14.12a–b).

Elevate the greater curvature of the stomach in a cephalad direction and identify the origin of the left gastric artery. Divide and ligate it as described in Fig. 14.13 and then perform an extensive Kocher maneuver (see Figs. 14.14, 14.15, and 14.16). Perform a pyloromyotomy (see Figs. 14.17, 14.18, and 14.19). Cover the abdominal incision with sterile towels and start the neck operation.

Cervical Dissection

Expose and mobilize the cervical esophagus as described in Chap. 14. Encircle the esophagus with a Penrose drain and apply cephalad traction. Use the index finger with the volar aspect of the fingers facing the esophagus to dissect the esophagus away gently from the overlying trachea and the posterior prevertebral fascia. With this dissection, the index finger can reach down almost to the carina of the trachea.

Transhiatal Dissection

Wear a headlamp for this phase of the operation. Adjust the Thompson retractor to elevate the sternum and liver. Enlarge the hiatal opening by incising the diaphragm with electrocautery in an anterior direction through the middle of the central tendon, dividing and ligating the transverse phrenic vein during this step. Dissect the central tendon away from the pericardium. If necessary, insert a flat malleable retractor behind the heart and elevate gently. Push the right and left diaphragmatic pleurae laterally to improve exposure. Palpate the esophagus and the tumor. Determine that they are flexible and mobile and that there are no points of tumor invasion that would make resection without thoracotomy inadvisable. Before embarking on further dissection, pass a 28F Argyle Saratoga suction catheter into the neck incision and then down into the lower mediastinum to facilitate evacuation of blood from the surgical field.

Despite the limited exposure allowed by the transhiatal approach, the transhiatal esophagectomy is neither a blind nor a crude operation. Dissection of the esophagus from the diaphragm to the arch of the aorta is performed under direct vision. Exposure can be enhanced by inserting long, narrow retractors along the lateral aspects of the hiatal aperture. Many of the vascular attachments to the esophagus can be divided and occluded by hemostatic clips or ligatures. When dissecting the esophagus in the mediastinum, make no special effort to excise any pleura or lymph nodes. The strategy of the operation is to separate the surrounding anatomy from the esophageal tube as efficiently as possible. When dissecting the esophagus along its posterior surface, keep the hand flat against the vertebral column. Orringer et al. stated that entry into one or both pleural cavities occurs in 75 % of patients during this operation. After the esophagus has been removed from the mediastinum, and before the stomach is brought into the chest, examine the pleura visually and by palpation. If a tear has occurred, insert an appropriate chest tube to prevent a postoperative tension pneumothorax.

After the lower esophagus has been mobilized, insert a small sponge on a long sponge holder ("sponge on a stick") along the prevertebral fascia in the neck behind the esophagus while the other hand is placed behind the esophagus in the mediastinum (Fig. 16.1). When the sponge-stick meets the hand, the posterior dissection of the esophagus has been completed. Try not to compress the heart unduly with the hand in the prevertebral space. Remind the anesthesiologist to monitor the arterial pressure carefully during this dissection. Now remove the sponge-stick from the neck. With the assistant exerting traction in a caudal direction on the Penrose drain encircling the esophagogastric junction, place the hand, palm down, on the anterior surface of the esophagus and with finger dissection free the esophagus from overlying pericardium and carina. With the other hand, insert one or two fingers, volar surface down, over the anterior face of the esophagus in the neck while cephalad traction is being applied to the Penrose drain encircling the cervical esophagus. Working with both hands simultaneously, disrupt the filmy attachments between the esophagus and the membranous trachea – left main stem bronchus. After this has been accomplished, there remain lateral attachments to be disrupted before the esophagus is freed. Again retract the upper esophagus in a cephalad direction and separate the esophagus from these attachments until the upper 8 cm of thoracic esophagus is freed circumferentially. Now insert the hand into the hiatus and slide upward along the anterior esophagus behind the trachea until the circumferentially freed upper esophagus is contacted. Trap the esophagus against the vertebral column between the index and middle fingers. Then

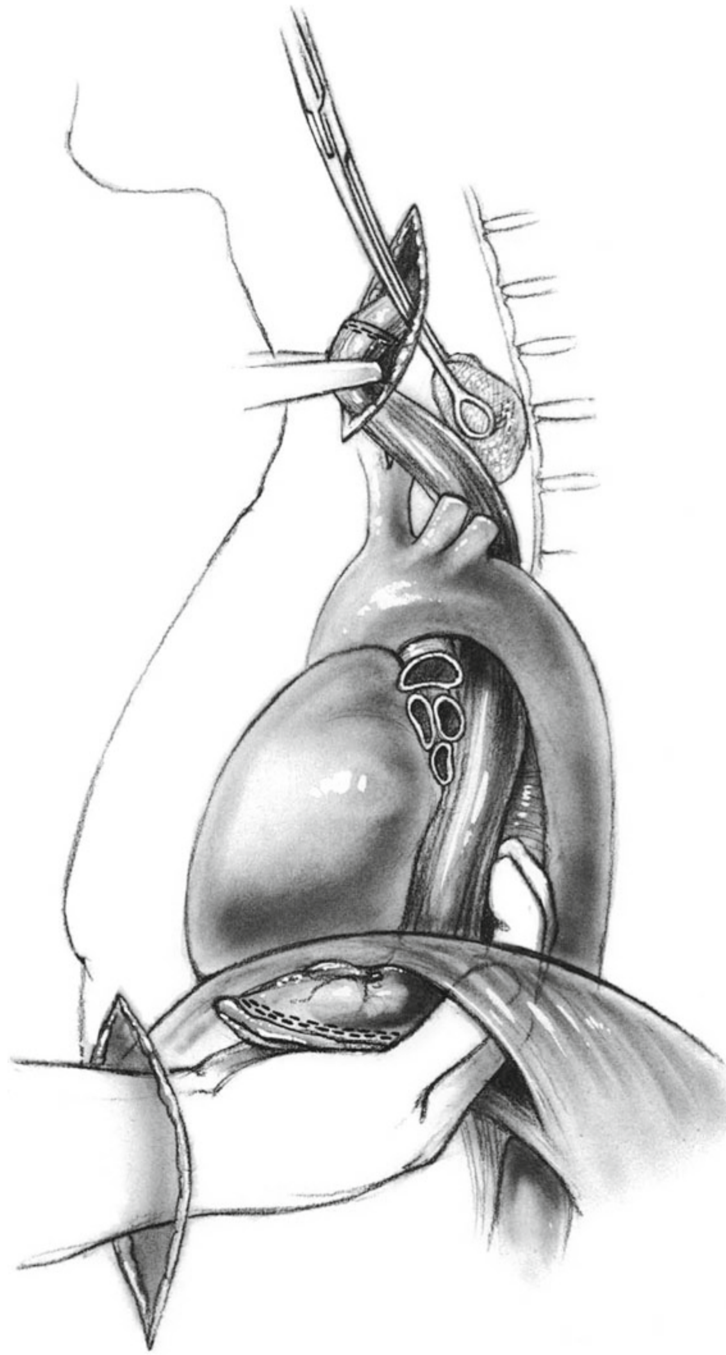


Fig. 16.1

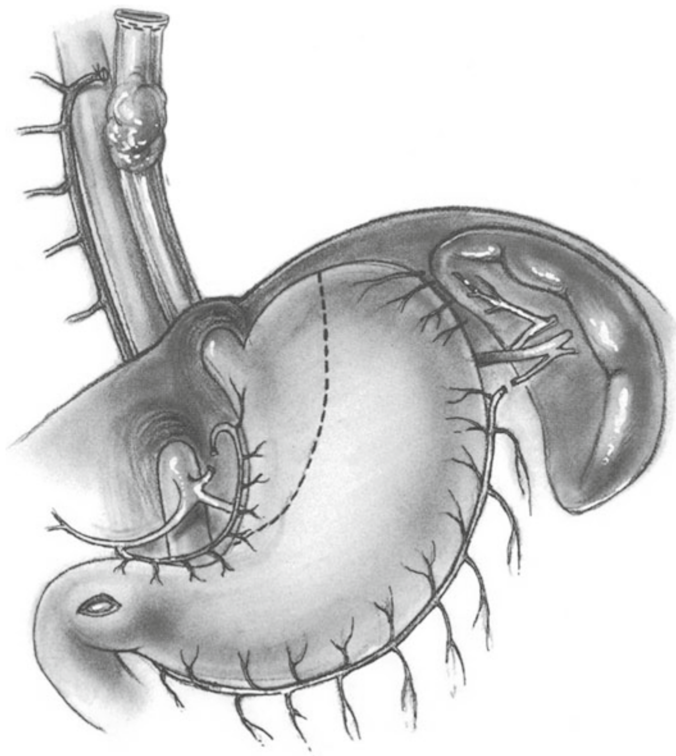


Fig. 16.2

with a downward raking motion, avulse the lateral attachments until the esophagus has been completely mobilized.

Deliver 7–8 cm of thoracic esophagus into the neck and transect the esophagus with a linear cutting surgical stapler. This maneuver provides a few centimeters of extra esophagus, allowing the option of selecting the best length when the anastomosis is performed.

Suture a long 2 cm wide Penrose drain to the distal end of the divided esophagus. Apply a hemostat to the proximal end of the drain in the neck. Draw the thoracic esophagus down into the abdomen. Then cut the drain and apply a hemostat to the proximal cut end in the abdomen. This drain with its two identifying hemostats is later used to draw the stomach up through the posterior mediastinum into the neck.

Insert two narrow retractors into the mediastinum and retract laterally. Inspect the mediastinum for any laceration of the pleura. If a laceration is encountered, insert a 32F chest tube into the chest cavity on the side of the laceration, in the midaxillary line. Then insert moist gauze packing into the mediastinum to help achieve hemostasis while the stomach is being prepared.

Exteriorize the stomach and attached esophagus by spreading it out along the patient's anterior chest wall. Because the blood supply to the lesser curvature subsequent to ligation of the left gastric artery is poor (Akiyama), the lesser curvature is excised, converting the stomach into a tubular structure (Fig. 16.2). Manually stretch the proximal tip of the cardia in a cephalad direction. Observe the esophagogastric junction and note where the second or third branch down of the left gastric artery enters the lesser curvature. At this point, apply the linear cutting stapler and aim it in a cephalad direction toward the cardia. While continuing to apply cephalad traction on the cardia, fire the stapler. Sequentially reapply and fire the stapler until the lesser curvature has been amputated, leaving about 6–8 cm width of cardia intact at the gastric tip (Fig. 16.3). Remember that

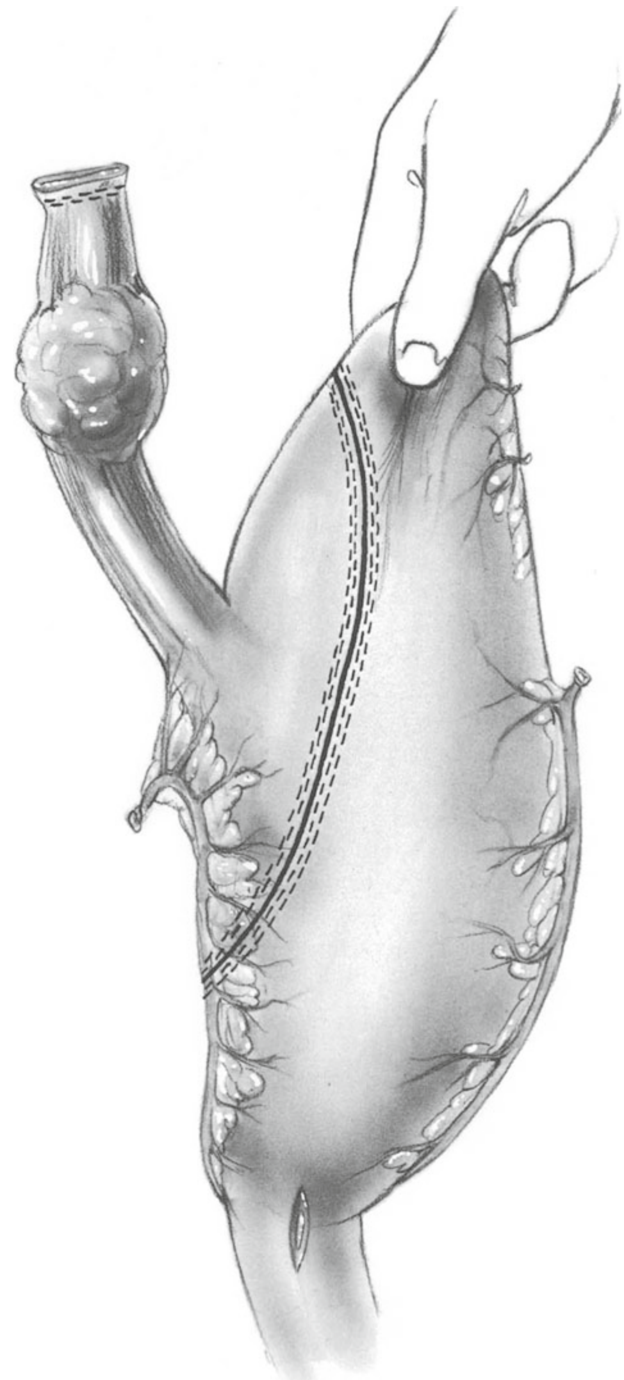


Fig. 16.3

with each application of the stapler, a small portion of the previous staple line must be included. Now invert the entire staple line by means of a continuous 4-0 Prolene Lembert suture. Remove the identifying hemostat from the previously positioned Penrose drain that was brought down from the neck into the mediastinum. Suture this Penrose drain to the most cephalad point of the gastric cardia using 3-0 silk sutures. Leave a 4–5 cm tail on the medial suture to identify the lesser curvature side of the gastric tube. Place gentle cephalad traction on the proximal end of the Penrose drain that remains in the cervical incision while using the right hand to maneuver the gastric tip gently through the hiatus and into the posterior mediastinum until the stomach has been manipulated into the neck. To avoid the possibility of gastric torsion, be certain that the staple line along the lesser curvature is located to the patient's right and the greater curvature to the patient's left. The long-tailed suture at the junction of the Penrose drain and the gastric cardia identify the medial aspect of the gastric tube. Confirm the absence of torsion by inserting the right hand through the hiatus and palpating the anterior surface of the stomach up to the aortic arch and with the left hand from the cervical approach. With both hands, deliver the gastric tip up to the apex of the cervical incision. Insert several sutures of 5-0 Vicryl to attach the gastric fundus to the fascia of the longus colli muscles on both sides of the neck. Do not take deep bites of stomach or tie the sutures so tight that necrosis of the gastric wall occurs.

Return to the abdomen and close the incision in the diaphragm with interrupted 2-0 silk sutures but do not constrict the newly formed hiatus to the point where it obstructs venous return from the gastric tube. Leave about three fingers' space between the diaphragm and the stomach. Then insert enough interrupted 3-0 silk sutures between the muscle surrounding the hiatus and the stomach to prevent the possibility of bowel herniating through the newly formed diaphragmatic hiatus. Cover the pyloromyotomy with omentum. Perform a feeding needle catheter jejunostomy in the proximal jejunum. Close the abdominal incision and then return to the neck to perform the esophagogastric anastomosis.

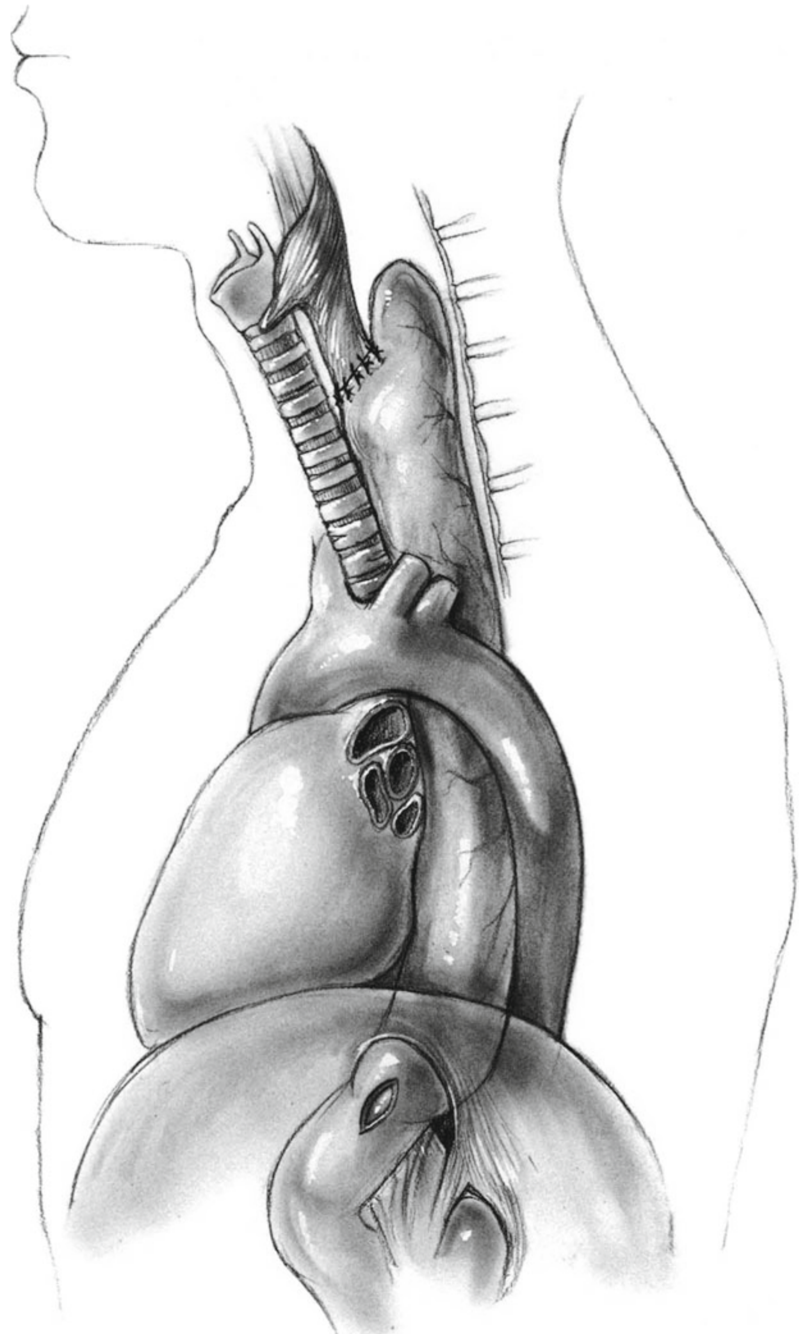
To avoid any tension whatsoever on the anastomosis, divide the cervical esophagus at a point where it can easily reach the clavicle. When dividing the esophagus, cut the anterior flap of esophagus so it is at least 1 cm longer than the posterior flap, as illustrated in Fig. 14.24. This maneuver converts the anastomotic suture line into an ellipse instead of a circle and should result in a larger stoma. Now reflect the esophagus in a cephalad position above the cervical incision. The uppermost gastric cardia has already been sutured to the neck muscles as high as is comfortable in the cervical incision. Using Babcock forceps, gently elevate the anterior wall of the stomach from behind the clavicle to a more superficial and superior location in the neck. The anastomosis between the end of the esophagus and the anterior wall of the stomach should be located 3–5 cm down from the apex of the gastric tube and above the level of the clavicle. Bring the esophagus back into the neck so it rests on the anterior wall of the gastric tube. Make an incision in the anterior wall of the gastric tube in a vertical direction, the length being appropriate to the diameter of the elliptical esophageal orifice, which is approximately 2.5 cm.

Be certain that the esophagus and stomach are positioned such that there is no tension on the suture line. Using 4-0 PG or PDS, insert the first stitch in the mucosa 4 mm from the cut end. This stitch passes through the muscle layer of the esophagus and then enters the cephalad margin of the gastric incision 4 mm above the incision, entering the lumen of the stomach. When tying these sutures, make the knot just tight enough to afford approximation, not strangulation. Place the second stitch through the left lateral wall of the esophagus into the lumen, again catching at least 4 mm of mucosa, and bring the stitch into the stomach and out the center of the left lateral wall of the stomach. Do not tie this stitch; rather, clamp it in a hemostat and place the third stitch in the same fashion in the right lateral margin of the esophagus and stomach. Ask the assistant to apply hemostats to stitches two and three and then to apply lateral traction to separate the two stitches. This maneuver lines up the esophagus and stomach so closing the posterior layer is simple. Insert interrupted sutures about 4 mm apart from each other. When the knots are tied the mucosa will automatically have been inverted into the lumen. Cut the tails of all the sutures in the posterior anastomosis but retain the hemostats on stitches two and three. Maintain lateral traction on these two stitches and begin the anterior anastomosis by inserting the first stitch at 12 o'clock at the midpoint of the inferior esophagus. Bring this stitch into the lumen of the stomach and bring it out of the stomach at 6 o'clock. Apply a hemostat to this stitch, which serves as an anchor. Now close the anterior layer by inserting Lembert sutures and then invert the tissues as the knots are being tied. These knots remain outside the lumen (Fig. 16.4). We frequently use the technique of successive bisection (see Figs. 4.19 and 4.20). After the anastomosis is completed, ask the anesthesiologist to pass a nasogastric tube and guide it through the anastomosis into the gastric pouch.

Closure

Close the cervical incision in layers with interrupted 4-0 PG after inserting a 1.5 cm latex drain to a point near the anastomosis. Consider a needle catheter jejunostomy. Close the abdominal cavity without drainage using the modified Smead-Jones closure described in Chap. 3 and no. 1 PDS sutures. Close the skin with interrupted fine nylon, subcuticular continuous 4-0 PG, or staples.

Fig. 16.4



Postoperative Care

Continue nasogastric suction for 4–5 days. Maintain the chest catheter on some type of underwater drainage for 4–5 days or until the volume of drainage becomes insignificant. Leave the cervical drain in place 7–10 days.

Complications

- *Anastomotic leak*. This is seen especially in cases of anastomoses involving the cervical esophagus.
- *Stricture of the cervical anastomosis*. This occurs especially after leaks.

- *Intestinal obstruction*. Obstruction is due to adhesions.
- *Trauma to recurrent laryngeal nerve*. The nerve is traumatized during dissection of the cervical esophagus.
- *Pneumothorax and intraoperative or postoperative hemorrhage*. Insert a large drainage tube into the right or left hemithorax (or both) if a pneumothorax has been produced by the transhiatal dissection. Inspection of the mediastinum reveals most gaps in the mediastinal pleura.
- *Chylothorax*. Chylothorax may follow transhiatal esophagectomy. It should be suspected whenever the chest tube drainage exceeds 800 ml per day after the third postoperative day. The diagnosis can be confirmed by administering cream via the jejunostomy catheter and observing an opalescent tinge to the pleural drainage. Early recognition, exploration, and transthoracic ligation may hasten resolution when compared with traditional conservative management.
- *Leaking thoracic duct*. To identify the leaking thoracic duct at reoperation, Orringer et al. injected cream into the jejunostomy feeding tube at a rate of 60–90 ml/h for 4–6 h prior to reoperation for duct ligation. A limited fifth-interspace posterolateral thoracotomy under one-lung anesthesia was the approach these authors employed for the reoperation.

Further Reading

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17 Minimally Invasive Esophagectomy

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Indications

Barrett esophagus with high-grade dysplasia
Carcinoma of the esophagus
Esophageal stricture
End-stage achalasia

Preoperative Preparation

Perform preoperative esophagogastroscopy and biopsy.
Use computed tomography and endoscopic ultrasound for preoperative staging.
Perform preoperative bronchoscopy in lesions located proximally to the carina to detect invasion of the tracheabronchial tree.
Consider neoadjuvant treatment for lesions T2 or greater and/or for suspected lymph node involvement.
Consider preoperative tube feedings in patients with significant weight loss or other evidence of malnutrition, especially if candidates for neoadjuvant treatment.
Insist on smoking cessation.
Prepare for possible massive blood loss during the thoracic dissection.
Administer preoperative antibiotics.
Insert a nasogastric tube.
Always use a double-lumen endotracheal tube to facilitate quick collapse of a lung, should exposure be needed emergently.

Pitfalls and Danger Points

Inadvertent interruption of the right gastroepiploic artery or the gastroepiploic arcade
Ischemia and/or trauma to the gastric tube and subsequent necrosis and sepsis
Anastomotic leak
Injury to spleen or splenic vessels
Excessive bleeding
Laceration of membranous trachea
Hypotension during mediastinal dissection due to compression of the heart
Trauma to the thoracic duct and resultant chylothorax
Traction injury or laceration of the recurrent laryngeal nerve
Undetected pneumothorax

Operative Strategy

A minimally invasive esophagectomy can be performed either by transhiatal or transthoracic approach. Choice of the technique is influenced by the surgeon's experience and personal preference, hospital resources, as well by the patient's wishes.

Typically, a minimally invasive transhiatal esophagectomy consists of a laparoscopic mobilization of stomach and esophagus, accompanied by isolation of the cervical esophagus through a limited cervical incision. Similar to the open transhiatal approach, dissection of the mid-esophagus might have to be performed semi-blindly, through both cervical and abdominal access.

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The minimally invasive Ivor Lewis esophagectomy with a thoracoscopic approach offers a better visualization of the periesophageal structures, especially near the main airways and subcarinal areas. It is also less affected by patient height and body habitus, and it might facilitate more complete nodal dissection. Since the transthoracic approach allows dissection of the mid-esophagus under direct vision, it is believed to be, at least in theory, a safer operation. The thoracoscopic portion of the minimally invasive transthoracic esophagectomy can be performed before or after the gastric mobilization depending on the surgeon's preference and the nature of the tumor. Although the dissection can be done with the patient supine or slightly rotated (which minimizes position change and operative time), it is much easier in right-side up or prone position. Where available, robot assistance might also be used for both intrathoracic and intra-abdominal dissection but its value is as yet unproven.

Abdominal Portion

The laparoscopic portion of an esophagectomy is designed to fully mobilize the stomach so that it can be used for a thoracic or cervical anastomosis. The steps of this portion of the operation are the same, regardless of whether a transhiatal or a transthoracic approach is chosen for the esophageal dissection.

The omentum is dissected away from the gastroepiploic artery. The surgeon should always keep in mind that this vessel constitutes the major blood supply to the tip of the gastric tube that is being constructed. In many areas, the gastroepiploic arcade is covered by omental fat so its exact location may not be obvious. For this reason, it is better to leave a few centimeters of omentum attached to the artery, as inadvertent division of this vessel makes the stomach useless as an esophageal substitute.

One should also be aware that the gastroepiploic artery does not continue to the tip of the gastric tube. Instead, the tip relies on intramural circulation for its blood supply. Although this circulation is normally adequate to sustain the healing process of the gastroesophageal anastomosis in the neck, unnecessary trauma to the proximal stomach can threaten the intramural circulation and the anastomosis. Consequently, rough handling and thermal injury must be avoided. Even inserting a suture between the gastric tip and the prevertebral fascia in the neck has been reported to cause focal necrosis of the stomach.

In addition to maintenance of the blood supply to the stomach, other operative details may help to minimize anastomotic leakage and postoperative stenosis. The esophageal hiatus must be enlarged sufficiently to prevent any element of venous stasis. The neo-esophagus should be at least 4–5 cm wide, as a narrow gastric tubule is prone to ischemia. However, a gastric tube that is much wider may have poorer emptying.

Transhiatal and Transthoracic Portions

Bleeding and transfusion requirements are less with the minimally invasive approach, but it is important to note that even small amounts of bleeding can obscure the operative field and may require conversion to an open procedure. Hence, the aortoesophageal branches must be identified and clipped. Bleeding from the azygous vein and peribronchial arteries also must be avoided. Injury to the posterior membranes on the bronchus and trachea must be carefully avoided, especially during lymph node dissection. Cautery and harmonic scalpel use in close proximity to the posterior membranous trachea or main stem bronchus can lead to tissue damage resulting in air leak, local ischemia, herniation of the gastric conduit, and subsequent development of a tracheogastric conduit fistula.

Laceration or avulsion of the azygous vein results in massive hemorrhage. Avoid this catastrophic complication by careful preoperative staging and careful dissection at the point where azygous vein crosses the esophagus to isolate the vein and completely control it with the appropriate stapling device.

If injury of the azygous vein is suspected during a transhiatal dissection, the right lung should be deflated and a right thoracotomy performed.

Since microscopic extension of cancer can be found even at considerable distance from the macroscopically visible tumor, the oncologic goal is to create a 10-cm margin of apparently normal esophagus. If there is any question about mucosal involvement, a frozen section examination should be done to confirm a negative proximal margin, prior to starting the esophagogastric reconstruction. Submucosal lymphatic extension to the margin may still be present but will not increase the risk of leak in grossly normal esophagus; it will however make surgical cure very unlikely.

The thoracic duct is at risk for subtle injuries leading to the development of chylothorax. More cautious dissection in the area with liberal use of endoclips will help avoid this complication.

Vocal cord paralysis resulting from the injury to the recurrent laryngeal nerve is minimized by dividing the vagus nerve just above the azygous vein and dissecting it away from the esophagus. Dissection of lymph nodes above this level is not done because of risk of injury to the recurrent laryngeal nerves and the lack of evidence that lymph node clearance is essential in this location for gastroesophageal junction tumors.

Cervical Portion

Aside from hoarseness, damage to the left recurrent laryngeal nerve during the cervical dissection can also result in impaired swallowing and postoperative aspiration. This complication can be minimized by avoiding excess traction on the nerves and by using the index finger rather than a rigid instrument to retract the trachea and the thyroid gland.

Documentation Basics

- Findings
- Transhiatal versus transthoracic
- Technique of anastomosis

Operative Technique: Transthoracic Approach

Positioning

Perform esophagogastroscopy in all patients to confirm the location of the tumor and the suitability of the stomach for *tubularization* to reach the cervical area. For tumors in the mid-esophagus, also perform bronchoscopy.

Ensure that a double-lumen endotracheal tube is used. Place the patient in the left lateral decubitus position with the superior iliac crest centered over the break in the bed. Reconfirm correct position of the endotracheal tube. Isolate the right lung to allow it to collapse, thus providing adequate visualization of the right pleural cavity. It is important to collapse the right lung early, to allow time for decompression. Flex the table to open the intercostal spaces.

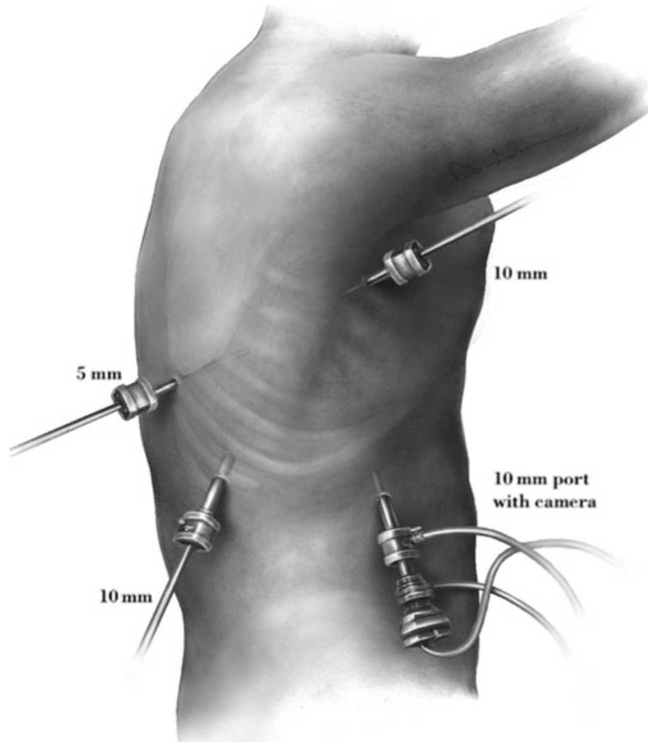

Fig. 17.1

Thoracoscopic Mobilization of the Intrathoracic Esophagus

After prepping and draping the patient, place four ports to access the chest for mobilization (Fig. 17.1). Create the first 10-mm port in the eighth intercostal space in the anterior axillary line. This will serve as the camera port. Place the second 10-mm port in the eighth or ninth intercostal space approximately 2 cm posterior to the posterior axillary line. This port is the main dissection port through which a harmonic scalpel will be used. Place the third 10-mm port in the fourth intercostal space along the anterior axillary line. Pass a fan retractor through this port to retract the lung. Finally, place a 5-mm port below the scapular tip.

In addition, place a suture in the central tendon of the right diaphragm. Bring this suture out percutaneously through the lower chest wall near the costal margin using the Endo-Close device (Covidien, Norwalk, CT). Use downward traction on this stitch to pull the diaphragm inferiorly and allow better visualization of the lower esophagus and hiatus.

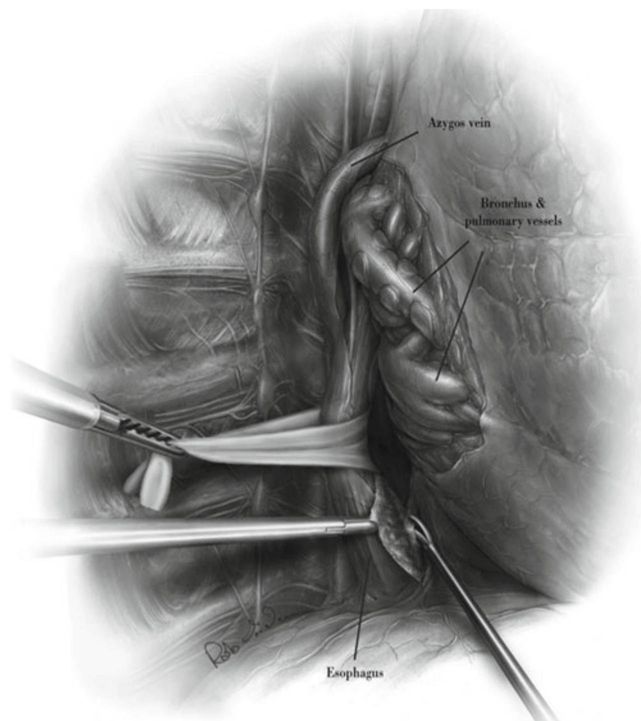

Fig. 17.2

Begin dissection by taking down the inferior pulmonary ligament. Dissect the mediastinal pleura anteriorly along the plane between the edge of the lung and the esophagus and resect it with the specimen up to the azygous vein. Take the subcarinal lymph nodes en bloc with the esophagus (Fig. 17.2). Take care to avoid injury to the posterior membrane of the right main stem bronchus, carina, and trachea.

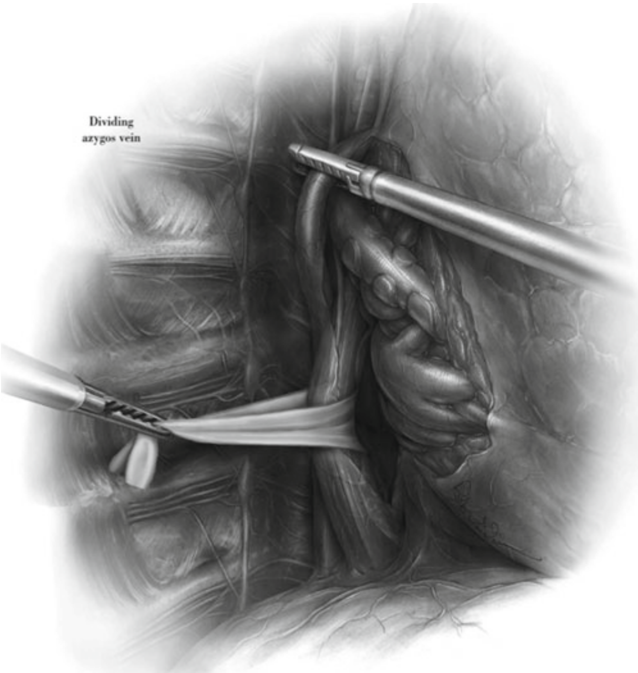

Fig. 17.3

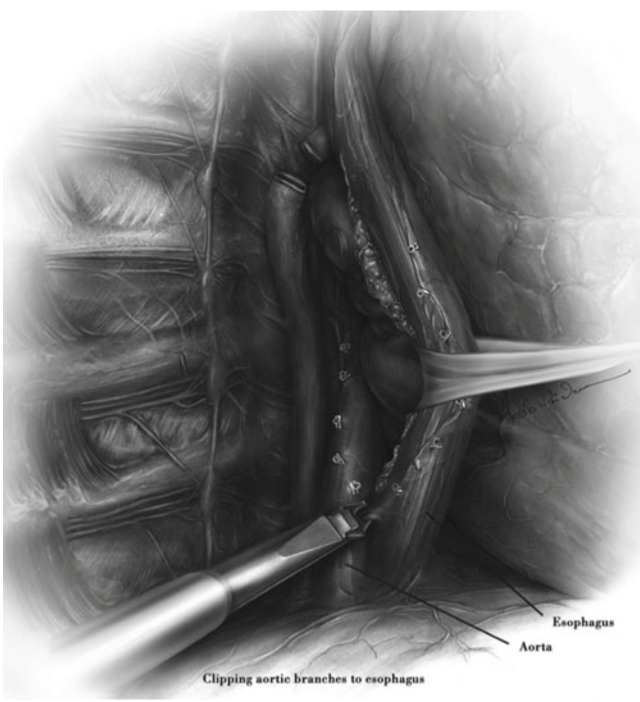

Fig. 17.4

Carry this dissection up to the azygous vein. Divide the vein with an Endo-GIA stapler (Fig. 17.3).

Divide the mediastinal pleura inferiorly near the hiatus. Place a Penrose drain around the inferior esophagus. Use this drain to provide retraction away from the posterior esophageal attachments and permit circumferential dissection along the esophagus. Tributaries from the thoracic duct to the esophagus may be divided in this tissue, with risk for subsequent postoperative chylous leak. Liberal use of endoclips here will minimize this risk.

Isolate, clip, and divide the aortoesophageal attachments (Fig. 17.4). All surrounding soft tissue is taken with the esophagus, including the lymph node packets. Once the dissection reaches the divided azygous vein, divide the vagus nerve and keep the dissection plane close to the esophagus. By dissecting the surrounding tissue away from the esophagus, traction on the vagus nerve is minimized, and the risk of recurrent nerve injury is decreased.

Take care to preserve the mediastinal pleura above the azygous vein. This precaution is an aid to maintaining the gastric tube in the mediastinum and seals the surrounding tissue to minimize leakage of any cervical drainage into the chest. Move the Penrose drain up to the thoracic inlet to facilitate retrieval of the cervical esophagus during the neck dissection. We inject bupivacaine around the intercostal nerve to provide regional anesthesia.

Inflate the lung to check for an injury to the posterior membranes of the trachea or bronchus. Place a 28-F chest tube through the camera port while the other ports are closed with Vicryl sutures. In general we strive to keep thoracoscopy under 2 h. Of note, however, adequate periesophageal dissection well into the thoracic inlet and low dissection toward the hiatus will decrease the time spent in the neck and abdomen.

Intrathoracic Anastomosis

The intrathoracic anastomoses can be completed in one of several ways. A traditional hand-sewn anastomoses can be done although technically more challenging when performed using minimally invasive techniques. My preference is to perform the anastomosis in an end-to-side fashion using the OrVil stapler (Covidien, Norwalk, CT).

Once the mobilization is complete, transect the esophagus using an Endo-GIA stapling device. Make a small esophagotomy and then pass the OrVil through the mouth into the esophagus and out of the esophagotomy. Create a gastrotomy at the apex of the gastric conduit (Fig. 17.6). Pass the EEA stapler through the posterior inferior port site, through the gastrotomy, and push the spike out of the posterior wall of the conduit.

Dock the spike to the OrVil and complete the anastomosis by firing the stapler (Fig. 17.7).

Transect the redundant conduit with a stapler after an NG tube is passed across the completed anastomosis. This will provide for an additional gastric margin. The staple line along the lesser curve of the stomach can then be oversewn with the use of an Endostitch device. Testing the anastomosis is optional but can be done by insufflating air through the NG tube after submerging the anastomosis with irrigation fluid.

Cervical Anastomosis

If indicated, a cervical anastomosis can be created instead of an intrathoracic one (see subsequent section).

Transhiatal Approach

Place the patient supine on the operative table. Implement at least one modality of DVT prophylaxis prior to anesthesia induction; we generally use both subcutaneous heparin and sequential compression devices.

A double-lumen tube should be used for endobronchial intubation: if thoracoscopy is planned, right lung isolation is necessary for adequate visualization and mobilization of the esophagus. Even for transhiatal esophagectomy, having a double-lumen endotracheal tube in place will provide the ability to collapse the right lung quickly, should emergency thoracotomy be required for intraoperative bleeding or for repair of a tracheal laceration.

Pad both arms and align them alongside the body. Maintain the head rotated to the right over a foam donut. Place a small blanket roll under the upper chest to maintain some extension of the neck.

We do not routinely use invasive cardiac monitoring, but if a central venous pressure or a Swan-Ganz catheter is to be used, it should be placed into the right internal jugular vein, as the left side of the neck is preserved for the esophagogastric anastomosis.

A nasogastric tube is inserted to decompress the stomach.

The whole abdomen, the chest, and the neck are prepped with chlorhexidine-based products and draped into the surgical field.

Abdominal Portion

As previously mentioned, the abdominal steps of a minimally invasive esophagectomy are common for both transhiatal and transthoracic approach and will be described first.

We use a GelPort (Applied Medical Resources, Rancho Santa Margarita, CA) device to assist the laparoscopic portion of the esophagectomy. We find that the minilaparotomy used for the GelPort is also helpful during blunt transhiatal esophageal dissection as well for removal of the specimen. Other surgeons prefer to perform a fully laparoscopic transhiatal esophagectomy and remove the surgical specimen through the neck incision.

Mark a subcostal incision on the patient's right, one fingerbreadth below the rib cage. Begin the incision at the midline and extend it laterally for a length that is a function of the surgeon's glove size (an incision of approximately 5 cm is typically required to insert a hand in the abdominal cavity).

At this time, if the situation appears favorable for resection, mobilize the duodenum with a Kocher maneuver to draw it medially and cephalad to facilitate subsequent delivery of the gastric tube in the chest.

Once the Kocher maneuver is completed, position the GelPort, establish 14-mmHg pneumoperitoneum, and insert a camera through the GelPort.

Insert the other trocars under direct vision. Place a 12-mm port about 15 cm caudal to the xiphoid, just to the left of the midline. In nonobese patient this port is generally located 2 cm above and to the left to the umbilicus. This port will be used for the camera and occasionally for staplers. Place a 5-mm port in the left upper quadrant (~4 cm below the rib cage at the left midclavicular line) to be used for the right working hand. Place an additional 5-mm port below the left rib cage along the anterior axillary line. This will be used by the assistant for retraction.

Once all of the ports have been positioned, pass your left hand through the GelPort and use it to hold the greater curvature and expose the gastrocolic ligament. At the same time, use the back of your left hand to keep the liver up and to the right, facilitating exposure. It is usually neither necessary nor advantageous to divide the left triangular hepatic ligament.

Assess the stomach to make sure that it is indeed suitable (soft, pliable, and free of unexpected pathology) for the development of a gastric tube that will reach up into the neck.

Identify the right gastroepiploic arcade. Divide the gastrocolic ligament in a right-to-left direction using the harmonic scalpel, therefore entering the lesser sac. Carefully preserve the gastroepiploic arcade by pinching it with thumb and index finger of the left hand and by dividing the omentum just lateral to it.

During this maneuver it is important not only to preserve the gastroepiploic vessels but also to take care not to injure the transverse colon. Use a bowel grasper introduced through the port at the left axillary line to retract the transverse colon or the greater omentum caudally and provide counter tension if necessary.

Continue the dissection of the gastrocolic ligament along the upper third of the greater curvature with the division of the left gastroepiploic vessels and then the gastrosplenic ligament with its short gastric vessels. This portion of the dissection is greatly facilitated by using the left hand to bring the stomach down and rolling it up to expose the back wall of the stomach.

At this time it is usually necessary to divide the avascular posterior gastropancreatic adhesions that are almost always present between the posterior wall of the stomach and the anterior surface of the pancreas.

Next, continue the dissection more cranially along the greater gastric curvature, until all of the short gastric vessels are divided and the fundus is completely mobilized. At this time the left crus and part of the hiatus with the distal esophagus should be visualized.

Still using the harmonic scalpel (or other equivalent sealing device) for dissection, divide the lateral portion of the phrenoesophageal ligament and expose the fibers of the left crus. In case of tumors of the gastroesophageal junction, it may be advisable to perform a wider dissection around the hiatus, taking a portion of diaphragm with the specimen.

Once the left crus is exposed, have the assistant retract the stomach down and to the left.

Divide the gastrohepatic ligament, paying attention to identify and preserve an accessory or replaced left hepatic artery. At this point the right crus is identified. Free the gastroesophageal junction from the hiatus by dissection up the right crus. Take down the phrenoesophageal ligament and proceed through the connective tissue posterior to the esophagus to extend the dissection toward the left crus.

Divide the right and left vagus nerves when identified. At this point, with the gastroesophageal junction dissected on both sides and posterior, use the left index finger to guide a 2-cm wide Penrose drain around the esophagus. Secure the two ends of the Penrose together with an Endo-GIA stapler (Covidien, Norwalk, CT) or an Endo-loop, leaving little space between the drain and the esophageal wall.

The assistant may now use the Penrose drain to retract the esophagus caudally and increase exposure of the hiatal region. Complete the dissection of the lower esophagus under direct laparoscopic vision using the harmonic or the fingers of your left hand.

Retract the stomach superiorly and to the right by elevating the greater curvature in a cephalad direction. This will expose the celiac axis above the pancreas. The left gastric vessels at this time should be readily identifiable caudad to the Penrose drain between the two "windows" created by the hiatal dissection and by the opening of the gastrohepatic ligament.

Sweep the connective and lymphatic tissue around the left gastric vessels toward the specimen with a combination of blunt and sharp dissection, and divide the vessels with an Endo-GIA using a vascular load. Insert the stapler through the GelPort along with the left hand or through the 12-mm port. In the latter case it will be necessary to use a 5-mm camera introduced through one of the other ports.

Division of the left gastric artery enhances subsequent exposure so that dissection of the intrathoracic esophagus can be performed under direct vision. Divide the right crus with the harmonic scalpel in order to facilitate transhiatal dissection and to prevent venous stasis of the gastric tube. Have the assistant retract the left crus laterally with either a closed bowel grasper or the suction irrigator to enhance exposure.

Now use your left hand to retract the right crus laterally. The esophagus is connected to the surrounding structures mainly by loose areolar tissue. Divide any vascular or fibrous attachments with the harmonic scalpel. Using the Penrose to pull down stomach and distal esophagus, continue the transhiatal dissection as high as possible under direct laparoscopic vision (generally to the level of the tracheal carina).

If the gastric mobilization has been adequate, the pylorus should easily reach the right crus.

We generally do not perform a pyloromyotomy or pyloroplasty. The emptying function of the gastric tube is influenced by several factors (e.g., width of the conduit) and not solely by the presence of a competent pylorus. The vast majority of patients will do well without pyloromyotomy. An endoscopic dilation of the pylorus can be performed postoperatively in patients with delayed gastric emptying.

The laparoscopic portion of the esophagectomy is now completed, and the operation will continue with either the cervical and transhiatal dissections or a thoracoscopy, depending on whether a transhiatal or a transthoracic esophagectomy is being performed.

Cervical Dissection

With the patient's head turned slightly to the right, make an oblique incision along the anterior border of the left sternomastoid muscle and carried deeper through the platysma.

Identify and transect the omohyoid muscle.

Retract the sternomastoid muscle and carotid sheath laterally and the prethyroid muscles medially, exposing the thyroid. If the middle thyroid vein is encountered, ligate and divide it.

Identify and protect the recurrent laryngeal nerve in the trachea-esophageal groove.

Take care to keep the dissection of the cervical esophagus well below the pharyngoesophageal junction marked by the cricoid cartilage. Pass your index finger between the esophagus and the prevertebral fascia, then back between the esophagus and the trachea to encircle the esophagus. It is very important to keep the finger close to the esophageal wall; otherwise the *left* recurrent laryngeal nerve might be injured.

Once the cervical esophagus is mobilized circumferentially, encircle it with a Penrose drain and apply cephalad traction. Use gentle finger dissection, applying the pads of your fingers on the esophageal wall to gently dissect the esophagus away from the overlying trachea and the posterior fascia.

As the dissection progresses, the thoracic esophagus is delivered through the cervical incision. The nasogastric tube is very helpful in providing tactile feedback of the relationship of the esophagus with the surrounding structures. With this dissection the index finger can reach down to the tracheal carina.

Transhiatal Dissection

Once the cervical dissection has been completed as far distal in the chest as possible, reposition your hand through the GelPort to complete the transhiatal dissection. The hiatus should have been already enlarged by dividing the right crus during the laparoscopic portion. If necessary to create a large enough opening, dissect the central tendon of the diaphragm away from the pericardium and partially divide it.

Pass your left hand through the diaphragmatic hiatus posterior to the esophagus and insert a dissecting gauze (sponge on a stick) into the posterior mediastinum through the cervical incision. Use this dissecting gauze to gently dissect the esophagus off of the prevertebral fascia. Continue this posterior dissection gradually until you can feel the sponge touching the fingers of your left hand, previously inserted through the diaphragmatic hiatus.

Once the esophagus has been freed up posteriorly off of the prevertebral fascia, the anterior dissection is begun. The assistant maintains the esophagus under tension by traction on the Penrose around the esophagogastric junction. Pass your right hand through the GelPort, place it palm down against the anterior esophagus, and advance it slowly upward into the mediastinum. Keep this hand flat against the vertebral column in order to minimize cardiac displacement and hypotension. Progressively mobilize the esophagus away from the posterior pericardium, the carina, and the trachea.

Once posterior and anterior esophageal dissections are completed, few lateral attachments are left to divide.

Gently pull the cervical esophagus upward, and divide its lateral attachments so that the upper thoracic esophagus can be gradually delivered into the neck wound. This results in a complete circumferential mobilization of the upper thoracic esophagus.

Next, pull the distal esophagus downward by traction on the Penrose at the gastroesophageal junction and advance one hand anterior to the esophagus until you feel the circumferentially mobilized upper esophagus. Divide any remaining distal periesophageal attachments using the harmonic scalpel under direct laparoscopic visualization or blindly fracture these by compression between fingers (or between fingers and vertebral bodies).

At this point the entire intrathoracic esophagus should have been mobilized. Elevate the proximal esophagus out of the mediastinum and into the cervical wound. Have the nasogastric tube pulled back until its tip is no longer palpable below the cricoid cartilage. Now place the Penrose drain previously used for cephalad retraction along the length of the esophagus, with its proximal end about 3 cm above the level chosen for the anastomosis. Simultaneously divide both the esophagus and Penrose drain with an Endo-GIA. The short portion of Penrose stapled to the esophageal stump can be used to locate the stump easily in case it retracts into the neck. Leave the longer part of the Penrose stapled to the distal esophagus.

Gently grasp the stomach with your hand and deliver it outside the abdomen through the right subcostal minilaparotomy (with the wound protector portion of the GelPort still in place). The Penrose drain will then occupy the retromediastinal esophageal bed and may be used to guide the gastric tube up in the neck.

Construction of the Gastric Tube

At this point, the esophagus and stomach have been delivered outside the duodenum through the wound protector part of the GelPort. Take care not to apply excessive tension to the duodenum during this manipulation.

Begin the construction of the gastric tube by firing the Endo-GIA stapler across the lesser curve vessels and fat at an angle toward the incisura. The first firing is aimed to take the vessels of the lesser curve distal to the right gastric vessels, which are preserved: a vascular load may minimize oozing.

Then proceed to fire the stapler across the stomach. The 4.8-mm staple loads are generally required for the antrum, but moving toward the fundus the 3.5-mm staples may be a better choice because the gastric wall is often thinner. Adjust the angle of the stapler for each firing to create a relatively narrow gastric tube that is approximately 4–5 cm wide. We find that keeping the stomach on stretch by simultaneous caudal and cephalad traction during the application of the stapler will afford a better length of the final tube. Continue to fire the stapler in line a parallel to the greater curvature to create a consistent tube width and avoid spiraling of the gastric conduit.

Sequential firings of Endo-GIA are used until the gastric tube is completed and the specimen is removed.

Because this long series of overlapping stapler applications creates a somewhat increased risk of staple line leakage, we oversew the staple line with running 3-0 PDS while waiting confirmation from the frozen sections that the resection margins are negative.

Cervical Anastomosis

A cervical anastomosis is routinely performed after a transhiatal dissection. However, a cervical anastomosis is sometimes used in lieu of an intrathoracic one even after transthoracic esophageal dissection (e.g., in order to obtain adequate margins for proximal tumors). In this session, however, we will describe the anastomosis as if performed to complete the steps of the transhiatal approach that we have been describing so far.

In order to avoid any trauma while positioning the gastric tube in the posterior mediastinum with its tip at the neck, we use one of those sterile plastic covers that are generally used to protect an intraoperative ultrasound transducer as a guide.

Make a 5-mm hole at the very tip of the plastic cover, where the transducer would usually be positioned. Inflate the balloon of a Foley catheter and tie the cover tightly around it. Taking care to avoid twisting, insert the neo-esophagus through the opening at the other end of the cover and guided through it until it reaches the very top of the cover (where the tip of the Foley has been previously secured).

Tie the tail of the Foley catheter to the Penrose previously left in the posterior mediastinum. Pull the Penrose out of the neck until the tail end of the Foley is visible in the cervical incision. At this point, apply suction to the lumen of the Foley catheter, so that negative pressure will be maintained inside the plastic bag, thus holding the tube in position.

While maintaining suction, pull the Foley completely out of the chest through the neck. This maneuver will also pull up the ultrasound bag with the gastric tube. Since the neo-esophagus is not held by forceps nor is pulled by any ligature at its tip, trauma is minimized.

Take great care to preserve proper orientation and prevent spiraling or tension at the hiatus.

We favor a semi mechanical side-to-side anastomosis, using a stapler for the posterior layer.

Begin by placing two full-thickness stay sutures on each side of the esophageal stump (Figs. 17.5 and 17.8). The purpose of these stays is to facilitate manipulation of the

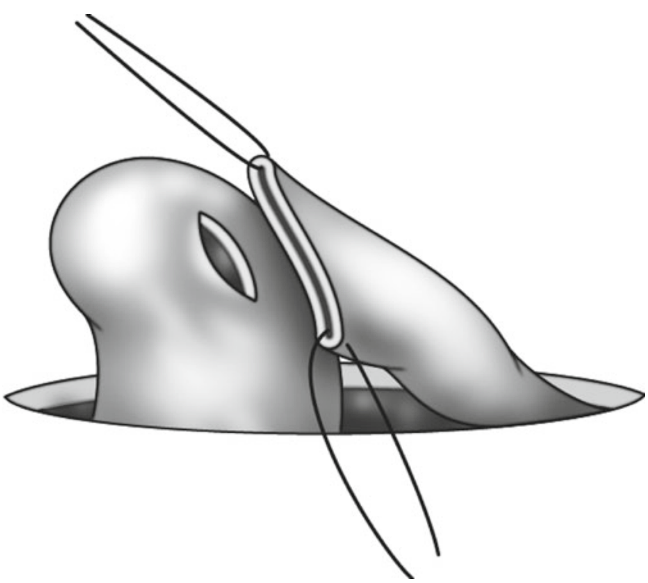

Fig. 17.5

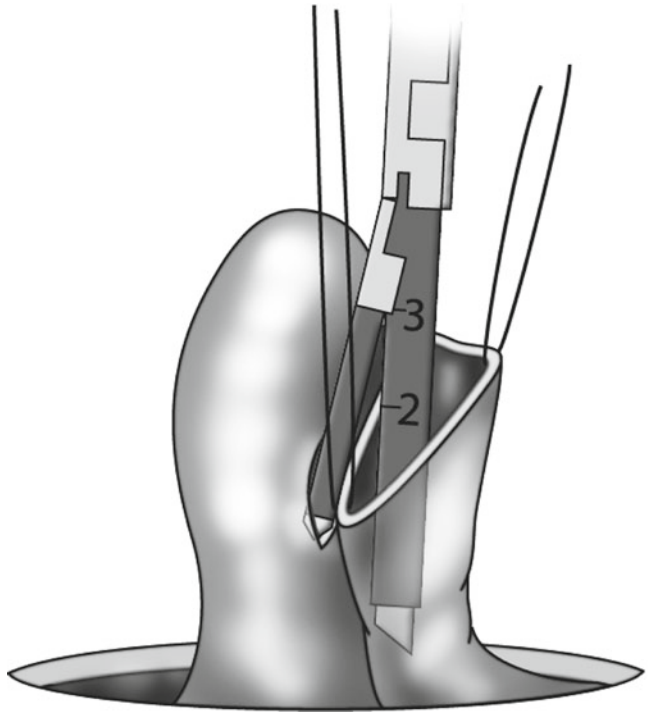

Fig. 17.6

esophagus, as well to avoid the tendency of the esophageal mucosa to retract proximally. Amputate the staple line (which included the short segment of the Penrose divided by the Endo-GIA).

Make a small incision in the posterior wall at the top of the gastric conduit (Fig. 17.5). Place the posterior wall of the esophageal stump and the posterior wall of the fundus side by side. A suture in and out of the gastrotomy and from outside to inside of the posterior tip of the divided esophagus may facilitate alignment and approximation of the back wall of the cervical esophagus to the posterior wall of the stomach. Place the two forks of a 30-mm Endo-GIA with 3.5 staples across the two opposing walls with the thin anvil in the gastric lumen and the thick cartridge of staples in the esophageal lumen (Fig. 17.6).

After the stapler is fired and removed, the two stapled edges retract laterally on the action of the intramural musculature while both stomach and esophagus tend to reassume their natural axial alignment inside the neck. The medial slit thus becomes a V-shaped opening that will constitute the posterior layer of the esophagogastric anastomosis (Fig. 17.7). Advance the nasogastric tube through the anastomosis until its tip is positioned just proximal to the pylorus (typically at the level of the diaphragmatic hiatus). Complete the anastomosis anteriorly by closing the gastrotomy with the remaining open esophagus using a single layer of interrupted full-thickness 3-0 silk sutures (Fig. 17.8).

We do not routinely leave a cervical drain.

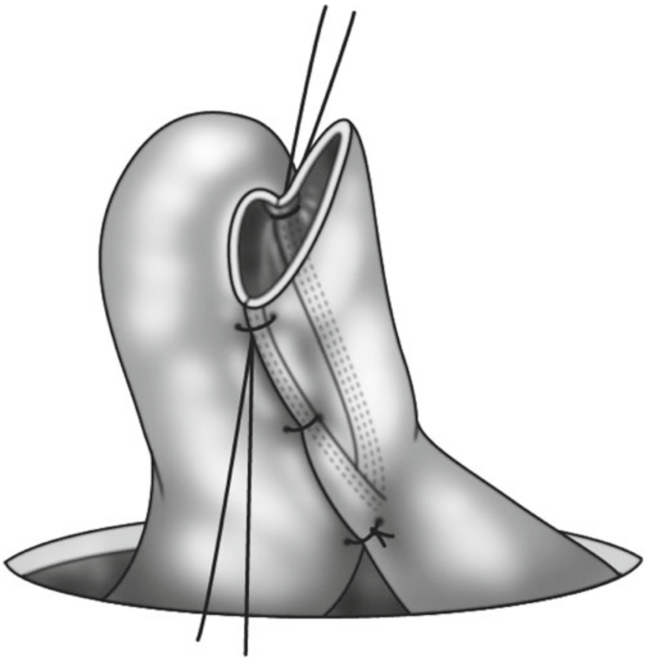

Fig. 17.7

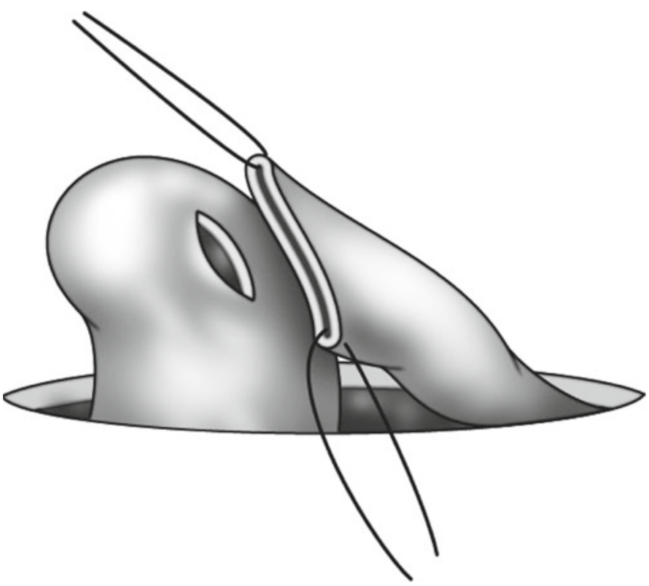

Fig. 17.8

Feeding Jejunostomy

We routinely place a feeding jejunostomy.

Identify a suitable loop of jejunum, about 20 cm distal to the ligament of Treit and deliver it outside the abdomen through the right subcostal incision, keeping the wound protector in place.

Construct a jejunostomy using a 14-French red rubber catheter, with the Witzel technique, paying attention not to narrow the jejunal lumen.

Insert a bowel grasper through the 5-mm port in the left flank and use it to grasp the end of the tube. By removing the port and the grasper while holding onto the tube, pull the end of the red rubber catheter out of the abdomen.

Position the GelPort again, re-create pneumoperitoneum and tack the loop of jejunum to the abdominal wall using interrupted 3-0 silk sutures for the entire length of the Witzel tunnel in order to prevent twisting of the jejunum around the tube and minimize leaking of the tube feedings.

Postoperative Care

We usually keep a nasogastric tube for 24 h in order to decrease gastric distension, which may compromise the integrity of the anastomosis. Whether this decreases the leak rate has not been proven.

Immediately after surgery patient is instructed to use incentive spirometry, cough, and take deep breaths. Also patients are encouraged to stay out of bed and ambulate within 12 h from surgery. No prophylactic antibiotics are used in the postoperative period. Unless an epidural catheter is used for analgesia, the Foley catheter is removed in postoperative day 1.

Enteral feeding is started on postoperative day 1, typically at rates as low as 1–20 ml/h. Feeding rate is advanced very slowly (by 10 ml/h every day).

If the patient does not appear at significant risk for aspiration, an esophagram with water-soluble contrast followed by thin barium is obtained in postoperative day 3–5. If no aspiration or leak is demonstrated, the patient is given a liquid diet, which is rapidly advanced to a postgastrectomy diet. Even after oral intake is resumed, we generally use supplementation with enteral feedings at night, especially in malnourished patients.

Postoperative Complications

The postoperative complications observed after minimally invasive esophagectomy generally are comparable with those of an open procedure. In the initial large series by Luketich et al. the cervical anastomotic leak rate was 11 %. Of note, the anastomotic leak rate increased to 26 % in a subset of 56 patients in whom a very narrow diameter (3 cm) gastric tube was constructed. However, in the other 166 patients, a 5-cm gastric conduit was used, and the observed leak rate was only 6 %.

The most common cardiopulmonary complications in the Luketich series included atrial fibrillation (11.7 %), pleural effusion (6.35), and pneumonia (7.7 %). Delayed gastric emptying was seen in only 1.8 %, and only 4 % of patients complained of recalcitrant long-term postoperative reflux symptoms. Moderate strictures at the gastroesophageal anastomosis are common and generally can be managed with one or two outpatient dilations.

Anastomotic Leak

Anastomotic leaks constitute one of the major complications of this operation. Treatment is guided by location of the anastomosis as well as magnitude of the leak.

Leaks from cervical anastomosis generally manifest with redness, drainage, and occasionally emphysema of the cervical surgical site. Since cervical leaks tend to heal on their own and very rarely tract to the mediastinum, in most cases the only action required is opening of the infected cervical incision at the bedside.

On the other hand, only a minor contained intrathoracic leak may be treated nonoperatively. Other leaks associated with an undrained fluid collection may be managed with percutaneous drainage and systemic antibiotics, as long as the patient is not septic and shows signs of improvement.

Otherwise operative drainage, diversion, repair, or a combination of these maneuvers will be required (see specific Chap. 27). There are now multiple series demonstrating that endoscopically placed removable esophageal stents may be very effective in obliteration of an anastomotic defect. Control of leak is obtained in 70–100 % of cases, with stent migration reported in 20–40 %.

Abscesses

Abscesses are usually the result of a leak, either at the anastomosis or along the gastric staple line.

Abscesses can be usually treated with percutaneous drainage. Presence of an underlying leak should be investigated and treated as described above.

Anastomotic Stricture

This occurs most often after leaks. A local recurrence needs to be ruled out by means of endoscopy and biopsies. Repeated balloon dilations or repeated passages of Maloney bougies may reverse this condition.

Chylothorax and Leaking Thoracic Duct

Chylothorax may follow transhiatal esophagectomy. It should be suspected whenever the chest tube drainage exceeds 800 ml per day after the third postoperative day. The diagnosis may be confirmed by an opalescent tinge to the pleural drainage and a high triglyceride level in the pleural fluid following administering cream via the jejunostomy catheter.

In the last 10 years, percutaneous embolization of the TD has been reported as a minimally invasive procedure for treatment of persistent or high-output chyle leaks. Percutaneous treatment of chylothorax is associated with very low morbidity and mortality and high success rates. Given the effectiveness of this minimally invasive treatment, early percutaneous lymphatic embolization could be a reasonable first option, before surgical repair of the thoracic duct is attempted for chyle leak.

For patients that have failed those options, ligation of the thoracic duct is necessary and can be performed either via thoracoscopy or a limited fifth-interspace posterolateral thoracotomy. To identify the leaking thoracic duct at reoperation, Orringer et al. injected cream into the jejunostomy feeding tube at a rate of 60–90 ml/h for 4–6 h prior to reoperation for duct ligation.

Pulmonary Complications

Pulmonary complications can be minimized by appropriate postoperative care and adequate pain control. Epidural analgesia is recommended.

Cardiac Arrhythmias

Cardiac failure and arrhythmia are not uncommon in elderly patients. Hemodynamic monitoring may help management.

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Operations to Replace or Bypass the Esophagus Colon or Jejunum Interposition

18

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Esophageal stricture or perforation

Preoperative Preparation

Nutritional rehabilitation, if needed
Perioperative antibiotics
Preoperative assessment of colon or jejunum by contrast studies, colonoscopy, and arteriography (if necessary)
Routine bowel preparation

Operative Strategy

Resect the damaged esophagus and replace it with a conduit whenever possible. When this is not feasible, a bypass leaving the damaged esophagus in situ is occasionally warranted. Patients who have an irreversible stricture due to peptic esophagitis require esophageal resection. Esophagectomy is also performed on patients who have undergone failed operations for neuromotor esophageal disorders or who have had diversion-exclusion operations (see Chap. 27) for esophageal perforations or anastomotic leakage. Transhiatal esophagectomy is an alternative (see Chap. 16).

The colon is a versatile conduit that is applicable to most situations unless the patient has had a previous colon resection. Sufficient length can be obtained to perform a cervical anastomosis if necessary. Jejunum provides a better size match than colon but is considerably more difficult to use owing to the small size of the vessels. It has been used for cervical reconstructions using microsurgical free flap techniques.

The conduit must be carefully developed to preserve the blood supply, positioned in an isoperistaltic fashion without kinking or twisting, and the gastrointestinal continuity restored. These complex operations require thorough preoperative planning and must be individualized.

Documentation Basics

Coding for esophageal procedures is complex. Consult the most recent edition of the AMA's Current Procedural Terminology book for details (see references at the end). In general, it is important to document:

- Findings
- Partial or total esophagectomy
- Choice of conduit
- Stapled or sutured anastomosis?
- Pyloromyotomy or not?

Operative Technique

Incision and Resection of Esophagus

The choice of incision is determined by whether, and how much, esophagus is to be resected. Transhiatal esophagectomy is an option that obviates the need for a thoracic incision (see Chap. 16).

We prefer a sixth-interspace left thoracoabdominal incision for most of these esophagectomies (see Figs. 15.3, 15.4, 15.5, 15.6, 15.7, and 15.8). Close the gastroesophageal junction in an area relatively free of disease using a 55- or 90-mm linear stapler on the stomach side. Close the esophageal end with another application of the stapling device. Dissect the esophagus out of the mediastinum. If the esophagus is

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markedly fibrotic, this dissection may require a scalpel. After the esophagus has been freed to the arch of the aorta, dissect the esophagus from underneath the arch of the aorta, as illustrated in Fig. 15.26. Temporarily leave the esophagus in its bed until the colon has been liberated.

Long-Segment Colon Interposition: Colon Dissection

The initial step for preparing a long colon segment is to liberate the hepatic flexure and the transverse and descending colon. If necessary, extend the thoracoabdominal incision below the umbilicus. Dissect the omentum away from the transverse colon and its mesentery, as illustrated in Figs. 37.3, 37.4, 51.3, and 51.8.

With this accomplished, inspect the blood supply of the left and transverse colon. Preserving the left colic artery in most cases permits transection of the middle colic vessels close to the point of origin and yields a segment of colon that could include a good portion of the descending colon as well as the entire transverse colon if it should be necessary. We have not encountered any cases where the "marginal artery" did not continue unimpeded from the left colon around to the transverse colon. However, verify this by careful palpation of the marginal artery and transillumination of the mesentery. Apply bulldog vascular clamps along the marginal artery at the points selected for division and check the adequacy of the pulse in the vessels being retained to supply the transplanted segment.

To ensure a vigorous blood supply to the proximal portion of the transverse colon, with sufficient length to reach the cervical region, ligate and divide the middle colic artery at a point well proximal to its bifurcation (along line A rather than line B in Fig. 18.1a). This allows the blood flow from the left colic artery to enter the left branch of the middle colic artery and to continue along the right branch to nourish the

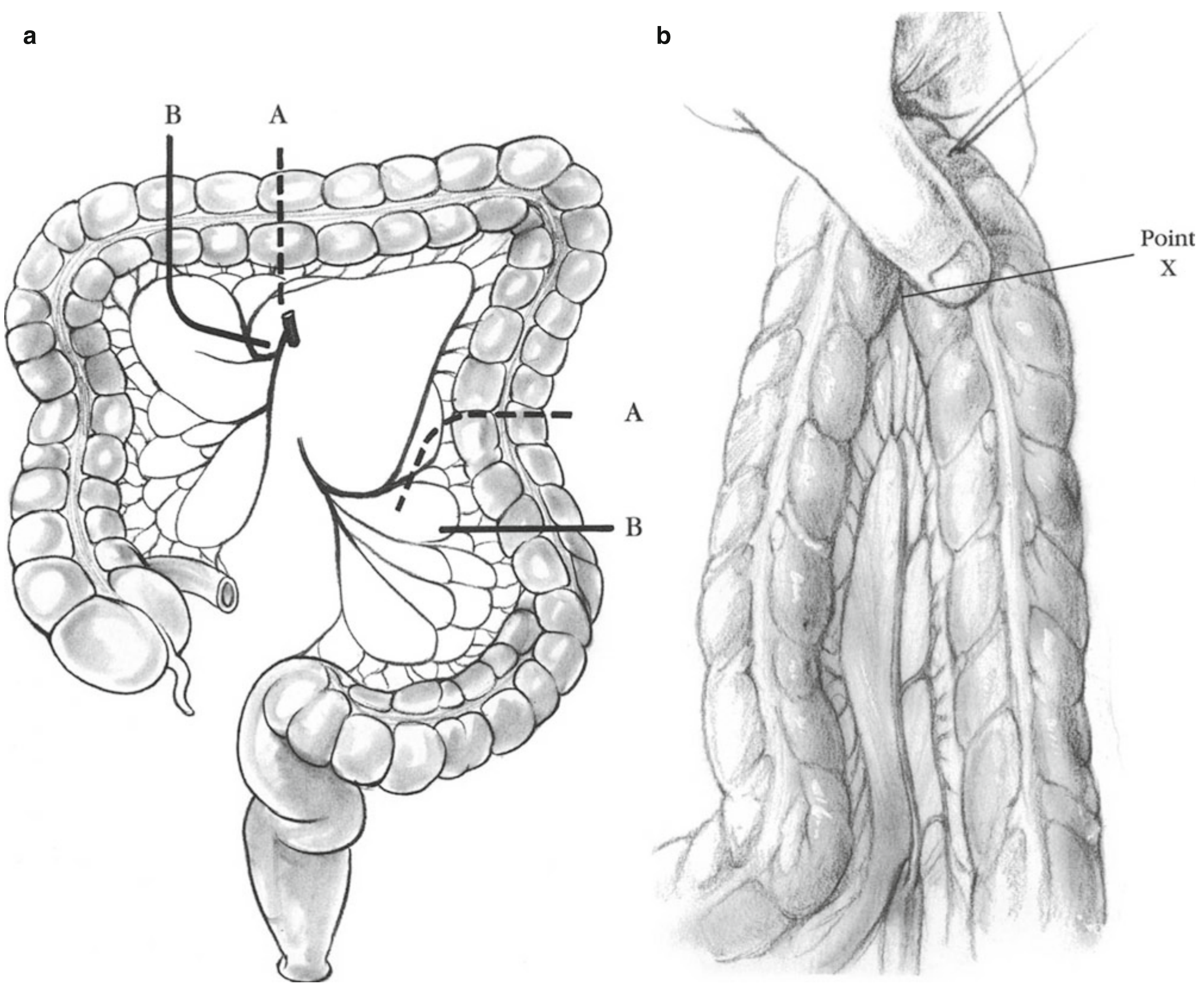

Fig. 18.1

right portion of the transverse colon. For this reason it is critical that this division and ligature of the middle colic artery and vein be done with great care.

Estimating the Length of Colon Required to Reach the Neck

After the omentum has been dissected off the colon and after both the left and right colon segments have been freed from the posterior abdominal wall, grasp the splenic flexure at the point of termination of the left colic artery and draw this segment of colon in a cephalad direction toward the sternum. Then measure the distance from this point (point X in Fig. 18.1b) on the sternum to the neck. This distance approximates the amount of colon required going in a proximal direction from the termination of the left colic artery. Add about 4–5 cm to the estimate and insert a marking stitch in the right transverse colon at this point. In most cases the point marked is at the right of the middle colic vessels, indicating that division of the origin of the middle colic artery and vein is required.

Transect the colon at the proximal margin of the segment selected for transplantation. Restore continuity to the colon by performing a stapled anastomosis as illustrated in Figs. 51.35, 51.36, 51.37, and 51.38. Close the proximal (right) margin of the colon transplant (temporarily) with a 55-mm linear stapler and leave the distal end of the colon segment open.

Cologastrostomy

Elevate the stomach with its attached omentum away from the pancreas. Divide the avascular attachments between the peritoneum overlying the pancreas and the back wall of the stomach. Also incise the avascular portion of the gastrohepatic omentum; then draw the colon transplant with its mesentery in an isoperistaltic direction through the retrogastric plane and through the opening in the gastrohepatic omentum. Be certain not to twist the mesentery. Verify that the colon does indeed reach the cervical esophagus without tension.

Prepare to anastomose the open end of the distal colon transplant to a point on the stomach approximately one-third the distance down from the fundus to the pylorus. The anastomosis may be made on the anterior or posterior side of the stomach. As illustrated in Fig. 18.2, make a 1.5-cm vertical incision in the stomach about one-third of the way down from the fundus; then insert the cutting linear stapler—one

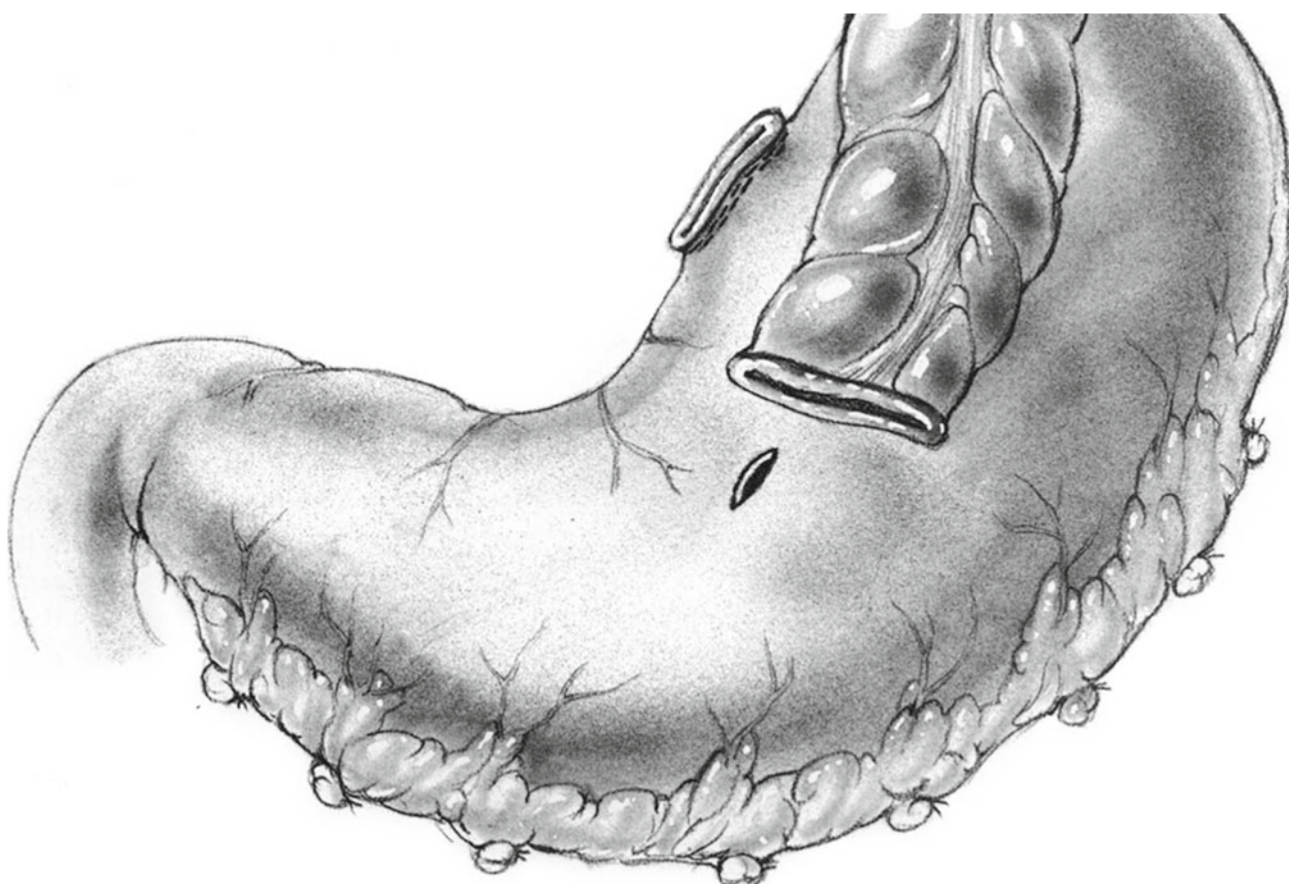

Fig. 18.2

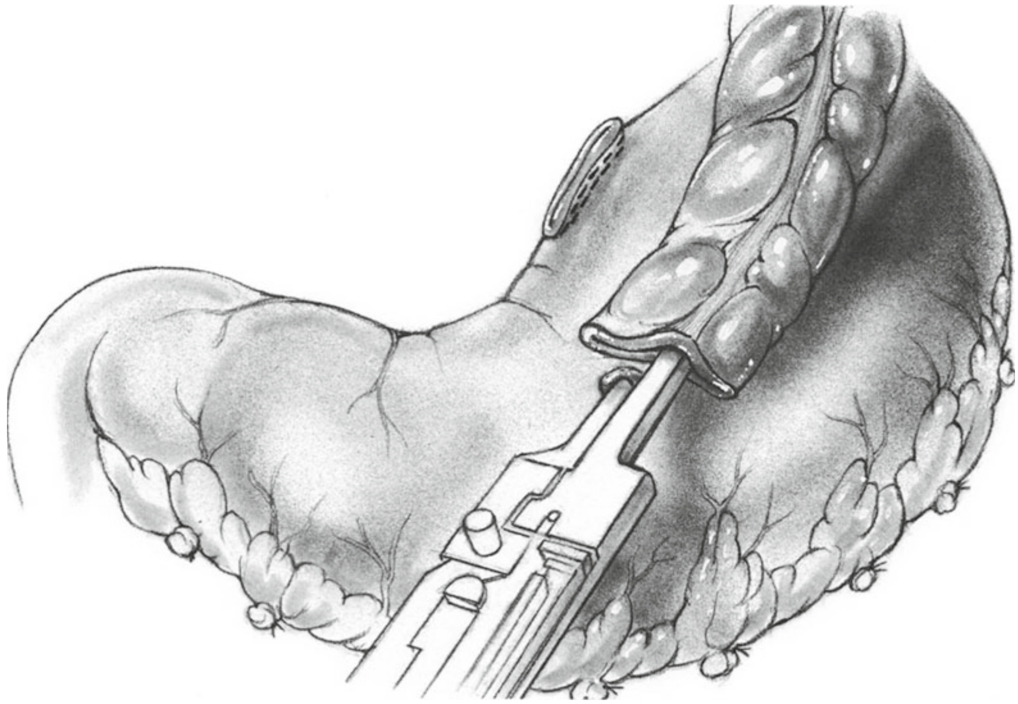

Fig. 18.3

fork in the stab wound of the stomach and one in the open lumen of the colon—to a depth of 3 cm and lock it (Fig. 18.3). Fire the stapler and remove it. Inspect the staple line for bleeding. Then apply Allis clamps to the left and right terminations of this staple line. Place a guy suture through the midpoint of the stab wound of the stomach as illustrated in Fig. 18.4. Close the remaining defect by two applications of the 55-mm linear stapler. First, apply the stapler just deep to the Allis clamp and the guy suture to close the left half of the gap. After firing the stapling device (Fig. 18.5), excise the surplus tissue but preserve the guy suture. Lightly electrocoagulate the everted mucosa and remove the stapling device. Then reapply the stapler in similar fashion to close the remaining defect. Be sure to place the stapler deep to the Allis clamp and the guy suture. After firing the stapling device, cut away the surplus tissue and lightly electrocoagulate the mucosa. This creates a fairly large anastomosis between the stomach and colon, as illustrated in Fig. 18.6.

DeMeester et al. pointed out that it is possible to divide the descending colon as it comes behind the stomach without simultaneously dividing the marginal artery of the descending colon. If the marginal artery is not divided, it provides an added avenue of blood flow to the colon that has been transplanted into the neck. By carefully transecting the colon behind the stomach and then dividing and ligating the end branches of the marginal artery close to the colon for a distance of about 4 cm, sufficient colon will have been liberated that a cologastric anastomosis can be constructed to the posterior wall of the stomach, and the distal segment of

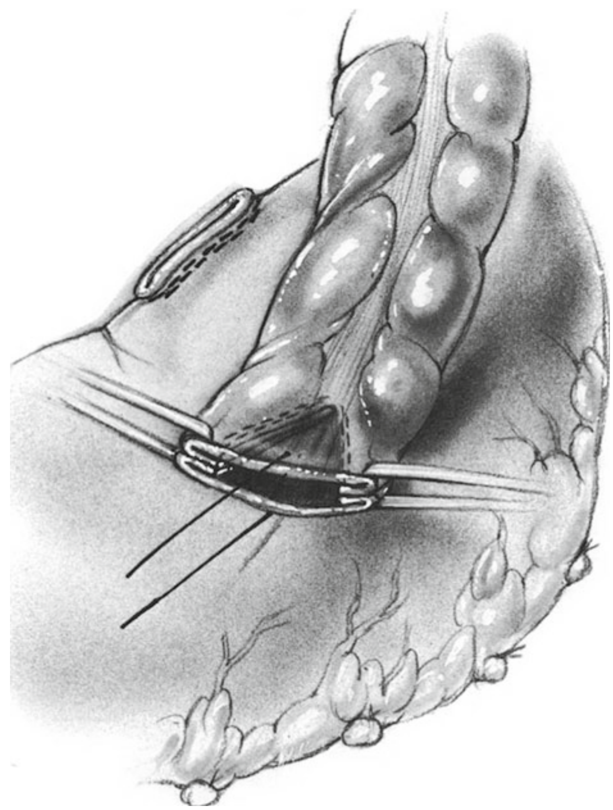

Fig. 18.4

descending colon can be anastomosed to the remaining hepatic flexure. If the anastomosis is made at the junction between the upper third and the lower two-thirds of the stomach, it seems not to matter whether the cologastrostomy is constructed on the posterior wall or the anterior wall of the stomach. However, if one wishes to preserve the marginal artery of the descending colon, it is necessary to place the cologastrostomy on the posterior wall of the stomach (Fig. 18.7a). The posterior cologastric anastomosis may be constructed by suturing (as illustrated here) or by stapling (as described in Figs. 18.3, 18.4, 18.5, and 18.6). In this manner the colocolostomy can also be performed close by, preserving the marginal artery (Fig. 18.7b).

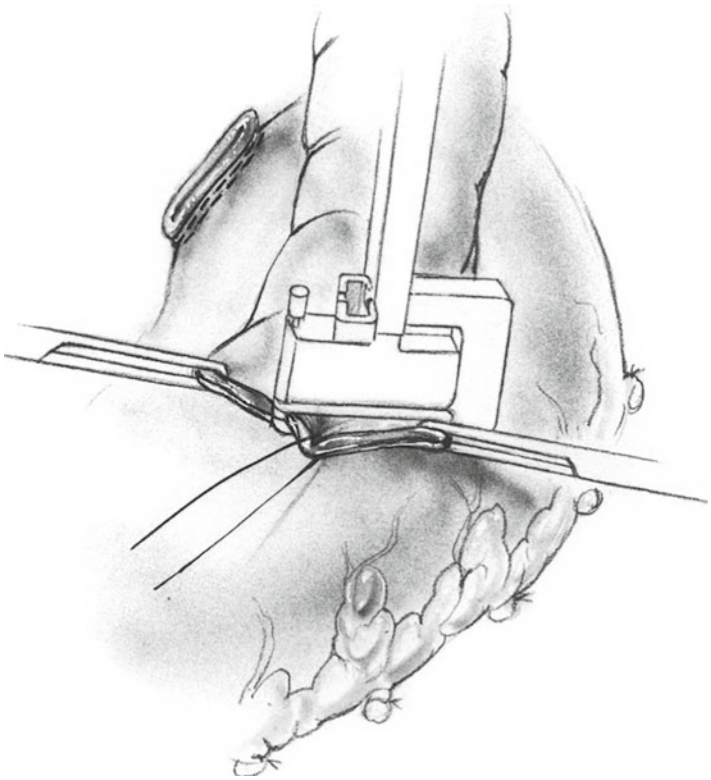

Fig. 18.5

Pyloromyotomy

In most conditions for which a thoracic esophagectomy is being performed, the vagus nerves are destroyed, which impairs gastric emptying to a fairly severe degree in about 20 % of cases. To prevent this complication, a pyloromyotomy may be performed by the technique illustrated in Figs. 14.17, 14.18, and 14.19.

Advancing the Colon Segment to the Neck

Be certain to enlarge the diaphragmatic hiatus (see Fig. 14.20) sufficiently that the veins in the colon mesentery are not compressed by the muscles of the hiatus. The most direct route to the neck follows the course of the original esophageal bed in the posterior mediastinum. Place several studies between the proximal end of the colon transplant and the distal end of the esophagus; then draw the colon up into the neck by withdrawing the esophagus into the neck. This brings the colon into the posterior mediastinum behind the arch of the aorta and into the neck posterior to the trachea. If there is no constriction in the chest along this route, the sternum and clavicle at the root of the neck are also not likely to compress the colon. On the other hand, if a substernal tunnel

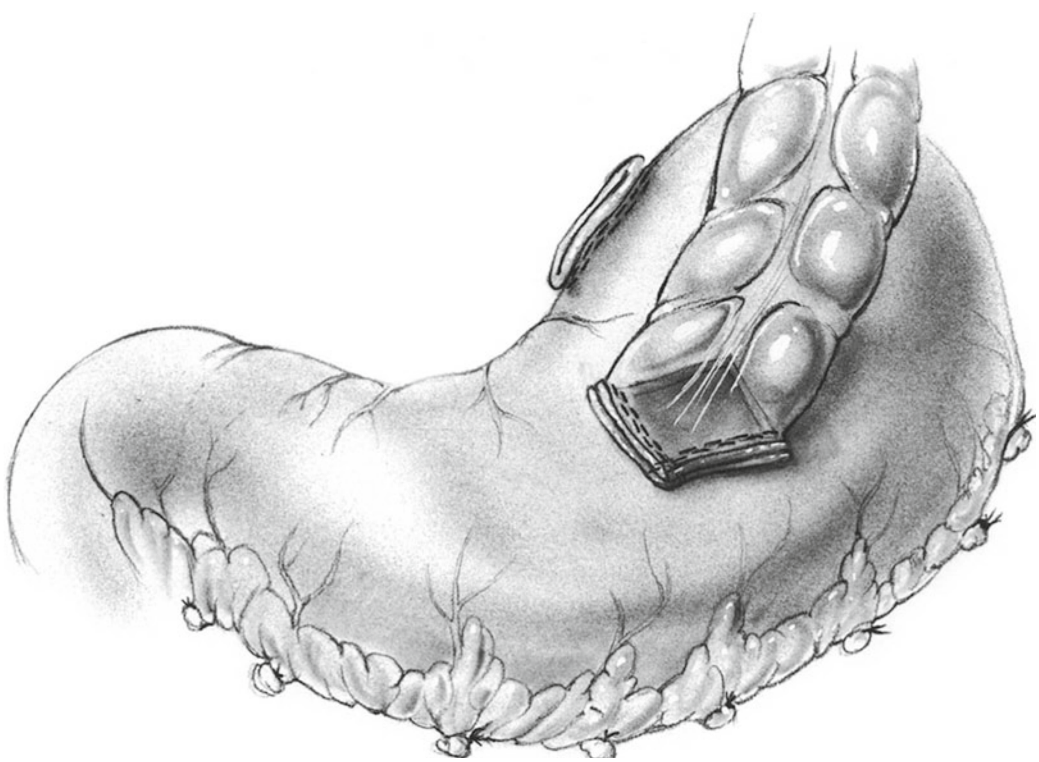

Fig. 18.6

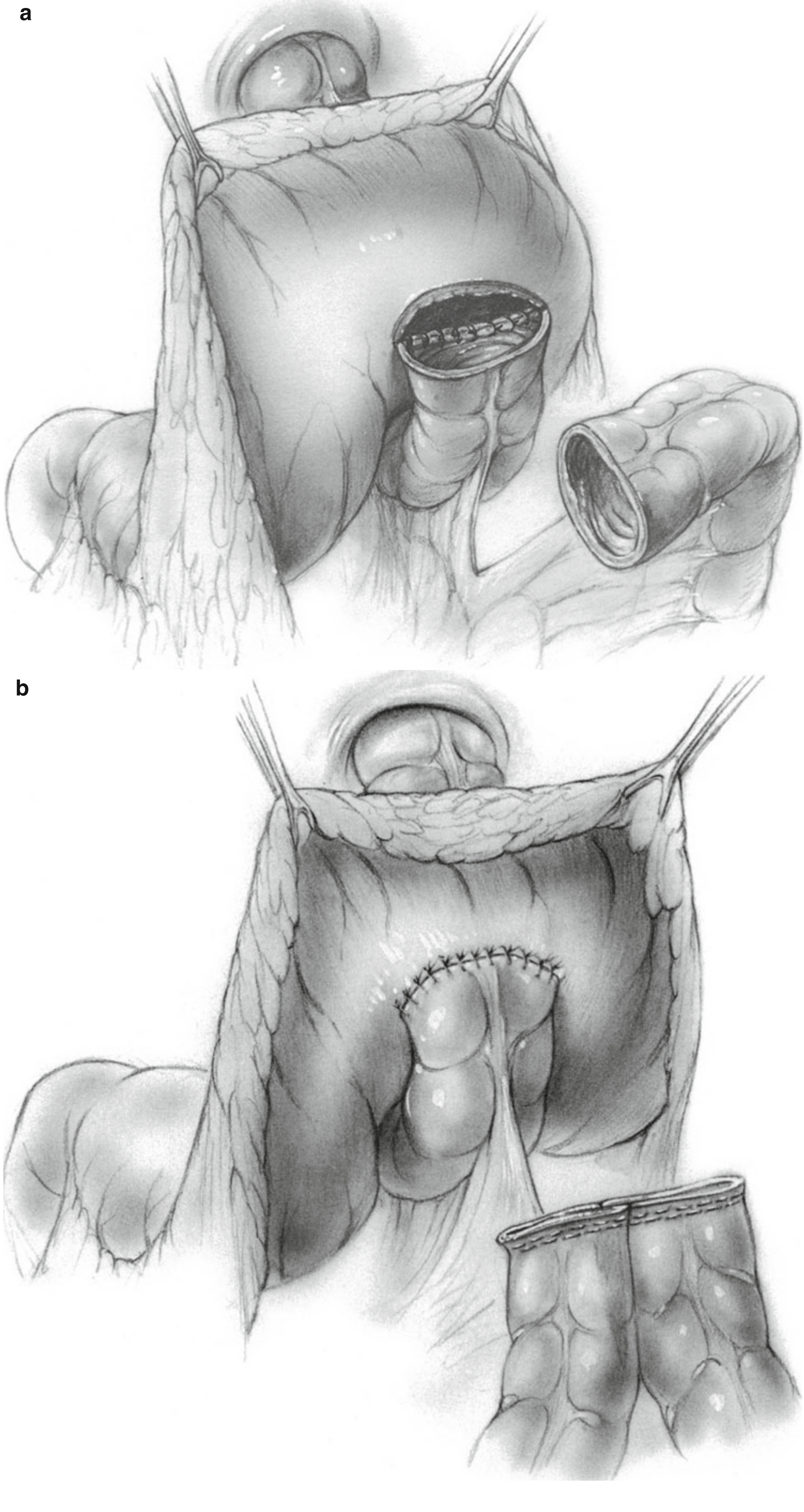

Fig. 18.7

is selected for passing the colon up to the neck, it is generally necessary to resect the head of one clavicle and a 2 cm width of adjacent sternal manubrium to be certain there is no obstruction at that point.

A good alternative method for transporting the colon up to the neck is to pass a 36F rubber catheter from the neck down into the abdominal cavity. Obtain a sterile plastic sheath such as a laser drape and suture the end of this plastic cylinder to the termination of the rubber catheter. Insert the proximal end of the colon into this plastic sheath and suture it lightly to the red rubber catheter. By withdrawing the catheter through the thoracic cavity into the neck, the colon with its delicate blood supply can be delivered into the neck without trauma.

Verify that the tube of colon from the neck to the abdominal cavity lies in a straight line and there is no surplus of colon in the chest. Leaving redundant colon in the thorax may produce a functional obstruction to the passage of food. Then suture the colon to the muscle of the diaphragmatic hiatus with interrupted sutures of atraumatic 4-0 Tevdek at intervals of about 2 cm around half the circumference of the colon. This helps maintain a direct passageway from the neck into the abdomen. Be sure not to pass the needle deep to the submucosa of the colon, as colonic leaks have been reported to result from this error.

Dissecting the Cervical Esophagus

Change the position of the patient's left hand, which is suspended from the ether screen. Bring the left hand laterally and place it along the left side of the patient. Turn the head slightly to the right and make an incision along the anterior border of the left sternomastoid muscle; continue the dissection as described in Figs. 14.27, 14.28, 14.29, and 14.30. Be careful not to damage the left or the right recurrent laryngeal nerve. After dissecting the esophagus free down into the superior mediastinum, extract the thoracic esophagus by applying gentle traction in the neck. In this way the thoracic esophagus and the attached colon interposition segment may be drawn gently into the neck. Divide the distal cervical esophagus and remove the thoracic esophagus. Inspect the end of the colon. There should be a good pulse in the marginal artery. Cyanosis indicates venous obstruction, which must be corrected. Draw the closed stapled end of the colon transplant to a point about 6–7 cm above the cut end of the esophagus and, taking care not to penetrate the lumen of the colon, suture the colon to the prevertebral fascia with several interrupted 4-0 silk sutures.

Esophagocolonic Anastomosis

Perform an end-to-side esophagocolonic anastomosis at a point about 4 cm below the proximal end of the colon using a technique similar to that described in Figs. 14.22, 14.23, 14.24, 14.25, and 14.26 and by using interrupted 4-0 silk Cushing sutures for the outer layer and 5-0 PG or PDS for the mucosal layer. Before closing the anterior portion of the anastomosis, ask the anesthesiologist to pass a nasogastric tube into the esophagus and guide this tube through the anastomosis into the colon.

Retrosternal Passage of Colon Transplant

When the posterior mediastinum is not a suitable pathway for the colon or if the esophagus has not been removed, make a retrosternal tunnel to pass the colon up to the neck. If the left lobe of the liver is large or if it appears to be exerting pressure on the posterior aspect of the colon transplant, liberate the left lobe by dividing the triangular ligament. This permits the left lobe to fall in a posterior direction and thereby relieves this pressure. If the xiphoid process curves posteriorly and impinges on the colon, resect the xiphoid.

Enter the plane just posterior to the periosteum of the sternum. Start the dissection with Metzenbaum scissors; then insert one or two fingers of the right hand. Finally, pass the entire hand just deep to the sternum up to the suprasternal notch. This is generally an avascular plane. Orient the colon segment so the mesentery enters from the patient's left side. Resect the medial 3–4 cm of clavicle using a Gigli saw. Then rongeur away about 2 cm of adjacent sternal manubrium to be certain the aperture at the root of the neck is sufficiently large to avoid any venous obstruction in the mesentery. Pass a long sponge holder into the retrosternal tunnel from the neck down into the abdomen and suture the proximal end of the colon segment to the tip of the sponge holder. Gently pass the colon into the substernal tunnel while simultaneously drawing the sutures in a cephalad direction.

There may be fewer symptoms after resection of the clavicular head if it is performed on the side opposite the dominant hand. Once it has been ascertained that the circulation to the colon segment is good, perform the esophagocolonic anastomosis as above. The final appearance of the colon interposition is depicted in Figs. 18.8 and 18.9.

Closure

Close the cervical incision in layers with interrupted 4-0 PG sutures. Insert one or two drains in the general vicinity of the anastomosis and leave them in place 7–10 days. Close the skin in the usual fashion. Close the thoracoabdominal incision as illustrated in Figs. 15.35, 15.36, 15.37, 15.38, 15.39, 15.40, and 15.41.

Colon Interposition, Short Segment

In rare cases of benign peptic stricture of the lower esophagus, it is impossible to dilate the stricture, even in the operating room, without rupturing the esophagus. If there is no significant amount of disease above the level of the inferior

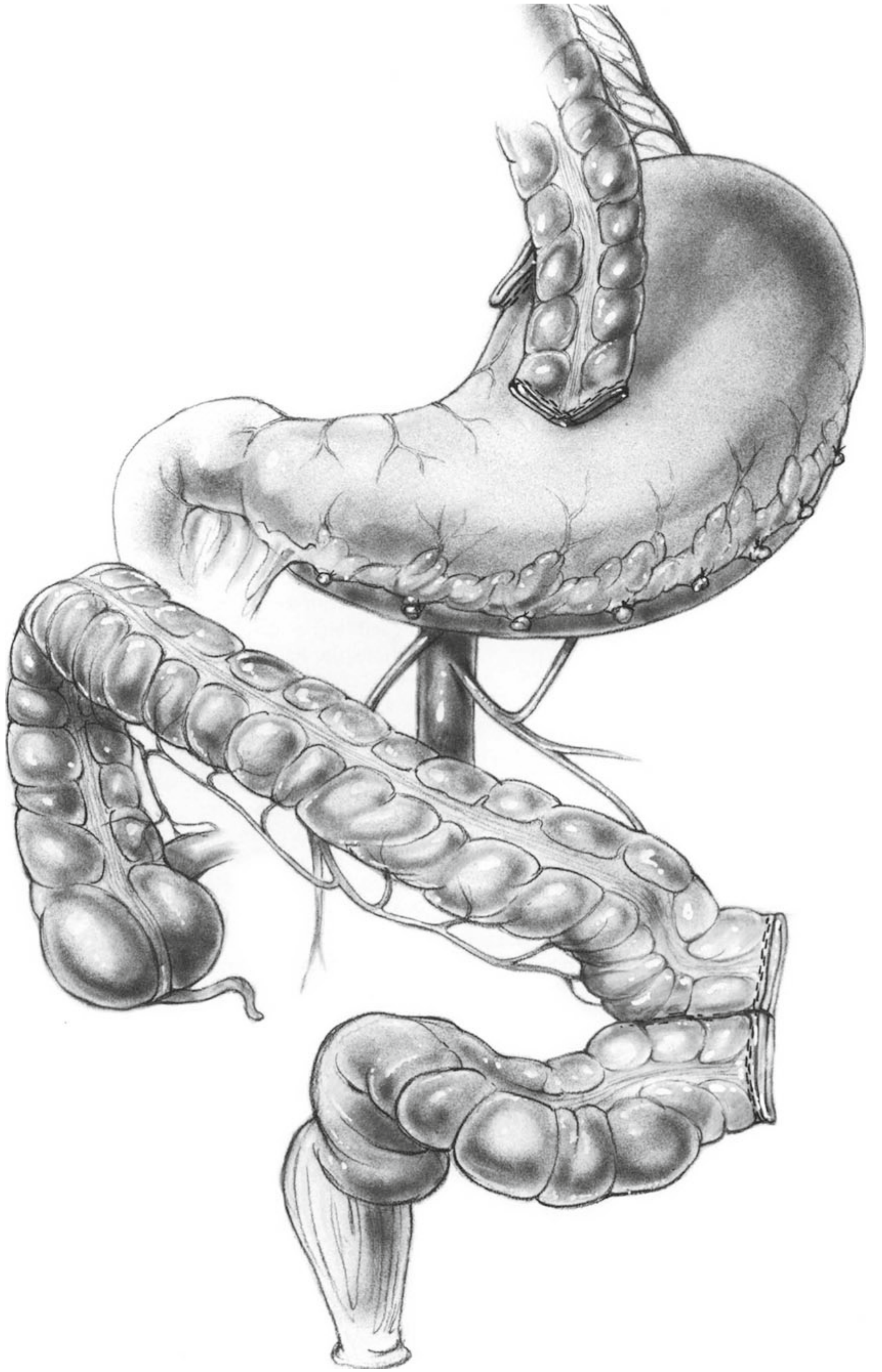

Fig. 18.8

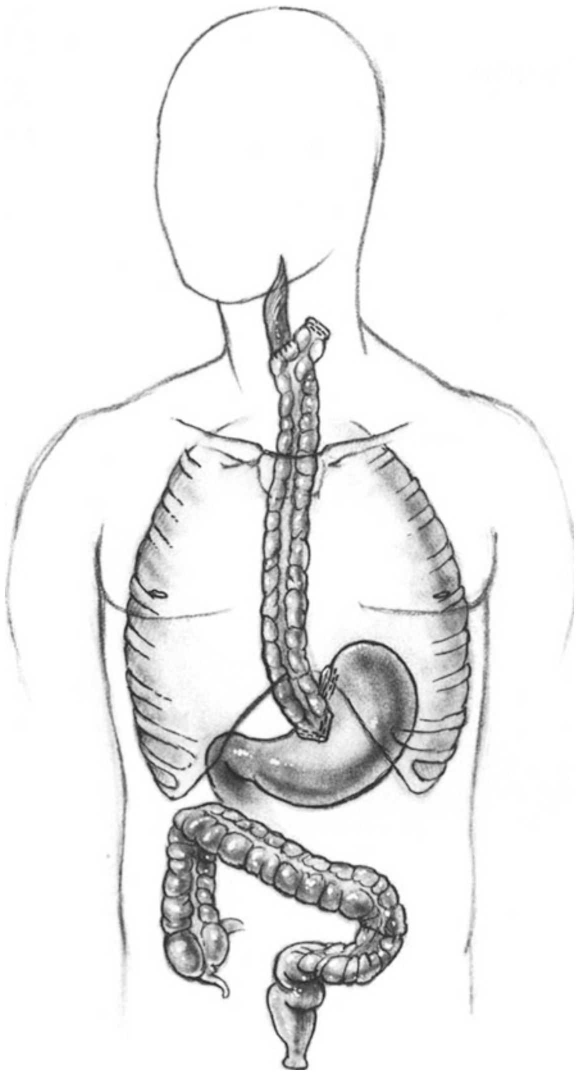

Fig. 18.9

pulmonary ligament, resect the diseased esophagus down to the esophagogastric junction and replace the missing esophagus with a short isoperistaltic segment of colon to extend from the divided esophagus to a point about one-third the distance between the fundus and the pylorus of the stomach. For a short-segment operation, it is not necessary to divide the middle colic artery, and only the distal portion of the transverse colon and the splenic flexure need be employed. Otherwise, the operation is much the same as described above. The cologastric anastomosis is identical. The esophagocolonic anastomosis may be sutured in an end-to-end fashion, an end-to-side fashion, or even by a stapling technique. The latter involves inserting a proper circular stapling cartridge (generally 28 or 25 mm) into the open proximal end of the colonic segment. The anastomosis is made between the end of the esophagus and the side of the colon by the usual circular stapling technique. Then, after disengaging the instrument, explore the anastomosis visually and manually with a finger through the open end of the colon. If the exploration appears satisfactory, close the opening in the colon about 1 cm away from the circular stapled anastomosis using a 55-/3.5-mm linear stapler. Excise the redundant tissue and remove the stapler.

Jejunum Interposition

Incision and Mobilization

Although Polk advocated mobilizing the esophagogastric junction through an upper midline abdominal incision, we prefer the left sixth-interspace thoracoabdominal incision with a vertical midline abdominal component. This is because the jejunal interposition operation is performed primarily in patients who have had multiple failed previous operations for reflux esophagitis. The Collis-Nissen gastroplasty combined with dilatation of the esophageal stricture suffices in most patients. This leaves a few of the most advanced cases that require a colon (short segment) or jejunum interposition.

The combined thoracoabdominal incision provides superb exposure and makes this operation as safe as possible. It should be emphasized that creating a jejunal segment is much more difficult than the short-segment colon interposition. When performing the thoracoabdominal incision, incise the diaphragm with electrocautery in a circumferential fashion, as depicted in Fig. 15.8.

Dissect the left lobe of the liver carefully away from the anterior wall of the stomach; in doing so, approach the dissection from the lesser curvature aspect of the stomach. At the same time, incise the gastrohepatic omentum by proceeding up toward the hiatus. This may require division of the accessory left hepatic artery, provided it has not been done at a previous operation (see Fig. 21.4). It may also be difficult to free the upper stomach from its posterior attachments to the pancreas. Careful dissection with good exposure from the thoracoabdominal incision should make it possible to preserve the spleen from irreparable injury. At the conclusion of this dissection, the upper portion of the stomach and lower esophagus should be free. Freeing the esophagus in the upper abdomen may be expedited by first dissecting the esophagus out of its bed in the lower mediastinum.

Resection of Diseased Esophagus

After the esophagus has been freed from its fibrotic attachments in the mediastinum and upper stomach, select a point near the esophagogastric junction for resection. If the upper stomach has been perforated during this dissection and the perforation can be included in the specimen, do so. If the upper stomach is not excessively thickened, apply a 55- or 90-mm linear stapling device with 4.8-mm staples and fire it. Transect the esophagogastric junction just above the stapling device. Lightly electrocoagulate the everted mucosa and remove the stapler. Deliver the transected esophagus into the chest and select the point of transection on the esophagus above the stricture. A mild degree of mucosal inflammation in the esophagus is acceptable at the point of transection. Remove the specimen.

If the point of division of the esophagus is not higher than the inferior pulmonary vein, jejunal interposition is a good method for establishing continuity. If the esophagus must be transected at a higher level, use a short segment of colon for the interposition or remove the remainder of the thoracic esophagus and reestablish continuity by means of a long-segment colon interposition from the neck to the stomach or by bringing the stomach up into the neck for this purpose, as described below. The graft of jejunum may be lengthened safely if its circulation can be boosted by creating microvascular anastomoses from a thoracic artery and vein to the upper end of the graft.

Mobilizing the Jejunum Graft

Because the vascular anatomy of the proximal jejunum varies somewhat from patient to patient, it is necessary to individualize the dissection according to the conditions encountered. First, try to stretch the proximal jejunum in a cephalad direction to determine where the greatest mobility is located. Be certain to leave intact at least the first major jejunal artery to the proximal jejunum. The average length of the jejunal segment to be transplanted varies between 12 and 20 cm, and the pedicle should consist of at least one major arcade vessel with careful preservation of the veins. Most jejunal grafts fail not because of poor arterial circulation but because the veins have been injured or compressed at some point. Follow the principles illustrated in Fig. 38.4 and try to preserve a vascular pedicle containing two arcade vessels with their veins intact. When dividing an arcade vessel, be sure to place the point of transection sufficiently proximal to a bifurcation so the continuity of the "marginal" artery and vein is not interrupted. Divide and temporarily close the jejunum proximally and distally with a linear cutting stapler, preserving a segment measuring 15–20 cm for interposition.

Make an incision in the transverse mesocolon through its avascular portion just to the left of the middle colic vessels. Carefully pass the jejunal graft together with its vascular pedicle through this incision into the previously dissected lesser sac behind the stomach. Be absolutely certain the incision in the mesentery does not constrict the veins of the vascular pedicle. Also be careful not to twist the pedicle. Pass the proximal portion of the jejunal segment through the hiatus into the chest. Be certain that the hiatus is large enough that it does not compress the veins in the vascular pedicle.

Esophagojejunostomy

Establish an end-to-side esophagojejunal anastomosis on the antimesenteric border of the jejunum beginning about 1 cm distal to the staple line on the proximal closed end of the jejunal segment. A technique similar to that described in Figs. 38.5, 38.6, 38.7, 38.8, 38.9, 38.10, 38.11, 38.12, 38.13, 38.14, and 38.15 using 4-0 atraumatic interrupted silk Cushing or Lembert sutures for the outer layer, and interrupted or continuous 5-0 Vicryl for the mucosal layer may be employed. Pass the nasogastric tube through this anastomosis down to the lower end of the jejunal graft. It is also possible to perform a stapled esophagojejunostomy by the technique described in Figs. 38.16.

Jejunogastrostomy

Place the jejunogastric anastomosis 5–7 cm below the proximal margin of the stomach in an area of stomach that is relatively free of fibrosis and that permits the vascular pedicle to be free of tension. This may be done by the same suture technique as mentioned above (see Figs. 38.5, 38.6, 38.7, 38.8, 38.9, 38.10, 38.11, 38.12, 38.13, 38.14, and 38.15), but if there is sufficient length of jejunum, it may also be performed by a stapled anastomosis similar to that described in Figs. 18.2, 18.3, 18.4, 18.5, and 18.6. The appearance of the completed anastomosis is shown in Fig. 18.10.

Jejunojejunostomy

Reestablish the continuity of the jejunum by creating a functional end-to-end anastomosis using the stapling technique described in Figs. 43.12, 43.13, 43.14, 43.15, and 43.16. Then carefully resuture the defect in the jejunal mesentery without compressing the vascular pedicle jejunal graft.

Use interrupted 4-0 Tevdek sutures to approximate the diaphragmatic hiatus to the seromuscular wall of the jejunum to avoid herniation of bowel through the hiatus. Be certain not to compress the vascular pedicle.

Gastrostomy; Pyloromyotomy

Although the nasogastric tube has been passed through the jejunal graft into the stomach to maintain the position of the graft, there is a risk that the nasogastric tube may be inadvertently removed before the patient's gastrointestinal tract has resumed function. For this reason, perform a Stamm gastrostomy as described in Figs. 36.1, 36.2, 36.3, 36.4, and 36.5 and remove the nasogastric tube.

Most surgeons advocate performing a pyloromyotomy or pyloroplasty during this type of operation because it is assumed that the vagus nerves have been interrupted during the course of dissecting a heavily scarred esophagus out of the mediastinum. Polk stated that this step may not be necessary.

Closure

Repair the diaphragm and close the thoracoabdominal incision as illustrated in Figs. 15.38, 15.39, 15.40, 15.41, 15.42, 15.43, and 15.44 after inserting a chest tube. No abdominal drains are utilized.

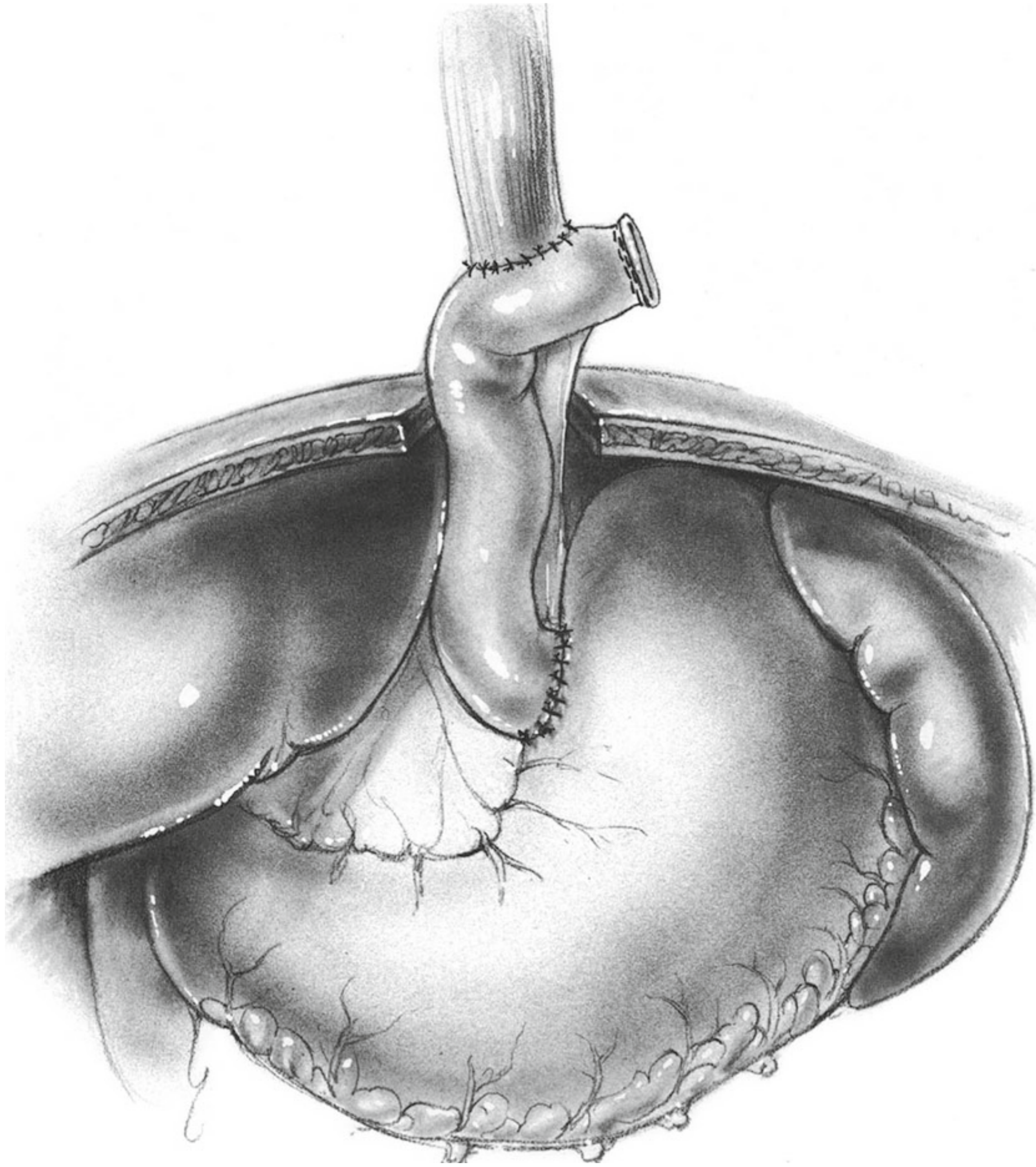

Fig. 18.10

Further Reading

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19 Transabdominal Nissen Fundoplication

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Gastroesophageal reflux (see Chap. 13), generally in patients in whom laparoscopic Nissen fundoplication is not applicable

Preoperative Preparation

Esophagogastroduodenoscopy with brushing and biopsies of any abnormal mucosa
Esophageal manometry or pH studies in selected patients

Pitfalls and Danger Points

Inadequate mobilization of gastric fundus and abdominal esophagus
Injury to spleen or to vagus nerves
Fundoplication wrap too tight or too long
Inadequate fundoplication suturing
Undiagnosed esophageal motility disorders, such as achalasia, diffuse spasm, aperistalsis, or scleroderma
Hiatal closure too tight, causing esophageal obstruction
Hiatal closure too loose, permitting postoperative paraesophageal herniation
Injury to left hepatic vein or vena cava when incising triangular ligament to liberate left lobe of liver

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Operative Strategy

Mobilizing the Gastric Fundus

To perform a hiatus hernia repair efficiently, the lower 5–7 cm of the esophagus and the entire gastric fundus from the gastroesophageal junction down to the upper short gastric vessel must be completely mobilized from all attachments to the diaphragm and the posterior abdominal wall. Identify the gastrophrenic ligament by passing the left hand behind the stomach so the fingertips can identify this avascular ligament, which attaches the greater curvature to the diaphragm. The ligament extends from the gastroesophageal junction down to the first short gastric vessel. It is simple to divide once it has been stretched by the surgeon's left hand behind the stomach. Although in a few cases no short gastric vessels must be divided, there should be no hesitation to divide one to three proximal short gastric vessels to create a loose fundoplication.

On the lesser curvature aspect of the gastroesophageal junction, it is necessary to divide the proximal portion of the gastrohepatic ligament. This ligament often contains an accessory left hepatic artery arising from the left gastric artery and going to the left lobe of the liver and the hepatic branch of the left vagus nerve. Division of the accessory left hepatic artery has, in our experience, not proved harmful. Do not divide the left gastric artery itself. Preserving the left gastric artery and the hepatic branch of the vagus nerve helps prevent the fundoplication from slipping in a caudal direction. The lower esophagus is freed by incising the overlying peritoneum and phrenoesophageal ligaments; continue this incision in a semicircular fashion so the muscular margins of the diaphragmatic crura are exposed down to the median arcuate ligament. During all of this mobilization, look for the major branches of the anterior and posterior vagus nerves and preserve them.

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Preventing Splenic Injury

Splenic trauma is a common but preventable complication of the Nissen operation. With use of the Thompson or upper hand retractor, there is no reason for any retractor to come into contact with the spleen. The mechanism of splenic injury is usually traction on the body of the stomach toward the patient's right, which avulses that portion of the splenic capsule attached to the omentum or to the gastrosplenic ligament. Early during the operation, make it a point to look at the anterior surface of the spleen. Note where the omentum may be adherent to the splenic capsule. If necessary, divide these attachments under direct vision. Otherwise, simply apply a moist gauze pad over the spleen and avoid lateral traction on the stomach. Traction on the gastroesophageal junction in a caudal direction along the *lesser* curve of the stomach generally does not cause injury to the spleen.

If a portion of the splenic capsule has been avulsed, it can almost always be managed by applying topical hemostatic agents followed by 10 min of pressure. Other splenic injuries can be repaired by suturing with 2-0 chromic catgut (see Chap. 97). Extensive disruption of the spleen at its hilus may necessitate splenectomy.

Avoiding Postoperative Dysphagia

Probably secondary to local edema, transient mild dysphagia is common during the first 2–3 weeks following operation, although some patients have difficulty swallowing for many months after a hiatus hernia operation. There are several possible causes for this dysphagia. First, it is possible to make the fundoplication wrap so tight or so wide that permanent dysphagia ensues (see below). Second, the defect in the hiatus may be sutured so tightly the hiatus impinges on the lumen of the esophagus and prevents passage of food. With an 18 F nasogastric tube in place, after the crural sutures have been tied to repair the defect in the hiatus, it should still be possible to insert an index finger without difficulty between the esophagus and the margins of the hiatus. There is no virtue in closing the hiatus snugly around the esophagus. A final cause of dysphagia in patients who have experienced this symptom as a preoperative complaint is the presence of an esophageal motility disorder such as achalasia or aperistalsis. Patients who present to the surgeon with reflux esophagitis and who also complain of dysphagia should undergo preoperative esophageal manometry to rule out motility disorders that may require surgery in addition to the antireflux procedure or instead of it.

How Tight Should the Fundoplication Be?

The Nissen operation produces a high pressure zone in the lower esophagus by transmitted gastric pressure in the wrap, rather than by the tightness of the wrap itself. An excessively tight wrap causes dysphagia and the gas bloat syndrome. Therefore the fundoplication should be made loose, rather than tight enough to constrict the esophagus. Many surgeons use an indwelling esophageal bougie to avoid creating a wrap that is too tight. Regardless of whether the indwelling bougie is used, it is possible to judge the tightness of the wrap by applying Babcock clamps to each side of the gastric fundus and tentatively bringing them together in front of the esophagus. This mimics the effect of the sutures. The surgeon should be able to pass one or two fingers between the wrap and the esophagus without difficulty with an 18 F nasogastric tube in place. Otherwise readjust the fundoplication so it is loose enough for this maneuver to be accomplished.

How Long Should the Fundoplication Be?

Another cause of postoperative dysphagia is making the fundoplication wrap too long. For the usual Nissen operation, do not wrap more than 2–3 cm of esophagus. A shorter wrap may be appropriate when esophageal dysmotility and gastroesophageal reflux coexist (e.g., when a fundoplication is added to a myotomy).

Avoiding Fundoplication Suture Line Disruption

Polk and others have noted that an important cause of failure after Nissen fundoplication has been disruption of the plication because the sutures broke. For this reason, use 2-0 sutures. Generally, the sutures that were found to have broken were silk. We have used 2-0 Tevdek because it retains its tensile strength for many years, whereas silk gradually degenerates in the tissues. It is also important not to pass the suture into the lumen of the stomach or esophagus. If this error is committed, tying the suture too tight causes strangulation and possibly leakage. Some insurance against the latter complication is to turn in the major fundoplication sutures with a layer of continuous 4-0 Prolene seromuscular Lembert sutures.

Failure to Bring the Esophagogastric Junction into the Abdomen

If it is not possible to mobilize the esophagogastric junction from the mediastinum and bring it into the abdomen while performing transabdominal repair of a hiatus hernia, it is likely that esophageal fibrosis has produced shortening. Such a situation can generally be suspected prior to operation when the lower esophagus is strictured. In our opinion, these patients require a transthoracic Collis-Nissen operation (see Chap. 22). Although it is possible to perform a

Collis-Nissen procedure in the abdomen, it is difficult. If it cannot be accomplished transabdominally, it is necessary to open the chest through a separate incision or through a thoracoabdominal extension to perform the Collis-Nissen operation.

Keeping the Fundoplication from Slipping

Various methods have been advocated to keep the fundoplication from sliding in a caudal direction, where it constricts the middle of the stomach instead of the esophagus and produces an "hourglass" stomach with partial obstruction. The most important means of preventing this caudal displacement of the wrap is to include the wall of the esophagus in each of the fundoplication sutures. Also, catch the wall of the stomach just below the gastroesophageal junction within the lowermost suture. This suture anchors the lower portion of the wrap (see Fig. 19.10 below).

Documentation Basic

- Findings
- Placement of wrap relative to vagus nerves
- Closure of hiatus?

Operative Technique

Incision

Elevate the head of the operating table 10–15°. Make a midline incision beginning at the xiphoid and continue about 2–3 cm beyond the umbilicus (Fig. 19.1). Explore the abdomen. Insert a Thompson or Upper Hand retractor to elevate the lower portion of the sternum. Reduce the hiatus hernia by traction along the anterior wall of the stomach. Look at the anterior surface of the spleen to determine whether there are omental adhesions to the capsule that may result in the capsule avulsing later during the operation. Place a moist gauze pad over the spleen. In most cases it is not necessary to free the left lobe of the liver; simply elevate the left lobe with a Weinberg retractor to expose the diaphragmatic hiatus.

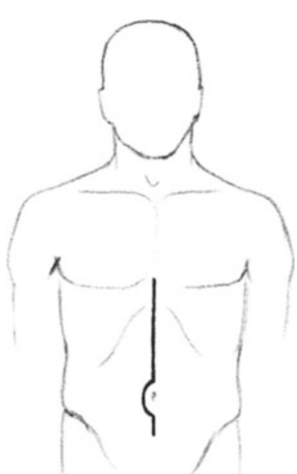


Fig. 19.1

Mobilizing the Esophagus and Gastric Fundus

Make a transverse incision in the peritoneum overlying the abdominal esophagus (Fig. 19.2) and continue this incision into the peritoneum overlying the right margin of the crus. Then divide the peritoneum overlying the left margin of the diaphragmatic hiatus. Separate the hiatal musculature from the esophagus using a peanut dissector until *most of the circumference of the esophagus has been exposed*. Then pass the index finger *gently* behind the esophagus and encircle it with a latex drain (Fig. 19.3). Enclose both the right and left vagus nerves in the latex drain and divide all the phrenoesophageal attachments behind the esophagus. If the right (posterior) vagus trunk courses at a distance from the esophagus, it is easier to dissect the nerve away from the upper stomach and to exclude the right vagus from the fundoplication wrap. Some exclude both vagus trunks from the wrap, but we prefer to include them inside the loose wrap. Before the complete circumference of the hiatus can be visualized, it is necessary to divide not only the phrenoesophageal ligaments but also the cephalad portion of the gastrohepatic ligament, which often contains an accessory left hepatic artery that may be divided (Fig. 19.4). The exposure at the conclusion of this maneuver is seen in Fig. 19.5. Now pass the left hand behind the esophagus and behind the gastric fundus to identify the gastrophrenic ligament and divide it carefully down to the proximal short gastric vessel (Fig. 19.6).

While the assistant is placing traction on the latex drain to draw the esophagus in a caudal direction, pass the right hand to deliver the gastric fundus behind the esophagus (Fig. 19.7). Apply Babcock clamps to the two points on the stomach where the first fundoplication suture will be inserted and bring these two Babcock clamps together tentatively to assess whether the fundus has been mobilized sufficiently to accomplish the fundoplication without tension. Figure 19.8, a cross-sectional view, demonstrates how the gastric fundus surrounds the lower esophagus and the vagus nerves.

Generally, there is inadequate mobility of the gastric fundus unless one divides the proximal one to three short gastric vessels. Ligate each with 2-0 silk.

On the greater curvature aspect of the esophagogastric junction, there is usually a small fat pad. Excising the fat pad improves adhesion of the gastric wrap to the esophagus.

Fig. 19.2

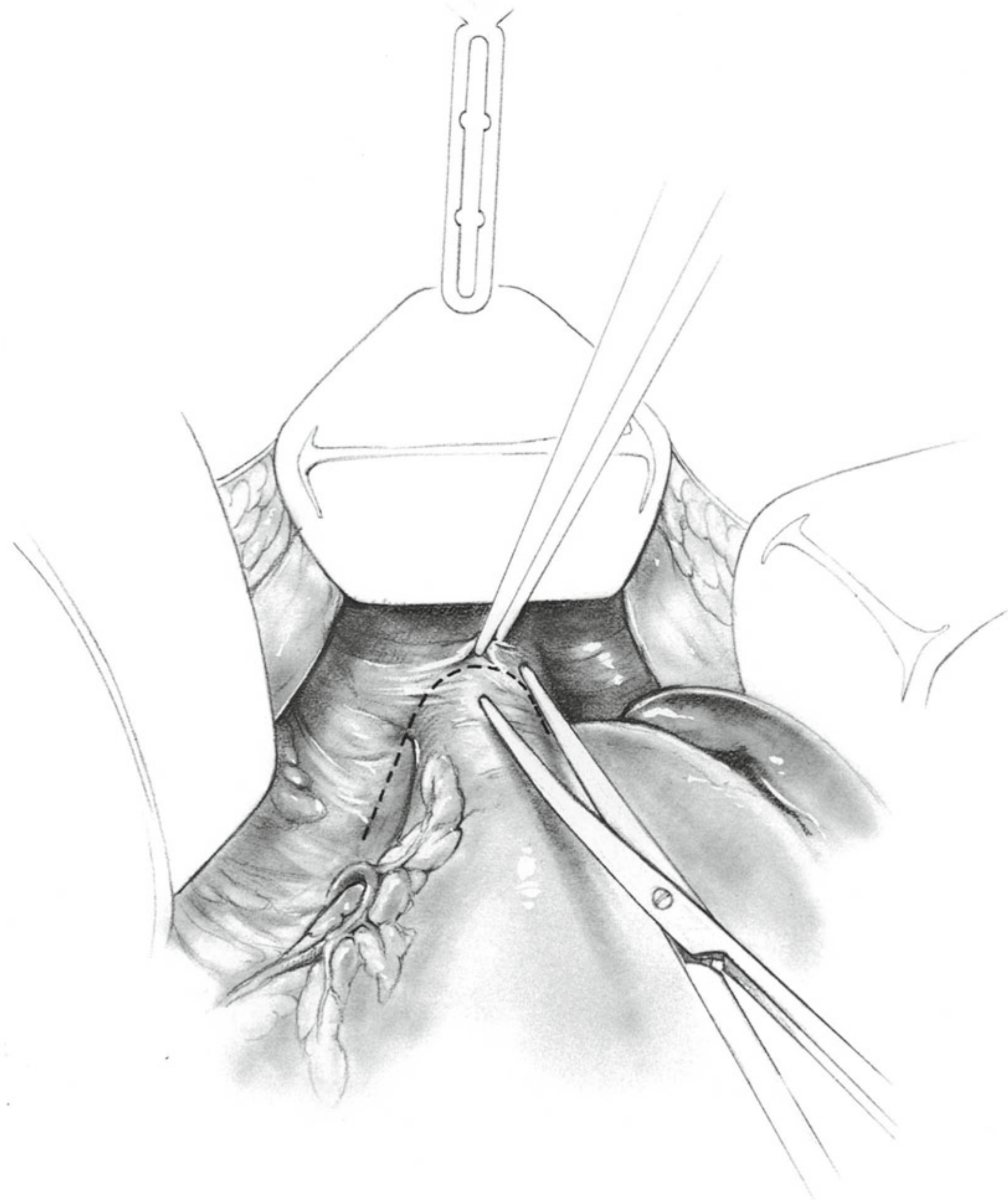
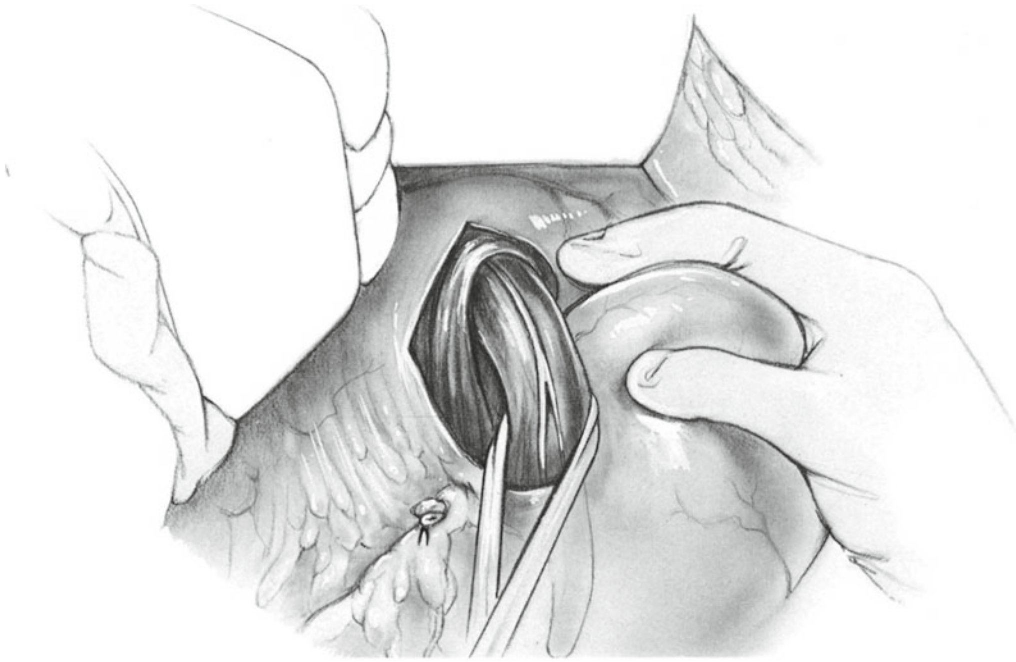


Fig. 19.3



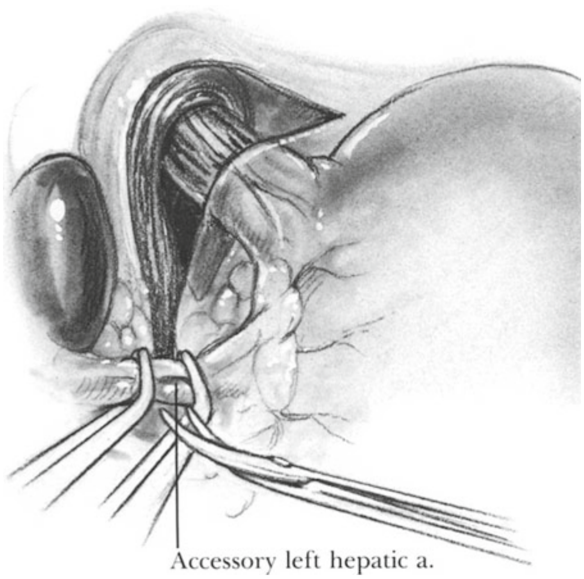


Fig. 19.4

Fig. 19.5

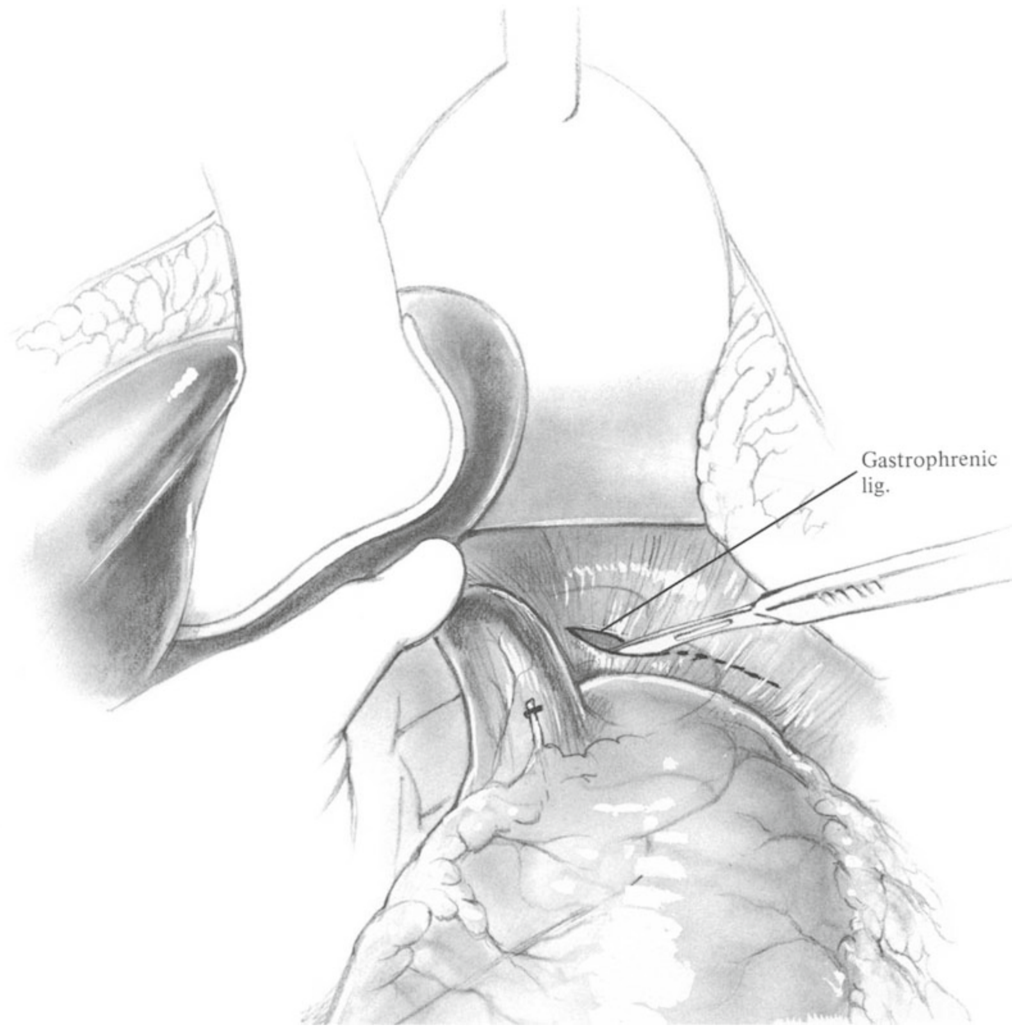


Fig. 19.6

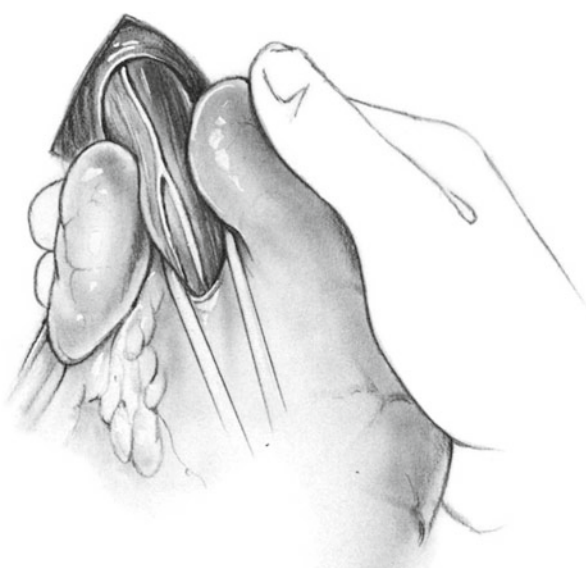


Fig. 19.7

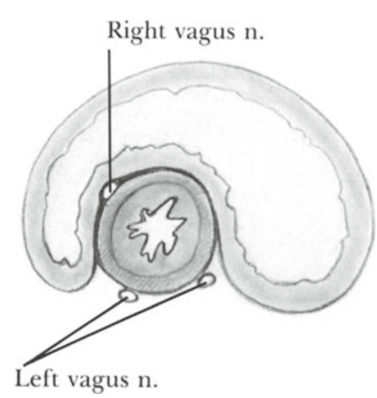
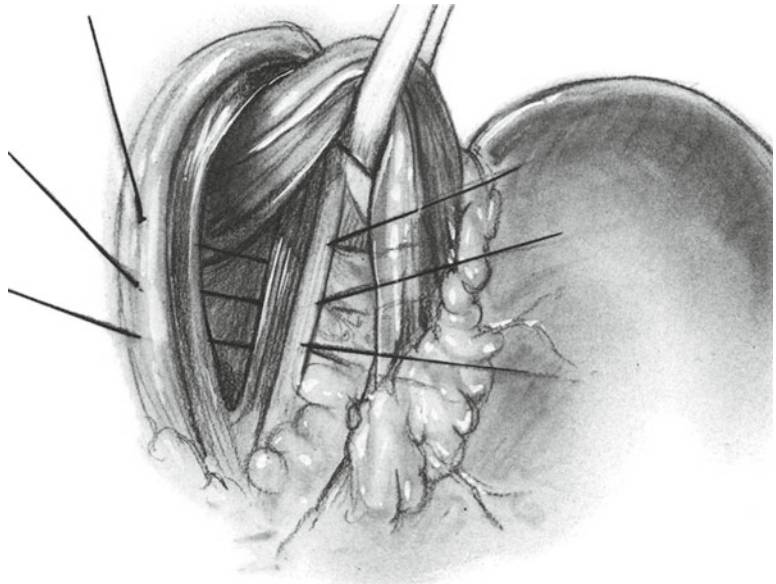


Fig. 19.8

Fig. 19.9



Repairing the Hiatal Defect

Using 0 Tevdek sutures on a large atraumatic needle, begin at the posterior margin of the hiatal defect and take a bite (1.3–2.0 cm in width) of the crus and its overlying peritoneum on each side of the hiatus. Insert the next suture about 1.0–1.2 cm cephalad and continue this process until the index finger can just be inserted *comfortably* between the esophagus and the margin of the hiatus (Fig. 19.9).

Suturing the Fundoplication

Pass a 40 F Maloney dilator into the stomach. Insert the first fundoplication suture by taking a bite of the fundus on the patient's left using 2-0 atraumatic Tevdek. Pass the needle through the seromuscular surface of the gastric lesser curve just distal to the esophagogastric junction; then take a final bite of the fundus on the patient's right. Attach a hemostat to tag this stitch but do not tie it. Each bite should contain 5–6 mm of tissue including submucosa, but it should not penetrate the lumen. Do not pierce any of the vagus nerves with a stitch. To perform a fundoplication without tension, it is necessary to insert the gastric sutures a sufficient distance lateral to the esophagogastric junction. Place additional sutures, as illustrated in Fig. 19.10, at intervals of about 1 cm. Each suture should contain one bite of fundus, then esophagus, and then the opposite side of the fundus. No more than 2–3 cm of esophagus should be encircled by the fundoplication. Now tie all of these sutures (Fig. 19.11). It should be possible to insert one or two fingers between the esophagus and the Nissen wrap (Fig. 19.12). If this cannot be done, the wrap is too tight.

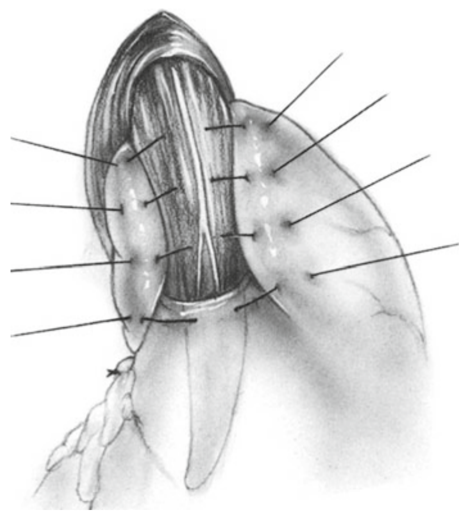


Fig. 19.10

A number of surgeons place sutures fixing the upper margin of the Nissen wrap to the esophagus to prevent the entire wrap from sliding downward and constricting the stomach in the shape of an hourglass. DeMeester and Stein, after considerable experience, advocated a Nissen wrap measuring only 1 cm in length, claiming that longer wraps produce postoperative dysphagia in a number of patients. Even with a 60 F Maloney bougie in the esophagus, a 1 cm wrap has effectuated excellent control of reflux. They constructed this wrap employing one horizontal mattress suture of 2-0 Prolene buttressed with Teflon pledgets (Figs. 19.13 and 19.14).

Optionally, at this point one may invert the layer of fundoplication sutures by inserting a continuous seromuscular layer of 4-0 Prolene Lembert sutures (not illustrated). This

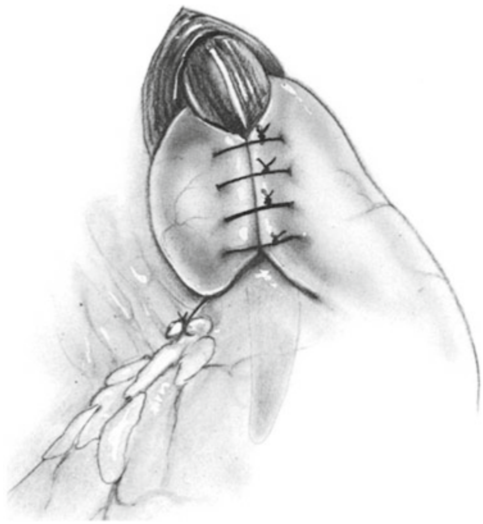
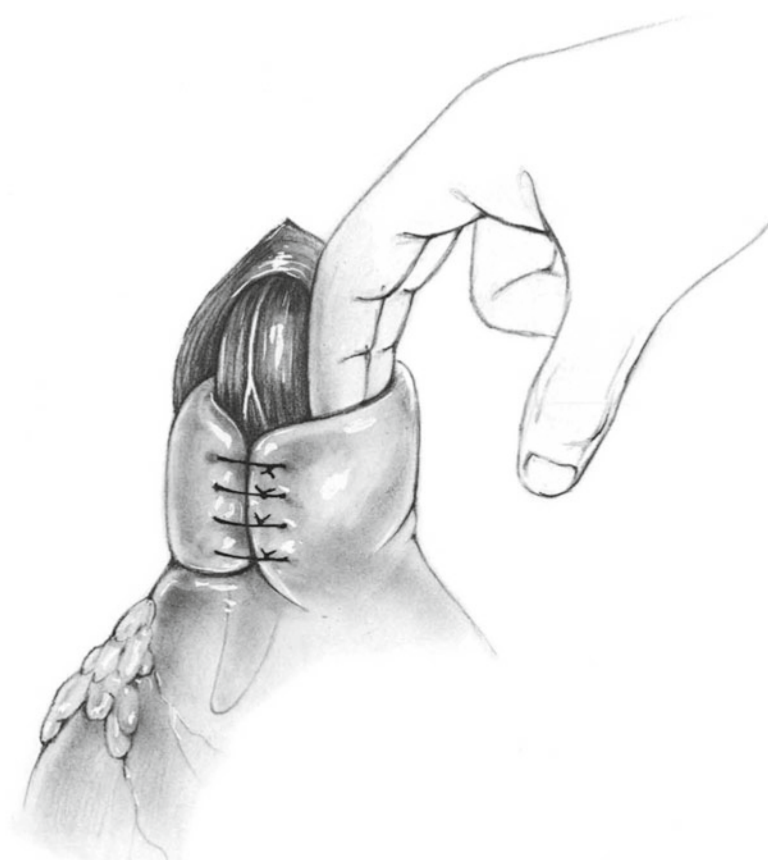


Fig. 19.11

Fig. 19.12



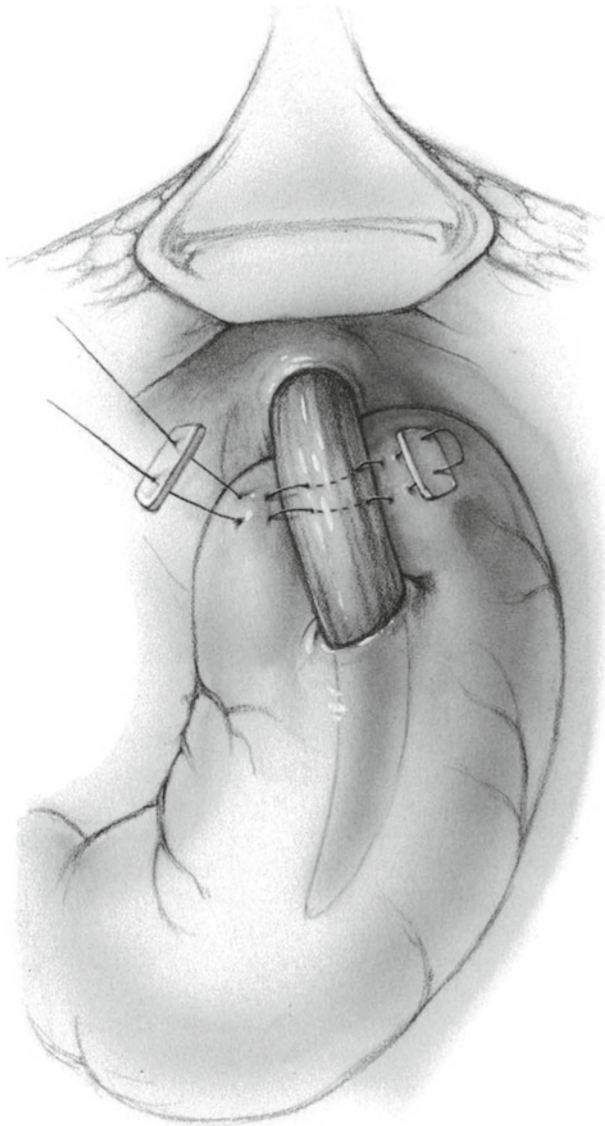


Fig. 19.13

layer provides protection against leakage if any of the fundoplication sutures were placed too deep.

Testing Antireflux Valve

Ask the anesthesiologist to inject 300–400 ml saline solution into the nasogastric tube and then withdraw the tube into the esophagus. Now try to expel the saline by compressing the stomach. If the saline cannot be forced into the esophagus by moderate manual compression of the stomach, the fundoplication has indeed created a competent antireflux valve.

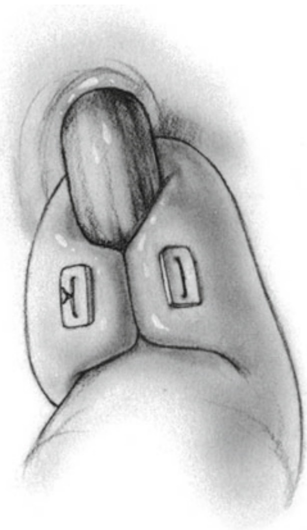


Fig. 19.14

Abdominal Closure

Close the abdomen without drainage in routine fashion.

Postoperative Care

Continue nasogastric suction for 1–2 days. Then initiate oral feeding. A barium esophagram is obtained before the patient is discharged. If a satisfactory repair has been accomplished, 3–4 cm of distal esophagus becomes progressively narrower, tapering to a point at the gastroesophageal junction. If this tapering effect is not noted, it suggests that the wrap may be too loose. Successful antireflux procedures, whether by the Nissen, Hill, Belsey, or Collis-Nissen technique, show similar narrowing of the distal esophagus on the postoperative esophagram. A typical postoperative barium esophagram is shown in Fig. 19.15.

Complications

Dysphagia, usually transient "gas bloat" (rare)
Disruption of fundoplication
Slipping downward of fundoplication with obstruction
Postoperative paraesophageal hernia if hiatal defect was not properly closed
Herniation of fundoplication into thorax
Esophageal or gastric perforation by deep necrosing sutures
Persistent gastroesophageal reflux

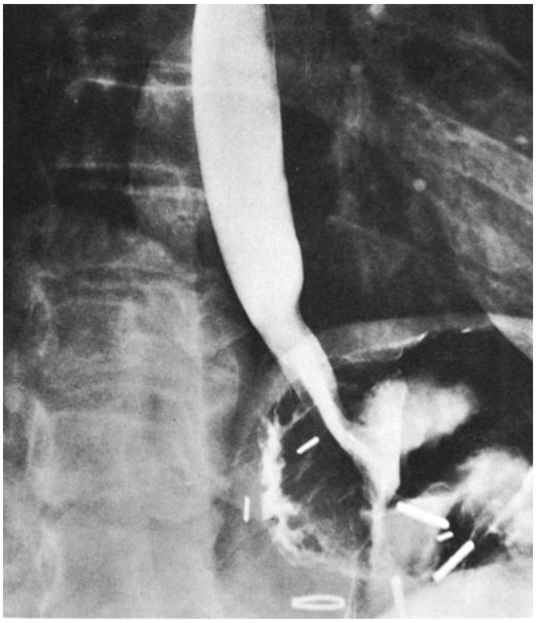


Fig. 19.15

Further Reading

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Laparoscopic Nissen Fundoplication

20

Carol E.H. Scott-Conner

Indications

Symptomatic reflux esophagitis refractory to medical therapy
Barrett's esophagus (consider mucosal ablation)

Preoperative Preparation

Pass a nasogastric tube to decompress the stomach.
See Chap. 19.

Pitfalls and Danger Points

Injury to the esophagus.
Tension pneumothorax due to unrecognized entry into the mediastinal pleura. Even a relatively small tear can allow CO_2 to enter the pleural space and compromise ventilation.
Injury to spleen or stomach.
Failure to create a sufficiently floppy wrap.

Operative Strategy

Several laparoscopic fundoplications have been devised. We prefer the laparoscopic Nissen fundoplication because it is intended to be virtually identical to a well-established open procedure when completed. The steps in the dissection are necessarily a bit different from those for the open procedure, and several additional features should be noted.

First, the hiatus is accessed by elevating the left lobe of the liver without dividing its attachments. Second, the esophagus is exposed and mobilized by dissecting the crura with minimal manipulation of the esophagus. The resulting extensive mediastinal dissection that accompanies esophageal mobilization makes approximation of the crura mandatory. Postoperative herniation of the stomach or small intestine may complicate the laparoscopic procedure when this step is omitted. Finally, several short gastric vessels *must* be divided to ensure creating a floppy wrap.

The operation has been adapted to a robotic approach. See references at the end for this and other adaptations to newer laparoscopic approaches.

Documentation Basics

- Findings
- Position of wrap relative to vagus nerves
- Associated paraesophageal hernia?

Operative Technique

Room Setup and Trocar Placement

Position the patient with the legs slightly spread and supported on padded stirrups (Fig. 20.1). Position the monitors at the head of the table. We place the primary monitor at the patient's left shoulder, with a secondary monitor at the patient's right, as shown. Some surgeons use a single monitor placed over the head of the operating table. We prefer to stand in the usual position, at the patient's side, for the initial puncture and entry into the abdomen. During dissection and suturing, the surgeon should stand between the patient's legs,

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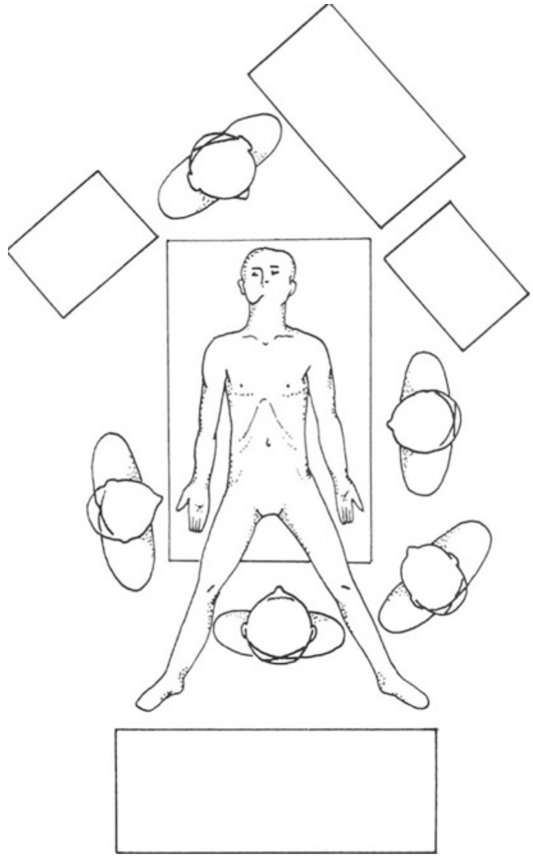

Fig. 20.1 (Reprinted with permission, from Scott-Conner CEH, editor. The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer; 1999)

directly facing the hiatus (Fig. 20.2). When choosing an initial puncture site (to be used for the laparoscope), recall that the hiatus is quite high and deep. The normal umbilical port site may therefore be too low. A trocar pattern must be individualized according to the patient's body habitus. A 30° angled laparoscope is mandatory for easy visualization.

Exposure of the Hiatus

Pass a liver retractor through the right lateral port site. A variety of liver retractors are available, and which one is chosen is largely a matter of the surgeon's preference. We prefer a flexible retractor that becomes rigid and assumes the shape shown in Fig. 20.3 when a screw is turned. The particular retractor shown is composed of many short segments with an internal cable. When the tension on the cable is released, the retractor becomes limp and may be straightened out to pass it through a trocar. Once the retractor is inside the abdomen, the cable is tightened by twisting a knob on the handle. Increasing tension on the internal cable forces the articulations to bend into the shape shown. The retractor is bent into shape by tightening the cable in the commodious right subphrenic space and is then passed underneath the liver.

The liver retractor is properly placed when stable exposure is obtained, and the diaphragmatic surface is seen behind the left lobe of the liver. It may not be possible to distinguish the actual hiatus at this point. This exposure generally requires that the retractor be "toed in" so the part of the retractor closest to the hiatus has maximal lift applied. The laparoscope and instruments are then insinuated underneath the left lobe of the liver in the working space thus created.

Generally, the stomach and some omentum partially or completely obscure the hiatus even with the liver retracted. Therefore the second part of obtaining exposure entails placing an endoscopic Babcock clamp on the stomach and pulling toward the left lower quadrant (Fig. 20.4).

Dissecting the Hiatus

The esophagus is dissected by clearing the peritoneum off the hiatus and carefully exposing the muscular crura. Properly performed, this maneuver automatically exposes the esophagus and creates a posterior window.

Begin the dissection by exposing the right crus. Start by opening the peritoneum just to the right of the probable hiatus. The first step involves dividing the lesser omentum. A grasper is used to elevate the flimsy lesser omentum close to the hiatus, and ultrasonic dissecting scissors are used to divide the omentum (Fig. 20.4).

It is tempting to begin this dissection by opening the transparent part of the omentum farther to the right. If you begin your omental window high, however, near the hiatus, you are less likely to encounter a hepatic artery. This has the additional advantage of keeping the window in the lesser omentum relatively small, which helps anchor the wrap and prevents slipping.

Do not try to identify and dissect the esophagus at this stage. To do so risks perforation. A far safer approach is to dissect and clearly define the muscular hiatus and both crura. First identify the right crus after dividing the peritoneum. Next carry the dissection up over the arch of the crura, concentrating on exposing the muscle fibers of the diaphragm. During this dissection, the esophagus becomes obvious by its orientation, longitudinal muscle, and overlying vagus nerve; it may also be gently displaced downward (Fig. 20.5) and to the left. The esophagus has a light pink to reddish pink color and characteristic longitudinal striations. If there is uncertainty as to the location of the esophagus, the nasogastric tube may be palpable to light touch with a grasper, or an esophagogastroduodenoscopy (EGD) scope may be passed and used to elevate and transilluminate the esophagus. These maneuvers are rarely needed.

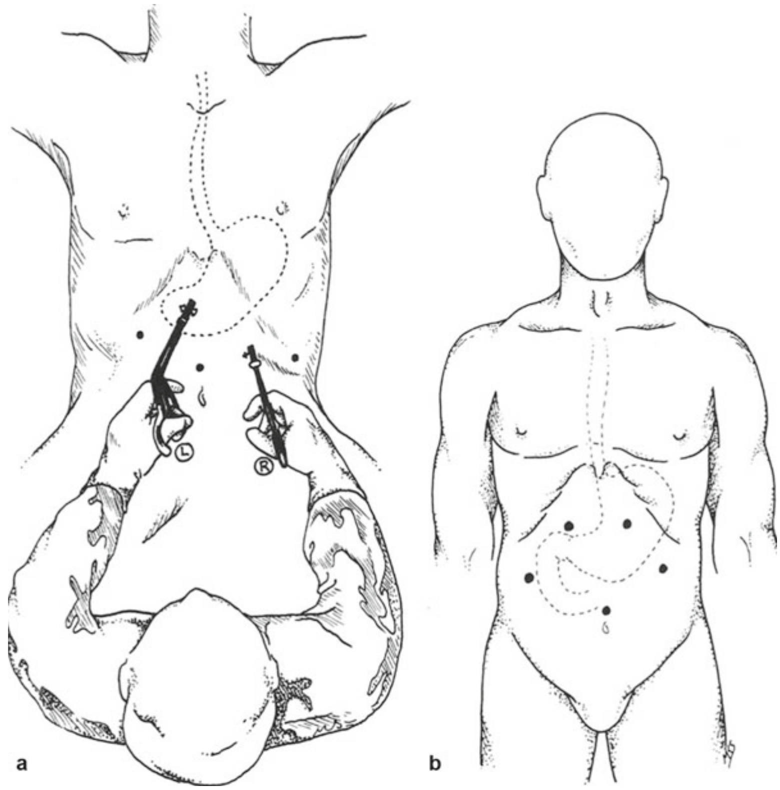

Fig. 20.2 (Reprinted with permission, from Scott-Conner CEH, editor. The SAGES manual: fundamentals of laparoscopy and GI endoscopy. New York: Springer; 1999)

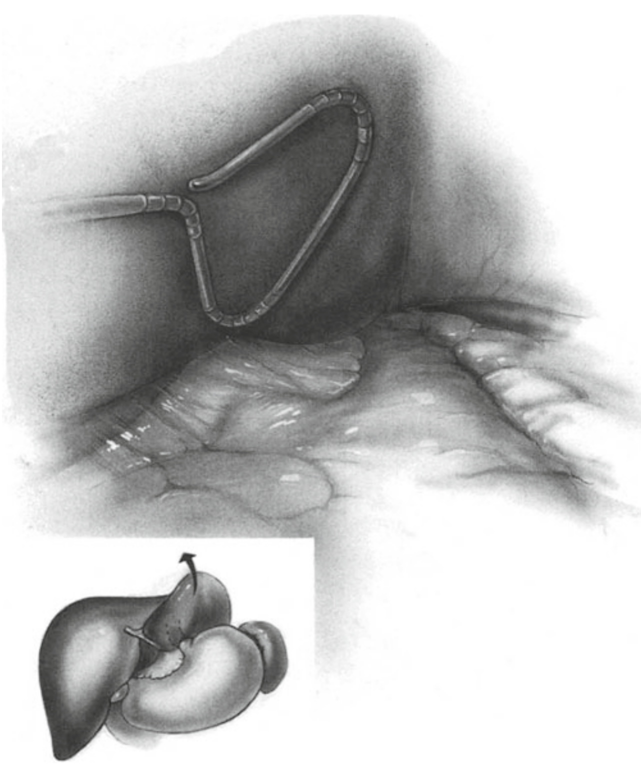

Fig. 20.3

A closed grasper is used to push the esophagus down. This grasper is introduced parallel to the esophagus through one of the left-sided trocars and is used to probe into the mediastinum by gently pushing the esophagus down.

When the upper part of the hiatus has been cleaned thoroughly, elevate the esophagus gently with a closed grasper and clean the lower part of the *left* crus from the *right* side by working underneath the esophagus (Fig. 20.6). This maneuver produces a window behind the esophagus while minimizing the risk of perforating the esophagus. The esophagus is *never actually grasped*; rather, it is gently displaced to one side or the other using a closed grasper. Frequently the anterior vagus nerve is seen on the right side of the esophagus.

It is fairly common to encounter a sizable vessel next to the esophagus on the right side (Fig. 20.7).

The vessel is smaller than it appears; it looks large because it is closer to the scope than the esophagus. This vessel is usually a branch of the inferior phrenic artery. It must be carefully secured with ultrasonic shears (Fig. 20.8). A replaced hepatic artery, sometimes encountered in this region, is usually larger and is seen to curve away toward the liver rather than pass cephalad toward the diaphragm. If a replaced hepatic artery is encountered, gently displace it to the right (out of the field of surgery) and protect it.

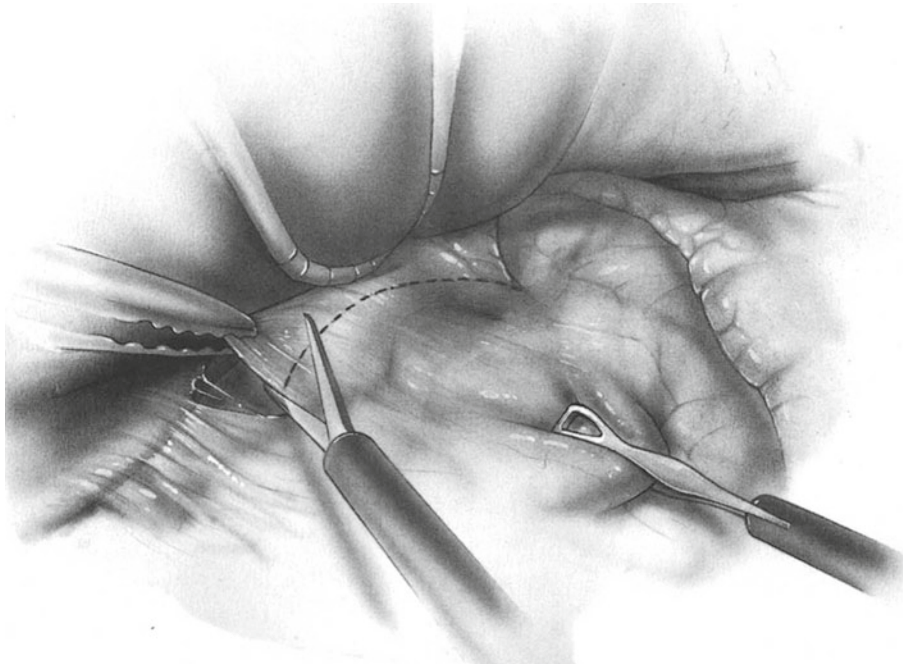

Fig. 20.4

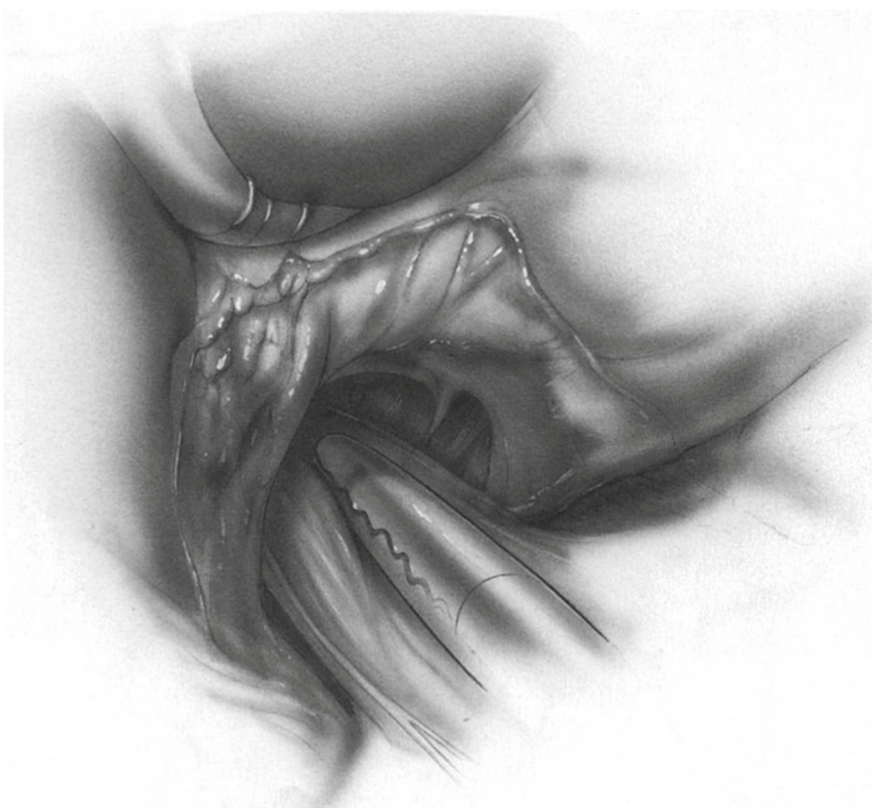

Fig. 20.5

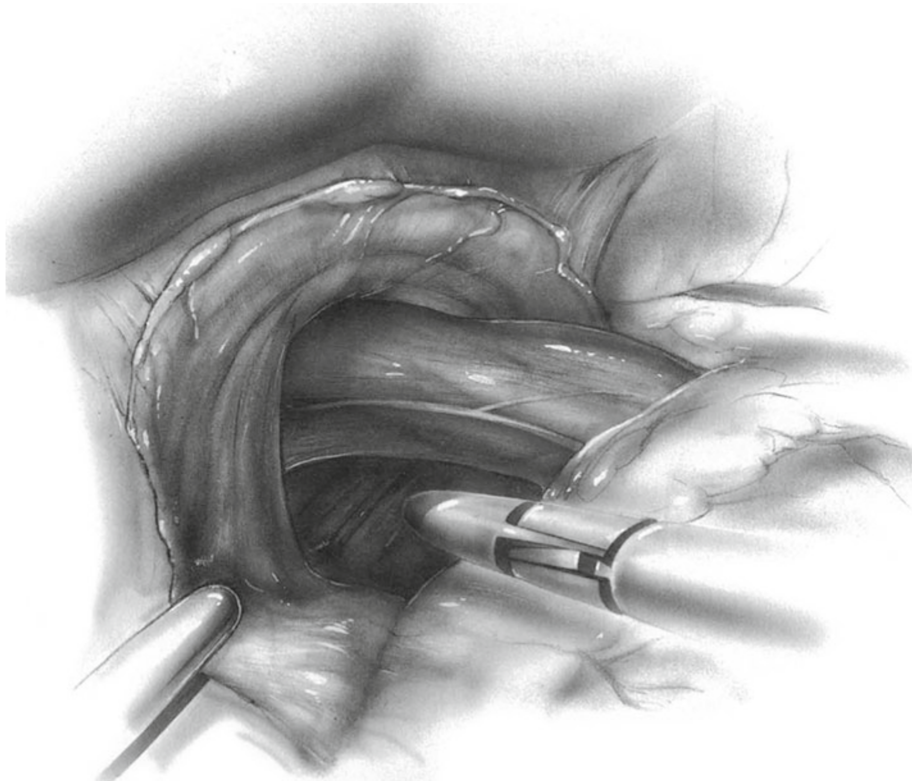

Fig. 20.6

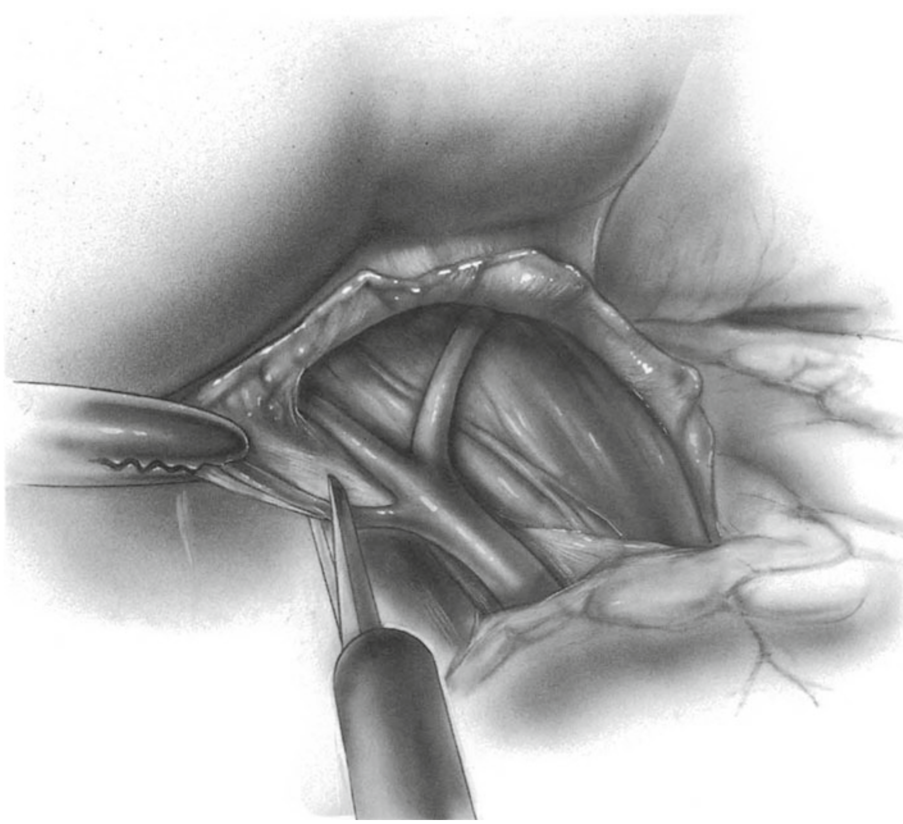

Fig. 20.7

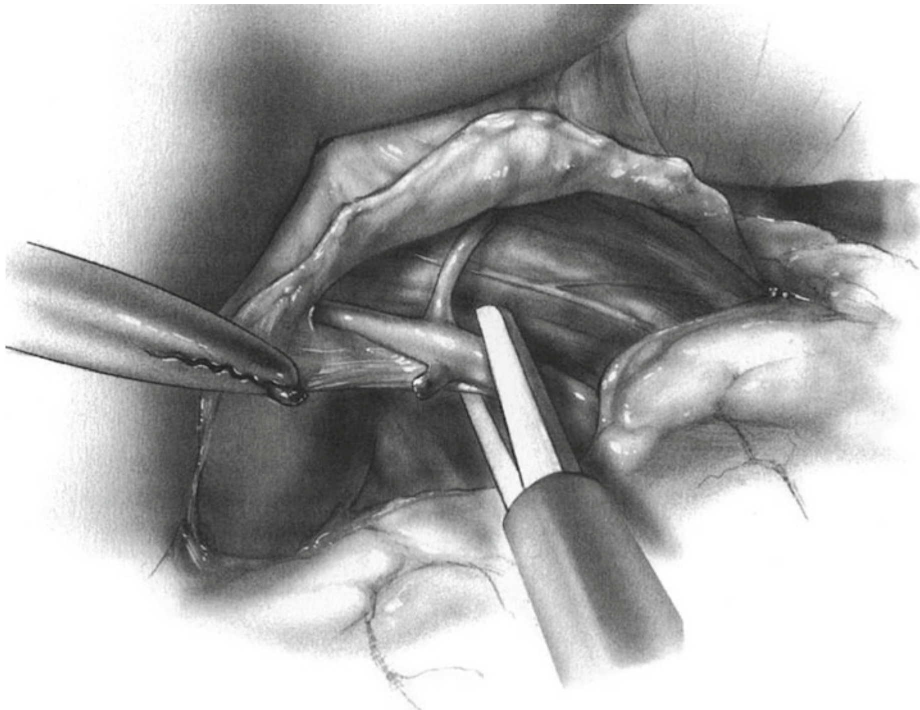

Fig. 20.8

Mobilizing the Esophagus

If the crura have been carefully dissected to create an adequate posterior window, there should be a clear space behind the esophagus and retractors should pass easily. The retractors we prefer are curved and paired. They are designed to be inserted from the left and right sides.

Pass the first retractor from the left side. The design of the retractor shown is similar to that of the liver retractor. It is passed into the abdomen limp, and the cable is tightened to make it assume its working configuration. Once the curve is set, the retractor is rigid and ready for use.

Follow the arc of the circle while passing the retractor. Gently swing it from behind. Do not attempt to create a window with the retractor—the window should already be there. Do not attempt to "hook up" under the esophagus; to do so risks posterior perforation. When the tip of the retractor is seen to emerge from the right side of the space behind the esophagus, lift the esophagus with the retractor (Fig. 20.9).

Pass the second esophageal retractor from the right. Follow the first retractor around, concentrating on the feel of metal on metal as the second retractor "rides" along parallel to the first. Maintain traction on the stomach to help generate a sufficient length of esophagus (Fig. 20.10).

Move the two retractors apart in a spreading movement, parallel to the long axis of the esophagus (Fig. 20.11) to enlarge the window behind the esophagus if needed. Generally only one of the retractors is needed for the remainder of the procedure.

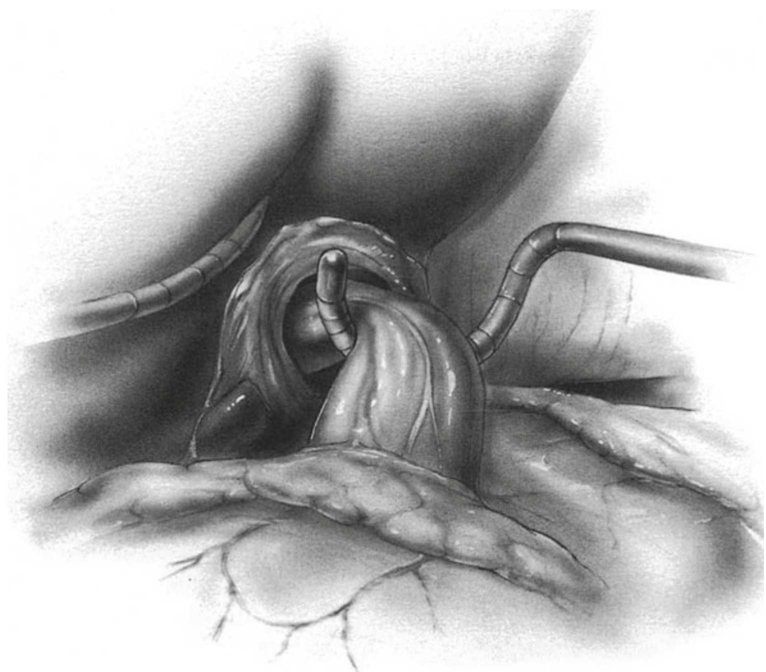

Fig. 20.9

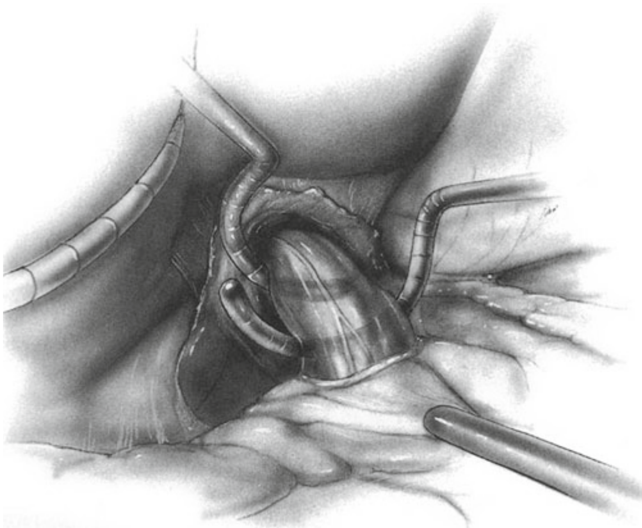

Fig. 20.10

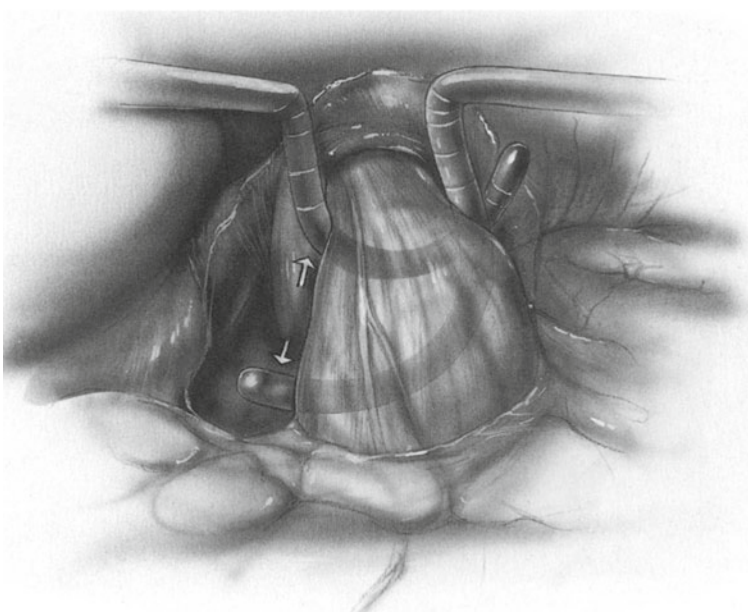

Fig. 20.11

Closing the Hiatus

The hiatus must be closed to avoid herniation of the stomach or small intestine. Place one or two simple sutures of 0 or 2-0 silk and tie them (Fig. 20.12). Leave a gap to avoid overtightening the hiatus, which may cause postoperative dysphagia.

Dividing the Short Gastric Vessels

The short gastric vessels tether the fundus of the stomach to the spleen (Fig. 20.13a). Begin dividing these vessels at a convenient point high on the fundus and work cephalad (Fig. 20.13b). We prefer ultrasonic shears for this division. Test the mobility of the fundus by passing it back and forth anterior to the esophagus (Fig. 20.14a, b).

If at any time there has been concern about injury to the esophagus or stomach, have the anesthesiologist instill methylene blue into the nasogastric tube and look for staining. Repair any areas of concern at this time. Use the wrap to buttress any esophageal repair.

Creating the Wrap

Remove the esophageal retractors and allow the esophagus to return to its normal anatomic position. Pass Maloney dilators from above. For most adults, sequentially pass dilators until a 56–60F dilator is in place (Fig. 20.15a).

Replace the left esophageal retractor and elevate the esophagus. Use an angled grasper to reach behind the esophagus from right to left. Grasp the fundus and pull it behind the esophagus. It should pass easily (Fig. 20.15b, c, d).

Bring additional fundus over from the left side to meet the portion that has been passed behind (Fig. 20.16). The wrap should meet easily and feel "floppy." Avoid the error of creating a twist by pulling the posterior part of the wrap too far to the right. Such a twist may contribute to postoperative dysphagia.

Place three sutures to complete the wrap. Catch a bit of the esophagus with the first suture or two to anchor the wrap well above the stomach (Fig. 20.17). Take care not to take an excessively deep bite and create a perforation. Some surgeons place clips on the knots to mark the location of the wrap. It facilitates postoperative evaluation with barium swallow. The completed wrap should lie easily below the diaphragm (Fig. 20.18).

Postoperative Care

We keep the nasogastric tube in place for the first 24 h to avoid gastric dilatation. A Hypaque swallow the first postoperative day should demonstrate free passage of Hypaque without extravasation. This is particularly important if there is any question of the integrity of the wrap or esophagus.

Complications

Esophageal perforation
Herniation of viscera through the hiatal opening
Slipped wrap
Dysphagia

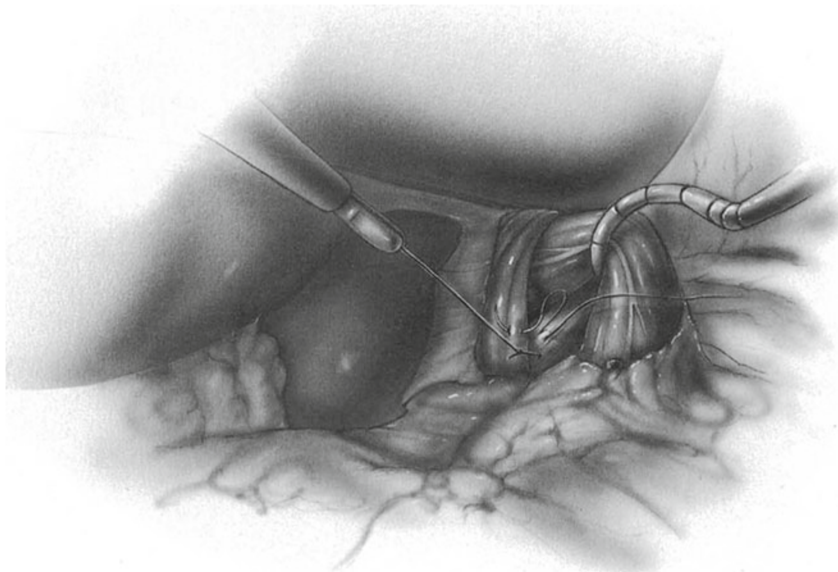

Fig. 20.12

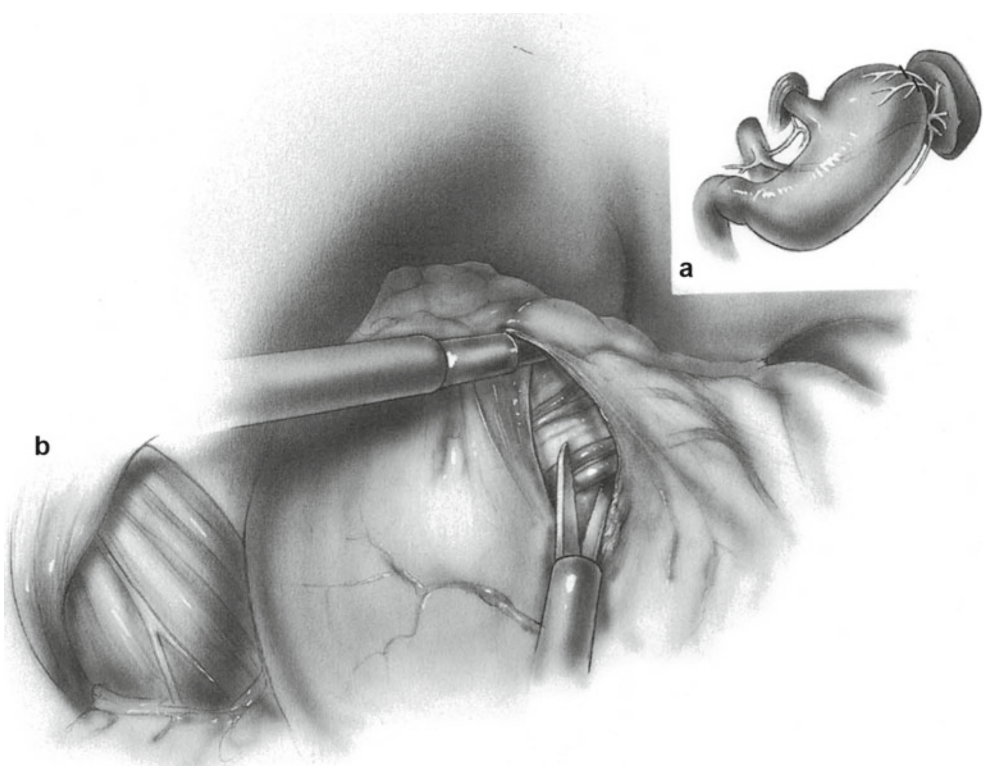

Fig. 20.13

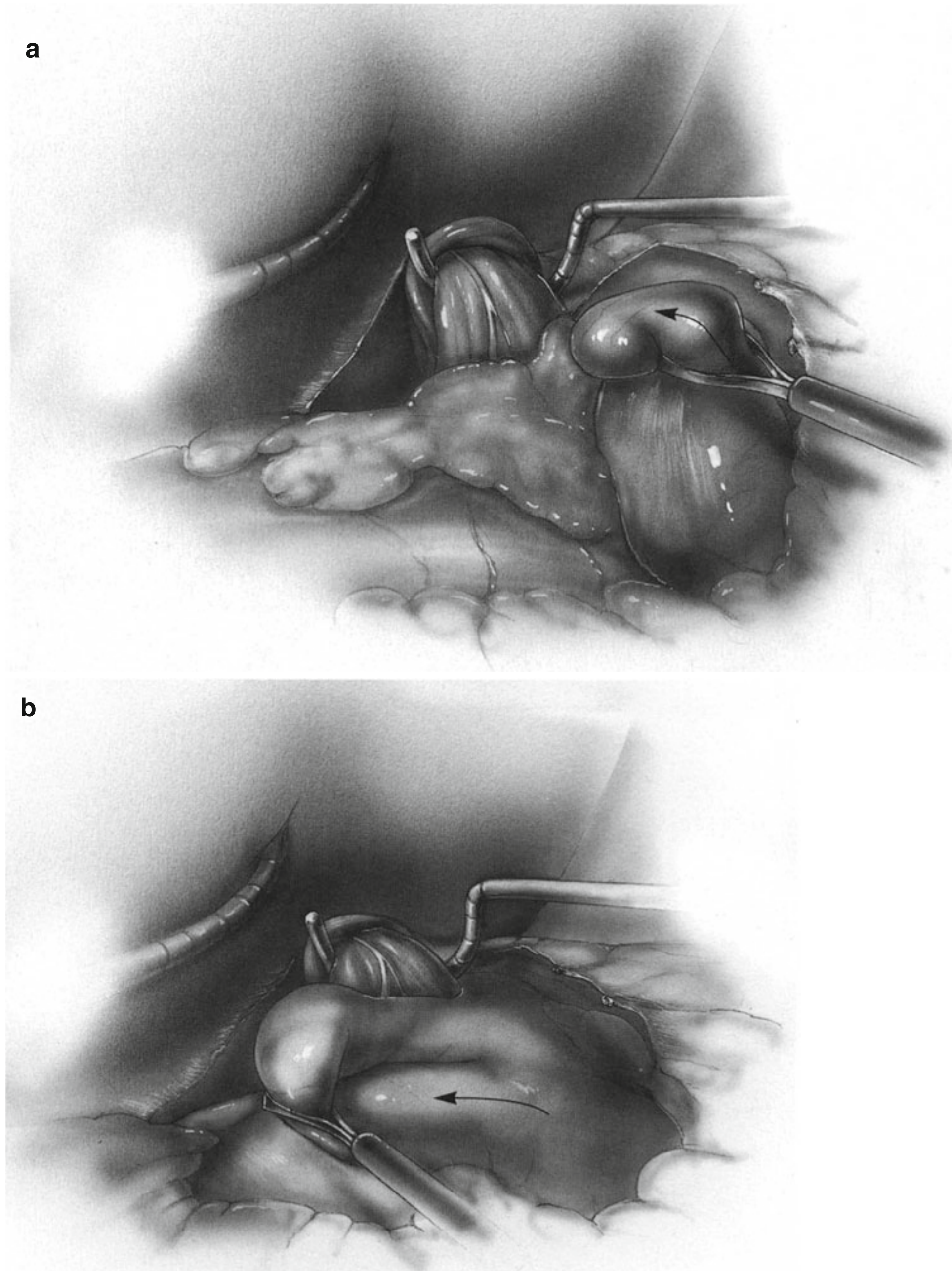

Fig. 20.14

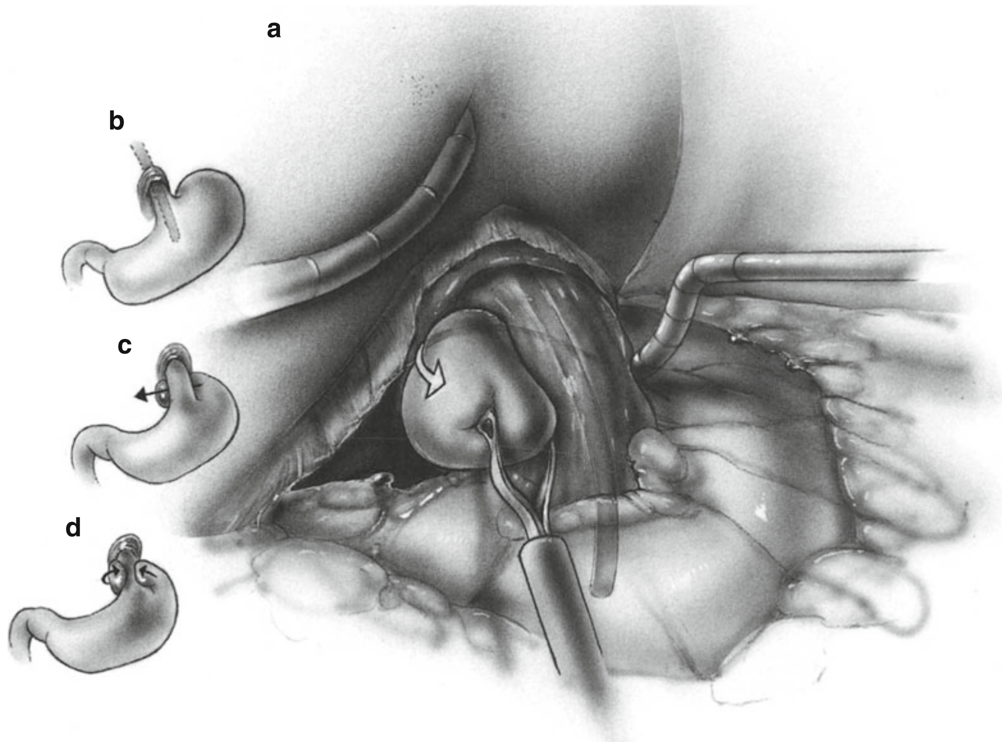

Fig. 20.15

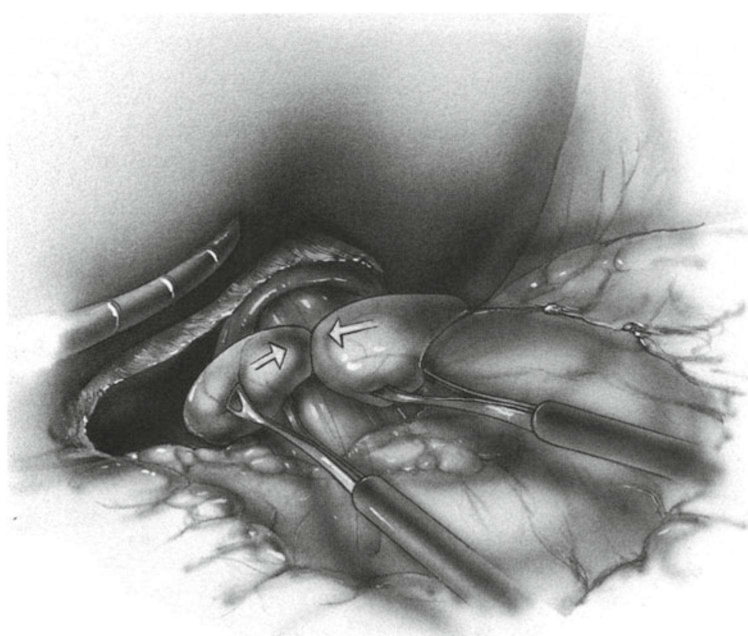

Fig. 20.16

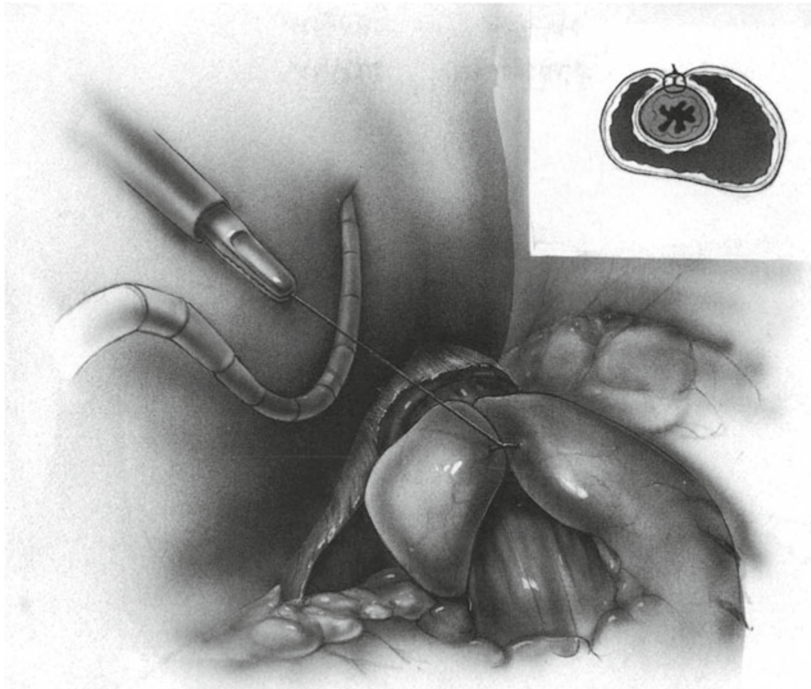

Fig. 20.17

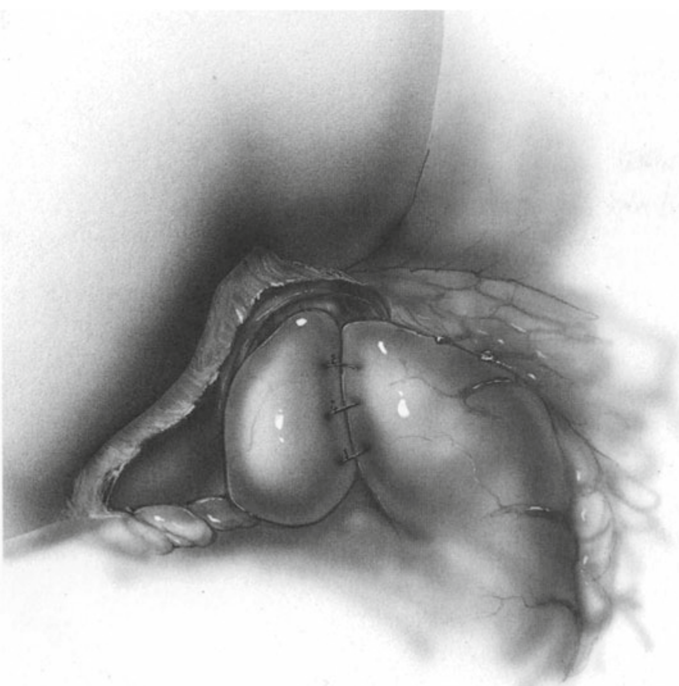

Fig. 20.18

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Posterior Gastropexy (Hill Repair): Surgical Legacy Technique

21

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

See Chap. 19.

Gastroesophageal reflux.

Successful execution of this operation requires that the esophagus be long enough to suture the esophagogastric junction to the level of the median arcuate ligament without tension (5–7 cm of intra-abdominal esophagus).

Preoperative Preparation

See Chap. 19.

Pitfalls and Danger Points

- Hemorrhage from laceration of celiac or inferior phrenic artery
- Injury to spleen
- Improper calibration of lumen of lower esophageal sphincter
- Excessive narrowing of diaphragmatic hiatus
- Failure to identify the median arcuate ligament
- Injury to left hepatic vein or vena cava when incising triangular ligament to liberate left lobe of liver

Operative Strategy

Dissecting the Median Arcuate Ligament

The median arcuate ligament constitutes the anterior portion of the aortic hiatus, the aperture in the diaphragm through which the aorta passes. The ligament, a condensation of preaortic fascia, arches over the anterior surface of the aorta just cephalad to the origin of the celiac artery and joins the right crus of the diaphragm at its insertion onto the vertebral column. This band of fibrous tissue covers about 3 cm of the aorta above the celiac axis and is in turn covered by crural muscle fibers. It can be identified by exposing the celiac artery and pushing it posteriorly with the finger at the inferior rim of the median arcuate ligament. For Hill's operation, the surgeon dissects the celiac artery and celiac ganglion away from the overlying median arcuate ligament in the midline, avoiding the two inferior phrenic arteries that arise from the aorta just to the right and just to the left of the midline. Nerve fibers from the celiac ganglion must be cut to liberate the median arcuate ligament.

An alternative method for identifying the median arcuate ligament is to visualize the anterior surface of the aorta above the aortic hiatus. A few fibers of preaortic fascia may have to be incised. Then with the left index fingernail pushing the anterior wall of the aorta posteriorly, pass the fingertip in a caudal direction. The fingertip passes behind a strong layer of preaortic fascia and median arcuate ligament. At a point about 2–3 cm caudal to the upper margin of the preaortic fascia, blocking further passage of the fingertip, is the attachment of the inferior border of the median arcuate ligament to the aorta at the origin of the celiac artery. The pulsation of the celiac artery is easily palpated by the fingertip, which is lodged between the aorta and the overlying ligament. Vansant and colleagues believed that the foregoing maneuver constitutes sufficient mobilization

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of the median arcuate ligament and that the ligament need not be dissected free from the celiac artery and ganglion to perform a posterior gastropexy. We believe that a surgeon who has not had considerable experience liberating the median arcuate ligament from the celiac artery may find Vansant's modification to be safer than Hill's approach. If one succeeds in catching a good bite of the preaortic fascia and median arcuate ligament by Vansant's technique, the end result should be satisfactory.

If the celiac artery or the aorta is lacerated during the course of the Hill operation, do not hesitate to divide the median arcuate ligament and preaortic fascia in the midline. This step may be necessary to expose the full length of the laceration.

Calibrating the Esophagocardiac Orifice

In addition to fixing the esophagocardiac junction to the median arcuate ligament, the Hill operation serves to narrow the entrance of the lower esophagus into the stomach by partially turning in the lesser curvature aspect of the esophagogastric junction. Calibration of this turn-in is important if reflux is to be prevented without at the same time causing chronic obstruction. Hill (1977) used intraoperative manometry to measure the pressure at the esophagocardiac junction before and after completing the gastropexy. He believed that a pressure of 50–55 mmHg ensures that the calibration is proper. Orringer et al. reported that intraoperative pressures did not correlate at all with pressures obtained at postoperative manometry, perhaps because of the variable influence of preoperative medication and anesthetic agents.

If intraoperative manometry is not used, the adequacy of the repair should be tested by invaginating the anterior wall of the stomach along the indwelling nasogastric tube upward into the esophagogastric junction. Prior to the repair, the index finger can pass freely into the esophagus because of the incompetent lower esophageal sphincter. After the sutures have been placed and drawn together but not tied, the tip of the index finger should be able to palpate the esophageal orifice but should not quite be able to enter the esophagus alongside the 18F nasogastric tube. This method of calibration has been successful in our hands.

Liberating Left Lobe of Liver

As discussed in Chap. 19, liberating the left lobe of the liver is rarely needed.

Documentation Basics

- Findings
- Placement of sutures

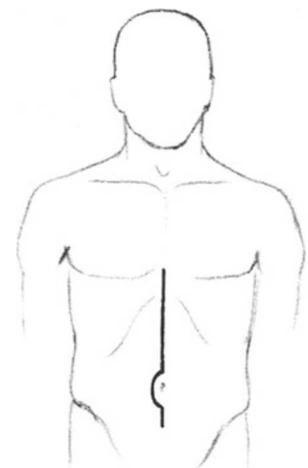

Fig. 21.1

Operative Technique

Incision and Exposure

With the patient in the supine position, elevate the head of the table about 10–15° from the horizontal. Make a midline incision from the xiphoid to a point about 4 cm below the umbilicus (Fig. 21.1). Insert a Thompson or Upper Hand retractor to elevate the lower portion of the sternum and draw it forcefully in a cephalad direction. Explore the abdomen for incidental pathology, such as a duodenal ulcer, cholelithiasis, chronic pancreatitis, or colon disease.

Mobilizing the Esophagogastric Junction

Identify the peritoneum overlying the abdominal esophagus by palpating the indwelling nasogastric tube. Divide this peritoneum with Metzenbaum scissors and continue the incision over the right and left branches of the crus (Fig. 21.2). After exposing the crus, elevate this muscle by inserting a peanut sponge dissector between the crus and the esophagus, first on the right and then on the left. Then insert the left index finger to encircle the esophagus by *gentle* dissection. If the esophagus is inflamed owing to inadequately treated esophagitis, it is easy to perforate it by rough finger dissection. Identify and protect both the right and left vagus nerves. Then encircle the esophagus with a latex drain and free it from posterior attachments by dividing the phrenoesophageal ligaments (Fig. 21.3).

Make an incis ion in the avascular portion of the gastrohepatic ligament. Continue this incision in a cephalad direction toward the right side of the hiatus. When dividing the gastrohepatic ligament, it is often necessary to divide an accessory left hepatic branch of the left gastric artery (Fig. 21.4). At the conclusion of this step, the muscular

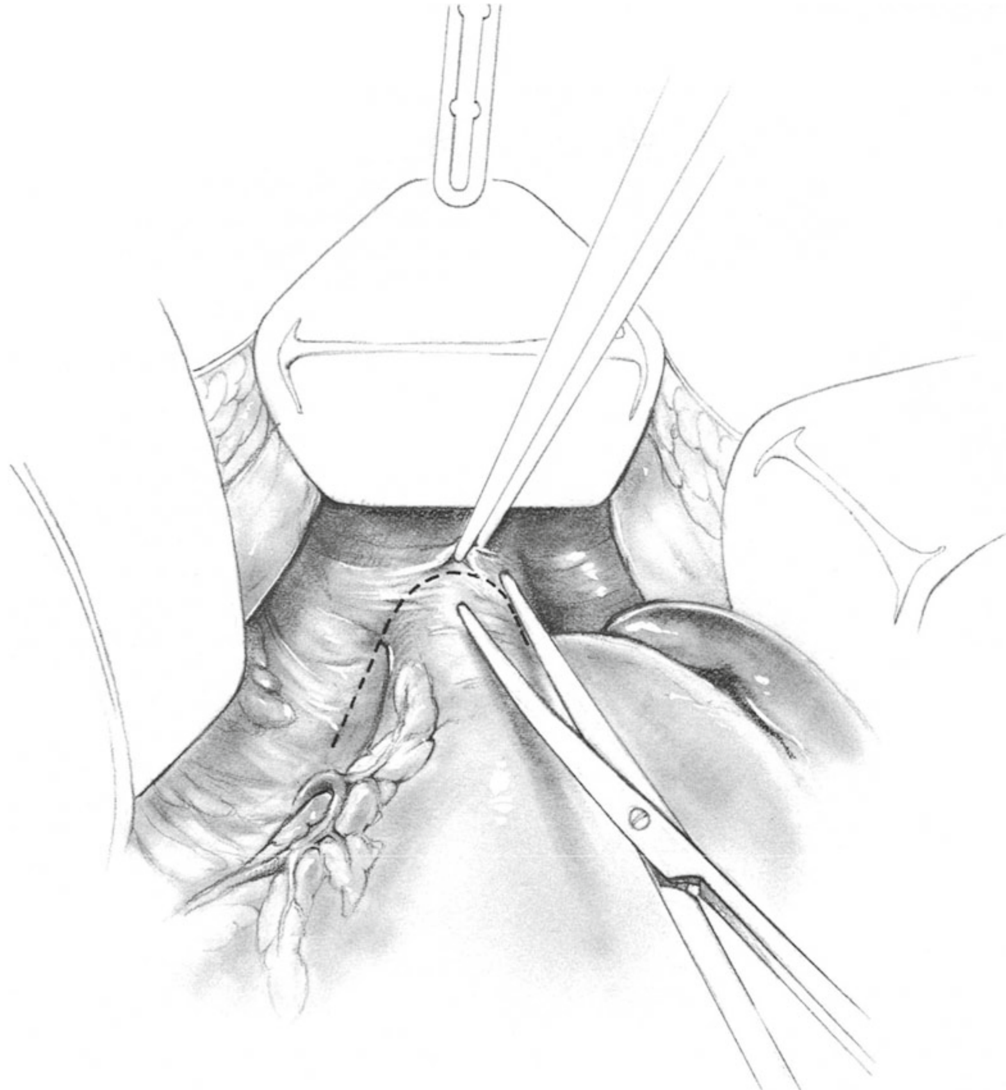

Fig. 21.2

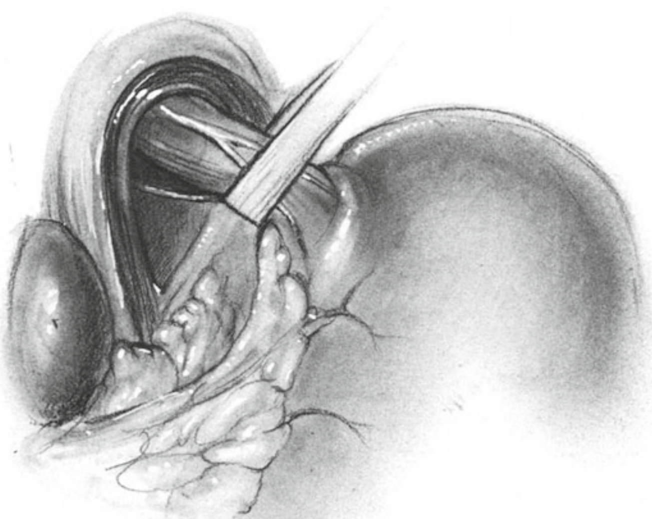

Fig. 21.3

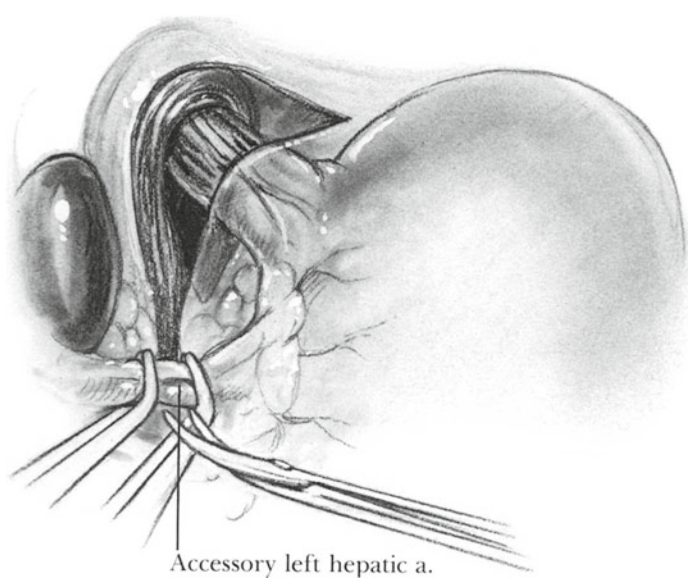

Fig. 21.4

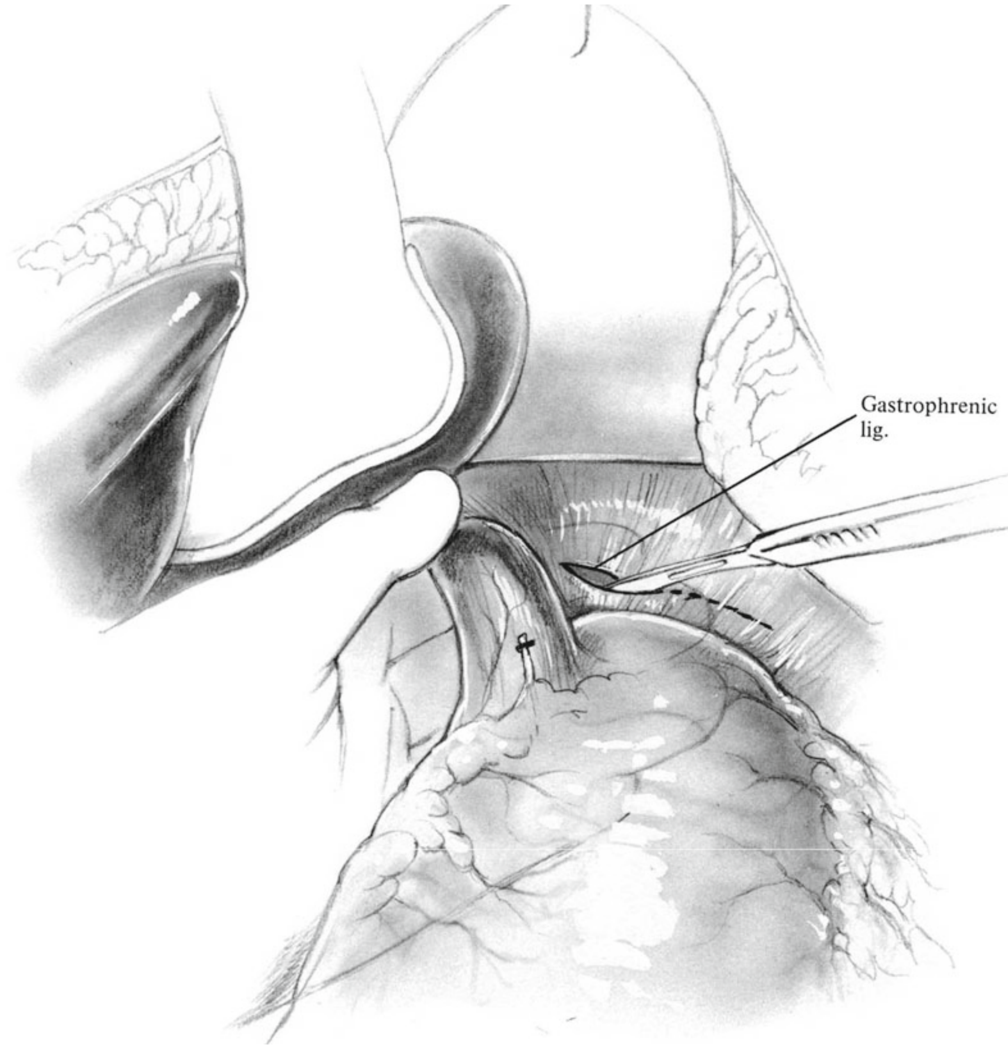

Fig. 21.5

portion of the crura surrounding the hiatus should be clearly visible throughout the circumference of the hiatus.

The only structure binding the gastric fundus to the posterior abdominal wall now is the gastrophrenic ligament. The best way to divide this ligament is to insert the left hand behind the esophagogastric junction and then bring the left index finger between the esophagogastric junction and the diaphragm. This places the ligament on stretch. Divide this avascular ligament (Fig. 21.5) from the esophagogastric junction along the greater curvature down to the first short gastric artery. It is often necessary to divide the first two short gastric vessels to achieve proper mobilization. This may be done by applying a hemoclip to the splenic side and a 2-0 silk ligature to the gastric side of the short gastric vessel.

Avoid injuring the spleen by carefully inspecting the anterior surface of this organ prior to dissection in this region. Divide any attachments between the omentum and the splenic capsule, as traction on the omentum would otherwise cause avulsion of the capsule and bleeding.

Inserting the Crural Sutures

Ask the first assistant to retract the esophagus toward the patient's left; then narrow the aperture of the hiatus by approximating the crural bundles behind the esophagus. Use 0 Tevdek atraumatic sutures on a substantial needle. Take a bite of 1.5–2.0 cm of crus on the left and a similar bite on the right. Include the overlying peritoneum together with the crural muscle (Fig. 21.6). Do not tie these sutures at this time but tag each with a small hemostat. It is sometimes helpful to grasp the left side of the crus with a long Babcock or Allis clamp. Do not apply excessive traction with these clamps or sutures, as the crural musculature tends to split along the line of its fibers. Insert three or four sutures of this type as

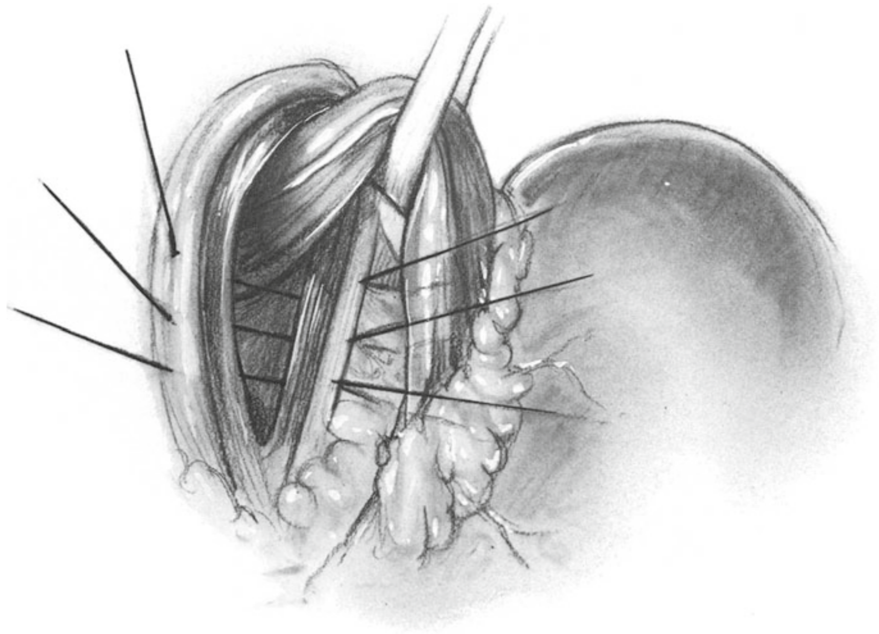

Fig. 21.6

necessary. Then tentatively draw the sutures together and insert the index finger into the remaining hiatal aperture. It should be possible to insert a fingertip into the remaining aperture alongside the esophagus with its indwelling nasogastric tube. Narrowing the hiatal aperture more than this may cause permanent dysphagia and does not help reduce reflux. Do not tie the crural sutures at this point.

Identifying the Median Arcuate Ligament

Hill's Method

After the lower esophagus and proximal stomach have been completely freed, identify the celiac artery and use the left index finger to press it posteriorly into the aorta. If the index finger slides in a cephalad direction, its tip meets the lower border of the median arcuate ligament. Between the aorta and median arcuate ligament are branches of the celiac ganglion as well as the right and left inferior phrenic arteries, which arise from the aorta in this vicinity. It is necessary to divide some of the nerve fibers; but once the inferior margin of the ligament is freed from the aorta in the midline, it is possible to pass an instrument in a cephalad direction without encountering any further resistance. Hill passed a Goodell cervical dilator between the median arcuate ligament and the aorta to protect the aorta while sutures were being inserted into the lower border of the ligament. He stated that if a small diaphragmatic branch of the aorta is disrupted, the bleeding often subsides with pressure. However, it is possible for the inexperienced surgeon to induce major hemorrhage by traumatizing the arteries in this vicinity. Caution is indicated.

Vansant's Method

Vansant and colleagues described another technique for identifying and liberating the median arcuate ligament by approaching it from its superior margin: Identify the anterior surface of the aorta in the hiatal aperture between the right and left branches of the crus. Occasionally, it is necessary to dissect away some areolar tissue. With the left index fingernail pressing posteriorly against the aorta about 4 cm cephalad to the diaphragm, slide the index finger in a caudal direction. Deep behind the confluence of the diaphragmatic crura, the tip of the index finger passes behind a dense band of preaortic fascia that crosses over the aorta as the aorta passes through the aortic hiatus in the posterior diaphragm. The width of this band is variable but averages perhaps 3 cm. At the lower margin of this band, the fingertip encounters pulsation of the celiac artery, which arises from the anterior wall of the aorta at the inferior margin of the median arcuate ligament. The median arcuate ligament lies between the fingertip and a thin layer of muscle fibers representing the caudal confluence of the diaphragmatic crura. With the index finger in place, Vansant and associates inserted three interrupted atraumatic sutures of no. 1 braided silk into the median arcuate ligament. Each suture is tagged with a hemostat, leaving each needle attached for later use when suturing the posterior gastropexy.

Suturing Posterior Gastropexy

Rotate the esophagogastric junction so the lesser curvature aspect of the stomach faces anteriorly. Then place a large

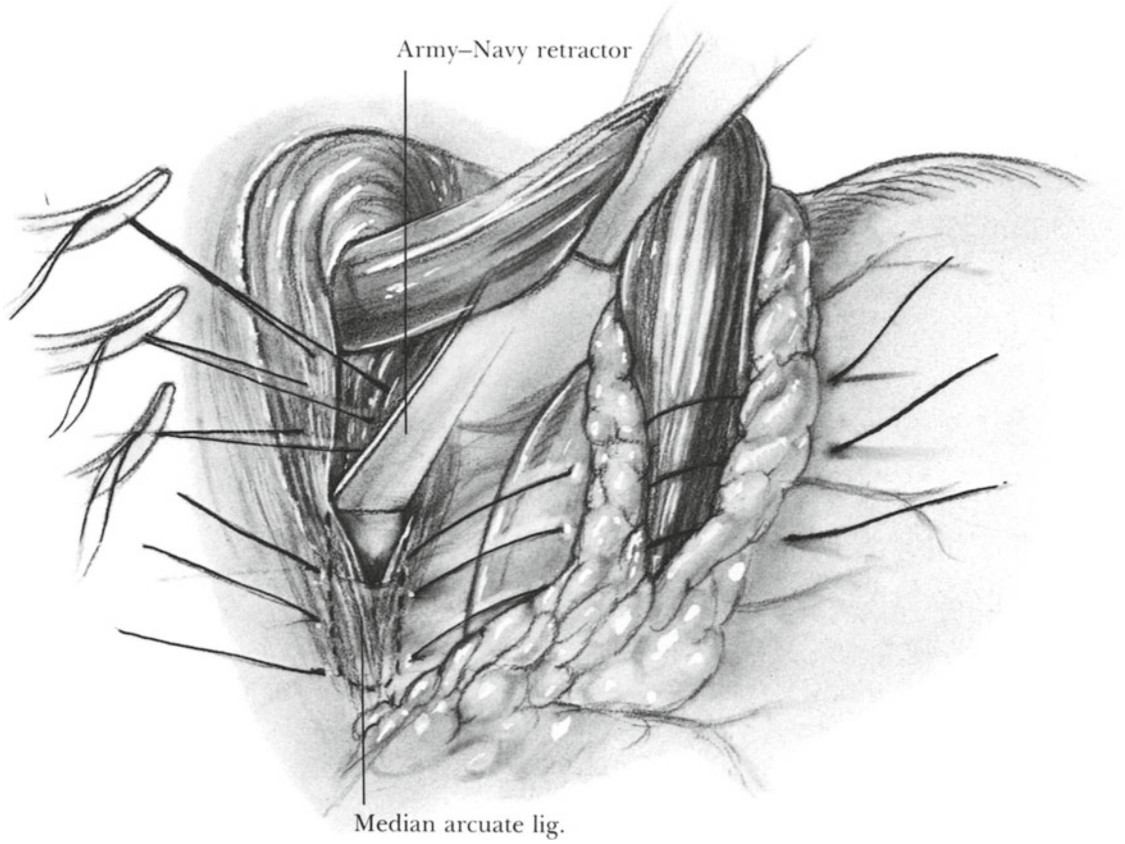

Fig. 21.7

Babcock clamp on the anterior and another clamp on the posterior phrenoesophageal bundle. Between these two bundles the longitudinal muscle fibers of the esophagus can be seen as they join the lesser curvature of the stomach. Where to place the proximal suture is an important consideration. Placing it too high causes excessive narrowing of the esophageal lumen; placing it too low does not increase the intraluminal pressure adequately in the lower esophageal sphincter area. We use 2-0 atraumatic Tevdek and include a few millimeters of adjacent gastric wall together with the phrenoesophageal bundle to ensure that the submucosa has been included in the suture. After placing the upper suture, cross the two ends or insert the first throw of a tie. Then estimate the lumen of the esophagogastric junction by invaginating the stomach with the index finger along the indwelling nasogastric tube. If this maneuver is attempted before tying down the suture, the finger passes easily into the lumen of the esophagus in patients who have an incompetent lower esophageal sphincter. After the first suture is tentatively closed, only the tip of the index finger should be able to enter the esophagus. In the absence of intraoperative esophageal manometry, this is the best method for calibrating proper placement of the gastropexy sutures.

If the first suture has been judged to be properly placed, tag it with a hemostat and insert three additional sutures of atraumatic 2-0 Tevdek into the phrenoesophageal bundles, at intervals of about 1 cm, caudal to the first suture. Place a hemostat on each suture as a tag. After all the sutures have been placed, tighten each and again use the index finger to calibrate the lumen of the esophagogastric junction. If it is satisfactory, expose the anterior wall of the aorta in the hiatal aperture behind the esophagus. With the index fingernail closely applied to the anterior wall of the aorta, pass the fingertip in a caudal direction underneath the preaortic fascia and median arcuate ligament down to the point where the fingertip palpates the pulsation of the celiac artery. Then remove the index finger and replace it with a narrow right-angled retractor such as the Army-Navy retractor (Fig. 21.7). Be certain that the retractor is indeed deep to the median arcuate ligament. This retractor serves to protect the aorta while the gastropexy sutures are being inserted through the preaortic fascia.

Identify the proximal suture that has already been placed in the phrenoesophageal bundles and pass the suture through the preaortic fascia. Be sure to take a substantial bite of the tissue anterior to the Army-Navy

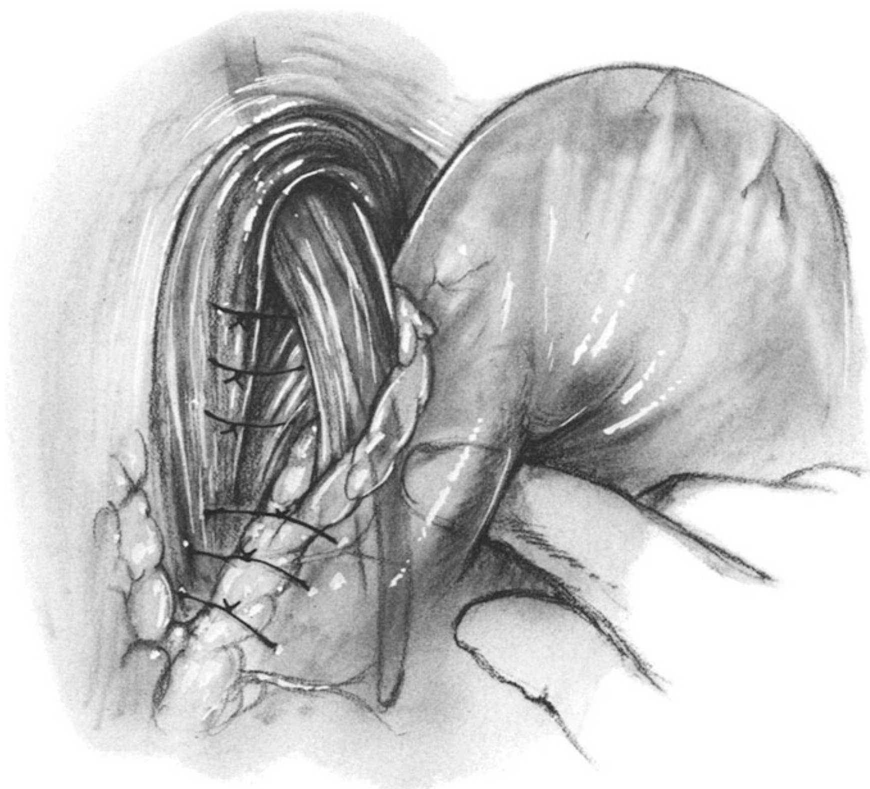

Fig. 21.8

retractor. Pass the needle deep enough so it makes contact with the metal retractor; otherwise, only some overlying crural muscle fibers may be included in the stitch, which is then not strong enough to ensure a long-term successful result. After the first stitch has been passed through the preaortic fascia, tag it with a hemostat; pass each of the remaining phrenoesophageal sutures through the preaortic fascia by the same technique and tag each with a hemostat (Fig. 21.7).

Another good method to expedite suturing of the median arcuate ligament is to use a large right-angle bronchus clamp. Insert the tip of the clamp behind the median arcuate ligament instead of behind the Army-Navy retractor. Use the clamp to draw the median arcuate ligament vigorously anteriorly. Pass the needle with the suture through the median arcuate ligament just deep to the clamp, which ensures that a large bite of ligament is included in each stitch. Be certain not to injure the underlying aorta with the needle.

At this point check the entire area for hemostasis. Then tie the previously placed crural sutures (Fig. 21.6), narrowing the aperture of the hiatus. After these sutures have been tied, the index finger should pass freely into the hiatal aperture with an indwelling 18F nasogastric tube in the esophagus. If this is not the case, replace the proximal crural suture as necessary. Now tie each of the previously placed *gastropexy* sutures and cut all the ends (Fig. 21.8).

Testing the Antireflux Valve

A simple method for testing the efficacy of the antireflux valve is to have the anesthesiologist inject about 500 ml of saline into the nasogastric tube and then withdraw the tube to a point above the esophagogastric junction. In the presence of a competent antireflux valve, compressing the saline-filled stomach fails to force the saline into the esophagus.

Abdominal Closure

Close the abdomen without drainage in routine fashion.

Postoperative Care

Continue nasogastric suction for 1–2 days.

Obtain a radiograph of the esophagogastric junction after a barium swallow before the patient is discharged from the hospital.

Complications

Dysphagia (usually transient).

Persistence or recurrence of gastroesophageal reflux. This and other complications following the Hill operation are uncommon.

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22 Transthoracic Gastroplasty (Collis) and Nissen Fundoplication: Surgical Legacy Technique

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Short esophagus due to reflux esophagitis

Recurrent gastroesophageal reflux with stricture after an antireflux procedure

Previous subtotal gastrectomy generally contraindicates a Collis-Nissen procedure

Preoperative Preparation

Dilate the esophageal stricture up to 40F. It can generally be done with Maloney dilators.

Insert a nasogastric tube down to the stricture.

Assessment for colon interposition is prudent in difficult cases (see Chap. 18). Bowel preparation allows colon to be used as a conduit if needed.

When esophagoscopy reveals severe acute ulcerative esophagitis with inflammation and bleeding, a 2- to 3-week period of preoperative intensive medical treatment with cimetidine, omeprazole, or both reduces inflammation and lessens the risk of intraoperative perforation of the esophagus.

Pitfalls and Danger Points

Esophageal perforation

Hemorrhage resulting from traumatizing or avulsing the accessory left hepatic artery, inferior phrenic artery, ascending branch of the left gastric artery, short gastric vessel, or inferior pulmonary vein

Laceration of spleen

Inadvertent vagotomy

Inadequate suturing, permitting the fundoplication to slip postoperatively

Operative Strategy

Performing an Adequate Gastroplasty

The object of performing a gastroplasty is to lengthen a shortened esophagus for an extent sufficient to prevent tension from being exerted on the antireflux operation and hernia repair. This newly constructed esophagus ("neoesophagus") consists of a tube made from the lesser curvature of the stomach. A 56F Maloney dilator is passed into the stomach, and the tube is constructed by applying an 80 mm linear cutting stapler precisely at the esophagogastric junction parallel to and snugly alongside the Maloney dilator. When the stapler is fired, the esophageal tube is lengthened by as much as 7 cm. If the stapler has been placed snugly against the esophagogastric junction, there are no irregularities or outpouchings at this point.

Mobilizing the Esophagus and Stomach

Not only is it important to mobilize the distal esophagus completely, at least as far up as the inferior pulmonary vein, but the proximal stomach must be entirely free of attachments, just as when a Nissen fundoplication is being performed through an abdominal approach. This operation can be accomplished without tension only with full mobilization. It requires dividing the phrenoesophageal and gastrophrenic ligaments, freeing the hiatus throughout its complete circumference from any attachments to the stomach or lower esophagus, and dividing an accessory left hepatic artery, which

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courses from the left gastric artery across the proximal gastrohepatic ligament to help supply the left lobe of the liver. After mobilization has been accomplished, the remaining maneuvers in the Collis-Nissen operation are not difficult.

If the esophagus is inadvertently perforated during the dissection, exercise careful judgment when deciding whether it is safe to suture the esophageal laceration or a resection and colon or jejunum interposition is necessary. If it is elected to suture the laceration, try to cover the suture line with a flap of parietal pleura (see Figs. 27.1, 27.2, and 27.3).

Avoiding Hemorrhage

Avoiding unnecessary bleeding during any operation requires a careful dissection and a knowledge of vascular anatomy. This is especially important when mobilizing the stomach through a thoracic approach because losing control of the accessory left hepatic, short gastric, or inferior phrenic artery causes the proximal bleeding arterial stump to retract deep into the abdomen. Controlling these retracted vessels is difficult and may require laparotomy or at least a peripheral incision in the diaphragm. Preventing this complication is not difficult if the dissection is orderly, and the surgeon is aware of the anatomic location of these vessels. Similarly, careful dissection and avoidance of traction along the greater curvature of the stomach helps prevent damaging the spleen.

Avoiding Esophageal Perforation

When the distal esophagus is baked into a fibrotic mediastinum, sharp scalpel dissection is safer than blunt dissection if injury to the esophagus and the vagus nerves is to be avoided. Sometimes the fibrosis terminates 8–9 cm above the diaphragm. If so, the esophagus and the vagus nerves can easily be encircled at this point, which provides a plane for subsequent dissection of the distal esophagus.

Operative Technique

Incision

With the patient under one-lung anesthesia in the lateral position, left side up, make a skin incision in the sixth intercostal space from the costal margin to the tip of the scapula (Fig. 22.1). Then identify the latissimus dorsi muscle and insert the index finger underneath it. Transect this muscle with electrocautery; then divide the underlying anterior serratus muscle in similar fashion (Fig. 22.2). In both cases, it is preferable to divide these muscles somewhat caudal to the skin incision, as it helps preserve muscle function. Then use

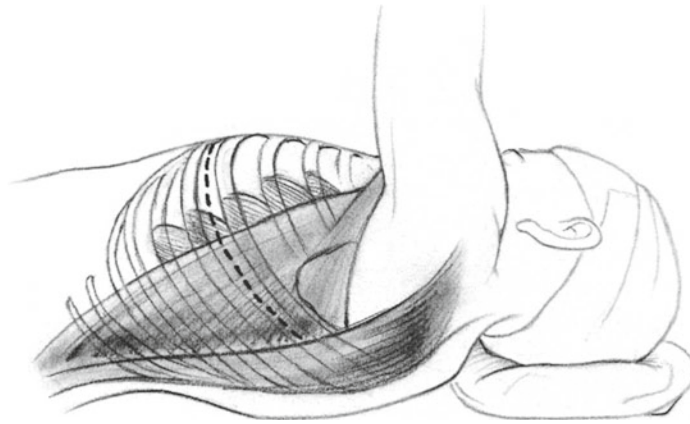

Fig. 22.1

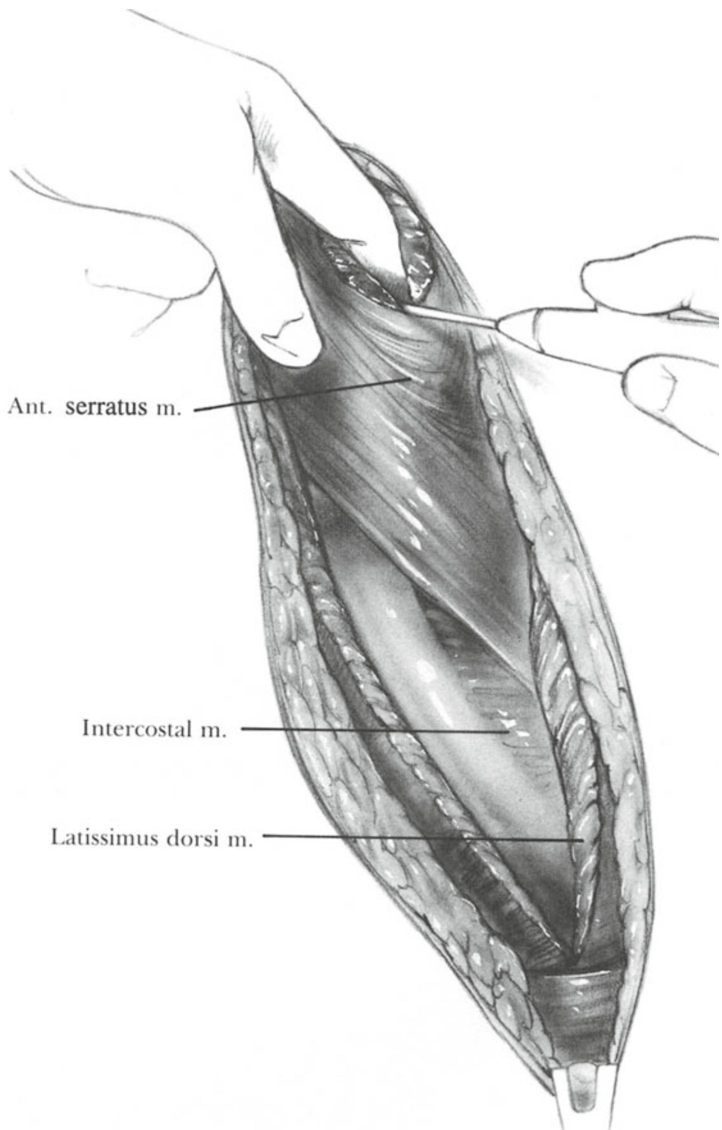

Fig. 22.2

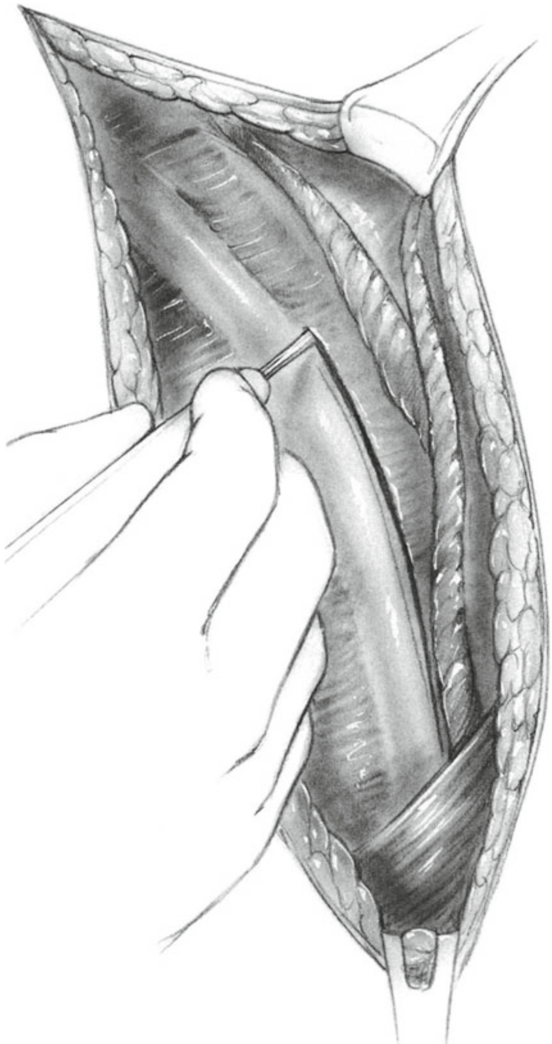

Fig. 22.3

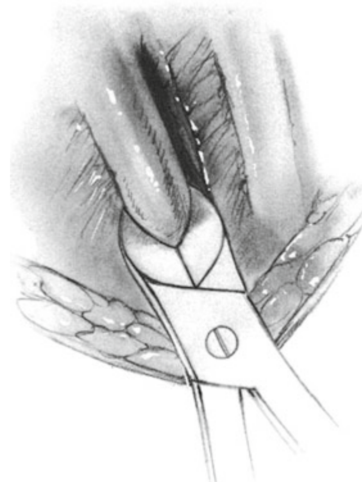

Fig. 22.4

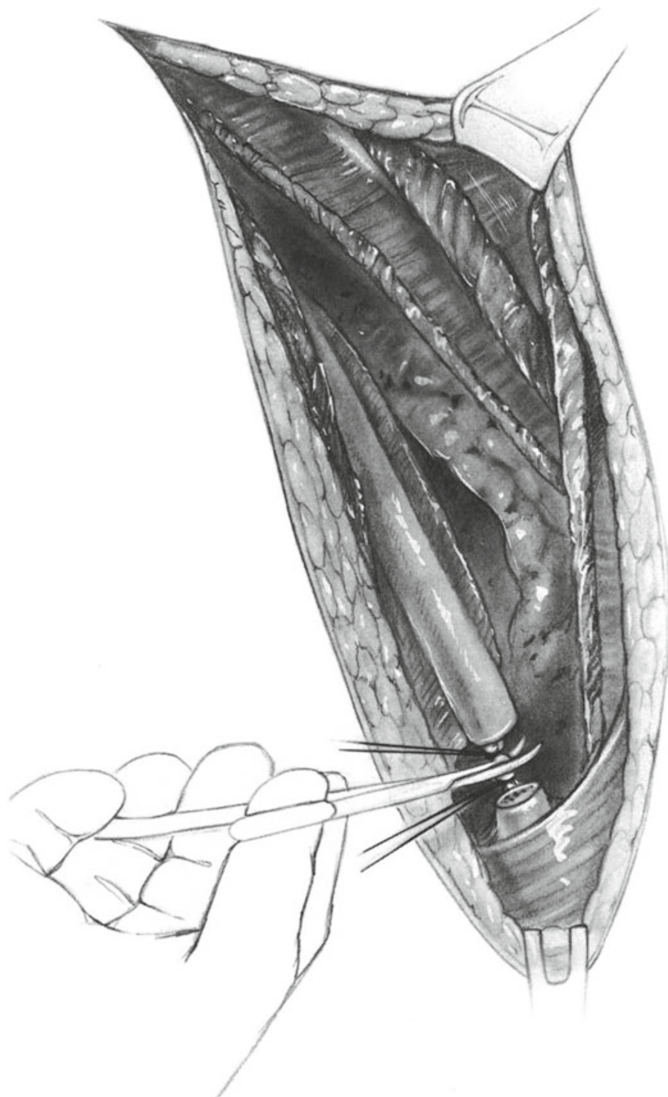

Fig. 22.5

electrocautery to divide the intercostal muscles along the upper border of the seventh rib (Fig. 22.3) and open the pleura. Complete this opening from the costal margin to the region of the lateral spinal muscles. Separate the periosteum and surrounding tissues from a 1 cm segment of the posterior portion of the seventh rib lateral to the spinal muscles. Excise a 1 cm segment of this rib (Fig. 22.4). Then divide the intercostal neurovascular bundle that runs along the inferior border of this rib (Fig. 22.5).

Insert a Finochietto retractor into the incision and gradually increase the distance between the blades of the retractor over a 10-min period to avoid causing rib fractures. In patients who have undergone previous surgery of the distal esophagus or proximal stomach, do not hesitate to continue this incision across the costal margin, converting it into a thoracoabdominal incision to facilitate dissection on the abdominal aspect of the diaphragmatic hiatus (see Figs. 15.6 and 15.7).

Liberating the Esophagus

Incise the inferior pulmonary ligament with electrocautery and then compress the lung and retract it in anterior and cephalad directions using moist gauze pads and Harrington retractors. Incise the mediastinal pleura just medial to the aorta (Figs. 22.6 and 22.7). Encircle the esophagus with the index finger using the indwelling nasogastric tube as a guide. If this cannot be done easily, it may be necessary to initiate sharp dissection at a somewhat higher level, where the fibrosis may be less advanced. Encircle the esophagus and the vagus nerves with a latex drain. Continue the dissection of the esophagus from the inferior pulmonary vein down to the diaphragmatic hiatus. After the mediastinal pleura has been incised down to the hiatus, continue the incision anteriorly and divide the pleura of the pericardiophrenic sulcus (Fig. 22.6); otherwise, the medial aspect of the hiatal ring is not visible. If the right pleural cavity has been inadvertently entered, simply place a moist gauze pad over the rent in the pleura to prevent excessive seepage of blood into the right chest and continue the dissection.

Excising the Hernial Sac

Identify the point at which the left branch of the crus of the diaphragm meets the hernial sac. Any attenuated fibers of the phrenoesophageal ligament and preperitoneal fat are made apparent by applying traction to the diaphragm. Incise these tissues and the underlying peritoneum (Fig. 22.8). Continue the incision in the peritoneum in a circumferential fashion, opening the lateral and anterior aspects of the hernial sac; expose the greater curvature of the stomach. Insert the left index finger into the sac and continue the incision along the medial (deep) margin of the hiatus using the finger as a guide (Fig. 22.9). A branch of the inferior phrenic artery may be noted posterolaterally near the left vagus nerve; it is divided and ligated with 2-0 silk. While attempting to circumnavigate the proximal stomach, the index finger in the hernial sac encounters an obstruction on the lesser curvature side of the esophagogastric junction. It represents the proximal margin of the gastrohepatic ligament, which often contains a 2- to 4-mm accessory left hepatic artery coming off the ascending left gastric artery. By hugging the lesser curvature side of the cardia with the index finger, this finger can be passed between the stomach and the gastrohepatic ligament, delivering the ligament into the chest, deep to the stomach. Identify the artery and ligate it proximally and distally with 2-0 silk. Divide it between the two ligatures (Fig. 22.10). After this step, it should be possible to pass the index finger around the entire circumference of the proximal stomach and encounter no attachments between the stomach and the hiatus. Throughout these maneuvers, repeatedly check on the location of the vagus nerves and preserve them. Excise the peritoneum that constituted the hernial sac.

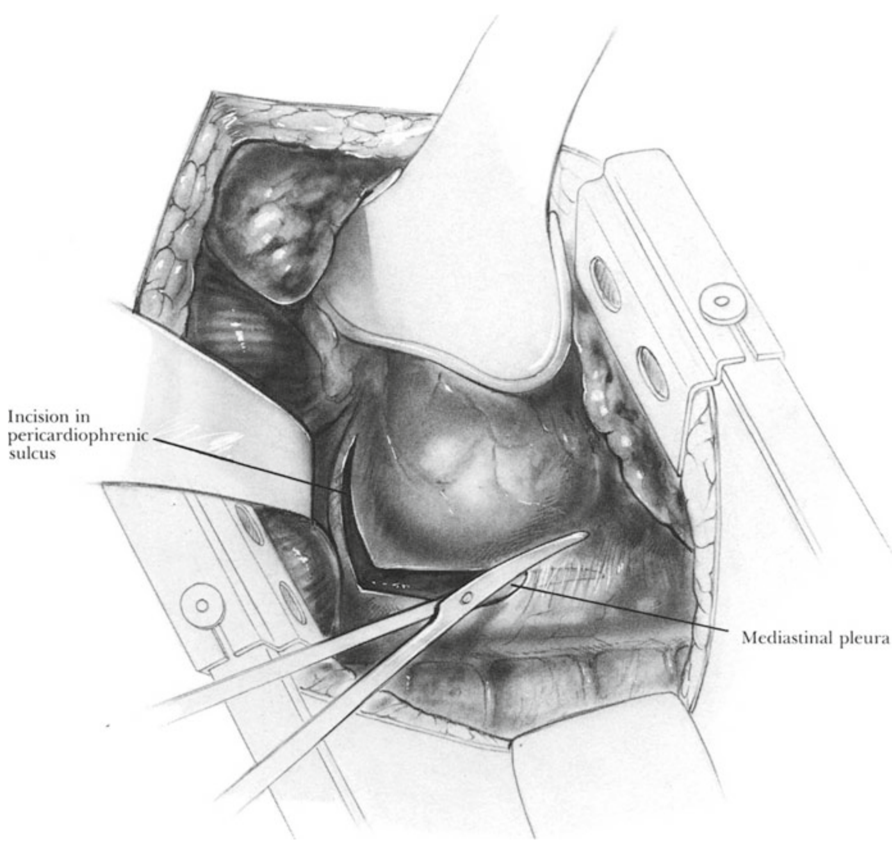

Fig. 22.6

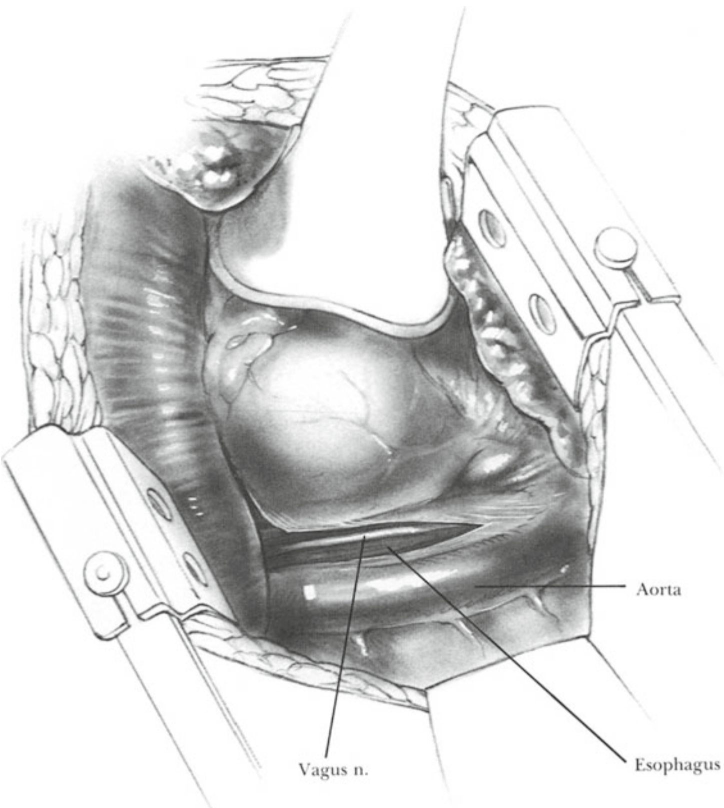

Fig. 22.7

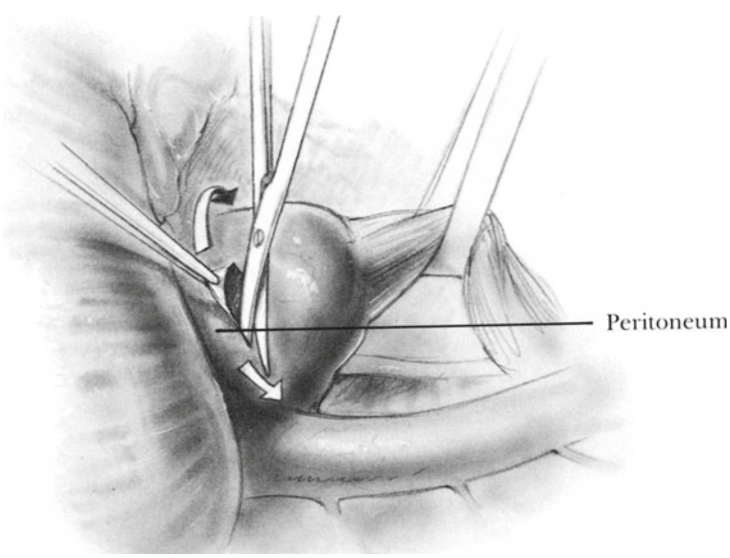

Fig. 22.8

Dilating an Esophageal Stricture

Ascertain that the esophagus is lying in a straight line in the mediastinum. Ask the anesthesiologist or a surgical assistant to pass Maloney dilators into the esophagus through the mouth after removing the indwelling nasogastric tube. As the dilator is passed down the esophagus, guide it manually into the lumen of the stricture. Successively larger bougies

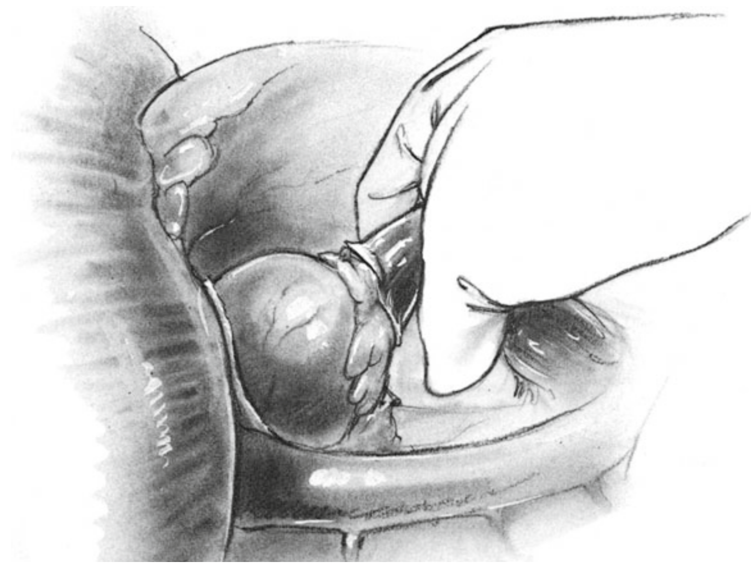

Fig. 22.9

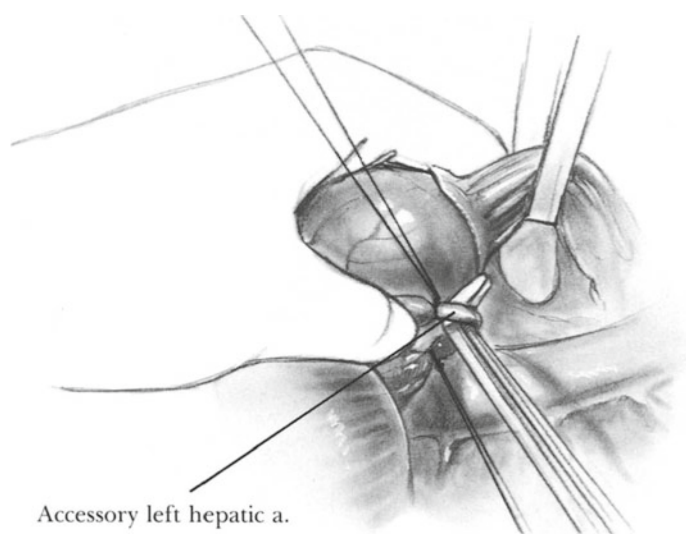

Fig. 22.10

are passed, up to size 50–60F, which can be successfully accomplished in probably 95 % of cases. Occasionally, forceful dilatation of this type causes the lower esophagus to burst in the presence of unyielding transmural fibrosis. In this case, resect the damaged esophagus and perform a colonic or jejunal interposition between the healthy esophagus and the stomach (see Chap. 18).

Dividing the Short Gastric Vessels

Continue the dissection along the greater curvature of the stomach in an inferior direction until the first short gastric vessel is encountered. Use a long right-angled Mixter clamp to encircle this vessel with two 2-0 silk ligatures. Tie each ligature, leaving at least 1 cm between them.

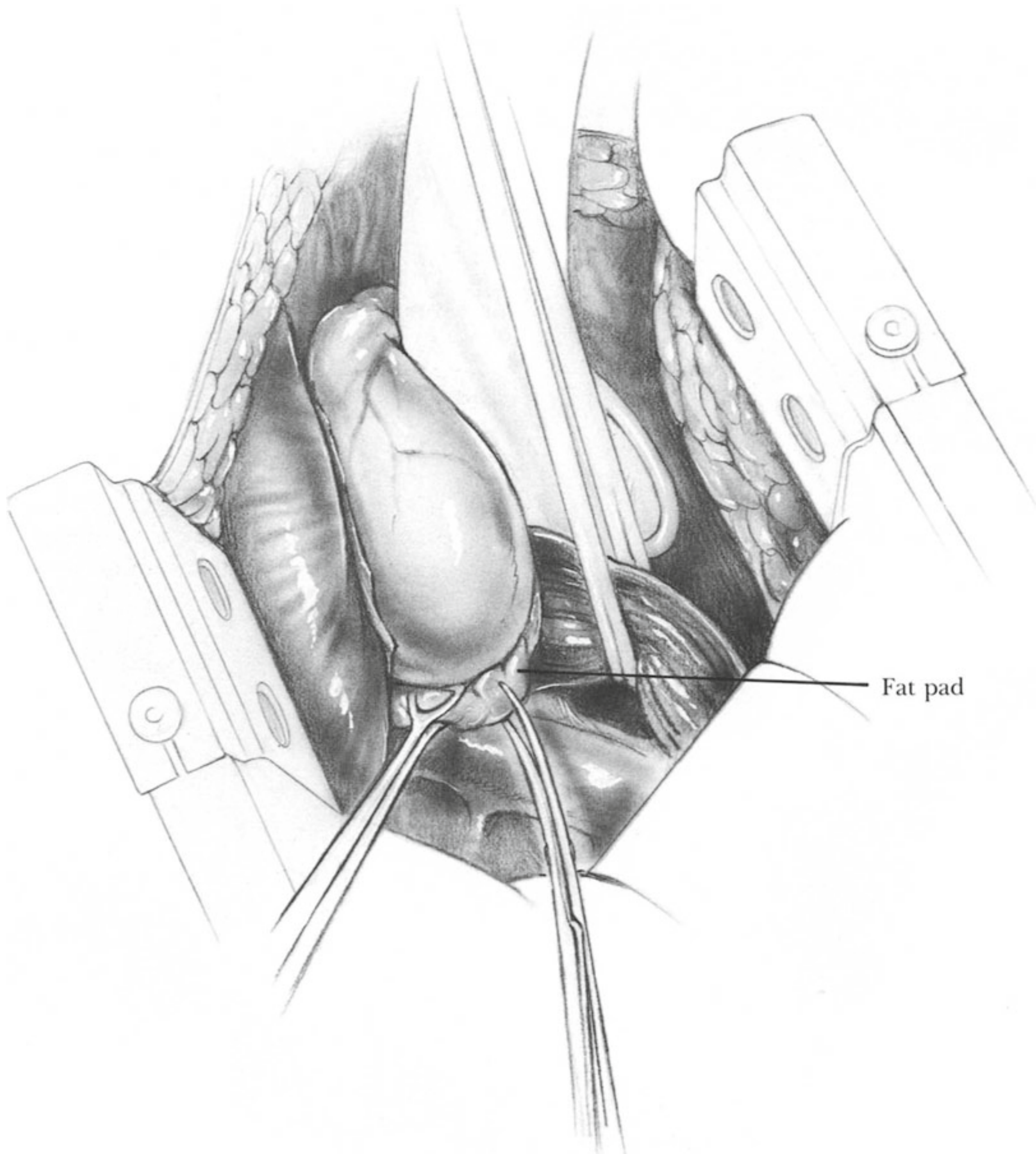

Fig. 22.11

Divide between ligatures. Continue this process until about five proximal short gastric vessels have been divided and about 12–15 cm of greater curvature has been mobilized.

Gastroplasty

Verify that the esophagogastric junction has indeed been completely mobilized. Identify the point at which the greater curvature of the stomach meets the esophagus. Overlying this area is a thin fat pad perhaps 3 cm in diameter. Carefully dissect this fat pad away from the serosa of the stomach and the longitudinal muscle of the esophagus (Fig. 22.11). Avoid damaging the anterior vagus nerve.

Pass a 56–60F Maloney dilator into the stomach and position it along the lesser curvature. Then apply an 80 mm linear cutting stapler parallel and closely adjacent to the Maloney dilator; a Babcock clamp retracts the greater curvature of the stomach in a lateral direction (Fig. 22.12). Fire the stapler and remove it. Verify that the staples have been shaped into an adequate B and that there are no leaks. Lightly electrocoagulate the everted mucosa. This maneuver will have lengthened the esophagus by approximately 6–7 cm (Fig. 22.13). In most cases no additional length of neoesophagus is necessary because of the greater lengths now available in these stapling devices. Although this step is not shown here, it is wise as a precautionary measure to oversew the staple lines with two continuous Lembert sutures of 4-0 Prolene or PDS: one

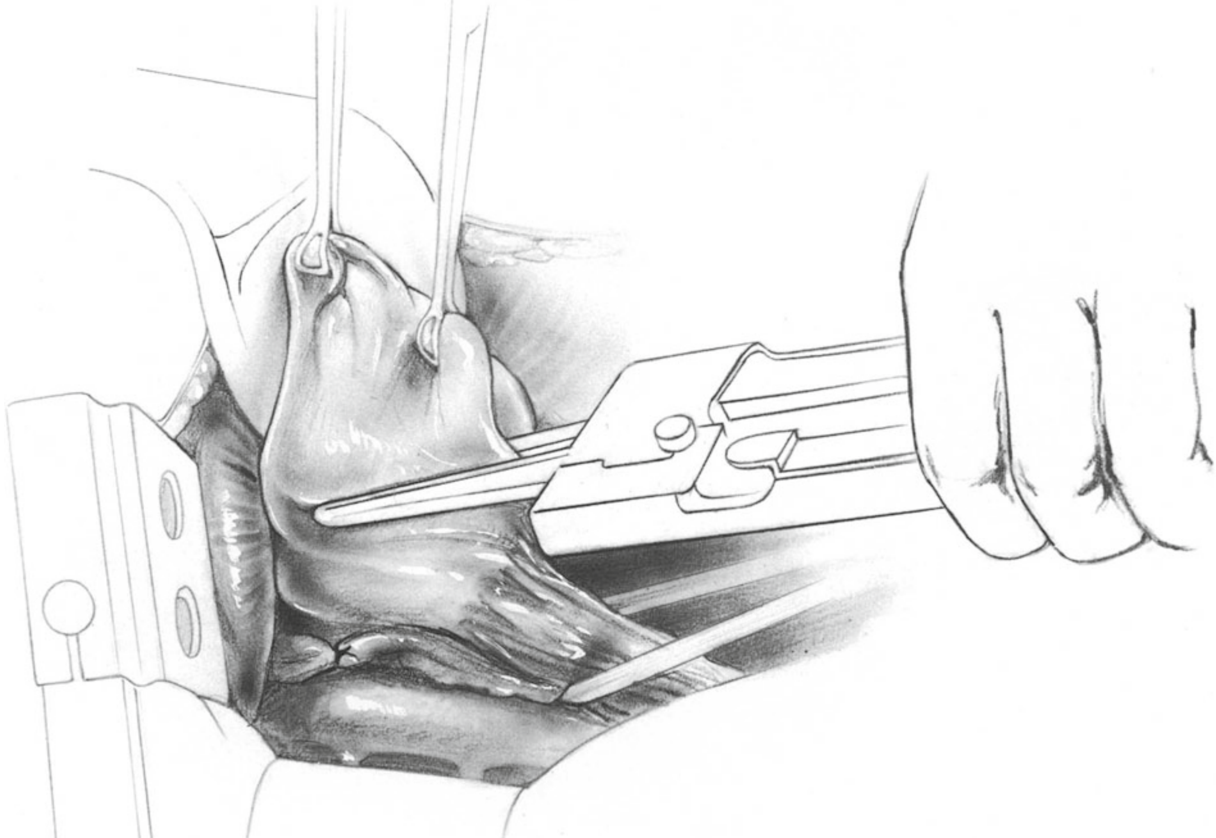

Fig. 22.12

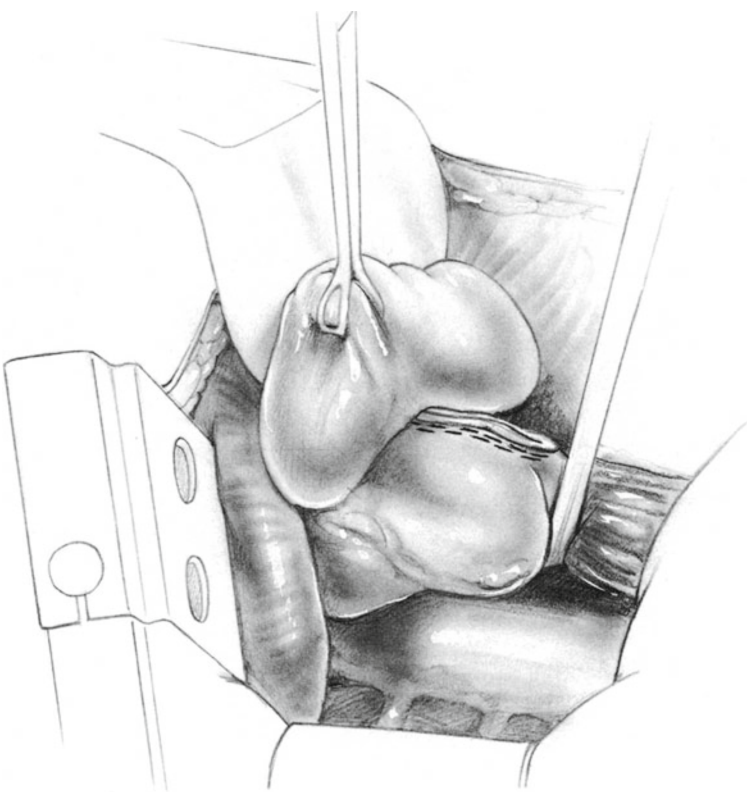

Fig. 22.13

continuous suture to invert the staple line along the neoesophagus and a second continuous suture to invert the staple line along the gastric fundus. A continuous suture of the Lembert type is suitable, taking care not to turn in an excessive amount of tissue, as it would narrow the neoesophagus unnecessarily.

Performing a Modified Nissen Fundoplication

Because the neoesophagus has utilized a portion of the gastric fundus, there may not be sufficient remaining stomach to perform the Nissen fundoplication in the classic manner. Instead, as seen in Fig. 22.14, the apex of the gastric fundus is wrapped around the neoesophagus in a counterclockwise fashion.

Before inserting any sutures, remove the indwelling large Maloney dilator and replace it with one of 50F. Place a large hemostatic clip at the site of the new esophagogastric junction (i.e., the junction of the neoesophagus with the stomach) as a radiographic marker. The fundoplication should encircle the neoesophagus in a loose wrap for a distance of 3 cm (Fig. 22.15).

Figure 22.15 illustrates insertion of the first Nissen fundoplication stitch including a 5- to 6-mm bite of gastric wall, then

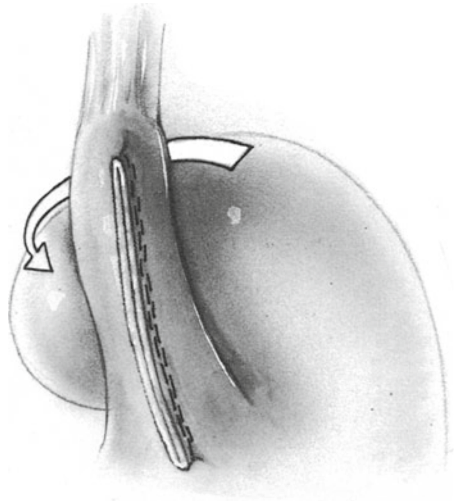

Fig. 22.14

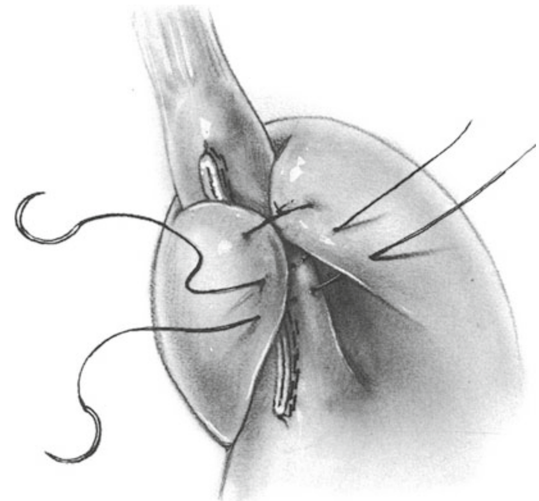

Fig. 22.16

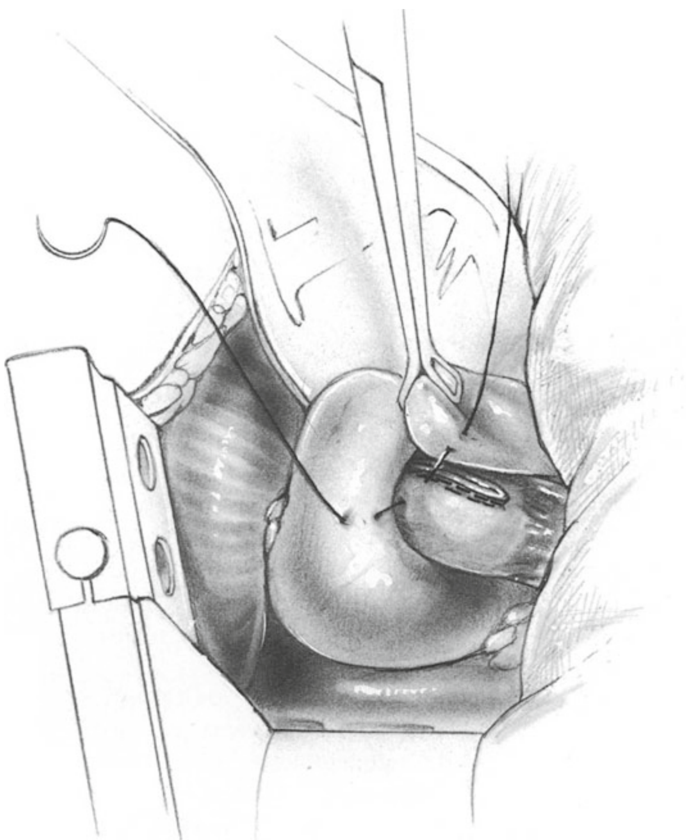

Fig. 22.15

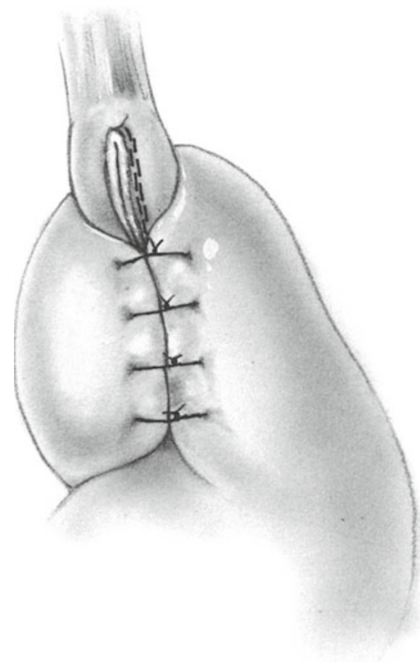

Fig. 22.17

a bite of the neoesophagus, and finally a bite of the opposite wall of the gastric fundus. These bites should be deep to the submucosa but not into the lumen of the stomach. We prefer 2-0 Tevdek for these sutures. A total of three or four fundoplication sutures are used at 1 cm intervals (Figs. 22.16 and 22.17). Now remove the Maloney dilator from the esophagus and replace it with a nasogastric tube. Figure 22.18 illustrates that the fundoplication wrap around the neoesophagus is loose enough to admit the fingertip. Optionally, invert the layer of fundoplication sutures by oversewing it with a continuous Lembert seromuscular suture of 4-0 Prolene (not illustrated).

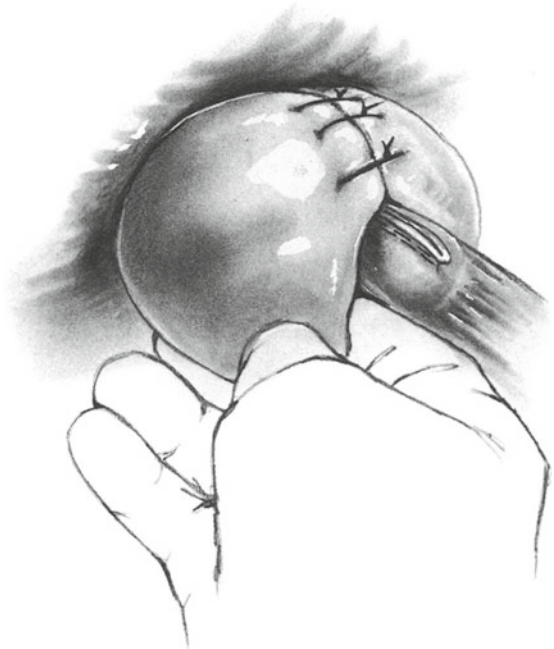

Fig. 22.18

Closing the Hiatal Defect

Close the defect in the posterior portion of the hiatus by inserting 0 Tevdek interrupted sutures through the right and left margins of the hiatus. Take a bite 1.5–2.0 cm in width and include overlying parietal pleura. After checking for hemostasis, reduce the fundoplication into the abdomen. It should slide down with ease. Then tie each of the sutures, leaving space for the surgeon's fingertip alongside the esophagus or neoesophagus with a nasogastric tube in place (Figs. 22.19 and 22.20). Place a hemostatic clip at the edge of the hiatus as a marker. It is not necessary to resuture the incision in the mediastinal pleura.

Irrigate the mediastinum and thoracic cavity with warm saline and check for complete hemostasis. Insert a 36F chest tube through a puncture wound below the level of the incision and bring the tube up the posterior gutter above the hilus of the lung. Insert three to five interrupted no. 2 PDS pericostal sutures and tie them to approximate the ribs. Close the overlying serratus and latissimus muscles in two layers with 2-0 PG continuous sutures. Close the skin with continuous or interrupted fine nylon sutures.

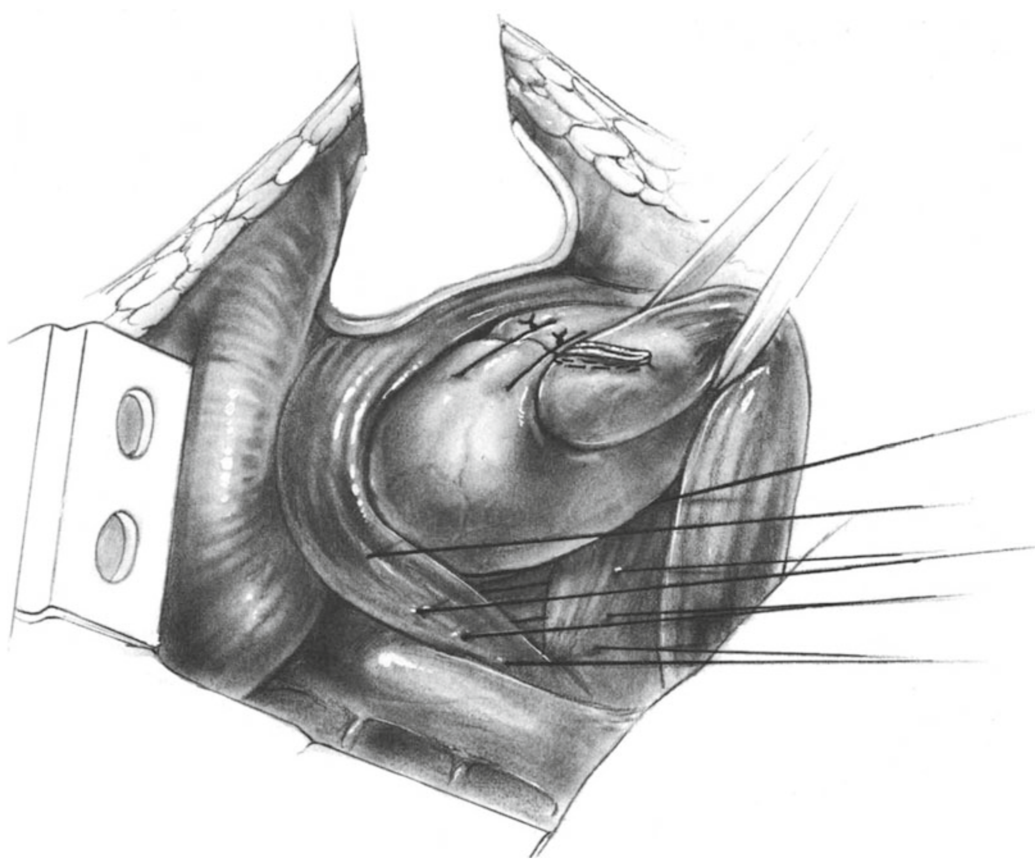

Fig. 22.19

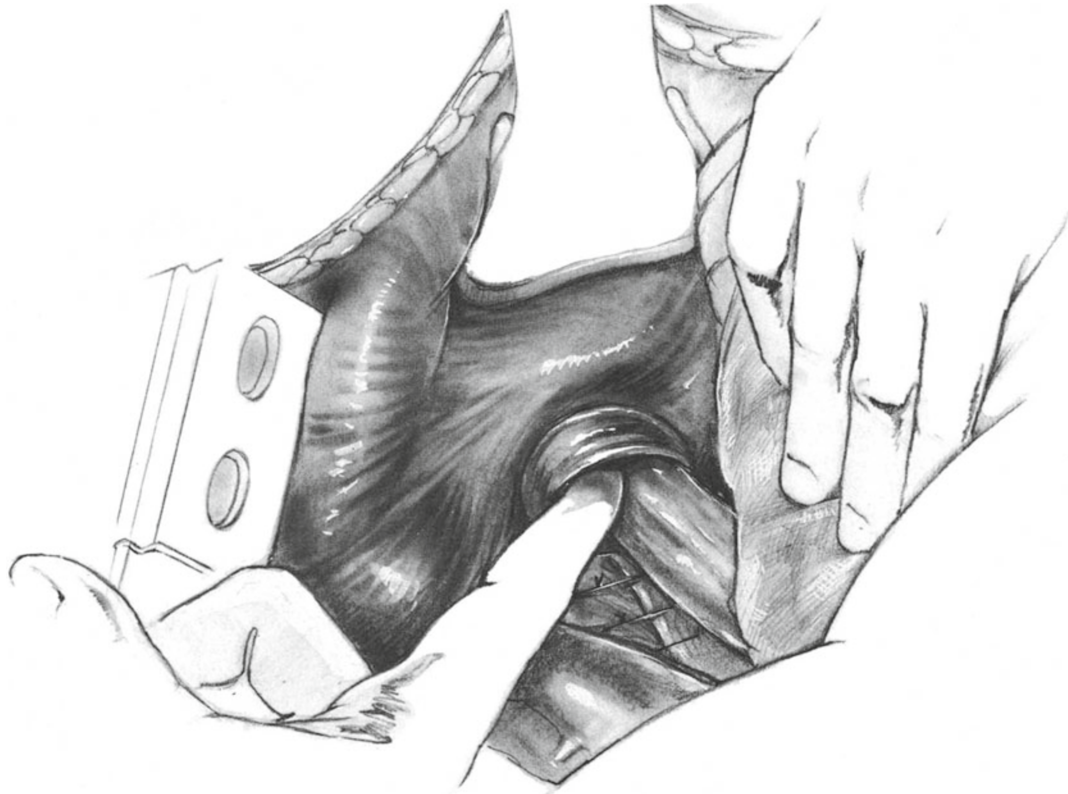

Fig. 22.20

Postoperative Care

Continue nasogastric suction for 1–3 days.

Continue perioperative antibiotics for 24 h.

Obtain an esophagram (first water-soluble then thin barium) on postoperative day 7.

Remove the chest drainage tube on day 3 unless drainage is excessive.

Complications

Obstruction. Occasionally there is a partial obstruction at the area of the fundoplication due to edema during the first 2 weeks following surgery. If the wrap is too tight, this obstruction may persist.

Recurrent gastroesophageal reflux. This is uncommon after the Collis-Nissen procedure unless the fundoplication suture line disrupts.

Leakage from the gastroplasty or fundoplication sutures. This complication is rare. If the fundoplication sutures are inserted into the lumen of the stomach and the suture is tied with strangulating force, a leak is possible. The risk of this occurring may be reduced by oversewing the fundoplication suture line with a continuous Lembert seromuscular suture.

Necrosis of the gastroplasty tube. This complication was reported by Orringer and Orringer during an operation for recurrent hiatus hernia. They warned that traumatizing the lesser curve of the stomach may doom a gastroplasty tube.

Further Reading

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23 Bile Diverting Operations for Management of Esophageal Disease

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Disabling bile reflux symptoms after esophageal surgery

Preoperative Preparation

Confirm bile reflux by visual inspection at endoscopy, radionuclide scan, or 24-h pH monitoring.
Insert a nasogastric tube.

Pitfalls and Danger Points

Injury to liver, pancreas, or stomach
Damaging blood supply to residual gastric pouch

Operative Strategy

Bile Diversion After Failed Antireflux Procedures

Bile diversion is considered only after multiple failed antireflux procedures. Generally vagotomy or antrectomy with bile diversion via a Roux-en-Y reconstruction (Figs. 23.1 and 23.2) is the procedure of choice. As with any reoperative surgery, careful preoperative assessment is mandatory, and the operative procedure must be tailored to the individual case.

The need for vagotomy, in particular, should be carefully assessed in light of alternative medical acid-suppressive therapies. It is important to recognize that bile-diverting operations may deprive acid-bathed mucosa of the normal buffering effect of bile and pancreatic juice and thus may be "ulcerogenic," hence the frequent inclusion of vagotomy. If vagotomy is desired and transabdominal vagotomy does not appear feasible because of excessive scar tissue around the abdominal esophagus, transthoracic or thoracoscopic vagotomy is an alternative.

Bile Diversion After Esophagogastrectomy

Bile diversion after esophagogastrectomy is used when bile reflux complicates otherwise successful esophageal resection

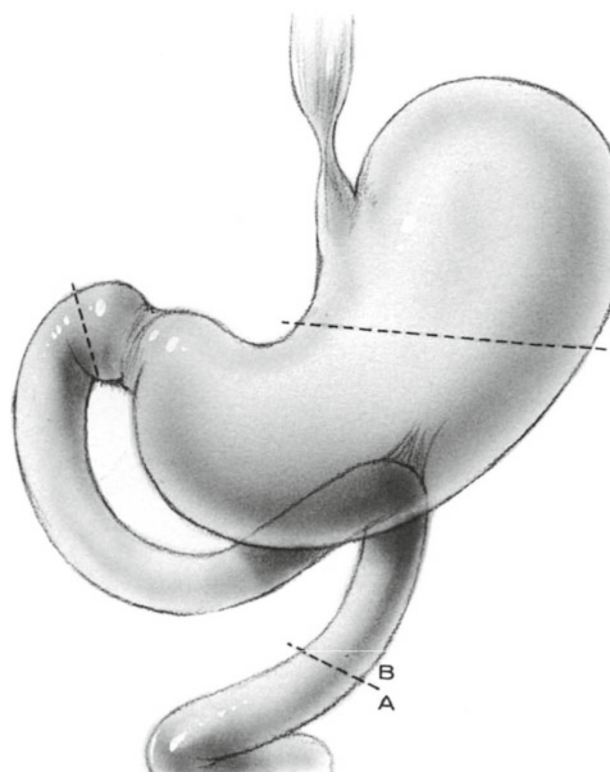

Fig. 23.1

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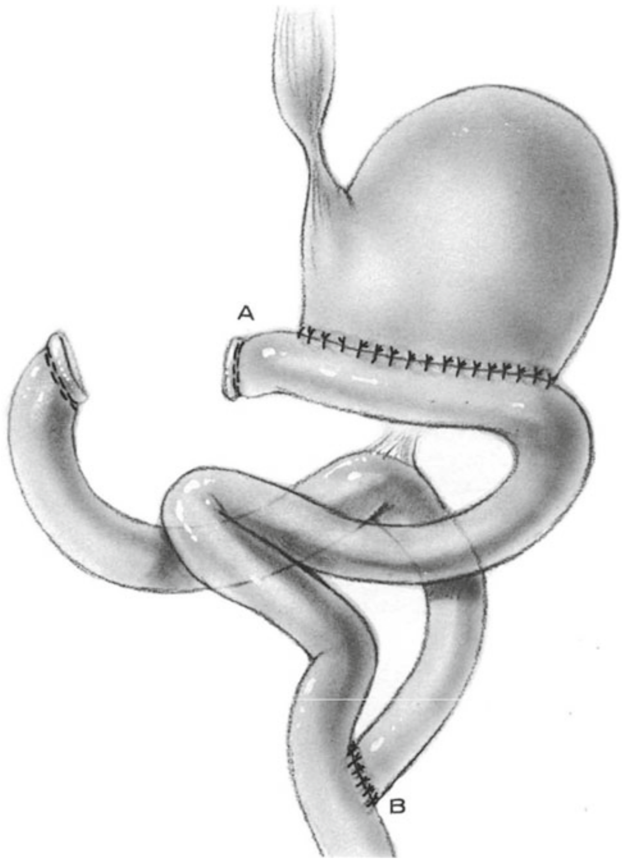


Fig. 23.2

with esophagogastrectomy. Perform the dissection with extreme care to avoid traumatizing the blood supply to the residual stomach. Generally, the gastric remnant is supplied only by the right gastric and right gastroepiploic vessels. A variation of this procedure, the duodenal switch procedure, is also illustrated.

Documentation Basics

As with any reoperative procedure, carefully describe indications and findings.

Document:

- Findings
- Vagotomy or not?
- Exact procedure performed

Operative Technique

Vagotomy and Antrectomy with Bile Diversion

Incision and Exposure

Ordinarily a long midline incision from the xiphoid to a point about 5 cm below the umbilicus is adequate for this operation. Divide the many adhesions and expose the stomach. Evaluate the difficulty of performing a hemigastrectomy, rather than other available operations. Insert an Upper Hand or Thompson retractor. If vagotomy is to be performed, do this as the first step of the operation. First, determine if a transabdominal vagotomy is feasible.

Vagotomy (Optional)

If it is feasible to perform a truncal vagotomy, follow the procedure described in Chap. 29. If dissecting the area of the esophagogastric junction appears too formidable a task, thoracoscopic or transthoracic vagotomy is an option.

Hemigastrectomy

Follow the procedure described in Chap. 33 for performance of a Billroth II gastric resection. Close the duodenal stump by stapling (see Fig. 33.43) or suturing (see Figs. 33.20, 33.21, and 33.22).

Roux-en-Y Gastrojejunostomy

Create a Roux-en-Y limb of jejunum by the technique described in Fig. 38.4. Then perform an end-to-side gastrojejunostomy using sutures (see Figs. 33.34, 33.35, 33.36, 33.37, 33.38, 33.39, and 33.40) or staples (see Figs. 33.42, 33.43, 33.44, 33.45, 33.46, and 33.47). Position this anastomosis so it sits about 1 cm proximal to the stapled closed end of the jejunum (see Fig. 33.49). Complete construction of the Roux-en-Y segment by anastomosing the proximal cut end of the jejunum near the ligament of Treitz to the side of the descending segment of jejunum at a point 60 cm distal to the gastrojejunostomy. Close the defect in the jejunal mesentery with interrupted sutures.

Closure

Close the abdominal wall without drainage in the usual fashion.

Bile Diversion Following Esophagogastrectomy

Incision and Exposure

Make a midline incision from the xiphoid to a point somewhat below the umbilicus. Divide the various adhesions subsequent to prior surgery and expose the pyloroduodenal region. Because of the previous surgery (esophagogastrectomy) (Fig. 23.3), this area is now located 5–8 cm from the diaphragmatic hiatus.

Dividing the Duodenum, Duodenojejunostomy, Roux-en-Y Reconstruction

Divide the duodenum at a point 2–3 cm beyond the pylorus. Be careful not to injure the right gastric or right

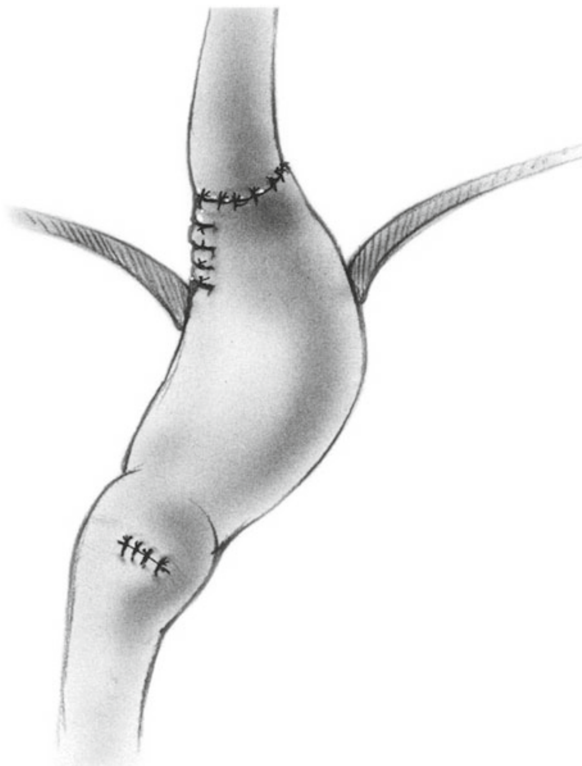


Fig. 23.3

gastroepiploic vessels, as they constitute the entire blood supply of the residual gastric pouch. To divide the duodenum, first free the posterior wall of the duodenum from the pancreas for a short distance. If possible, pass one jaw of a 55/3.5 mm linear stapler behind the duodenum, close the device, and fire the stapler. Then divide the duodenum flush with the stapling device. Lightly cauterize the everted mucosa and remove the stapler, which leaves the proximal duodenum open. Leave 1 cm of the posterior wall of the duodenum free (Fig. 23.4A) to construct an anastomosis with the jejunum.

Develop a Roux-en-Y limb of jejunum by the technique described in Fig. 38.4. Bring the open distal end of the divided jejunum (Fig. 23.4D) to the level of the duodenum. Generally it most comfortably assumes an antecolic position, but occasionally it is feasible to bring it through an incision in the mesocolon (retrocolic).

Establish an end-to-end duodenojejunostomy (Fig. 23.5, point A to point D) utilizing one layer of interrupted 4-0 silk for the seromuscular layer and continuous or interrupted sutures of atraumatic 5-0 PG for the mucosal layers (see Figs. 43.2, 43.3, 43.4, 43.5, 43.6, 43.7, 43.8, 43.9, and 43.10).

Complete the construction of the Roux-en-Y segment by creating an end-to-side jejunojejunostomy at a point 60 cm distal to the duodenojejunostomy using the technique shown in Figs. 38.26, 38.27, 38.28, 38.29, and 38.30. Close the defect in the jejunal mesentery with interrupted sutures.

Bile Diversion by Duodenojejunostomy Roux-en-Y Switch Operation

Incision and Exposure

Make a midline incision from the xiphoid to a point about 3–4 cm below the umbilicus.

Duodenojejunostomy

Perform a thorough Kocher maneuver, freeing the head of the pancreas and duodenum anteriorly and posteriorly. Place a marking suture on the anterior wall of the duodenum precisely 3 cm distal to the pylorus. This represents the probable point at which the duodenum will be transected. Now approach the point at which the duodenum and pancreas meet. Divide and carefully ligate the numerous small vessels emerging from the area of the pancreas and entering the duodenum on both anterior and posterior surfaces until a 2 cm area of the posterior wall of duodenum has been cleared. Do not dissect the proximal 2–3 cm of duodenum from its attachment to the pancreas. Dissecting the next 2 cm of duodenum free of the pancreas provides enough length to allow stapled closure of the duodenal stump and a duodenojejunal end-to-end anastomosis. Be careful not to injure the pancreatic segment of the distal common bile duct or the duct of Santorini, which enters the duodenum at a point about 2 cm proximal to the papilla of Vater.

After this step has been completed, make a 2 cm transverse incision across the anterior wall of the duodenum near the marking suture (Fig. 23.6). Insert an index finger and palpate the ampulla. Confirm its location by compressing the gallbladder and liver, observing the influx of bile into the distal duodenum. Now use a 55/3.5 mm linear stapler to occlude the duodenal stump just distal to the marking suture. Complete the transection of the duodenum after the stapler has been fired by cutting along the stapling device with a scalpel, cauterize the mucosa, and check the staple line in the usual fashion.

At a point 20 cm distal to the ligament of Treitz, transect the jejunum and incise its mesentery down to, but not across, the arcade vessel (Fig. 23.7, C and D). Limiting the incision in the mesentery to 3 cm helps preserve the innervation of the intestinal pacemaker in the upper jejunal mesentery. Bring the distal transected end of the jejunum through a small incision in the mesocolon and make an end-to-end anastomosis between the proximal transected duodenum to the jejunum using 4-0 interrupted silk sutures for the seromuscular layer and 5-0 Vicryl sutures for the mucosa (Fig. 23.8, A and C). Then perform an end-to-side jejunojejunostomy to the descending limb of jejunum (Fig. 23.8) at a point 60 cm distal to the duodenojejunostomy by the technique described in Figs. 38.26, 38.27, 38.28, 38.29, and 38.30. Eliminate any

Fig. 23.4

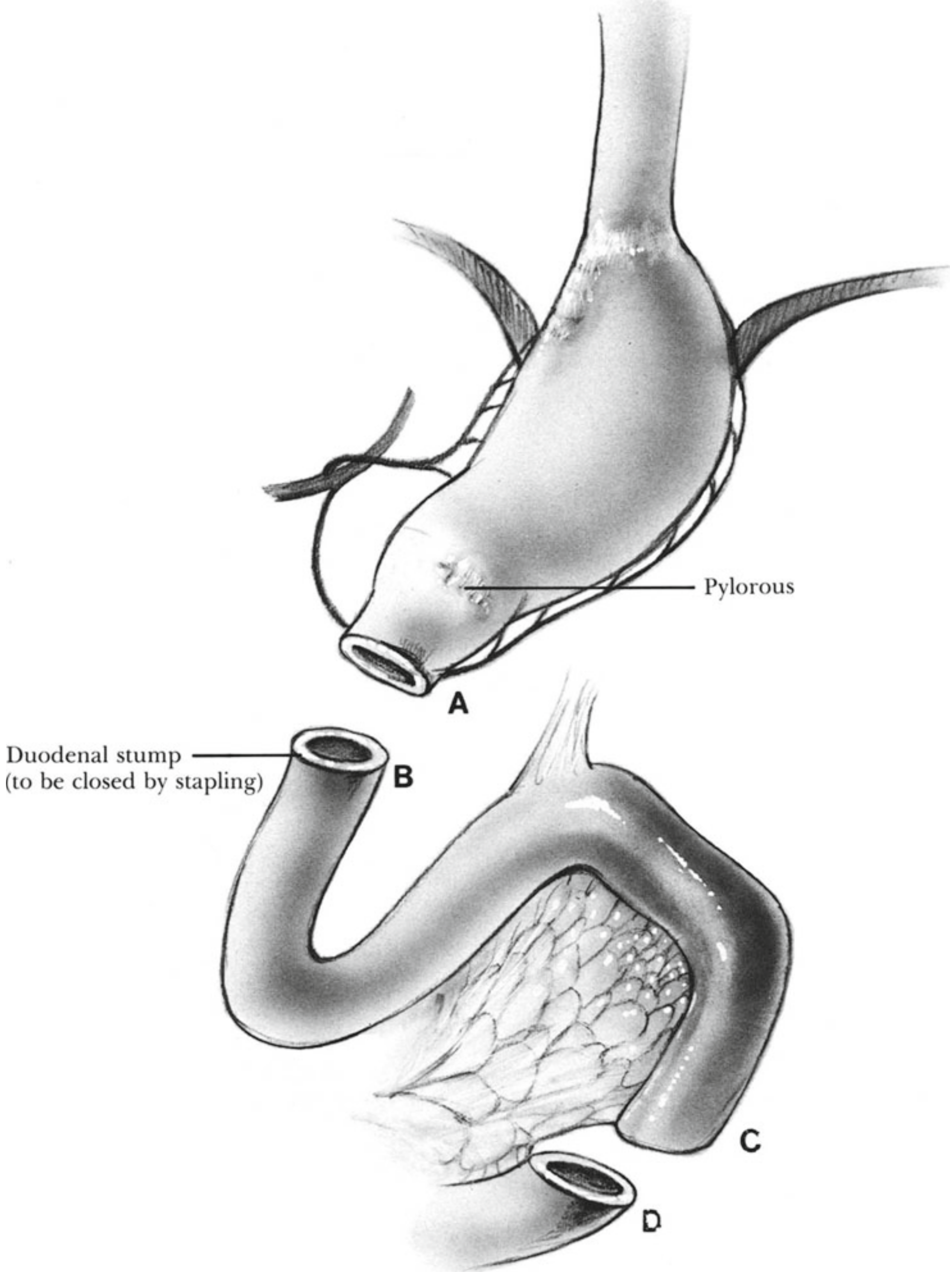


Fig. 23.5

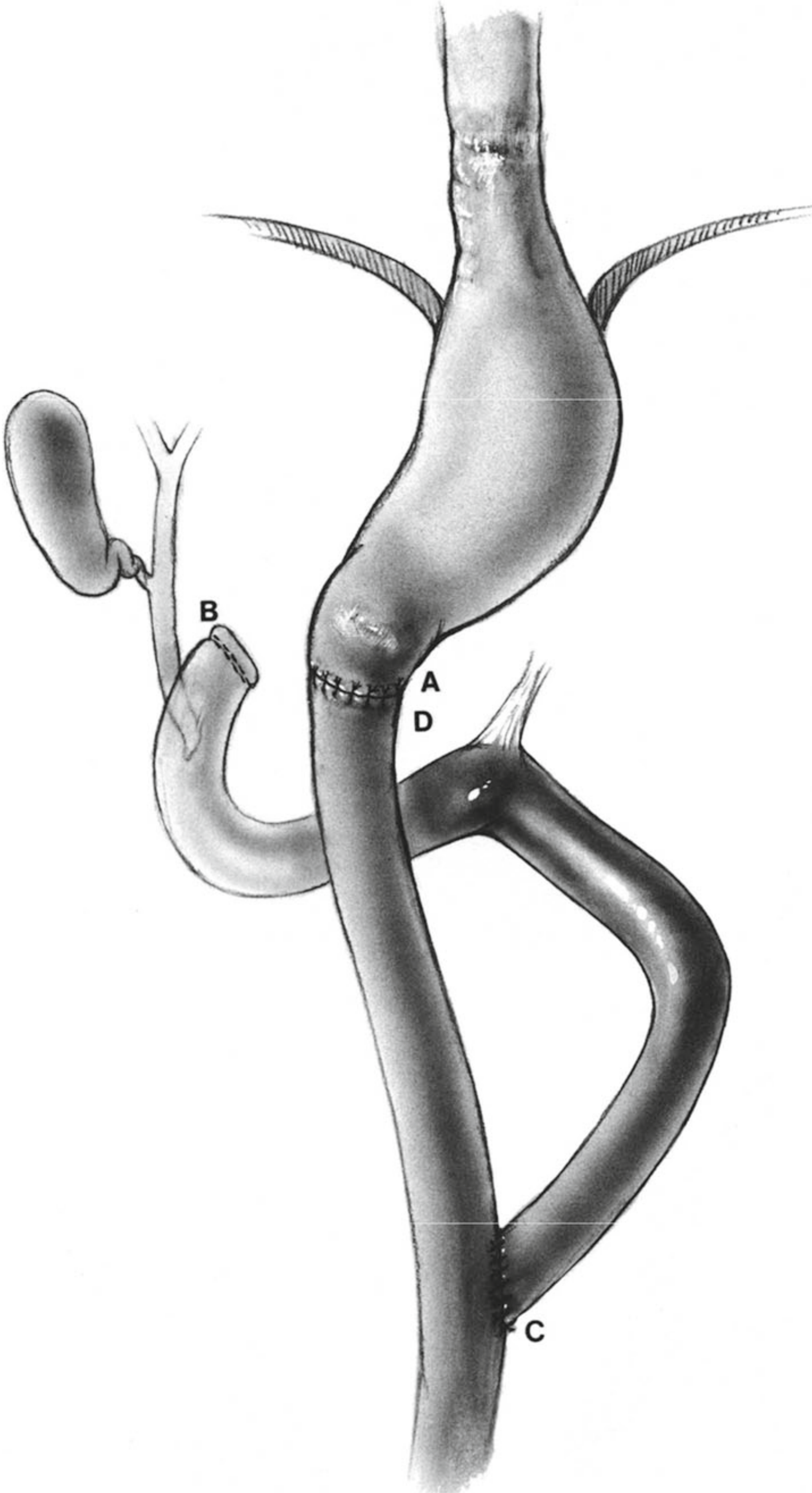
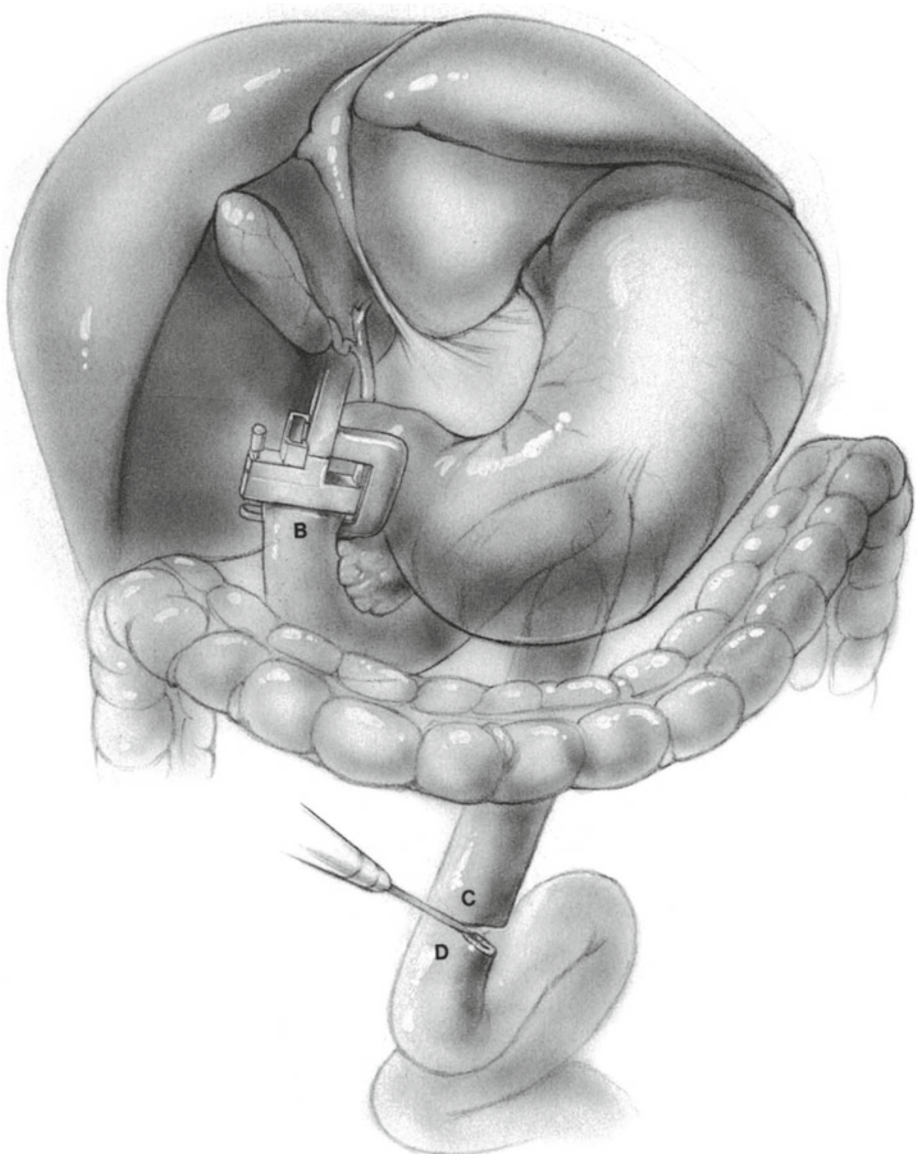


Fig. 23.6



defect in the mesocolon or the jejunal mesentery by suturing. Irrigate the abdominal cavity and abdominal wound and close the abdomen in the usual fashion without drainage.

Complications

Intestinal obstruction
Anastomotic leak

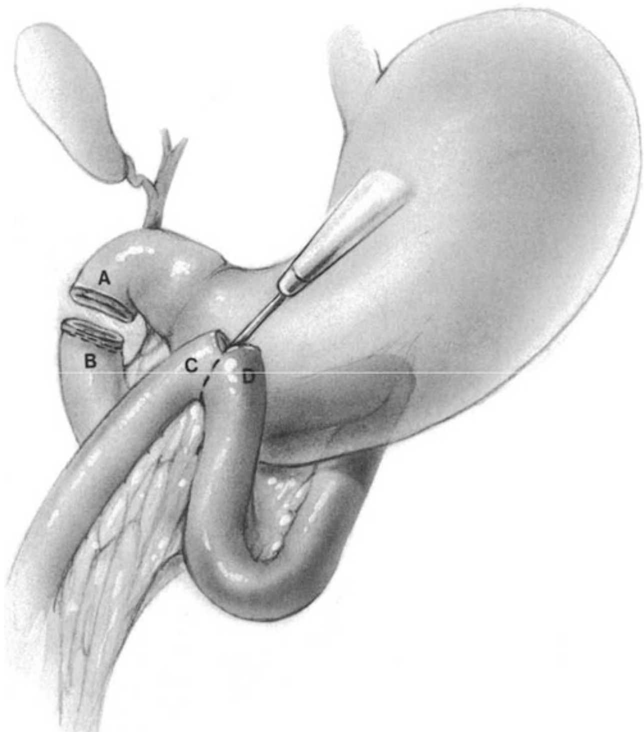


Fig. 23.7

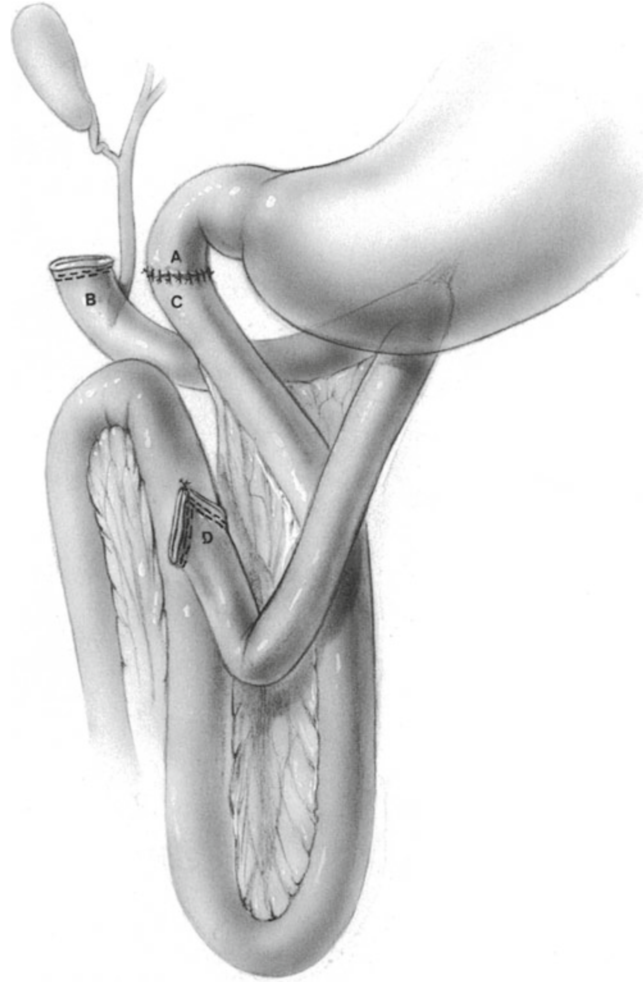


Fig. 23.8

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Cricopharyngeal Myotomy and Operation for Pharyngoesophageal (Zenker's) Diverticulum

24

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Symptomatic Zenker's diverticulum

Preoperative Preparation

Perioperative antibiotics

Operative Strategy

Adequate Myotomy

Performing a cricopharyngeal myotomy is similar to performing a cardiomyotomy. The physiologic upper esophageal sphincter is considerably wider than the anatomic cricopharyngeus muscle. The transverse muscle fibers are only about 2.0–2.5 cm wide, whereas the high-pressure zone corresponding to the cricopharyngeus area can be 4 cm wide. Consequently, a proper cricopharyngeal myotomy should not only transect all of the transverse fibers of the cricopharyngeus muscle but also 1–2 cm of the proximal esophagus so the myotomy is at least 4 cm long. The incision in the muscle is carried down to the mucosa of the esophagus, which should bulge out through the myotomy after all the muscle fibers have been divided. Additionally, the mucosa is freed from the overlying muscle over the posterior half of the esophagus.

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Is Diverticulectomy Necessary?

If the pharyngoesophageal diverticulum is a small diffuse bulge measuring no more than 2–3 cm in diameter, we perform only a myotomy and make no attempt to excise any part of the diverticulum because after the myotomy there is only a gentle bulge of mucosa and no true diverticulum. On the other hand, longer, finger-like projections of mucosa should be amputated because there have been a few case reports of recurrent symptoms due to the persistence of diverticula left behind in patients in whom an otherwise adequate myotomy had been done. Belsey advocated suturing the most dependent point of the diverticulum to the prevertebral fascia in the upper cervical region. This procedure effectively upends the diverticulum so it can drain freely into the esophageal lumen by gravity. We prefer to amputate diverticula larger than 3 cm rather than perform a diverticulopexy. With application of a stapling device, amputation of the diverticulum takes only about 1 min of additional operating time, and the results have been excellent. Endoscopic alternatives have been developed and are described in the references at the end of this chapter.

Documentation Basics

Findings
Myotomy only or myotomy with diverticulectomy?

Operative Technique

Incision and Exposure

With the patient's head turned somewhat toward his or her right, make an incision along the anterior border of the left sternomastoid muscle beginning at a point 2–3 cm above the clavicle (Fig. 24.1). Divide the platysma muscle.

†Deceased

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Electrocoagulate the bleeding points. Free the anterior border of the sternomastoid muscle and retract it laterally, exposing the omohyoid muscle crossing the field from medial to lateral. Transect this muscle (Fig. 24.2). The diverticulum is located deep to the omohyoid muscle. Identify the carotid sheath and the descending hypoglossal nerve and retract these structures laterally. The thyroid gland is seen in the medial portion of the operative field underneath the strap muscles. Retract the thyroid gland and the larynx in a medial direction, revealing in most cases a prominent middle thyroid vein (Fig. 24.3). Ligate and divide this vein.

Fig. 24.1

Divide the areolar tissue anterior to the carotid artery and identify the inferior thyroid artery and the recurrent laryngeal nerve. In some patients there appears to be no true left inferior thyroid artery arising from the thyrocervical trunk, in which case the lower thyroid is supplied by branches of the superior thyroid artery. In most patients with the inferior thyroid artery emerging from underneath the carotid artery and crossing the esophagus to supply the lower thyroid (see Figs. 120.10 and 120.11), divide and ligate this vessel after identifying the recurrent laryngeal nerve. After this step has been completed, retracting the larynx in an anteromedial direction and the carotid artery laterally exposes the lateral and posterior aspects of the cervical esophagus and the pharyngoesophageal junction. Often it is not necessary to divide the inferior thyroid artery or its branches to develop adequate exposure for diverticulectomy.

Dissecting the Pharyngoesophageal Diverticulum

The pharyngoesophageal diverticulum emerges posteriorly between the pharyngeal constrictor and the cricopharyngeus muscles. Its neck is at the level of the cricoid cartilage, and the dependent portion of the diverticulum descends between the posterior wall of the esophagus and the prevertebral fascia overlying the bodies of the cervical vertebrae. Blunt

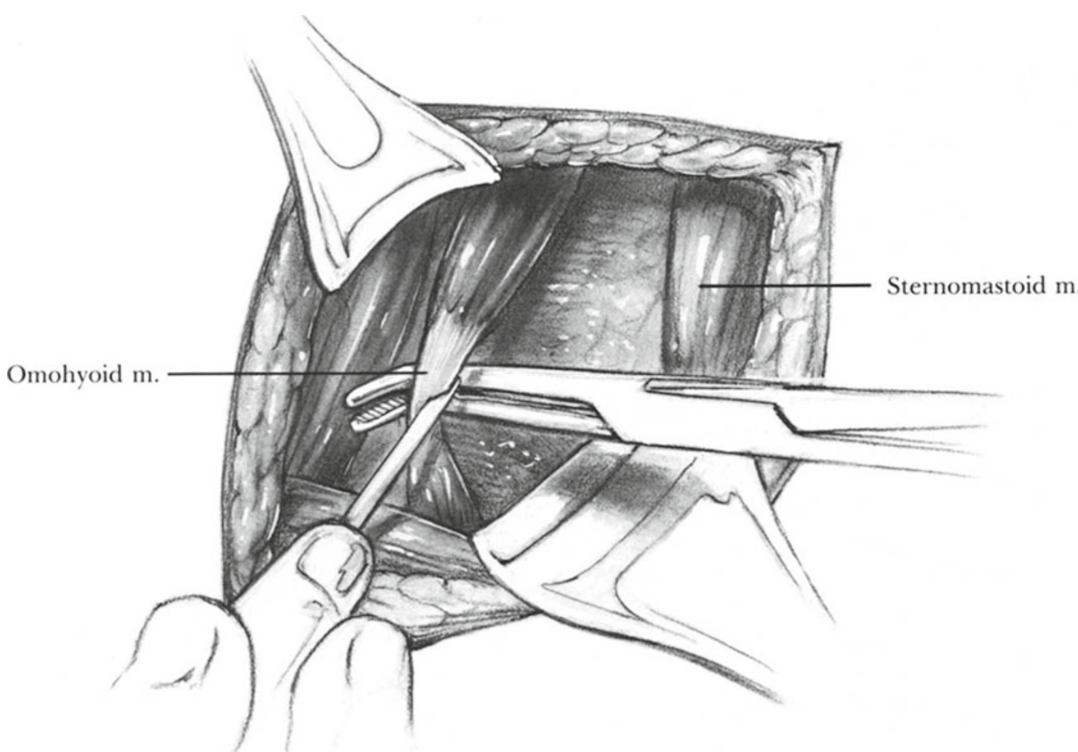

Fig. 24.2

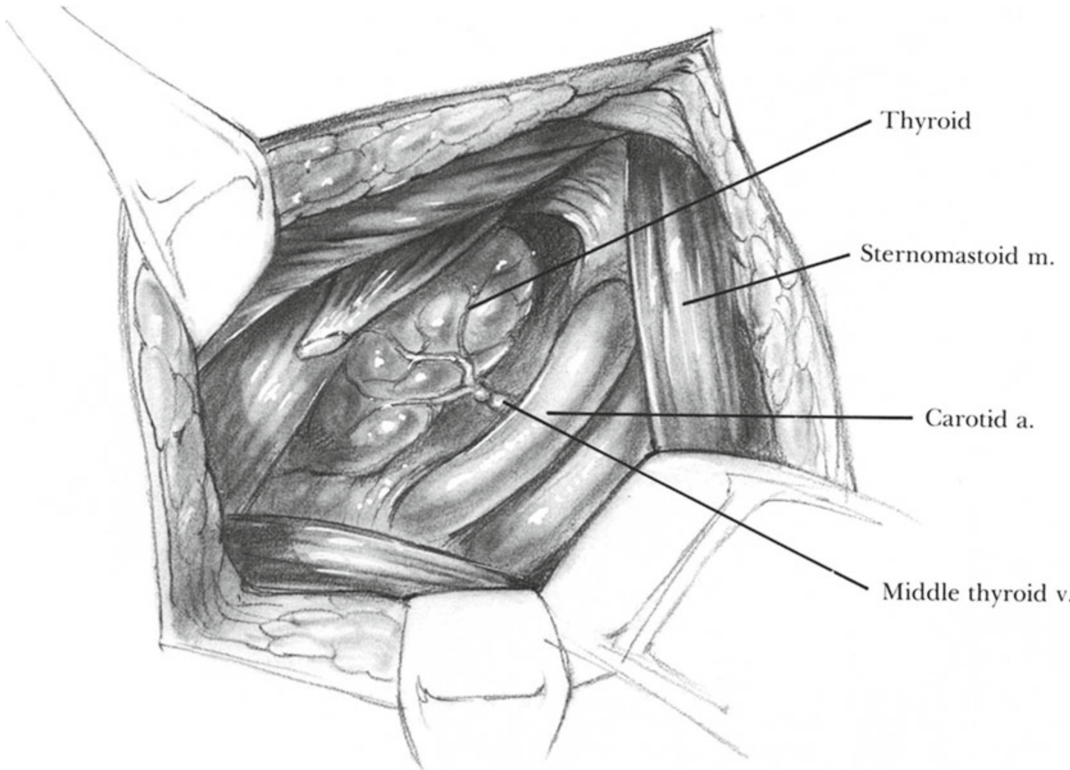

Fig. 24.3

dissection with the index finger or a peanut sponge generally identifies the most dependent portion of the diverticulum. Grasp it with a Babcock clamp and elevate the diverticulum in a cephalad direction. Mobilize the diverticulum by sharp and blunt dissection down to its neck. If there is any confusion about the anatomy, especially in patients who have undergone previous operations in this area, ask the anesthesiologist to pass a 40F Maloney bougie through the mouth into the cervical esophagus. Guide the tip of the bougie past the neck of the diverticulum so it enters the esophagus. The exact location of the junction between the esophagus and the diverticulum can then be identified. There is generally some fibrous tissue overlying the mucosa of the diverticulum. Lightly incise it with a scalpel near the neck of the sac down to the submucosa. At this point the transverse fibers of the cricopharyngeus muscle are easily identified.

Cricopharyngeal and Esophageal Myotomy

Insert a blunt-tipped right-angled hemostat between the mucosa and the transverse fibers of the cricopharyngeus muscle just distal to the neck of the diverticulum (Fig. 24.4). Elevate the hemostat in the posterior midline and incise the fibers of the cricopharyngeus muscle with a scalpel. Continue this dissection down the posterior wall of the esophagus for a total distance of about 5–6 cm. Now elevate the incised muscles of the cricopharyngeus and the upper esophagus from the underlying mucosal layer over the posterior half of the esophageal circumference by blunt dissection.

After the mucosa has been permitted to bulge out through the myotomy, determine whether the diverticulum is large enough to warrant resection. If so, apply a 30- or 55-mm linear stapler with 3.5-mm staples across the neck of the diverticulum (Fig. 24.5). Close the stapler. Fire the staples and amputate the diverticulum flush with the stapling device. The 40F Maloney dilator in the lumen of the esophagus protects against excising too much mucosa and narrowing the lumen. After removing the stapling device, carefully inspect the staple line and the staples for proper closure. Check for complete hemostasis (Fig. 24.6).

An alternative method for performing the myotomy is illustrated in Fig. 24.7, where the incision is initiated 1.0–1.5 cm cephalad to the cricopharyngeus muscle, in the

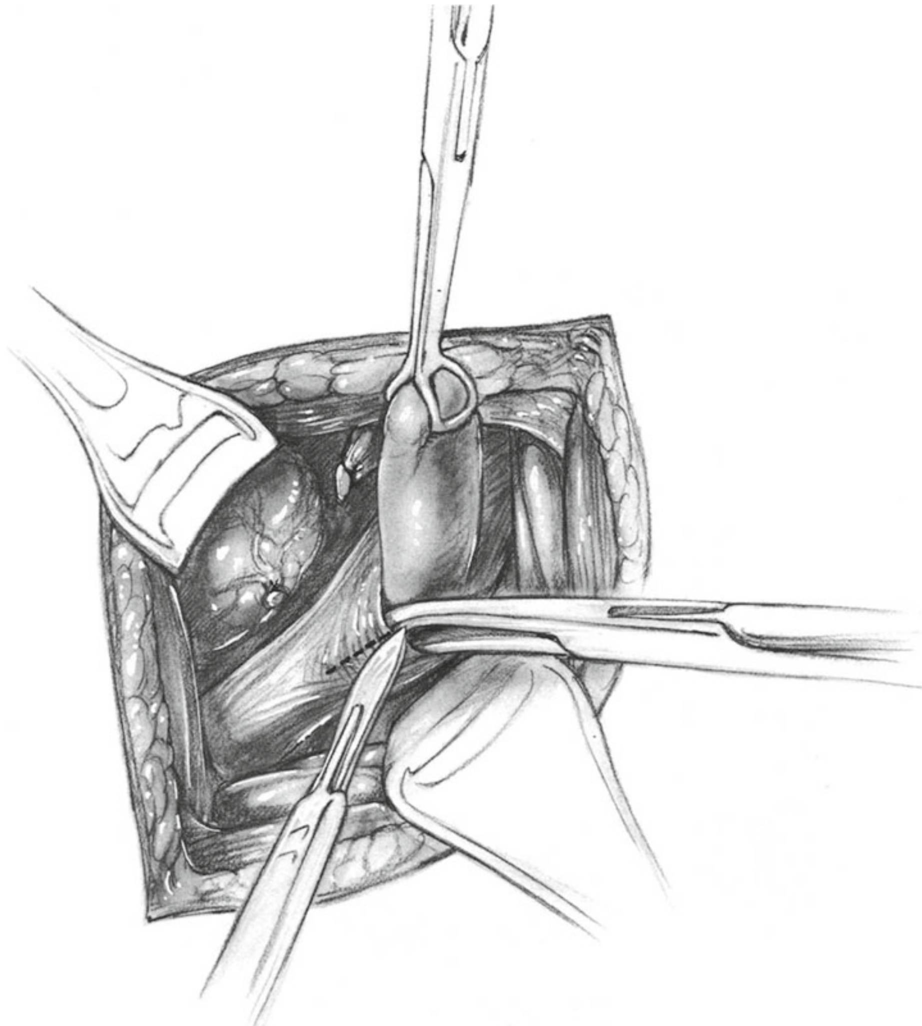

Fig. 24.4

pharyngeal constrictor muscle. It is then continued downward for 4–5 cm. Remove the diverticulum in the usual fashion.

Drainage and Closure

After carefully inspecting the area and ensuring complete hemostasis, insert a medium-size latex drain into the prevertebral space just below the area of the diverticulectomy. Bring the drain out through the lower pole of the incision.

Close the incision in layers with interrupted 4-0 PG sutures to the muscle fascia and platysma. Close the skin with continuous subcuticular sutures of 4-0 PG, interrupted nylon sutures, or skin staples.

Postoperative Care

Remove the drain by postoperative day 4. Initiate a liquid diet on the first postoperative day and progress to a full diet over the next 2–3 days. Continue perioperative antibiotics for a second dose.

Complications

Esophageal Fistula. When the fistula is small and drains primarily saliva, it generally closes after a week of intravenous feeding if the patient's operative site has been drained as described above.

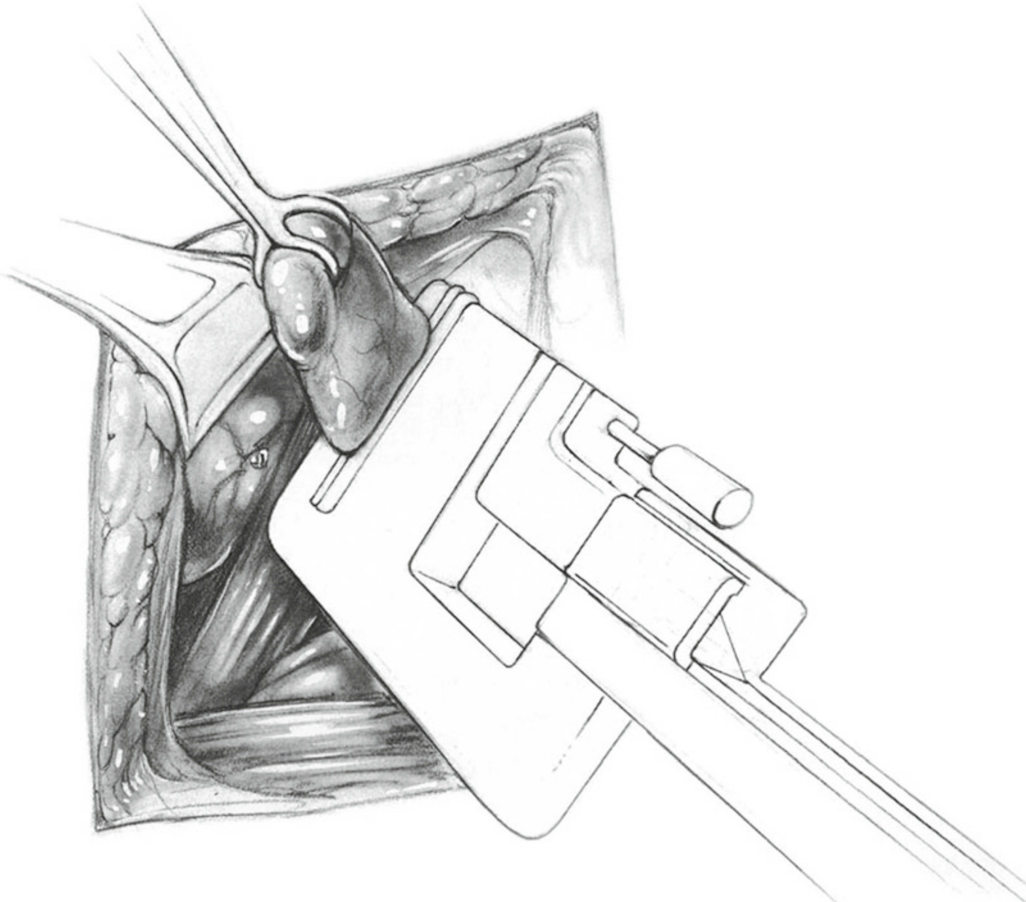

Fig. 24.5

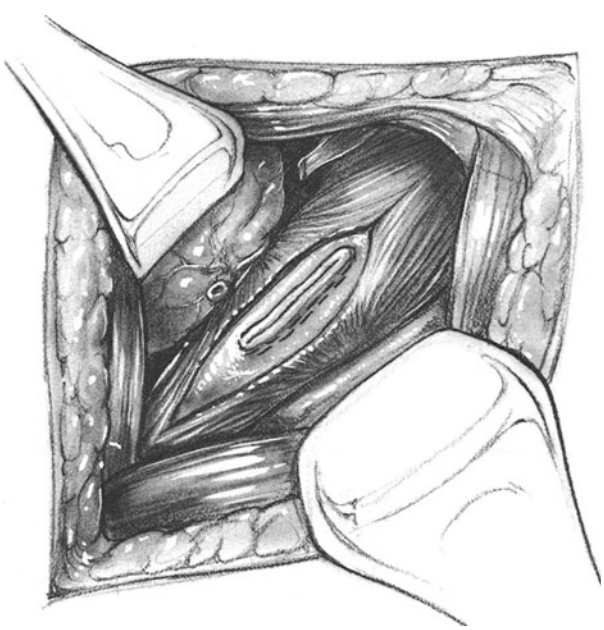

Fig. 24.6

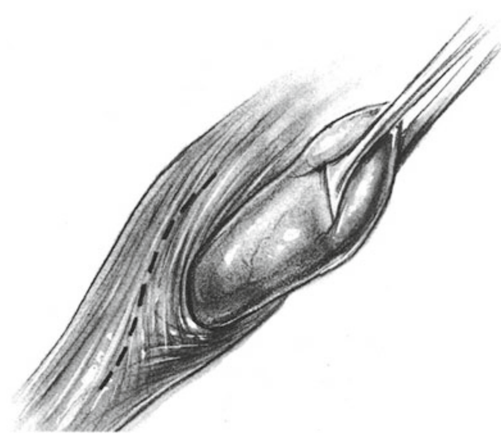

Fig. 24.7

Recurrent Laryngeal Nerve Palsy. It is generally temporary, secondary to excessive traction on the thyroid cartilage or to direct trauma to the nerve.

Persistent Dysphagia. This is due to inadequate myotomy.

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Esophagomyotomy for Achalasia and Diffuse Esophageal Spasm: Surgical Legacy Technique

25

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Achalasia
Extended myotomy sometimes performed for diffuse esophageal spasm

Preoperative Preparation

Obtain a barium swallow esophagram.
Perform esophagoscopy with biopsy and brushings of the narrowed portion of distal esophagus if any mucosal abnormalities are noted.
Perform esophageal manometry.
For advanced cases, lavage the dilated esophagus with a Levine tube and warm saline for 1–2 days prior to operation to evacuate retained food particles. Combine this with a liquid diet.
Pass a nasogastric tube into the esophagus the morning of operation.
Administer perioperative antibiotics.

Pitfalls and Danger Points

Extending the myotomy too far on the stomach
Perforating the esophageal mucosa
Performing an inadequate circumferential liberation of the mucosa
Creating a hiatus hernia

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Operative Strategy

Length of Myotomy for Achalasia

Ellis et al. (1980) attributed their low incidence of postoperative gastroesophageal regurgitation (3 %) to the fact that the myotomy terminates only a few millimeters beyond the esophagogastric junction. At the esophagogastric junction, several veins run in a transverse direction just superficial to the esophageal mucosa. One does not encounter any other transverse vein of this size during myotomy of the more proximal esophagus. Once these veins are encountered, terminate the myotomy. In no case should more than 1 cm of gastric musculature be divided. Continue the myotomy in a cephalad direction for 1–2 cm beyond the point at which the esophagus begins to dilate. For early cases, where no significant esophageal dilatation is evident, the length of the myotomy should be 5–8 cm.

Choice of Operative Approach

Laparoscopic myotomy is an excellent alternative for patients with achalasia in whom the narrow segment is limited to the distal esophagus (see Chap. 26). Open esophagomyotomy may be performed through a thoracotomy incision (as shown here) or transabdominally. The thoracic approach allows excellent exposure without disrupting the phrenoesophageal ligaments, potentially contributing to postoperative gastroesophageal reflux. It facilitates a long myotomy in cases of diffuse esophageal spasm.

Mucosal Perforation

Mucosal perforation is easily repaired if recognized. It is advisable for the surgeon to test the integrity of the mucosal layer following myotomy by having the anesthesiologist

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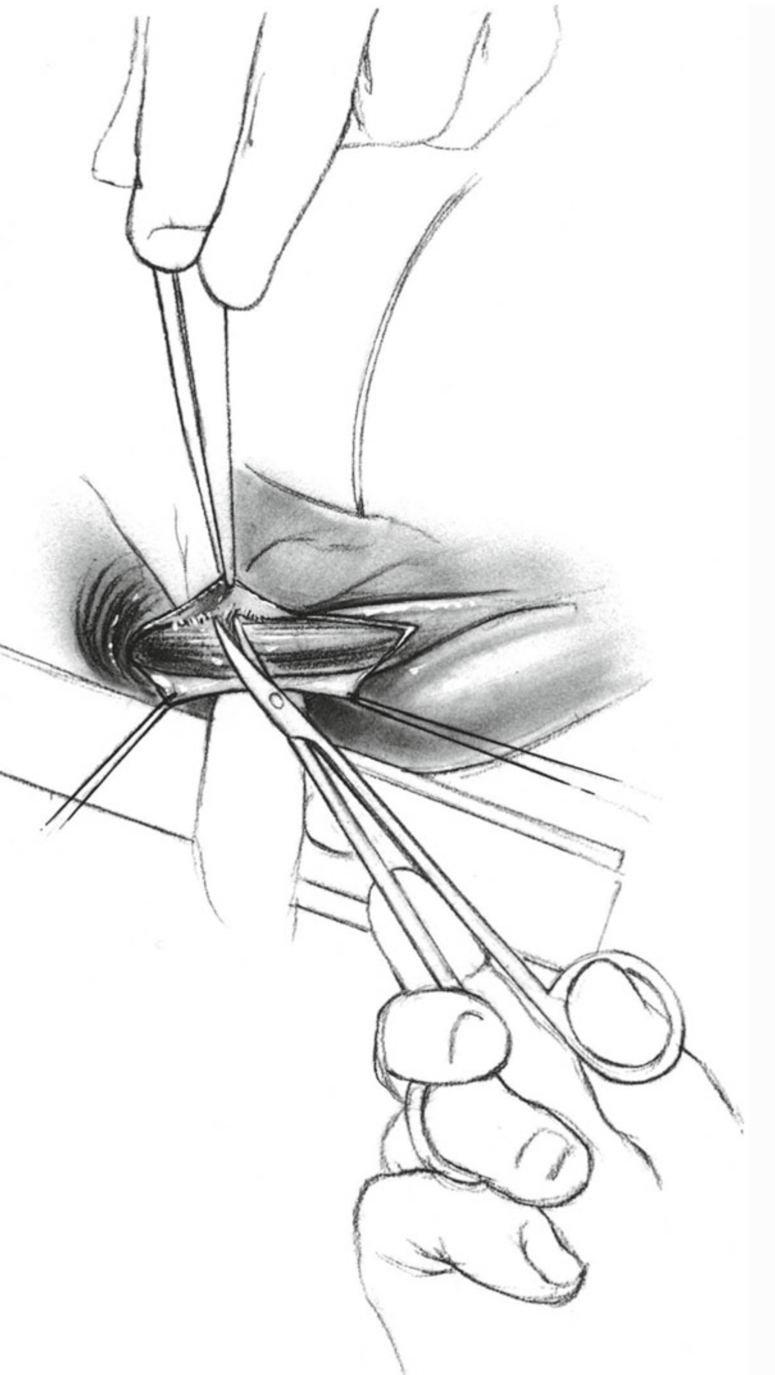

Fig. 25.1

insert 100–200 ml of a methylene blue solution through the nasogastric tube. When a mucosal perforation is identified during the operation, careful suturing of the mucosa generally avoids further difficulty. Some surgeons close the muscle over the perforation and then rotate the esophagus so the myotomy can be performed at a different point on the esophageal circumference. Closing the mediastinal pleura over the esophagus, as we do routinely, helps buttress a sutured perforation of the mucosa (see Figs. 27.1, 27.2, and 27.3).

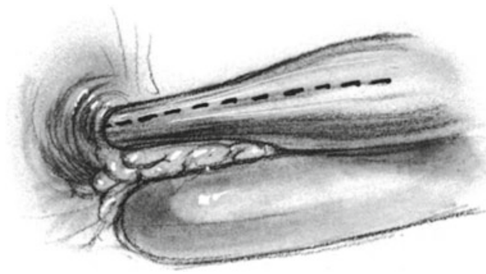

Fig. 25.2

Operative Technique

Incision and Exposure

Place the patient in the full left thoracotomy position. Make a skin incision along the course of the seventh intercostal space. Incise the serratus and latissimus muscles with electrocautery; then make an incision along the upper border of the eighth rib through the intercostal musculature (see Figs. 22.1, 22.2, and 22.3). Open the pleura for the length of the eighth rib. Insert a Finochietto retractor and gradually increase the space between the seventh and eighth ribs. Divide the inferior pulmonary ligament and retract the left lung in a cephalad and anterior direction using large moist gauze pads and Harrington retractors. Make an incision in the mediastinal pleura overlying the distal esophagus (Fig. 25.1). Then gently encircle the esophagus with the index finger, which is facilitated by the indwelling nasogastric tube. Encircle the esophagus with a latex drain. Be careful to identify and preserve the vagus nerves. Free the esophagus from surrounding structures to the level of the diaphragm but no lower (Fig. 25.2).

Esophagomyotomy for Achalasia

Place the left index finger underneath the distal esophagus. Make a longitudinal incision through both the longitudinal and circular muscle layers of the esophagus until the mucosal surface is exposed (Fig. 25.3). Continue this incision in a cephalad direction for a distance of about 2 cm above the point where the esophagus begins to dilate, or at least 5–7 cm.

Continue the myotomy in a caudal direction as far as the esophagogastric junction (Fig. 25.4). This junction can be identified by noting one or two veins crossing transversely over the mucosa deep to the musculature. Do not continue the incision more than 1 cm into the gastric musculature. Another way to confirm the location of the esophagogastric junction is that the gastric musculature differs from that of the esophagus.

To prevent the muscle fibers from reuniting, it is important to free at least 50 % of the circumference of the mucosa from its muscular coat. This may be accomplished using

Fig. 25.3

Metzenbaum scissors to elevate the circular muscle from the underlying mucosa, proceeding medially and then laterally to the initial longitudinal myotomy until the mucosa bulges out, as seen in the cross section in Fig. 25.5. Achieve complete hemostasis by cautious electrocoagulation and fine-suture ligatures, especially in the incised esophageal muscle.

If the mucosa has been inadvertently incised, carefully repair the laceration with one or more 5-0 nonabsorbable sutures. At this point, ask the anesthesiologist to inject a solution of methylene blue into the esophagus to prove that there is no mucosal perforation.

Esophagomyotomy for Diffuse Esophageal Spasm

The technique for performing a myotomy to alleviate diffuse spasm differs from that described for achalasia only in the length of the myotomy. If the lower esophageal sphincter can relax normally when swallowing occurs, do not extend the myotomy to the terminal esophagus. The preoperative manometric assessment of the patient's esophageal contractions determines how far the esophagomyotomy should be extended.

Closure and Drainage

Bring a 30 F chest tube out through a stab wound in the ninth intercostal space in the anterior axillary line. Approximate the ribs with two or three pericostal sutures of no. 2 PDS. Close the remainder of the wound in layers, as illustrated in Figs. 15.42, 15.43, and 15.44.

Postoperative Care

Remove the nasogastric tube the day following surgery.

Initiate oral intake of liquids on the first or second postoperative day, if tolerated.

Remove the chest tube as soon as the drainage becomes minimal, about the third or fourth postoperative day.

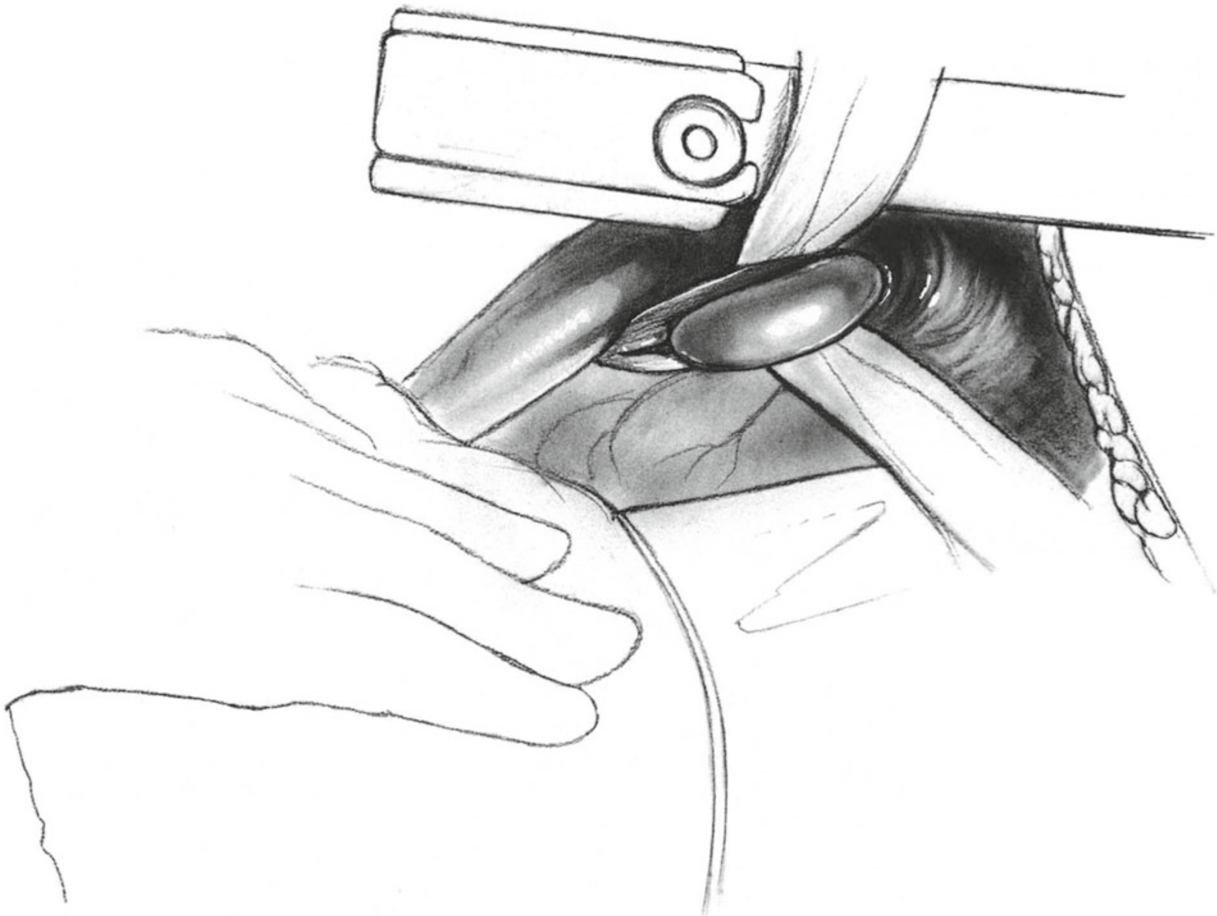

Fig. 25.4

Fig. 25.5

Complications

Persistent Dysphagia. In some cases an inadequate myotomy for achalasia fails to relieve the patient's dysphagia. About 2 weeks following operation in such cases, esophageal dilatation with Maloney dilators may help. If reoperation is needed, consider laparoscopic myotomy, as the problem is generally at the distal end of the myotomy.

Recurrent Dysphagia Following Initial Relief of Symptoms. It is possible that in these cases, the muscular tissues have reunited. A trial of bougienage with Maloney bougies up to 50 F may prove successful. Because esophageal carcinoma occasionally complicates long-standing achalasia, patients with recurrent dysphagia following a symptom-free interval after esophagomyotomy should have complete evaluation by radiography, esophagoscopy, and biopsy.

Reflux Esophagitis. Although most patients with symptoms of reflux can be handled conservatively, an anti-reflux operation is required in severe cases.

Diaphragmatic Hernia.

Empyema.

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26 Laparoscopic Esophagomyotomy

Carol E.H. Scott-Conner

Indications

Achalasia in which the high-pressure zone is localized to the distal esophagus

Preoperative Preparation

See Chaps. 20 and 25.

Pitfalls and Danger Points

Inadequate Myotomy. Careful review of preoperative studies (esophagoscopy, manometry, contrast esophagography) helps determine whether the high-pressure zone is limited to the distal esophagus and hence is accessible from the abdominal approach. Intraoperative endoscopy assists in ensuring that an adequate myotomy has been performed.

Esophageal Perforation.

Creation of Severe Gastroesophageal Reflux. Overzealous myotomy, extension of the myotomy too far down on the cardia, poor patient selection, and excessive mobilization of the esophagus contribute to postoperative reflux. Selective use of partial fundoplications (Dor and Toupet) is advocated by some surgeons. We believe this is not necessary routinely.

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Operative Strategy

The first laparoscopic esophagomyotomies were done through the left chest using a thoracoscope in a manner analogous to the open Heller myotomy (see Chap. 25). As experience with laparoscopic Nissen fundoplication grew, it became obvious that access to the distal esophagus was better through the laparoscopic approach than through the thoracoscopic approach. For the typical patient with achalasia limited to the distal esophagus, laparoscopic approach is the easiest. References at the end of the chapter describe the thoracoscopic approach, which is needed when a long myotomy is required for diffuse esophageal spasm. Most surgeons who perform this procedure are already facile in laparoscopic Nissen fundoplication (see Chap. 20).

Documentation

- Findings
- Fundoplication? Type?

Operative Technique

Patient Position, Room Setup, Trocar Placement

Use the same patient position and room setup shown for the Nissen fundoplication (see Figs. 20.1 and 20.2). Allow room at the head of the table for an esophagogastroduodenoscopy (EGD) scope, which is used at the end of the procedure to judge the adequacy of the myotomy. Typical trocar placement is shown in Fig. 26.1. The supraumbilical trocar and the right subcostal trocar are placed 15 cm from the xiphoid, the left subcostal trocar about 10 cm from the xiphoid. The epigastric trocar is placed as high as the liver edge allows and as lateral

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as the falciform ligament allows. The left flank port is about 7 cm lateral to the left subcostal trocar. Generally five ports are required, and the general considerations discussed in Chap. 20 apply to trocar site placement for this procedure.

Initial Exposure and Esophageal Mobilization

Place a liver retractor and obtain access to the hiatus in the usual fashion (see Figs. 20.3, 20.4, and 20.5). Concentrate on the anterior dissection. It is not strictly necessary to mobilize the esophagus fully both anteriorly and posteriorly if both the *narrowed segment and the dilated segment above it* are easily visualized once the hiatus has been cleared. Many surgeons believe that preserving the posterior attachments of the esophagus at the hiatus may decrease the incidence of postoperative reflux. Additional length may be gained, if necessary, by minimal additional dissection, sufficient to pass an articulating curved grasper behind the esophagus (Fig. 26.2a) and encircling the esophagus with a 6-in. segment of a 0.25-in. Penrose drain (Fig. 26.2b). Grasp the drain and pull down toward the left lower quadrant to lengthen the segment of intra-abdominal esophagus.

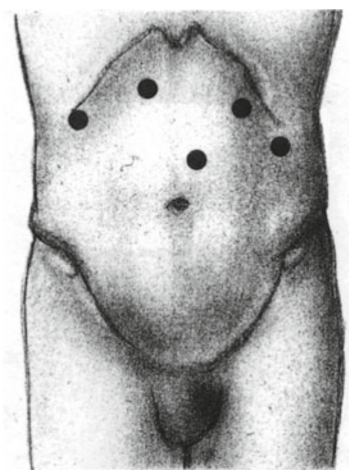


Fig. 26.1

Myotomy

Begin the myotomy at a convenient location on the midportion of the thickened distal esophagus (Fig. 26.3a). Curved scissors attached to electrocautery are useful for splitting, elevating, lightly cauterizing, and cutting parallel to the longitudinal muscle fibers. Use atraumatic graspers to elevate and pull down on the longitudinal muscle to improve exposure (Fig. 26.3b). The underlying hypertrophied circular muscle fibers then come into view. Release the tension on the Penrose drain (if one was placed) to avoid pushing the walls of the esophagus together, which would increase the probability of injury to the epithelial tube.

Sequentially elevate the circular muscle fibers on the blade of the scissors, lightly cauterize, and cut. As the esophageal wall starts to open, place atraumatic graspers on the left and right cut edges of the muscular tube and pull gently apart and toward the patient's feet.

The epithelial tube is readily identified by its whitish color, smooth texture, and the small blood vessels that cross it. It may

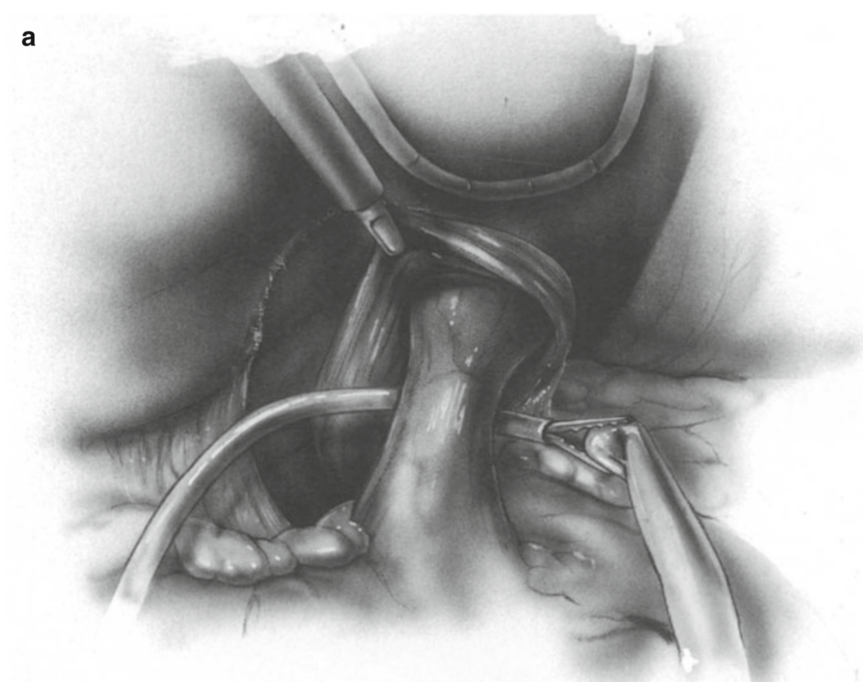
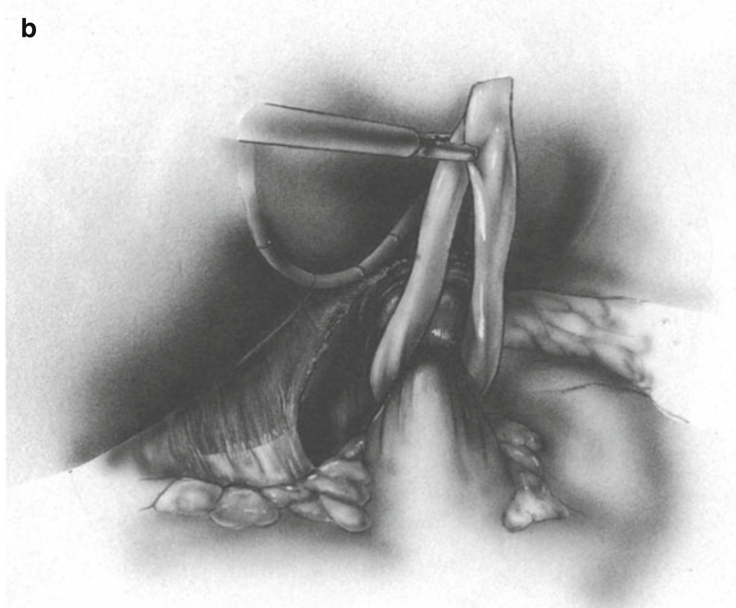


Fig. 26.2

Fig. 26.2 (continued)



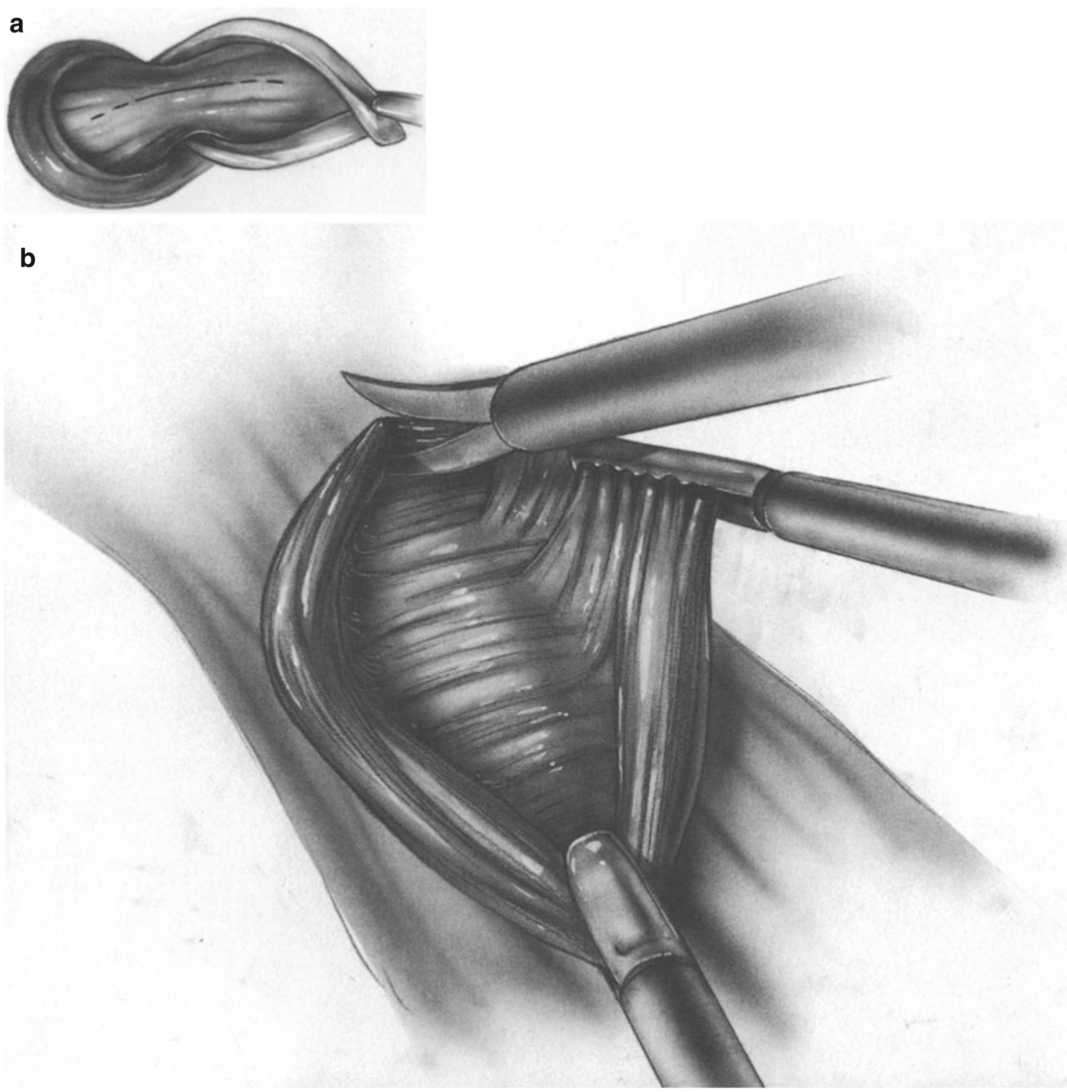


Fig. 26.3

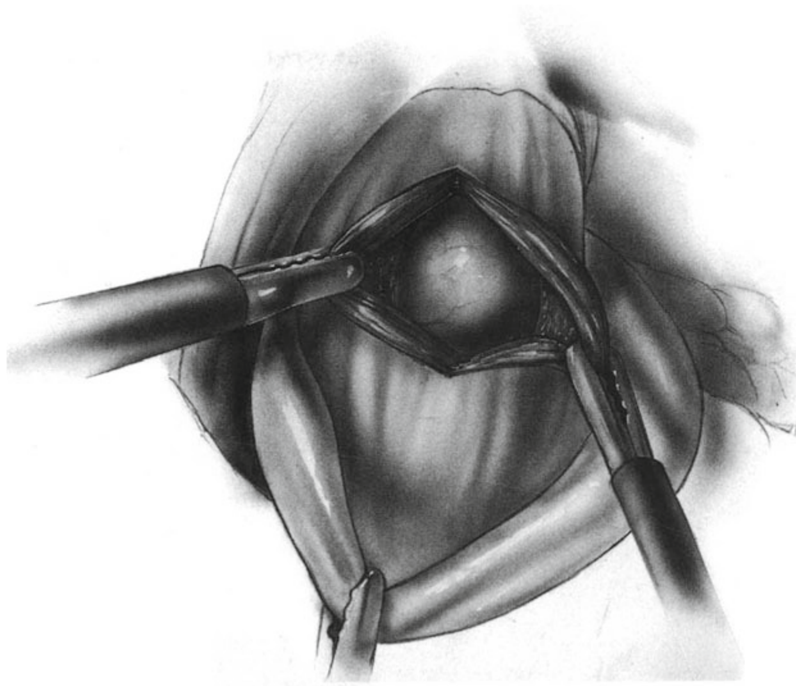
appear to balloon out into the field and is easily injured (Fig. 26.4). Elevating the muscle edges helps minimize this tendency.

Extend the myotomy cephalad with the scissors until the circular muscle layer becomes thinner and the esophagus is dilated by sequentially lifting the circular muscle away from the epithelial tube with the blade of the scissors and cutting it (Fig. 26.5a, b).

Complete the myotomy distally with hook cautery. Engage the hook under the circular muscle fibers; lift it up to avoid burning the underlying epithelial tube, and pull it down to cauterize and divide the muscle (Fig. 26.6). Some surgeons pass a right-angle clamp under the circular muscle and use it to displace the epithelial tube deep, out of harm's way.

Generally, a complete myotomy must extend about 1 cm onto the stomach (Fig. 26.7). Release all instruments from the esophagus. Pass an EGD scope into the distal esophagus and visualize the gastroesophageal junction, identifiable by the Z-line where the color changes between whitish esophageal epithelium and pink gastric mucosa. The opening should be patulous if an adequate myotomy was performed.

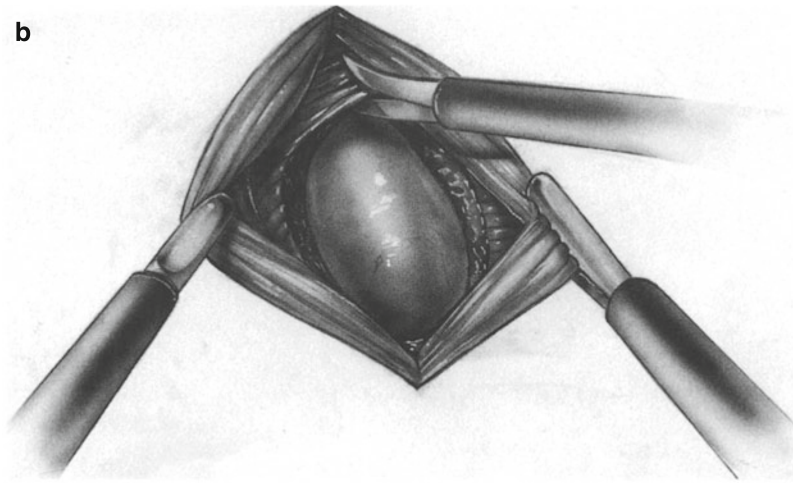
Fig. 26.4



a

Fig. 26.5

Fig. 26.5 (continued)



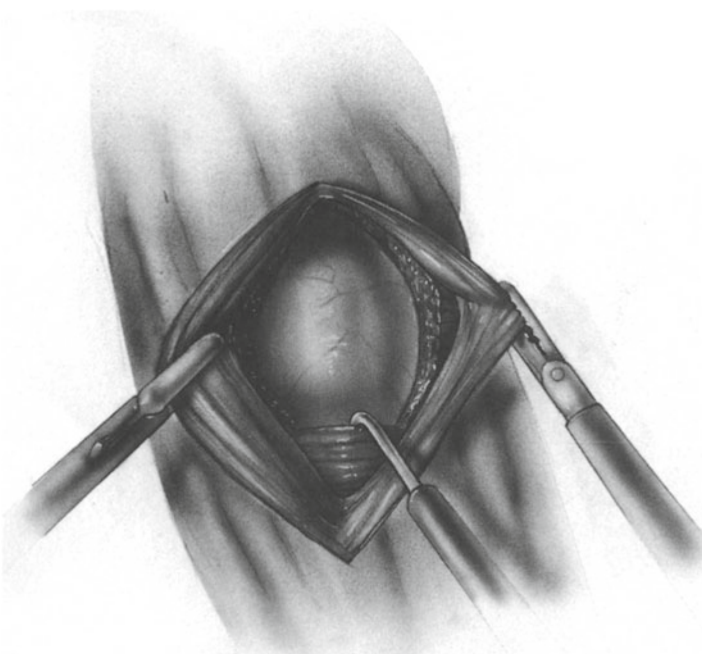


Fig. 26.6

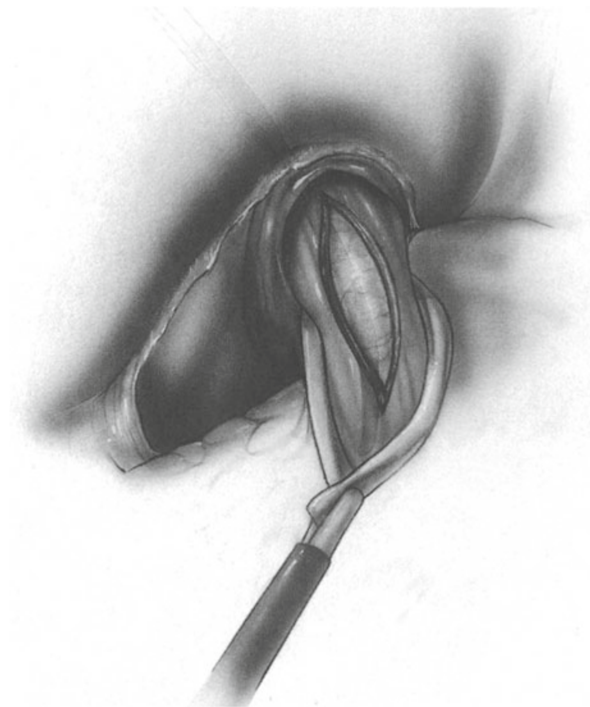


Fig. 26.7

Irrigate the abdomen with saline and fill the left upper quadrant. Insufflate with the EGD scope and watch for bubbles. The completed myotomy is shown in Fig. 26.7.

Fundoplication

Some surgeons perform a partial fundoplication at the conclusion of the procedure. An anterior (Dor) fundoplication is a simple way to buttress a small (repaired) perforation. A posterior partial (Toupet) fundoplication is said to help keep their edges of the myotomy separate. We use a partial fundoplication selectively.

Complications

Inadequate myotomy
Gastroesophageal reflux
Esophageal perforation

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27 Operations for Esophageal Perforation and Anastomotic Leaks

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Instrumental or emetogenic esophageal perforation
Postoperative leak

Preoperative Preparation

Confirm perforation with diagnostic studies such as chest radiography; for suspected cervical perforations, lateral neck films in hyperextension; computed tomography (CT) scan or esophageal contrast radiographs.
Administer nasoesophageal suction proximal to perforation of the thoracic esophagus.
Insert a thoracostomy tube for pneumothorax.
Maintain fluid resuscitation.
Administer appropriate systemic antibiotics.
Insert appropriate central venous or pulmonary artery pressure monitors.
Control the airway with endotracheal intubation.

Pitfalls and Danger Points

Delayed diagnosis of the perforation
Inadequate attention to pulmonary function
Inadequate surgery to control continuing contamination
Inadequate drainage
Depending on sutured closure of inflamed esophagus
Suturing a perforated esophagus proximal to an obstruction
Inadequate pleural toilet and lung decortication

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Operative Strategy

Visualize and thoroughly explore the region of the perforation. What appears to be a 1-cm perforation may prove to be three to four times that length after it is mobilized from the mediastinal pleura. Debride necrotic material around the perforation if suturing is anticipated. When the defect appears too large or the tissues too inflamed for suturing, it may be possible to apply a roof patch consisting of a flap of muscle pedicle, pleura, or pericardium that is sutured over the perforation. Otherwise, a diversion-exclusion operation or transhiatal esophagectomy is necessary.

Documentation

- Findings
- Nature of operative procedure
- Location of drains

Operative Technique

Pleural Flap Repair of Thoracic Esophageal Perforation

Incision

Make an incision in the left or right thoracic cavity depending on which side the perforation appears to present on the contrast esophageal radiograph. Generally, the lower half of the esophagus is approached through a left sixth or seventh intercostal space thoracotomy. The uncommon perforations of the upper esophagus are better approached through the right chest.

Exposure; Locating the Perforation

Incise the mediastinal pleura above and below the area of suspected perforation. Free the mediastinal pleura from the

†Deceased

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esophagus so the esophagus can be elevated from its bed for thorough exploration. Sometimes the perforation is obscured by a layer of necrotic tissue. If the perforation is not immediately apparent, ask the anesthesiologist to instill air or a solution of methylene blue into the nasoesophageal tube and look for bubbling or the area of blue staining on the esophageal wall. Most patients have a pleural and a significant mediastinal infection with necrosis. Complete debridement of the mediastinum and decortication of the lung with removal of both parietal and visceral peels are used to control infection and ensure maximal lung function. Complete expansion of the lung is the best secondary defense against breakdown of an esophageal repair and helps control any fistula that develops.

Repair

When operation is performed soon (8 h) after perforation, it may be possible to debride the tissues around the esophagus if marked edema and inflammation have not yet occurred; a viable tissue buttress should always be added to the repair. For suture closure, close the mucosal layer with interrupted sutures of 4-0 or 5-0 nonabsorbable synthetic suture and approximate the muscular layer with interrupted Lembert sutures of 4-0 silk or Prolene. In selected cases, a stapled closure may work. There must be sufficient good tissue to achieve an everted stapled closure without narrowing the lumen. Mobilize the edges of the effect and use Allis clamps to bring the full thickness of the esophageal wall within the jaws of a linear thick tissue stapler. Cover the suture line with a pleural flap. If the perforation is located in the lateral aspect of the esophagus, a simple rectangular flap of pleura is elevated and brought over the suture line. Use many interrupted 4-0 nonabsorbable sutures to fix the pleural flap around the sutured perforation.

When the perforation is not suitable for a sutured closure due to marked edema and inflammation, employ a pleural flap, an intercostal muscle flap, or some other viable buttress as a roof patch over the open defect in the esophagus. First, debride the obvious necrotic tissue around the perforation. When the esophagus is too inflamed to hold sutures, it is advisable to exclude the upper esophagus from the gastrointestinal tract by one of the methods described below to supplement the pleural roof patch. With an extensive defect in the esophagus or one located on the posterior surface, outline a large rectangular flap of pleura as illustrated in Fig. 27.1. In the presence of mediastinitis, the pleura is thickened and easy to mobilize from the posterior thoracic wall. Leave the base of the pedicle attached to the adjacent aorta. Slide the pedicle flap underneath the esophagus (Fig. 27.2) so it surrounds the entire organ. Insert multiple 4-0 interrupted nonabsorbable sutures deep enough to catch the submucosa of the esophagus around the entire circumference of the perforation as well as the entire circumference of the esophagus above and below the perforation, as illustrated in Fig. 27.3.

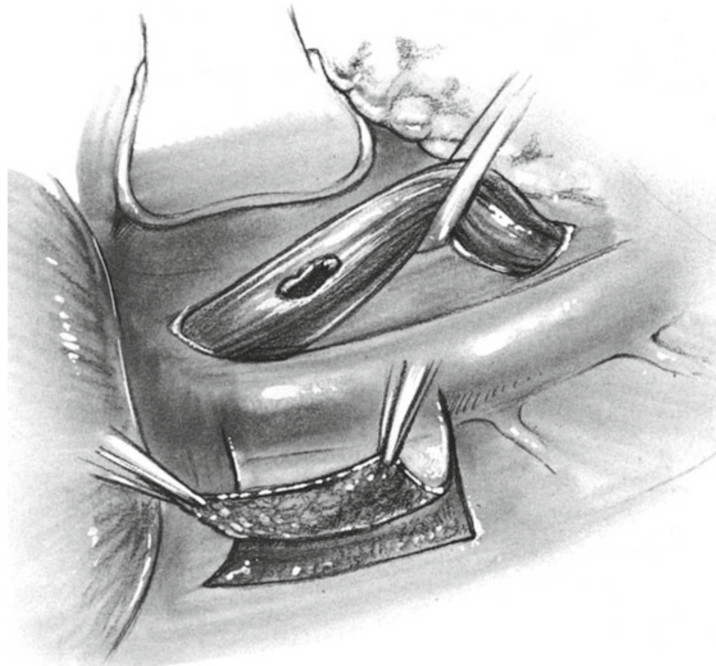

Fig. 27.1

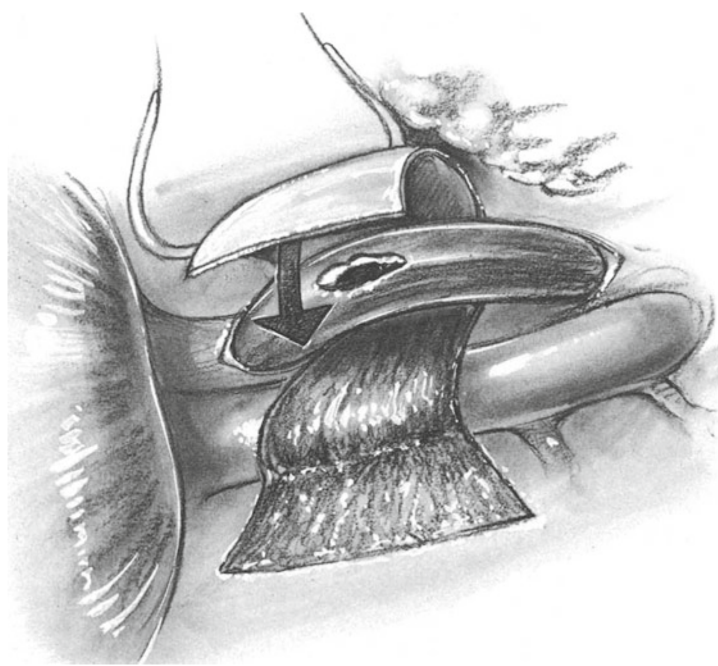

Fig. 27.2

Drainage

Place the tip of a 36 F chest tube near the site of the esophageal perforation. Suture it to the mediastinal tissues with a catgut stitch. Bring this tube out through a

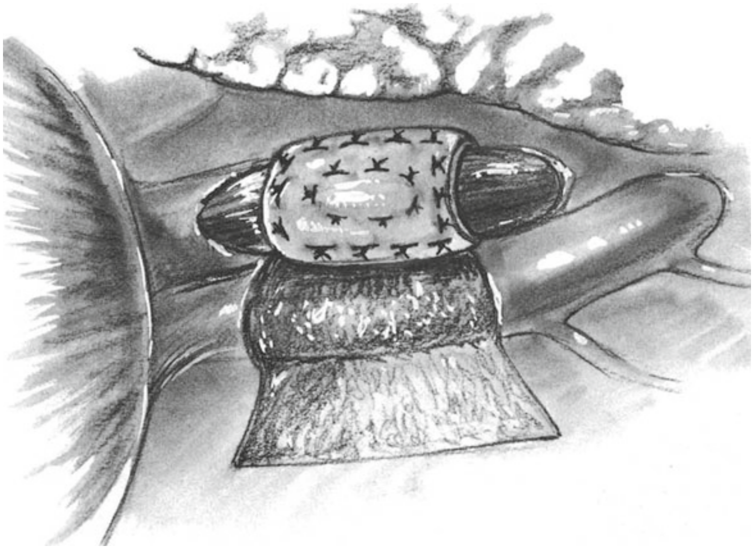

Fig. 27.3

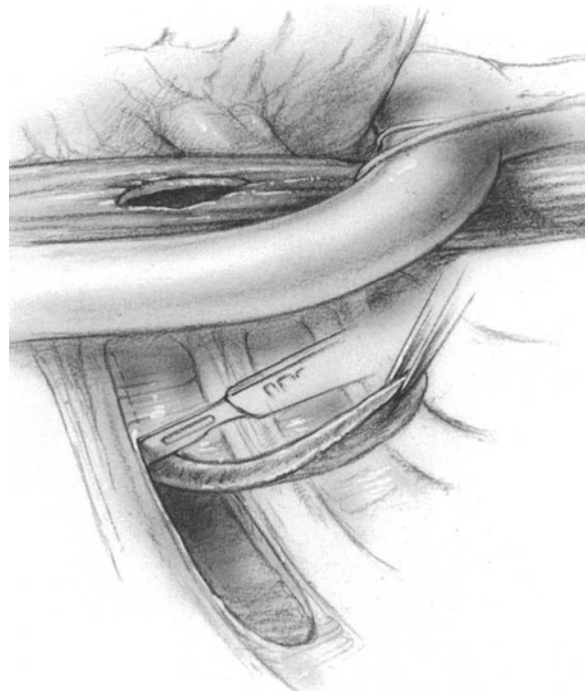

Fig. 27.4

small incision through the ninth or tenth interspace in the anterior axillary line. Place a smaller chest tube in the posterior portion of the apex of the chest and bring it out through a second stab wound. Attach both to underwater suction drainage.

Intercostal Muscle Flap Repair of Esophageal Perforation

Another method for bringing viable tissue to the site of an esophageal perforation is to create a vascularized flap of the appropriate intercostal muscle with which to wrap the perforation of the esophagus. If the patient undergoes surgery within the first 8 h after a perforation, minor debridement and primary suturing generally remedy the situation. However, for perforations that have been leaking for a longer interval before surgery is undertaken, debridement of necrotic tissue and primary suturing may not be adequate; in these situations wrapping with a viable muscle flap may help achieve primary healing. In cases where the perforation is too large for suture closure, a roof patch consisting of viable intercostal muscle sutured to the intact esophagus around the perforation may be effective. Richardson et al. have reported remarkable success with this technique for esophageal defects due to penetrating trauma.

To achieve a viable muscle flap, care must be taken to preserve the intercostal vessels. These vessels must be left attached to the muscle as it is being dissected away from the upper and lower rib borders. Figure 27.4 illustrates dissection of the full thickness of the intercostal muscle from its attachments to the adjacent ribs. Figures 27.5, 27.6, and 27.7 illustrate application of the intercostal muscle flap as a roof patch over a perforation that was not suitable for sutured closure. Large perforations (longer than the width of the muscle flap) may be difficult to repair by this technique. Drain the mediastinum and chest as described above. If the repair proves to be of poor quality, do not hesitate to resect the esophagus or to apply a temporary occlusion technique to the esophagus, as described below.

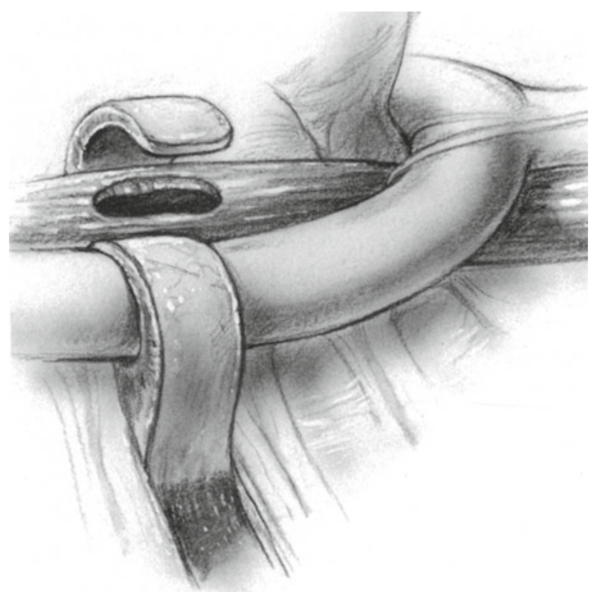

Fig. 27.5

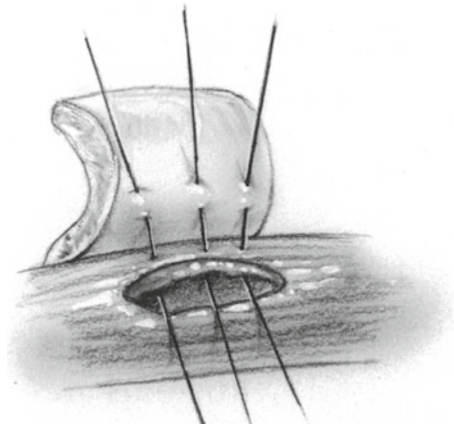

Fig. 27.6

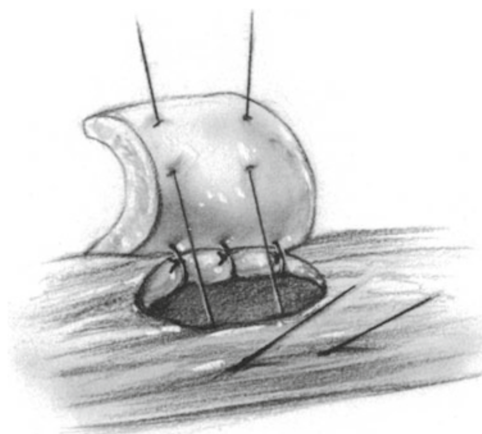

Fig. 27.7

Esophageal Occlusion Methods Without Cervical Esophagostomy

When cervical esophagostomy is used for diversion in the neck, it is sometimes difficult to reconstruct the esophagus after the perforation heals. An alternative but less secure method is staple occlusion of the proximal esophagus. Avoid capturing the vagus nerves when stapling the lower esophagus. It is possible to occlude the esophagus above a thoracic perforation through the exploratory chest incision if the thoracic esophagus above the perforation is healthy. A sump-type nasoesophageal suction catheter is placed above the staple line.

Esophageal Diversion by Cervical Esophagostomy

Incision and Exposure

With the patient's head turned toward the right, make an incision along the anterior border of the sternomastoid muscle beginning 2–3 cm below the level of the mandibular angle and continuing down to the clavicle (see Fig. 14.27). Liberate the anterior border of the sternomastoid muscle. Divide the omohyoid muscle if it crosses the operative field. Retract the sternomastoid muscle and carotid sheath laterally and retract the prethyroid muscles medially, exposing the thyroid gland (see Fig. 14.29). Carefully divide the areolar tissue between the thyroid gland and the carotid sheath to expose the inferior thyroid artery and the recurrent laryngeal nerve. In some cases it is necessary to divide the inferior thyroid artery. Preserve the recurrent nerve. Identify the tracheoesophageal groove. Begin the dissection on the prevertebral fascia and free the esophagus posteriorly. Then encircle the esophagus with the index finger or a right angle clamp, but keep the plane of dissection close to the esophagus; otherwise, it is possible to traumatize the *opposite* recurrent laryngeal nerve or injure the membranous posterior wall of the trachea. After the esophagus has been encircled, pass a latex drain around the esophagus for purposes of traction. Mobilize the esophagus from the level of the hypopharynx down to the upper mediastinum.

Suturing the Esophagostomy

After mobilization is satisfactory, suture the sternomastoid muscle back in place by means of several interrupted 4-0 synthetic absorbable stitches. Close the platysma muscle with interrupted sutures of the same material, leaving sufficient space to suture the esophagostomy to the skin. Then insert interrupted 4-0 PG subcuticular sutures to close the skin, leaving a 3- to 4-cm gap in the closure for the esophagostomy.

Now make a transverse incision across the anterior half of the circumference of the esophagus. Suture the full thickness of the esophagus to the subcuticular layer of skin with interrupted 4-0 absorbable synthetic sutures (Fig. 27.8).

In one case we found that, despite thorough mobilization of the esophagus, the incised esophagus could not be sutured to the skin without tension. A subtotal thyroid lobectomy was carried out. The incised esophagus was then sutured to the platysma muscle with interrupted sutures, leaving the skin in this area open. These steps produced a satisfactory result. As an alternative, mobilize the proximal thoracic esophagus and staple it closed with the linear stapler. Then either return it to its bed and decompress the closed esophageal remnant with a nasoesophageal tube or a lateral pharyngostomy tube or explant it to a subcutaneous position and create a stoma as described below.

Anterior Thoracic Esophagostomy

When a thoracic esophagectomy (Orringer and Stirling 1990) is carried out in these patients, an incision is made in the neck along the anterior border of the sternomastoid muscle. After the esophagus has been delivered through this

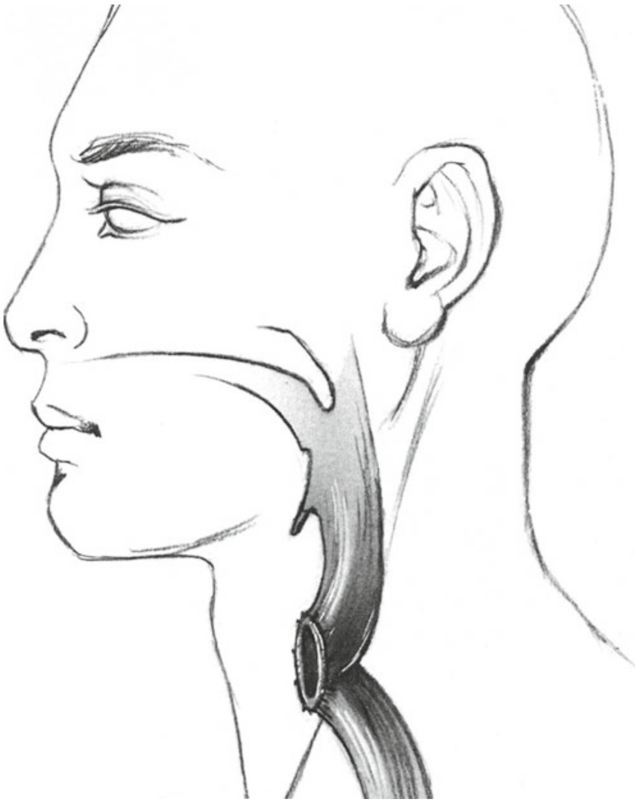

Fig. 27.8

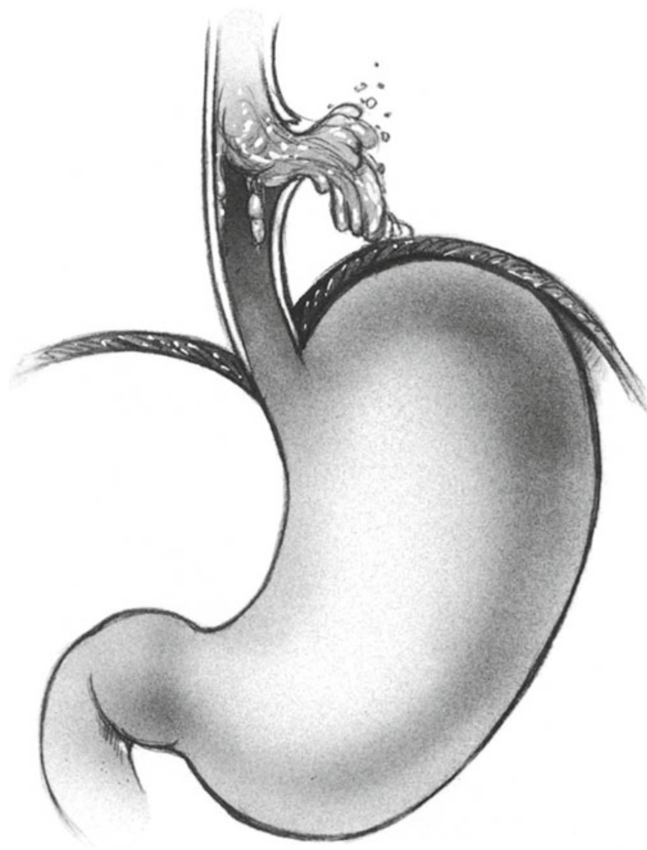

Fig. 27.9

incision, excise the segment that is nonviable and preserve all the viable esophagus. Make a subcutaneous tunnel from the incision in the neck over the anterior thorax. This tunnel should equal the length of the preserved esophagus. Make the esophagostomy on the anterior wall of the chest by making an incision in the skin and suturing the full thickness of the esophagus to the subcuticular layer of skin with interrupted 5-0 Vicryl sutures. It is much easier to apply stoma collection bags to the anterior chest than to a cervical esophageal stoma.

Excluding the Esophagus from the Gastrointestinal Tract

Perform a thoracotomy as described for the pleural flap operation. Incise the mediastinal pleura and liberate the esophagus from its bed (Fig. 27.9). The perforation may be sutured or covered with a pleural flap (Fig. 27.3).

Then free the esophagus around its entire circumference distal to the perforation. Urschel et al. occluded the esophagus by surrounding it with a strip of Teflon that was sutured to itself to form a circumferential constricting band. Do not make this band so tight it strangulates the tissue. An umbilical tape may be passed around the Teflon band and tied to ensure the proper degree of constriction. Try to avoid including the vagus nerves in the constricting band.

An alternative method of occluding the lower esophagus is to ligate it with a Silastic tube, such as the Jackson-Pratt catheter (Figs. 27.10 and 27.11). This material appears to be less irritating to the tissues than Teflon or umbilical tape. Another alternative is to use the TA-55 stapling device *with 4.8-mm staples* to occlude the esophagus. When applying the staples, separate the vagus nerves from the esophagus so they are not trapped in the staple line. Use staples only if the esophagus is not markedly thickened or inflamed. Otherwise, the thickened tissues may be strangulated by the staples. After a period of 3–4 weeks, a gap often appears in this staple line. This gap can usually be dilated by gentle passage of Maloney dilators. If the gap is small, the interventional radiologist can pass a guidewire over which dilating devices may be passed.

Another reported method for occluding the esophagus is passage of no. 2 chromic catgut or PG twice around the esophagus, which is then tied in a snug but not strangulating knot. The esophagus should respond easily to dilatation by the end of 2–4 weeks. It has been reported that even with delayed operations in patients who suffer large lacerations of the thoracic esophagus, spontaneous healing occasionally occurs over a period of weeks, so esophageal replacement with either colon or stomach is not necessary.

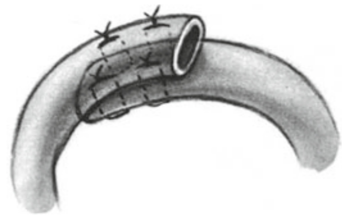

Fig. 27.10

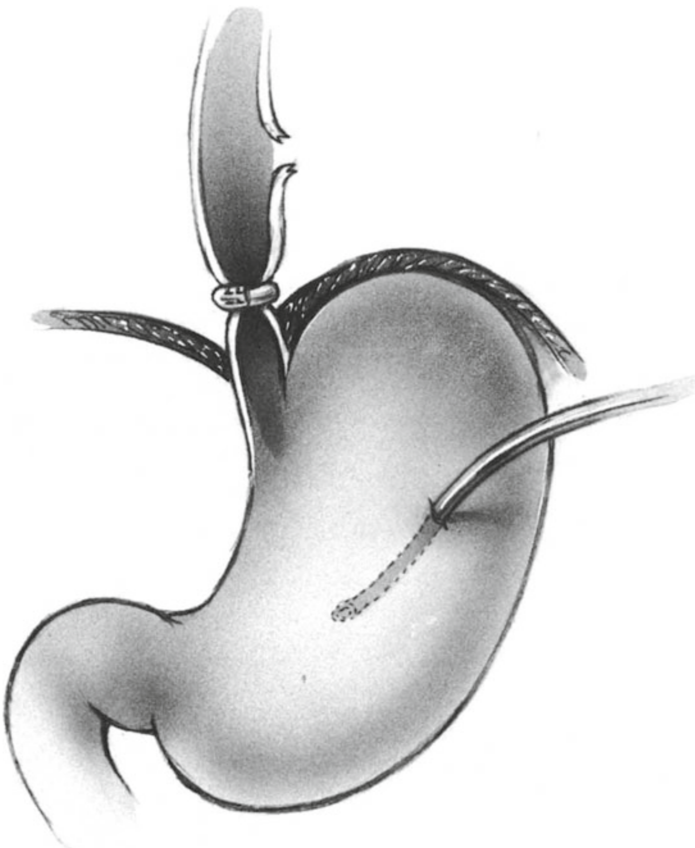

Fig. 27.11

This technique should be used if the patient has significant reflux. In other circumstances, we eliminate this step altogether because it is a distal obstruction and can prevent healing of a fistula.

To decompress the stomach and prevent pressure against the esophageal closure, a Stamm gastrostomy should be performed. In contrast to the usual location shown in Fig. 27.11, it is wise to place this gastrostomy near the lesser curvature of the stomach if possible. In this way, if a gastric pull-up operation is to be performed to replace the esophagus, the gastrostomy defect can be included in the segment of the lesser curvature that is customarily excised when preparing the stomach for advancement into the neck. It does not interfere with the blood supply to the greater curvature.

Finally, place proper drainage tubes to the area of perforation and close the thoracic incision. All of these patients require a tube gastrostomy to decompress the stomach; after the esophageal perforation has healed, the gastrostomy tube is used for purposes of feeding.

Postoperative Care

Most of these patients require *ventilatory support* for several days. Careful *cardiopulmonary monitoring* is a necessity.

Paste a small *drainage* bag or ileostomy bag over the esophagostomy to collect saliva. In patients without an esophagostomy, maintain nasoesophageal sump suction postoperatively.

These patients require intensive *antibiotic* treatment, depending on bacterial cultures of the mediastinum.

Do not remove the thoracotomy drainage tubes until drainage has ceased.

Total parenteral nutrition is necessary until the gastrostomy tube can be used for feeding.

Obtain frequent *chest radiographs* or *CT scans* in a search for loculated collections of pus.

Complications

Esophagocutaneous fistula

Uncontrolled sepsis including empyema or mediastinal abscess

Subphrenic abscess

Limited expansion of lung, requiring surgical decortication after active infection has subsided

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Part III

Stomach and Duodenum

Concepts in Surgery of the Stomach and Duodenum

28

Dustin M. Bermudez and Daniel T. Dempsey

The most common indications for gastric operation are ulcer disease, neoplasm, morbid obesity, and the need for chronic gastric intubation (gastrostomy). This chapter discusses important concepts relevant to the choice of operation for these common indications. Included are brief discussions on the current role of vagotomy in the management of peptic ulcer disease, the choice of drainage procedure after gastric resection, and the management of postoperative complications.

Surgery for Peptic Ulcer

It is now generally recognized that most peptic ulcers are caused by *Helicobacter pylori* infection, NSAID use (including aspirin), smoking, and/or stress. While acid hypersecretion alone, in the absence of one or more of these factors, rarely causes peptic ulceration (Zollinger-Ellison syndrome is the obvious exception), acid/peptic damage to the gastroduodenal mucosa is the mechanism of injury common to all peptic ulcers. Cheap, relatively safe, and effective suppressors of gastric acid secretion are now readily available (proton pump inhibitors and H2 blockers). Clearly these developments together with advances in therapeutic endoscopy account for the current reality that the large majority of operations for peptic ulcer disease today are done urgently or emergently for complications (perforation, bleeding, obstruction). These facts also have some important implications for the surgeon:

1. Beware of the patient with intractable or nonhealing peptic ulcer disease. This should be a rare indication for operation in the modern era. If helicobacter is treated, NSAIDs and aspirin are avoided, smoking is eliminated, and acid suppressed, then virtually all peptic ulcers should heal. Thus nonhealing peptic ulcer implies either noncompliance and/or malignancy and/or an unusual etiology of the ulcer (e.g., motility disorder) or symptoms (e.g., visceral hypersensitivity). Today, patients with abdominal symptoms and a demonstrable nonhealing benign peptic ulcer may be just as difficult to cure with operation as they are with medication. Since an ill-conceived ulcer operation can result in a 10 % weight loss, asthenic patients with nonhealing ulcer are particularly problematic.
2. Postoperative recurrent peptic ulcer or marginal ulceration is more easily treated today than in the distant past, because (as indicated above) we have both a better understanding of ulcer pathophysiology and a better medical treatment armamentarium. Thus prevention of ulcer recurrence has become a weaker argument for a larger initial ulcer operation.
3. Patients with peptic ulcer disease severe enough to merit hospitalization or surgical consultation should be treated empirically for helicobacter infection and should be considered for chronic acid suppression (unless vagotomy is performed). Peptic ulcer patients who require NSAIDs and/or aspirin, or in whom smoking cannot be eliminated, should be treated with maintenance PPI (unless vagotomy is performed).

The Role of Vagotomy in Peptic Ulcer Surgery

Between 1993 and 2006, the use of vagotomy in peptic ulcer operation decreased by about 70 % (Wang et al. 2010). While the reasons for this are myriad (evolving surgeon experience and initiative, ready availability of medical acid suppression, overenthusiasm for the pathophysiologic primacy of helicobacter, fear of postvagotomy side effects, etc.), there can be little doubt that the preponderance of operations performed in the USA today for peptic ulcer disease omit vagotomy.

The decision to add truncal or proximal gastric (parietal cell) vagotomy to an ulcer operation is a risk/benefit analysis. It is nearly impossible to perform this analysis in an evidence-based fashion since essentially all the prospective

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clinical trials of ulcer surgery were performed in the pre-Helicobacter, pre-PPI era (Harbison and Dempsey 2005). But the following should be considered before abandoning vagotomy altogether as an important part of the ulcer surgeon's armamentarium.

1. Vagotomy is quite efficacious in suppressing gastric acid secretion, and PPIs may not be more effective at decreasing gastric acid. Parietal cell vagotomy decreases basal gastric acid output by 50–80 % and decreases stimulated (peak) gastric acid output by 80–90 % (Cohen et al. 1993). Truncal vagotomy should be comparable. Similarly, regular dosing with proton pump inhibitors can maintain gastric luminal pH above 4 for 80–90 % of a continuously monitored 24-h time period, but in some patients this occurs only at higher dose levels (Rohss et al. 2010).
2. Neither chronic PPI therapy nor vagotomy is without complications. Medication side effects, fundic gland polyps, dosage compliance, and cost are recognized problems with PPIs, while technical and postvagotomy complications are acknowledged problems with vagotomy. Parietal cell vagotomy is very safe, but it is time consuming and perhaps less effective in inexperienced hands. Truncal vagotomy is quicker but may be associated with diarrhea, dumping due to the concomitant drainage procedure, or gastroparesis. Technical complications of either operation include bleeding, esophagogastric perforation, and incomplete vagotomy.
3. In the pre-Helicobacter, pre-PPI era, the addition of vagotomy was shown to significantly improve the clinical outcomes in patients requiring closure of perforated duodenal ulcer (Boey et al. 1982; Jordan and Thornby 1995), but in the modern era results of simple closure of perforated duodenal ulcer are very good provided that helicobacter infection is treated (Ng et al. 2000). But not all patients requiring ulcer surgery have helicobacter infection, and many patients will be noncompliant with the treatment or will have treatment-resistant infection or will have other important pathophysiologic factors like NSAIDs and smoking.

Given the modern clinical context, it may be acceptable to surgically treat many peptic ulcer patients without vagotomy. However, in the stable good risk patient requiring operation for peptic ulcer disease, vagotomy should be considered in patients with ulcer chronicity, failure of medical treatment, and noncompliance. It seems unwise to rely on medical treatment alone (e.g., antibiotics for helicobacter, chronic PPI, avoidance of NSAIDs and aspirin, no smoking) in all these patients.

The Choice of Drainage Operation

The most common indications for a drainage procedure in the intact stomach are truncal vagotomy and gastric outlet obstruction, sometimes benign but usually malignant. In the setting of vagotomy, pyloroplasty and gastrojejunostomy are equally effective drainage operations. The major advantages of the pyloroplasty are that it does not require entry into the infra-mesocolic abdomen, and perhaps a leak might be more easily managed with drainage and gastric suction, since it is proximal to the entry of bile and pancreatic juice. The major advantages of the gastrojejunostomy are that it is easily reversible (unlike pyloroplasty) and does not interfere with duodenal stump closure if subsequent gastrectomy is required. Previous pyloroplasty can make the handling of the duodenal stump quite problematic. Possible complications of gastrojejunostomy include marginal ulcer, afferent or efferent loop obstruction, and "circus movement" of duodenal contents. The risk of marginal ulceration is probably decreased by a technically sound vagotomy or PPI therapy. Obviously, if the indication for a drainage procedure in the intact stomach is gastric outlet obstruction, pyloroplasty is not an option.

The Role of Resection in Peptic Ulcer Surgery

Between 1993 and 2006, the number of gastrectomies for peptic ulcer decreased by 50 % (Wang et al. 2010). Distal gastric resection is a good surgical option for low-risk patients with distal gastric ulcer or gastric outlet obstruction from gastric and/or duodenal ulcer. Gastric ulcers should always be biopsied to rule out malignancy, and admittedly the ultimate biopsy is gastric resection to include the ulcer. Typically duodenal ulcers do not require biopsy, but we have operated on two patients with a preoperative diagnosis of obstructing duodenal ulcer disease who subsequently required a Whipple operation for duodenal cancer. This remote possibility should be kept in mind by the surgeon who opts for laparoscopic proximal gastric vagotomy and gastrojejunostomy to treat obstructing duodenal ulcer.

In the emergency situation, distal gastric resection can be considered for perforated gastric ulcer or bleeding peptic ulcer, but if possible it should be avoided in unstable and high-risk patients. In the nonemergent situation, gastric resection is a tempting option to treat thin patients with peptic ulcer because it is an easy operation in the nonobese patient. However, resection should be avoided in these patients, because of postoperative nutritional side effects and/or additional weight loss.

Reconstruction After Distal Gastrectomy

Billroth I or Billroth II

Following distal gastrectomy for benign disease, gastrointestinal continuity can be reestablished by gastroduodenostomy (Billroth I) or gastrojejunostomy (Billroth II). Functionally these operations give equally good results. The advantage of the Billroth I is the avoidance of a duodenal stump and other possible complications of Billroth II such as afferent or efferent loop obstruction, internal hernia, and intussusception. Theoretically, there may also be a lower incidence of marginal ulceration with Billroth I anastomosis. The advantage of the Billroth II is ease of construction and the requirement for less duodenal mobilization. The amount of chronic postoperative enterogastric reflux is similar for the two operations. Gastroduodenostomy should be avoided when malignancy is the indication for gastrectomy particularly when recurrence at the duodenal margin is a possibility. Both Billroth I and II arrangements should be avoided in the setting of a small gastric pouch since bile esophagitis is a risk. When doing a Billroth II operation, we always position the tip of the NG tube into the afferent limb to prevent postoperative duodenal distention. Extra side holes may be cut to ensure gastric drainage. We prefer to staple the duodenal stump and do not oversew the staple line but routinely cover the staple line with healthy omentum.

Billroth II or Roux-en-Y

The major advantage of Roux-en-Y reconstruction after distal gastrectomy is the avoidance of enterogastric reflux of bilious duodenal contents which can cause bile reflux gastritis and esophagitis. The Roux limb should be at least 45 cm and preferably 60 cm long to ensure the absence of bile in the gastric pouch. The Roux anastomosis may also be somewhat safer than a Billroth II since if leak occurs at the gastrojejunostomy, it does not discharge duodenal contents into the peritoneal cavity. There are however several disadvantages to Roux reconstruction. Compared to Billroth II gastrojejunostomy, Roux-en-Y reconstruction requires another anastomosis (enteroenterostomy), and early postoperative problems with this anastomosis might cause duodenal stump disruption. Also, the Roux gastrojejunostomy is more susceptible to marginal ulceration than the Billroth II, due to the complete lack of duodenal contents in the vicinity of the gastrojejunostomy. And the motility of the Roux limb is deranged which may lead to delayed gastric emptying. Because of these last two observations, it is unwise to utilize the Roux reconstruction in the presence of a large gastric remnant.

Other Reconstruction Options

There are two alternatives to Roux reconstruction which also decrease the risk of bile gastritis and bile esophagitis. The Braun modification of the Billroth II adds an anastomosis between the afferent and efferent limbs, theoretically allowing bilious duodenal contents to go from the former to the latter without having to enter the stomach (Vogel et al. 1994). The Henley loop reestablishes gastrointestinal continuity with the interposition of a 40 cm isoperistaltic isolated segment of jejunum between the gastric remnant proximally and the duodenum distally (Aronow et al. 1995).

Operation for Perforated Peptic Ulcer

Perforated peptic ulcer, on rare instances treated in a nonoperative fashion, most often requires urgent surgical intervention. The choice of operation depends on whether a definitive ulcer operation is desirable. Perforated gastric ulcers should be biopsied to rule out malignancy. In all perforated peptic ulcers, consideration can be given to mucosal biopsy (if accessible) to evaluate for helicobacter infection. Patients with major premorbid medical illness, shock, or delayed diagnosis of perforation are probably best treated with omental patch closure (Graham patch) alone (Boey et al. 1982). Even low-risk patients with perforated duodenal or gastric ulcer do well with patch closure if the etiologic agents (helicobacter, NSAIDs, aspirin, smoking) can be eliminated (Ng et al. 2000). Laparoscopic closure of perforated peptic ulcer and peritoneal washout is an excellent alternative to laparotomy.

Good operative candidates with perforated duodenal ulcer, especially those with an ulcer history, may be better treated with closure of the perforation and proximal gastric vagotomy (Jordan and Thornby 1995). The latter approach not only fixes the acute process but also provides long-term protection from recurrence with minimal side effects. In some cases, where there is extensive scarring of the pyloric region, truncal vagotomy with gastrojejunostomy should be considered. Good operative candidates with perforated gastric ulcer can be considered for distal gastrectomy or wedge resection, usually without vagotomy. All these definitive operations for perforated peptic ulcer can be done laparoscopically by the experienced surgeon.

Operation for Bleeding Peptic Ulcer

Patients admitted to hospital with bleeding peptic ulcer should be treated with PPI infusion. Risk stratification is important to help identify the 25 % most likely to continue bleeding or to rebleed; essentially all bleeding ulcer deaths occur in this group. Hypotension or shock, hematemesis, endoscopic stigmata of recent hemorrhage, and ongoing transfusion requirement identify this high-risk group in whom endoscopic treatment of bleeding ulcer should be considered and surgical consultation obtained. Operation should be strongly considered in patients requiring transfusion of 4 or more units of blood, especially in patients who have exhibited hemodynamic instability or who have high-risk ulcers (e.g., deep posterior duodenal ulcer with visible vessel and deep gastric ulcer on lesser curvature with active bleeding). The use of advanced endoscopic techniques to control bleeding ulcer has increased dramatically over the last two decades and has decreased both the need for operation and the mortality of bleeding peptic ulcer (Calvet et al. 2004). However, bleeding is by far the most common peptic ulcer complication requiring hospitalization, and it remains a not infrequent indication for urgent or emergent surgical intervention.

During operation for bleeding peptic ulcer, the first concern should be localization and management of the bleeding ulcer site. For bleeding duodenal lesions, this is most often accomplished via a longitudinal duodenotomy, which may be extended through the pylorus. The bleeding duodenal ulcer is controlled with nonabsorbable sutures. For posterior penetrating bleeding duodenal ulcer involving the gastroduodenal artery and its branches, multiple deep sutures are often necessary. If definitive operation is not planned, the duodenotomy and pylorotomy may be closed either longitudinally or as a pyloroplasty. Alternatively, a proximal gastric or truncal vagotomy can be added. Although one might consider truncal vagotomy with antrectomy for bleeding duodenal ulcer in the stable good risk patient, this operation can create a problematic duodenal stump, and it carries a much higher perioperative risk in this patient population than in the elective setting.

For bleeding gastric ulcer, high-risk or unstable patients are best treated with biopsy and oversewing or wedge resection. Stable low-risk patients can be treated with distal gastrectomy to include the bleeding lesion. The role of vagotomy in gastric ulcer is controversial.

Operation for Obstructing Peptic Ulcer

Gastric outlet obstruction (GOO) secondary to peptic ulcer disease is typically not a surgical emergency. Fluid resuscitation, nasogastric decompression, acid suppression, and *H. pylori* treatment are the mainstays of medical therapy. An attempt at endoscopic balloon dilation may yield initial success, but recurrent obstruction is not uncommon (Yusuf and Brugge 2006). The operative choices for GOO include vagotomy and drainage (we prefer PGV and gastrojejunostomy) and vagotomy and antrectomy. These operations were comparable in a small randomized clinical trial (Csendes et al. 1993). The advantage of PGV and GJ is that it can be done laparoscopically quite easily. Furthermore, the GJ is easily reversible and does not interfere with subsequent gastrectomy if necessary. The disadvantage of PGV and GJ is that a proximal duodenal or distal gastric cancer may be missed. The advantage of vagotomy and antrectomy is the very low ulcer recurrence rate and the fact that tissue is sent to pathology for analysis. This operation is usually well tolerated in the patient who was well nourished or overnourished prior to the development of gastric outlet obstruction, though the operative mortality risk is probably two or three times higher than vagotomy and drainage.

Operation for Nonhealing Gastric Ulcer

Type I gastric ulcers are located in the body of the stomach and are not associated with high acid output. Types II and III gastric ulcers have a duodenal (II) or prepyloric component and thus are surgically treated more like duodenal ulcers. Type IV gastric ulcer is relatively uncommon and occurs high on the lesser curvature close to the gastroesophageal (GE) junction.

Elective surgery for nonhealing type I gastric ulcer should be preceded by an appropriate biopsy to rule out occult carcinoma. Historically, the elective operation of choice has been distal gastrectomy to include the ulcer with reconstruction in a Billroth I or Billroth II fashion. Data from the pre-Helicobacter, pre-PPI era showed a mortality rate for this elective operation around 2 % with a recurrent ulcer rate of about 4 %. This compared favorably to a 20 % recurrence rate following vagotomy and drainage. Proximal gastric vagotomy with excision of the ulcer yielded lower morbidity and mortality and a recurrence rate in the range of 4–15 % (Emas et al. 1994). Obviously excision of a lesser curve ulcer can be challenging and may denervate the antrum and pylorus, thwarting the “highly selective” vagotomy. Type IV gastric ulceration poses a challenge because of its relation to the GE junction. Ideally, the ulcer is resected in continuity with a distal gastrectomy and reconstruction with gastroduodenostomy (Pauchet operation). Other options include vagotomy and drainage with biopsy or excision of the ulcer, biopsy of the ulcer followed by distal gastric resection, or Roux-en-Y esophagogastrojejunostomy (Csendes operation). Total gastrectomy for benign gastric ulcer should be avoided, and it must be recognized that any type of distal gastric resection can be nutritionally problematic in chronically thin patient.

Operation for Nonhealing Duodenal Ulcer

Elective surgery for intractable or nonhealing duodenal ulcer is now rare. The surgical options include proximal gastric vagotomy, truncal vagotomy with drainage procedure, or vagotomy and antrectomy. Any elective surgery for an intractable duodenal ulcer should have low morbidity. In the pre-Helicobacter, pre-PPI era, clinical data showed that, compared to other surgical options, PGV had the lowest postoperative morbidity and mortality rate while providing an acceptably low recurrence rate when performed electively for intractable duodenal (Harbison and Dempsey 2005;

Millat et al. 2000). But in the modern era, why should PGV be any better than PPI, and most surgeons are not experienced with the operation. PGV remains a consideration however in patients in need of safe acid suppression who cannot afford, tolerate, or comply with chronic PPI treatment. Truncal vagotomy (TV) and drainage or TV and antrectomy are associated with higher postoperative morbidity and mortality rates than PGV. These operations should be needed most infrequently nowadays as an elective treatment for intractable duodenal ulcer, given the rarity of this problem in the modern era. Obviously prior to embarking on this course, the surgeon should consider the irreversibility of both pyloroplasty and antrectomy.

Operation for Postoperative Recurrent Ulcer or Marginal Ulcer

In the modern era, most postoperative recurrent peptic ulcers are marginal ulcers (e.g., after distal gastrectomy and Billroth II or Roux-en-Y for gastric ulcer). But most marginal ulcers are not recurrent ulcers (e.g., after Roux Y gastric bypass for morbid obesity). When evaluating patients with recurrent peptic ulcer following an ulcer operation or with a marginal ulcer following some other gastric operation, the differential diagnosis includes:

1. Large parietal cell mass. For example, the patient has a hemigastrectomy and Roux reconstruction without vagotomy for gastric ulcer. Or the patient has a truncal vagotomy and gastrojejunostomy, but the vagotomy is incomplete. Or the patient has a Roux Y gastric bypass for severe obesity and the proximal pouch is large, and/or the patient develops a gastrogastric fistula.
2. Hypergastrinemia. Causes include retained antrum which is out of continuity with the proximal stomach or gastrinoma.
3. Smoking.
4. NSAID or aspirin use.
5. Ischemia of the jejunal limb. This is more common in Roux-en-Y gastrojejunostomy, particularly gastric bypass.
6. Stump cancer may present as recurrent ulcer disease years after the first ulcer operation.
7. Noncompliance. Many patients referred to the surgeon with recurrent or marginal ulcer do not regularly take the prescribed PPIs, continue to smoke, and/or continue to use NSAIDs or aspirin. This is an important point, since continued noncompliance predicts another recurrent ulcer after revisional operation. On the other hand, good compliance usually predicts success with revisional operation and may even obviate the need for revisional operation.

In addition to assessing ongoing compliance with medical treatment, prior to reoperating on the patient for recurrent peptic ulcer or marginal ulcer, the surgeon should review the prior operative notes and pathology reports. Workup should include upper GI series, upper endoscopy, gastric emptying scan, tests for helicobacter, and serum gastrin level. Other tests to consider include secretin stimulation test to rule out gastrinoma as a cause of hypergastrinemia, urine nicotine level, serum salicylates, and sham feeding to evaluate completeness of vagotomy (serum pancreatic polypeptide response or gastric acid secretory response is assessed). Surgical options for recurrent peptic ulcer depend upon the original operation. Options include thoracoscopic vagotomy, takedown of loop gastrojejunostomy if gastric outlet is intact, distal gastric resection to include the gastrojejunal anastomosis and recurrent ulcer, conversion of Roux Y to Billroth II (not advisable with small gastric remnant), and subtotal or near-total gastrectomy with Roux reconstruction. Reoperation for recurrent ulcer after hemigastrectomy or marginal ulcer after Roux Y gastric bypass can be challenging because of involvement of adjacent structures such as pancreas, celiac artery branches, spleen, liver, colon, and/or bypassed stomach. Preoperative evaluation often underestimates the extensiveness of the inflammatory process. During revision of gastric bypass for marginal ulceration, if part of the bypassed stomach is resected, it is important that some parietal cell mass be left in continuity with the antrum. Otherwise, unremitting antral gastrin secretion ensues since there is no luminal acid (the shut off signal for gastrin secretion) in the antrum. Complete resection of the bypassed stomach to include the antrum is preferable to this situation.

Gastrostomy and Duodenostomy

Gastrostomy

Gastrostomy tubes may be placed endoscopically (percutaneous endoscopic gastrostomy or PEG), radiologically, laparoscopically, or in a conventional open fashion. Each method has its unique advantages and limitations. PEG is a relatively simple method that can be performed outside the operating room and does not require general anesthesia. The limitation of this method lies in the blind nature of the tube insertion and the lack of suture fixation of the stomach to the inner abdominal wall. Laparoscopic gastrostomy provides direct visualization as well as a method of suture fixation but is more invasive. Open gastrostomy is the most invasive but may be the only option in certain patients with prior abdominal surgery. The Stamm gastrostomy is the most commonly used open method. This can be done under local anesthesia and sedation in many patients. Options for tube type include simple Foley balloon catheter, commercially available gastrostomy catheter, button gastrostomy, and GJ tubes which allow gastric drainage and transpyloric enteral feeding. The

Janeway gastrostomy creates a permanent mucosa-lined gastrocutaneous fistula, obviating the need for a continuous indwelling tube. Appropriately, it is performed infrequently.

Duodenostomy

A tube is positioned in the duodenum for decompression, usually to protect a tenuous duodenal suture line. The safest way to accomplish this is via a 14 F or 16 F jejunal tube placed in a retrograde Witzel fashion with the tip in the descending duodenum. Alternatively, the tube may be placed in a Stamm fashion into the lateral duodenum or into the end of the duodenal stump. A closed suction drain is placed nearby. If it is not possible to obtain apposition between the duodenal tube site and the abdominal wall, the site should be covered with omentum. Lateral duodenostomy tubes (especially balloon or mushroom catheters) can create problems early in the postoperative period if inadvertently dislodged.

Operation for Gastric Cancer

Adenocarcinoma of the stomach often extends submucosally much farther than is appreciated on gross examination. Early metastasis is usually to regional lymph nodes, but the lymphatic drainage of the stomach is extensive and often unpredictable. These facts support a generous gastric resection for treatment of this disease, with the ideal being 5 cm of normal tissue proximal and distal to the tumor. A lesser margin may be acceptable for the intestinal subtype of gastric cancer. The goal of operation for gastric cancer is an R-0 resection with negative margins and an adequate lymph node dissection. Frozen section analysis is important for the intraoperative confirmation of negative margins. For the past two decades, the standard operation performed for gastric adenocarcinoma of the body or antrum has been "radical subtotal gastrectomy," which includes (Wang et al. 2010) a 70–90 % distal gastrectomy; (Harbison and Dempsey 2005) ligation of the right gastric, right gastroepiploic, and left gastric arteries at their origin with removal of associated lymphoid tissue; and (Cohen et al. 1993) removal of the lesser and greater omentum. Cancers of the cardia or fundus are treated with total gastrectomy or proximal subtotal gastrectomy with high ligation of the left gastric artery and removal of the gastrosplenic ligament and lesser omentum together with the crural lymphatic tissue. For lesions close to the GE junction, some distal esophagus is usually removed. Despite increasing interest in more extensive surgical procedures for the treatment of gastric adenocarcinoma, none has definitively improved the cure rate (Hartgrink et al. 2000; Patel and Kooby 2011).

Subtotal Versus Total Gastrectomy

Routine total gastrectomy for gastric adenocarcinoma is unnecessary and should be avoided. When compared to subtotal resection, the operative mortality is higher, the nutritional side effects more devastating, and the cure rate no better after total gastrectomy than it is after subtotal gastrectomy (Bozzetti et al. 1999). Most tumors of the distal stomach are adequately resected with distal subtotal gastrectomy described above. If at least 30 % of the proximal stomach remains, continuity is reestablished with the Billroth II gastrojejunostomy. A Billroth I reconstruction should be avoided in cases of gastric malignancy because of the risk of recurrence at the duodenal margin (usually the margin with the least tumor clearance). If 20 % or less of the proximal stomach remains, reconstruction should be with a Roux limb or a Billroth II with Braun enteroenterostomy.

Total gastrectomy should be considered for extensive cancers if necessary for R-0 resection. For proximal gastric cancer, total gastrectomy and proximal subtotal gastrectomy give equal cure rates, but the latter can be associated with debilitating bile esophagitis especially if pyloroplasty is added (Harrison et al. 1997). We favor total gastrectomy for proximal gastric cancer though occasionally we have used a proximal gastrectomy with esophagogastrostomy without pyloroplasty in patients with a poor prognosis. In this instance, we always add a feeding jejunostomy. A better option for reconstruction following proximal gastric resection may be isoperistaltic jejunal interposition (Henley loop).

By far, the most common reconstruction following total gastrectomy is end-to-side Roux esophagojejunostomy. We favor the construction of some sort of jejunal reservoir, though there are studies that show this makes little difference. A recent meta-analysis showed better quality of life and nutritional status with jejunal pouch after total gastrectomy (Gertler et al. 2009). Roux-en-Y esophagojejunostomy with a J-pouch is easy to construct and functions well.

Extent of Lymphadenectomy

There is near universal agreement that when performing a formal gastrectomy for adenocarcinoma of the stomach, a minimum of 15 lymph nodes must be removed and assessed pathologically. While it is generally acknowledged in this situation that the more lymph nodes removed the better, the role of extended lymph node dissection for gastric cancer remains controversial. A D1 dissection removes the level N1 perigastric lymph nodes (lesser and greater curvature, suprapyloric and infrapyloric, right and left crural), while a D2 dissection removes level N1 and N2 nodes (nodes along the left gastric, common hepatic, celiac, and splenic arteries). Splenectomy and distal pancreatectomy are not routinely performed as part of D2 gastrectomy, as this extensive surgery has been shown to increase perioperative morbidity without improving the cure rate. The extent of gastric resection is generally the same for D1 and D2 resections for distal gastric tumors (70 % distal gastrectomy) and for proximal gastric tumors (total gastrectomy).

Except for one (Wu et al. 2006), all randomized clinical trials comparing extended lymphadenectomy to D1 lymphadenectomy in gastric cancer have failed to show a survival advantage, and most have shown increased morbidity and/or mortality with the extended dissection (Cuschieri et al. 1996; Bonenkamp et al. 1999; de Bree et al. 2010). A recent Cochrane Collaboration meta-analysis showed no survival advantage of D2 over D1, except in patients T3 or T4 tumors (but the numbers were small). There was higher morbidity with the D2 resection, and this was related to splenectomy, pancreatectomy, and surgeon experience (McCulloch et al. 2003, 2004).

Splenectomy should be performed as part of radical gastrectomy for cancer if the primary tumor is adherent to the spleen and R0 resection is feasible. It should also be considered for tumors of the greater curvature that involve the gastrosplenic ligament. Otherwise, splenectomy should not be part of the routine surgical treatment for gastric adenocarcinoma (Kitamura et al. 1999).

Laparoscopy

Should staging laparoscopy be a routine part of the preoperative evaluation of gastric carcinoma? The answer to this question depends somewhat on the surgeon's attitude toward "palliative gastrectomy." Despite improvements in preoperative staging with dynamic computed tomography (CT), endoscopic ultrasonography, and PET scan, unexpected liver or peritoneal metastases are found in 10 % of patients with gastric cancer. In the absence of significant bleeding or impending obstruction from the primary tumor, many surgeons (the authors included) believe that gastrectomy is contraindicated if liver or peritoneal disease is extensive. Laparoscopy helps avoid a major unnecessary operation in this small group of patients. Finally, it is clear that in experienced hands, laparoscopic radical gastrectomy for gastric cancer is a safe, oncologically sound operation (Kim et al. 2010).

Operation for Morbid Obesity

Most patients with BMI > 40 (or BMI > 35 with weight-related comorbidities) cannot sustain significant weight loss with a diet and exercise program. These patients should be considered for bariatric surgery and referral to a multidisciplinary bariatric surgery center for evaluation. Surgical weight loss options include laparoscopic adjustable gastric band, sleeve gastrectomy, Roux-en-Y gastric bypass (RYGBP), and duodenal switch or biliopancreatic diversion (Smith et al. 2011; Lim et al. 2010). All these operations can be performed laparoscopically with the benefits of quicker recovery, less pain medicine, and fewer wound complications. The operative mortality risk varies inversely with the expected weight loss and directly with the extent of comorbidities and patient size. Lap band has a mortality risk of <0.3 % and an expected durable weight loss of 20–25 %. RYGBP has a mortality risk around 0.5 % and an expected durable weight loss of 25–30 %. Duodenal switch has a mortality risk of 1–2 % and an expected durable weight loss of 40–50 %. The likelihood of significant improvement in comorbidities, e.g., type 2 diabetes, varies directly with the expected durable weight loss. These mortality rates may be doubled or tripled in the very large patient or in the patient with multiple comorbid conditions.

Selection of the appropriate operation for the individual patient requires experience and judgment. The technical challenges of performing RYGBP in someone with BMI = 70 may push one toward sleeve gastrectomy. Reflux esophagitis and a history of MRSA skin infection favor gastric bypass rather than lap band. Inadequate weight loss after a technically sound RYGBP can be treated with conversion to duodenal switch.

Preoperative, intraoperative, and postoperative care by a multidisciplinary experienced bariatric team optimizes outcomes and maximizes patient safety. Pulmonary embolism, cardiac events, and GI leak are the most common causes of postoperative death, now a relatively rare event following bariatric surgery. Perioperative DVT prophylaxis must be meticulous, and patients with a history of DVT or PE should be considered for removable IVC filter. Routine continuation of prophylactic low molecular weight heparin at home for a while after hospital discharge is controversial but it has been our practice. Admittedly there is a small risk of HIT and little data demonstrating the effectiveness of this practice in preventing fatal PE. Preoperative cardiac assessment should be liberally utilized. Intraoperative testing of gastric anastomosis or staple lines is routine.

Each bariatric operation has a specific set of possible long-term complications, nutritional and otherwise. Iron, B12, and calcium deficiencies are less common with lap band and sleeve gastrectomy than with RYGBP and duodenal switch. Lap-band slippage can be a surgical emergency since gastric necrosis may ensue, but band erosion into the stomach typically is handled with elective band removal and drainage. Stricture or torsion of the proximal gastric tube may complicate sleeve gastrectomy. Internal hernia, anastomotic stricture (either GJ or enteroenterostomy), and marginal ulcer can complicate RYGBP. Duodenal switch and biliopancreatic diversion are not commonly performed bariatric procedures.

Surgical Treatment of Gastrointestinal Stromal Tumors (GISTs)

Gastrointestinal stromal tumors (GISTs) arise from the interstitial cells of Cajal, and though they may occur anywhere in the GI tract, they are found most commonly in the stomach and proximal small intestine (Kingham and DeMatteo 2009; Ho and Blanke 2011). Almost all GISTs (95 %) express KIT (CD117). There are three histologic subtypes: spindle cell (70 %), epithelioid (20 %), and mixed (10 %). Surgical treatment is resection with negative margin. Wide margins and lymphadenectomy are unnecessary. For patients with completely resected nonmetastatic disease, prognosis is related to (inter alia) tumor size and mitotic activity. GISTs are quite sensitive to the tyrosine receptor kinase blocker imatinib (Gleevec).

Upon presentation, one-third of patients with GIST are asymptomatic, and one-third of patients have metastatic disease to the liver or peritoneum. Most patients referred to the surgeon have resectable disease. Preoperative workup includes endoscopy and EUS, barium study, and CT scan. Lesions have a typical appearance on endoscopy and EUS. There may be a role for preoperative imatinib for very large tumors that appear marginally resectable on imaging studies. Patients with completely resected GISTs which are deemed to be moderate- or high-risk lesions based on size and pathologic analysis are usually treated adjuvantly with imatinib. Patients who experience disease progression or intolerable side effects on imatinib are treated with the second-line tyrosine kinase inhibitor sunitinib (Sutent).

Gastric GISTs are most commonly treated with wedge resection, but larger tumors may require subtotal or total gastrectomy. Concomitant intraoperative endoscopy may be helpful during laparoscopic resection. Wedge resection for GIST located near the GE junction or pylorus can result in symptomatic luminal narrowing or obstruction. Wedge resection for lesser curvature GIST may vagotomize the antrum and pylorus, resulting in gastric stasis. While many smaller lesions are amenable to laparoscopic gastric wedge resection, it is important not to compromise oncologic principles just to avoid an open operation. Furthermore, laparoscopic wedge resection of gastric GIST by the inexperienced surgeon may result unnecessarily in a distorted and dysfunctional gastric remnant.

Duodenal GISTs are usually treated by segmental duodenal resection. Lesions some distance from the ampullary complex can be excised with negative margins with a full-thickness piece of the involved duodenal wall. Reconstruction options include primary repair or anastomosis and Roux duodenojejunostomy. Proximal duodenal GISTs may require distal gastrectomy and Billroth II reconstruction.

Stapling the Stomach and Duodenum

Most gastric and duodenal resections in the USA utilize stapling instruments, typically "GIA," "TA," and "EEA" devices. For safe application, it is important to adhere to certain principles. In this era of six sigma manufacturing, "surgeon failure" (i.e., pilot error) is far more common than "stapler failure":

1. Choose the appropriate staple size for the tissue. When dividing stomach or duodenum if the staples are too big, excessive staple-line bleeding can occur or rarely leakage of air and GI contents through the intact staple line. If the staples are too small, they will not go full thickness through both walls and the staples will not form correctly. This results in staple-line failure and leak. It is probably better to use a staple size that is too big than one that is too small. It is also important to recognize that occasionally the tissue (usually the stomach in a reoperative situation) is simply too thick for the stapler. Hand sewing in this situation is the best option.
2. Similar staplers made by different companies are similar but different. The surgeon who has been using one company's stapler for 10 years cannot assume that she knows exactly how to use the other company's similar stapler. There are subtle differences in how the instrument is designed to function, and when changing stapler supplier, the surgeon must take it upon herself to become familiar with the new instrument before using it in the operating room.
3. Allow the stapling instrument to compress the tissue for a few seconds prior to firing the instrument.
4. Heavy braided suture material may snag the "EEA" stapler making it difficult to remove after firing without disrupting the fresh anastomosis.
5. Firing the GIA on top of an existing parallel staple line or suture line may result in the knife catching the existing staples or sutures, resulting in disruption and leak. This is why when stapling across an existing staple line with a GIA, it is best to position the stapler so that the knife hits the existing line at a 90° angle or close to it.
6. There are no good data to support or refute the practice of oversewing staple lines. We do not do this routinely, but we always gently abrade the TA staple line looking for bleeders that are handled with gentle discreet cautery or gentle discreet suture ligature.
7. When tissue is resected with the "GIA" device, the specimen staple line should be inspected. If the specimen staple line is incompetent, the patient staple line may also be bad.
8. When feasible, staple lines in the stomach and duodenum should be tested intraoperatively. The simplest method is air insufflation via NG tube and distention of the submerged staple lines which should be airtight. Instillation

of methylene blue and intraoperative endoscopy are other useful methods to confirm staple-line integrity.

9. Staple-line bleeding into the lumen can be problematic and rarely can be life threatening. This usually occurs after a GIA- or EEA-type anastomosis. Prior to closure of the common channel after a GIA anastomosis, the lumen should be inspected for excessive hemorrhage and bleeders controlled. Following EEA gastrojejunostomy, intraoperative endoscopy should be performed if excessive staple-line hemorrhage is suspected (copious bleeding from EEA insertion site, or luminal distention, or copious blood from NG tube). Bleeders can be controlled with endoscopic cautery or full-thickness suture.
10. When performing a Roux gastrojejunostomy with the "EEA" device, care must be taken not to catch the back wall of the jejunum which results in a stenotic or obstructed efferent limb.

Postoperative Complications

Pulmonary Problems

Atelectasis is probably the most common complication after gastric operation. Adequate analgesia, incentive spirometry, and early ambulation help minimize this problem. Pneumonia is a less common but feared complication. Predisposing factors are atelectasis, vomiting, and preexisting lung disease. Pulmonary embolism is unusual with current prophylactic practices but should be considered in any postoperative patient with acute shortness of breath, chest pain, or unexplained fever and tachycardia.

GI Leak

Following a gastric or duodenal operation, any suture line may leak and create a potentially fatal situation. These problems manifest by the fifth or sixth postoperative day and are associated with increasing abdominal pain, fever, distension, and leukocytosis. These findings should prompt an aggressive diagnostic evaluation including obstruction series, contrast CT scan, or Gastrografin upper gastrointestinal (GI) series. Although small leaks can sometimes be managed nonoperatively with a strategically placed drain, reoperation should not be delayed in the deteriorating patient with sepsis. Irrigation and drainage of the peritoneal cavity, decompression of the leaking segment (e.g., duodenostomy or gastrostomy), closure or intubation of the leak (or both), and feeding jejunostomy are important aspects of management. If the initial operation was laparoscopic, sometimes an adequate reoperation can be accomplished laparoscopically.

Pancreatitis

Pancreatitis following gastroduodenal operation is generally caused by operative trauma to the gland itself or to the major or minor papilla. Treatment is nonoperative except in cases of infected necrotizing pancreatitis or persistent pancreatic fistula. Either of the papillae can be injured during aggressive dissection of the postbulbar duodenum. More commonly, the more proximal minor papilla is occluded or transected. This is usually a self-limited problem unless the patient has pancreas divisum. Occasionally, a duodenal stump leak is misdiagnosed as pancreatitis.

Wound Problems

Wound infection, dehiscence, and herniation can occur after major gastric operations. This is one obvious advantage of laparoscopic surgery. The problems are interrelated in that infection predisposes to the other two complications, and all three share risk factors. Wound infection is related to intraoperative contamination, which is more significant in the setting of acid suppression, gastric cancer, and obstruction. Appropriate use of prophylactic antibiotics and good surgical technique are important preventative measures. Pulmonary disease, abdominal distension, obesity, infection, malnutrition, and steroid therapy have all been shown to increase the incidence of wound failure.

Early Gastric Stasis

Occasionally in the hospitalized patient who is recovering from gastric surgery, the nasogastric tube "cannot be removed" because of persistent nausea and vomiting. Frequently, the gastric outlet is anatomically patent. Alternative methods of gastric intubation and alimentation are preferable to a major reoperation during the first 6 weeks postoperatively when the inflammatory response in the surgical field may be intense. Reoperation during this early postoperative period is often difficult, hazardous, and usually unnecessary. If an adequate gastric remnant remains, a decompressing gastrostomy may be placed laparoscopically or endoscopically. Sometimes another smaller tube or the long end of a GJ tube can be advanced into the jejunum for enteral feeding. Alternatively TPN can be administered and the nasogastric tube placed to gravity drainage. In patients with a small gastric remnant where a Stamm gastrostomy technique is impossible, a decompressing gastric tube can be passed retrograde through the jejunal efferent limb (using a Witzel technique), and another (distal) tube may be placed antegrade as a Witzel feeding jejunostomy. If these patients can be nursed through the first 3 months postoperatively, reoperation is often unnecessary and GI function is satisfactory. Reoperation should thus usually be delayed for 3–6 months after the first operation unless a high-grade or complete mechanical obstruction has been demonstrated in the small intestine. This may represent a process that predisposes to small bowel strangulation (e.g., herniation through the transverse mesocolon or proximal adhesive small bowel obstruction) and should be operated on promptly.

Dumping Syndrome

Clinically significant dumping occurs in 5–10 % of patients after pyloroplasty, pyloromyotomy, or distal gastrectomy. The symptoms are thought to be a result of the abrupt delivery of a hyperosmolar load into the small bowel. It is usually due to ablation of the pylorus, but decreased gastric compliance with accelerated emptying of liquids (e.g., after PGV) is another accepted mechanism.

"Early" dumping syndrome occurs about 15–30 min after a meal when the patient typically becomes diaphoretic, weak, light-headed, and tachycardic. These symptoms may be ameliorated by recumbence or saline infusion. Abdominal pain or cramping is common. Diarrhea often follows. A variety of aberrations in GI hormones have been observed. Medical therapy for early dumping syndrome consists of dietary management and if necessary somatostatin analog (octreotide). "Late" dumping occurs 2–3 h after a meal and represents a form of postprandial hypoglycemia.

It is the rare patient with dumping symptoms who requires an operation. Most patients improve with time (months and even years), dietary management, and medication. The results of remedial operation for dumping are variable and unpredictable. A variety of surgical approaches have been described, none of which works consistently well. Options include simple takedown of the gastrojejunostomy if the antrum and pylorus are intact and patent or conversion of Billroth I or Billroth II into a Roux-en-Y configuration (Miedema and Kelly 1991). Whether Roux-en-Y proximal duodenojejunostomy (i.e., duodenal switch procedure) would benefit the rare patient with disabling dumping following pyloroplasty is unclear.

Diarrhea

Truncal vagotomy is associated with clinically significant diarrhea in 5–10 % of patients. It occurs soon after operation and is usually not associated with other symptoms, a fact that helps distinguish it from dumping (see above). The diarrhea may be a daily occurrence or it may be more sporadic and unpredictable. Possible mechanisms include intestinal dysmotility and accelerated transit, bile acid malabsorption, rapid gastric emptying, and bacterial overgrowth. Some patients with postvagotomy diarrhea respond to cholestyramine, and in others codeine or loperamide is useful.

Bile Reflux Gastritis

Following ablation or resection of the pylorus, most patients have bile in the stomach on endoscopic examination along with some degree of gross or microscopic gastric inflammation (Malagelada et al. 1985; Ritchie 1980). Attributing postoperative symptoms to bile reflux is therefore problematic, as most asymptomatic patients also have bile reflux. It is generally accepted that a small subset of patients have bile reflux gastritis; they present with nausea, bilious vomiting, epigastric pain, and quantitative evidence of excess enterogastric reflux. Curiously, symptoms often develop months or years after the initial operation. The differential diagnosis includes afferent or efferent loop obstruction, gastric stasis, small bowel obstruction, and gastric stump cancer. Plain abdominal radiography, upper endoscopy, upper GI series, abdominal CT scans, and gastric emptying scans are helpful for evaluating these possibilities. Bile reflux may be quantitated with gastric analysis or more commonly scintigraphy (bile reflux scan).

Remedial operation eliminates the bile from the vomitus and may improve the epigastric pain, but it is quite unusual to render these patients completely asymptomatic, especially if they are narcotic dependent. Bile reflux gastritis after distal gastric resection may be treated by Roux-en-Y gastrojejunostomy, Henley loop, or Billroth II gastrojejunostomy with Braun enteroenterostomy. To eliminate bile reflux, the Roux limb or Henley loop should be at least 45 cm long, and a Braun enteroenterostomy should be placed a similar distance from the stomach. Excessively long jejunal limbs may be associated with obstruction or malabsorption. All operations can result in marginal ulceration and thus are combined with a generous distal gastrectomy. If this has already been done at a previous operation, the Roux or Braun operations may be attractively simple. The benefits of decreased acid secretion following total gastric vagotomy may be outweighed by vagotomy-associated dysmotility in the gastric remnant, especially during the current era when excellent and safe acid suppression is available. The Roux operation may be associated with an increased risk of emptying problems compared to the other two options, but controlled data are lacking.

Primary bile reflux gastritis (i.e., no previous operation) is rare and may be treated with duodenal switch operation, essentially an end-to-end Roux-en-Y to the proximal duodenum. The Achilles' heel of this operation is, not surprisingly, marginal ulceration. Thus, it should be combined with proximal gastric vagotomy and/or chronic acid suppressive medication.

Postoperative Gastric Stasis and Roux Syndrome

Gastric stasis following operation on the stomach may be due to gastric motor dysfunction or mechanical obstruction (Speicher et al. 2009; Forstner-Barthell et al. 1999). The gastric motility abnormality may have been preexistent and unrecognized by the operating surgeon. Alternatively, it may be secondary to deliberate or unintentional vagotomy or resection of the dominant gastric pacemaker. An obstruction may be mechanical (e.g., anastomotic stricture, marginal ulcer, efferent limb kink from adhesions or constricting mesocolon, or a proximal small bowel obstruction) or functional (e.g., retrograde peristalsis in a Roux limb). The latter situation is referred to as the Roux syndrome (Schirmer 1994; Vogel and Woodward 1989).

Gastric stasis presents with vomiting (often of undigested food), bloating, epigastric pain, and weight loss. Evaluation includes esophagogastroduodenoscopy (EGD), upper gastrointestinal series, gastric emptying scan, and gastric motor testing. Once mechanical obstruction has been ruled out, medical treatment is successful in most cases of motor dysfunction that follows previous gastric surgery. It consists of dietary modification and promotility agents. Intermittent oral antibiotic therapy may be helpful for treating bacterial overgrowth with its attendant symptoms of bloating, flatulence, and diarrhea.

Gastroparesis following vagotomy and drainage may be treated with subtotal (75 %) gastrectomy. Billroth II anastomosis with Braun enteroenterostomy may be preferable to Roux-en-Y reconstruction since recurrent gastric stasis attributable to the Roux syndrome may result. If gastric stasis is felt to be related to recurrent or marginal ulcer, this usually responds to medical therapy. Endoscopic dilation is occasionally helpful. Gastroparesis following subtotal gastric resection is best treated with near-total (95 %) or total gastric resection and Roux-en-Y reconstruction. Gastric pacing is promising, but it has not achieved widespread clinical usefulness in the treatment of postoperative gastric atony.

The Roux syndrome seems to be more common in patients with a generous gastric treatment. Truncal vagotomy has also been implicated. Medical treatment consists of promotility agents. Surgical treatment consists of paring down the gastric remnant. If gastric motility is severely disordered, a 95 % gastrectomy should be done. The Roux limb should be resected if it is dilated and flaccid, and doing so does not put the patient at risk for short bowel problems. Gastrointestinal continuity may be reestablished with another Roux or a Henley isoperistaltic isolated jejunal loop interposed between the small gastric remnant and the duodenum.

While some patients with severe gastric stasis problems following gastric surgery can be helped with near-total or total gastrectomy, many patients remain significantly symptomatic (Visick 3 or 4), and most have chronic nutritional problems (Speicher et al. 2009; Forstner-Barthell et al. 1999; Schirmer 1994; Vogel and Woodward 1989).

Metabolic Problems

Weight Loss. Weight loss is common in patients who have undergone vagotomy or gastric resection (or both) (Harju 1990). The degree of weight loss tends to parallel the magnitude of the operation. It may be insignificant in the large person or devastating in the asthenic female patient. The surgeon should always reconsider before performing a gastric resection for benign disease in a thin patient. The causes of weight loss after gastric surgery generally fall into one of two categories: altered dietary intake or malabsorption. If a stain for fecal fat is negative, it is likely that decreased caloric intake is the problem. This is the most common cause of weight loss after gastric surgery and may be due to small stomach syndrome, postoperative gastroparesis, change in appetite, or self-imposed dietary modification because of dumping or diarrhea. Consultation with an experienced dietitian may prove invaluable.

Anemia. Iron absorption takes place primarily in the proximal gastrointestinal tract and is facilitated by an acidic environment. Intrinsic factor, essential for the enteric absorption of vitamin B_{12}, is produced by the parietal cells of the stomach. Vitamin B_{12} bioavailability is also facilitated by an acidic environment. Leafy vegetables, a rich source of folate, may be poorly tolerated after gastric surgery. Thus, patients who have had a gastric operation are at risk for anemia and should be monitored and treated appropriately. Anemia is the most common metabolic side effect in patients who have undergone gastric bypass for morbid obesity. It also occurs in up to one-third of patients who have had a vagotomy or gastric resection (or both). Iron deficiency is the most common cause, but vitamin B_{12} or folate deficiency also occurs. Of course, patients who have had a total gastrectomy will all develop vitamin B_{12} deficiency without supplementation.

Bone Disease. Abnormalities of calcium and vitamin D metabolism can contribute to metabolic bone disease in patients following gastric surgery. Calcium absorption occurs primarily in the duodenum, which is bypassed with a gastrojejunostomy, distal gastric resection, or gastric bypass. Fat malabsorption due to bacterial overgrowth or inefficient digestion can significantly affect absorption of vitamin D, a fat-soluble vitamin. The problems usually manifest as pain or fractures years after the gastric operation. Musculoskeletal symptoms should prompt a study of bone density. Dietary supplementation of calcium and vitamin D may be useful for preventing these complications. Routine skeletal monitoring of patients at high risk (e.g., elderly men and women; postmenopausal women) may prove useful for identifying skeletal deterioration that with appropriate treatment can be arrested.

Acknowledgment This chapter was contributed by Michael W. Grabowski in the previous edition.

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29 Truncal Vagotomy: Surgical Legacy Technique

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Indications

Truncal vagotomy is rarely indicated as an adjunct to management of refractory duodenal ulcer disease or during performance of other procedures (see Chap. 28).

Preoperative Preparation

See Chap. 28.

Pitfalls and Danger Points

Esophageal trauma
Splenic trauma
Inadequate vagotomy
Disruption of esophageal hiatus with postoperative hiatal hernia; gastroesophageal reflux

Operative Strategy

Avoiding Esophageal Trauma

The best way to avoid trauma to the esophagus is by performing most of the esophageal dissection under *direct vision*. Forceful, blind finger dissection can be dangerous. After the peritoneum overlying the abdominal esophagus is incised (Figs. 29.1, 29.2, and 29.3), the crural musculature should be clearly exposed. The next vital step in this sequence is to develop a groove between the esophagus and the adjoining crux on each side. This should be done under direct vision using a peanut dissector (Fig. 29.4). Only after the anterior two-thirds of the esophagus has been exposed is it permissible to insert an index finger and encircle the esophagus.

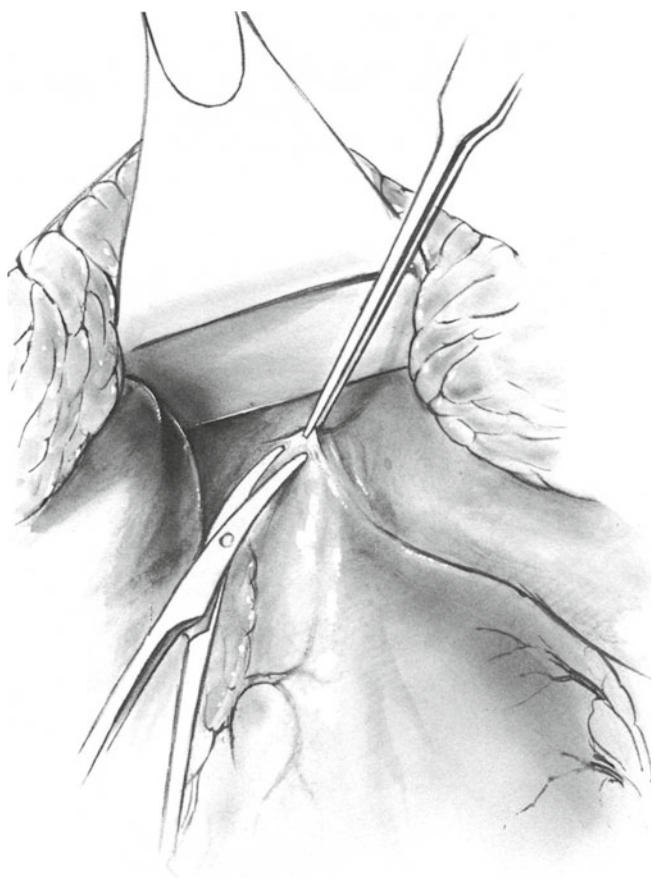

Fig. 29.1

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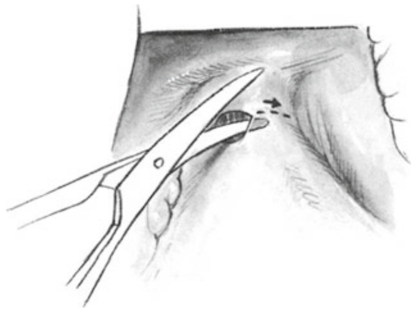

Fig. 29.2

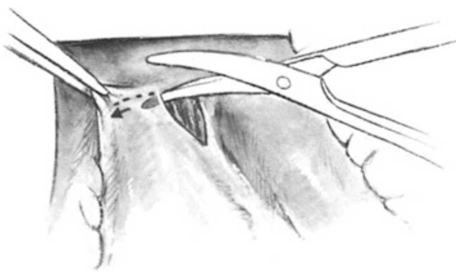

Fig. 29.3

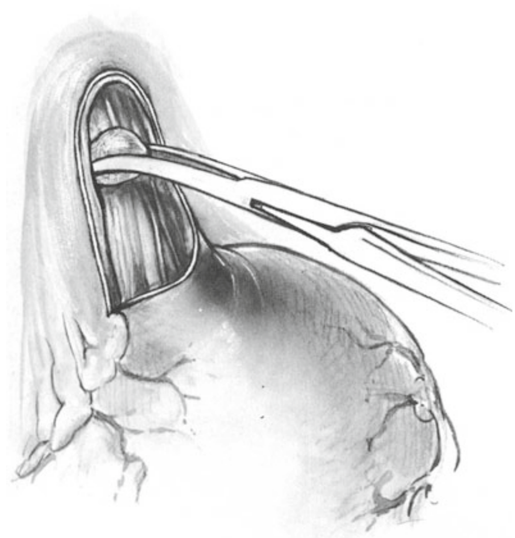

Fig. 29.4

Avoiding Splenic Trauma

Splenic trauma can be prevented by avoiding any traction that draws the stomach toward the patient's right. Such traction may avulse the splenic capsule because of attachments between the omentum and the surface of the spleen. Consequently, all traction on the stomach should be applied on the lesser curvature side and directed toward the patient's feet. Avulsion of a portion of the splenic capsule, in the absence of gross disruption of the splenic pulp, does not require splenectomy. Application of topical hemostatic agents and pressure may control bleeding satisfactorily.

Preventing Incomplete Vagotomy

In most cases of recurrent marginal ulcer, it turns out that the posterior vagal trunk has not been divided. This trunk is generally the largest trunk encountered. The surgeon's failure to locate the posterior vagus suggests inadequate knowledge of the anatomy of the posterior vagus. The right (posterior) vagal trunk is frequently 2 cm or more distant from the right lateral wall of the esophagus. It is often not delivered into the field by the usual maneuver of encircling the esophagus with the index finger. If the technique described below is carefully followed, this trunk is rarely overlooked.

To improve tissue recognition skills, the surgeon should place each nerve specimen removed from the vicinity of the esophagus into a separate bottle for histologic examination. Each bottle should have a label indicating the anatomic area from which the nerve was removed. The pathology report that arrives several days after the operation can serve as a test of the surgeon's ability to identify nerves visually. The surgeon may be surprised to find that four or five specimens of nerve have been removed during a complete truncal vagotomy. Frozen section examination is helpful but not conclusive because it cannot prove that all the vagal nerve branches have been removed. The surgeon must gain sufficient skill at identifying nerve trunks to be certain no significant nerve fiber remains.

Hiatus Hernia

Significant hiatal hernia following vagotomy occurs in no more than 1–2 % of cases. This percentage can probably be reduced if the surgeon repairs any large defects seen in the hiatus after the dissection has been completed.

Documentation Basics

Findings

Operative Technique

Incision and Exposure

Make a midline incision from the xiphoid to a point about 5 cm below the umbilicus. The incision can be extended into the xiphocostal junction if necessary. Elevate the sternum 8–10 cm by means of an Upper Hand or Thompson retractor.

Elevate the upper half of the operating table about 10°. Retract the left lobe of the liver in a cephalad direction utilizing Harrington or Weinberg retractors. In rare instances, the triangular ligament must be incised, and the left lobe of the liver retracted to the patient's right for exposure (see Chap. 19).

Using long DeBakey forceps and long Metzenbaum scissors, incise the peritoneum overlying the abdominal esophagus (Figs. 29.1, 29.2, and 29.3). Next identify the muscles of the right and left branches of the crux. Use a peanut dissector to develop a groove between the esophagus and the adjacent crux, exposing the anterior two-thirds of the esophagus (Fig. 29.4). At this point insert the right index finger gently behind the esophagus and encircle it.

Left (Anterior) Vagal Trunks

In our experience, whereas the posterior trunk often exists as a single structure in the abdomen, the anterior vagus divides into two *or more* trunks in more than 50 % of cases. The main left trunk generally runs along the anterior wall of the lower esophagus, and the other branches may be closely applied to the longitudinal muscle of the anterior esophagus. The major nerve branches may be accentuated by caudal traction on the stomach, which makes the anterior nerves prominent against the esophagus. After applying hemostatic clips, remove segments from each of the anterior branches (Fig. 29.5). Any suspicious fibers should be removed with forceps and sent to the pathology laboratory for analysis.

Identification of the Right (Posterior) Vagus

The posterior vagal trunk often is situated 2–3 cm lateral and posterior to the right wall of the esophagus. Consequently, its identification requires that when the surgeon's right index finger encircles the lowermost esophagus, proceeding from the patient's left to right, the fingernail should pass over the anterior aorta. The finger should then go a considerable distance toward the patient's right before the finger is flexed. The fingernail then rolls against the *deep* aspect of the right branch of the crural muscle. When this maneuver is completed, the right trunk, a structure measuring 2–3 mm in diameter, is contained in the encircled finger to the right of the esophagus (Fig. 29.6). Its identification may be confirmed in two ways. First, look for a major branch going toward the celiac ganglion. Second, insert a finger above the left gastric artery near the lesser curvature of the stomach, and draw the left gastric vessel in a caudal direction. This applied traction to the posterior vagus, which then stands out as a stout cord. The right trunk rarely divides in the abdomen above the level of the esophagogastric junction.

Apply a long Mixter clamp to the nerve, place hemostatic clips above and below the clamp, and remove a 2–3 cm segment of nerve and submit it for histologic study. Rotate the esophagus and inspect the posterior wall. At the conclusion of this step the lower 5 cm of esophagus should be cleared of all nerve fibers. One should see only longitudinal muscle throughout its circumference (Fig. 29.7).

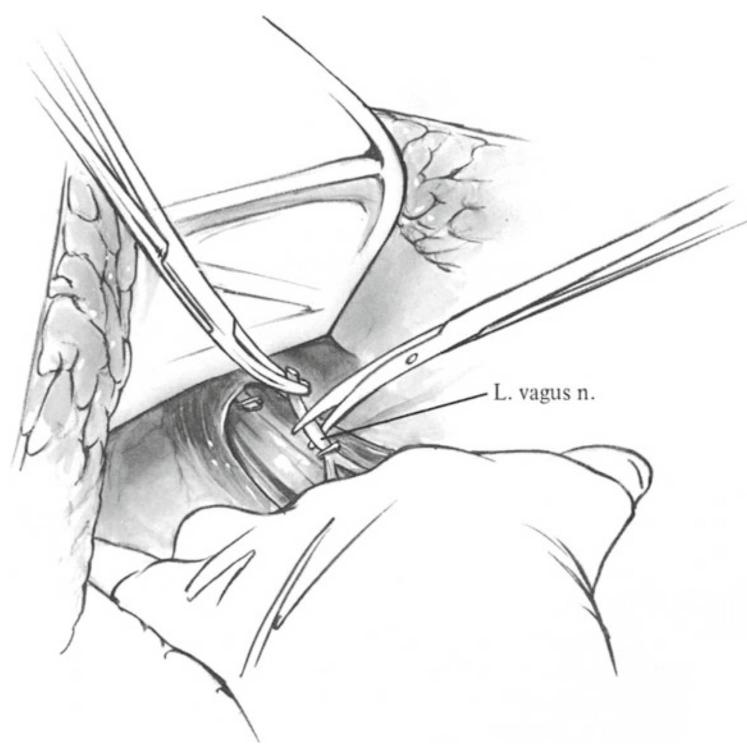

Fig. 29.5

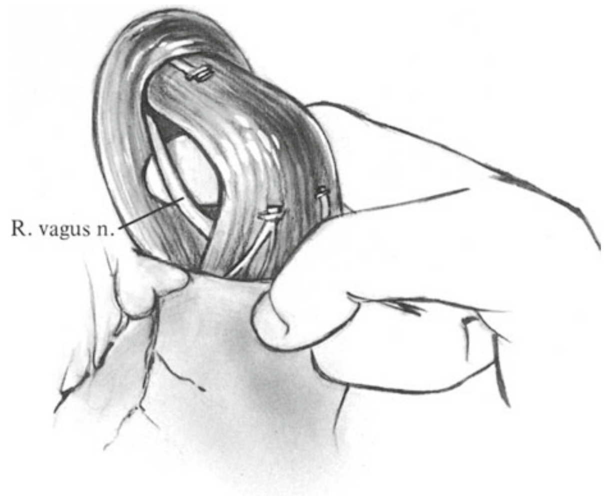

Fig. 29.6

Fig. 29.7

Suture of Crural Musculature

If the hiatus admits two or more fingers alongside the esophagus, one or two sutures of 0 cotton or Tevdek should be placed to approximate the muscle bundles behind the esophagus, taking care to leave a gap of one fingerbreadth between the esophagus and the newly constructed hiatus. No attempt at fundoplication or any other antireflux procedure need be undertaken unless the patient had symptoms or other evidence of gastroesophageal reflux and esophagitis before the operation. Check hemostasis before going on to the gastric resection or drainage procedure.

Postoperative Care

See Chap. 31.

Complications

Operative Perforation of the Esophagus. This injury must be carefully repaired with two layers of interrupted sutures. If additional exposure is needed, do not hesitate to extend the abdominal incision into the left sixth or seventh intercostal space. For additional security when repairing a low esophageal tear, cover the suture line with gastric wall by performing a Nissen fundoplication.

Postoperative Gastric Stasis. Because this complication is unpredictable and difficult to manage, a drainage procedure such as pyloroplasty or gastrojejunostomy is generally done with truncal vagotomy.

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30 Proximal Gastric Vagotomy: Surgical Legacy Technique

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Peptic ulcer disease refractory to medical management
See Chap. 28

Preoperative Preparation

Esophagogastroduodenoscopy to confirm the diagnosis

Pitfalls and Danger Points

Hematoma of gastrohepatic ligament
Incomplete vagotomy
Damage to innervation of pyloric antrum
Injury to spleen
Necrosis or perforation of lesser curvature of stomach

Operative Strategy

Exposure

The visibility of the area around the lower esophagus is greatly enhanced if the Thompson or the Upper Hand retractor is attached so the blade underlying the lower border of the sternum elevates the sternum and draws it in a cephalad direction.

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Prevention of Hematoma and Injury to Gastric Lesser Curve

Hematomas in the region of the gastrohepatic ligament along the lesser curve of the stomach increase the difficulty of identifying the terminal branches of the nerve of Latarjet. Furthermore, rough dissection and hematomas in this area may damage the deserosalized muscle along the lesser curve to such an extent that necrosis may occur. This rare complication is preventable if dissection is performed gently. Resuturing the peritoneum produces inversion of the deserosalized portion of the lesser curve and helps prevent perforation.

Preserving Innervation of the Antrum

The anterior and posterior nerves of Latarjet terminate in a configuration resembling the foot of a crow. This crow's foot portion maintains innervation of the antrum and pylorus and ensures adequate emptying of the stomach.

Adequacy of Proximal Vagotomy

Hallenbeck et al. demonstrated that the incidence of recurrent postoperative ulcer dropped markedly when they extended the dissection so the lower esophagus was completely freed of any vagal innervation. This required meticulous removal of all nerve branches reaching the lower 5–7 cm of the esophagus and the proximal stomach. Grassi noted that one reason the proximal vagotomy technique fails is that surgeons sometimes overlook a branch leading from the posterior vagus nerve to the posterior wall of the upper stomach. He named it the "criminal nerve." If all the vagal nerve branches that enter the distal esophagus or proximal stomach are divided, interruption of the criminal nerve is included in the dissection.

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Postoperative Gastroesophageal Reflux

Extensive dissection in the region of the esophagogastric junction may produce or exacerbate gastroesophageal reflux. Patients with preoperative gastroesophageal reflux should undergo an antireflux procedure at completion of the proximal gastric vagotomy. A posterior gastropexy (see Chap. 21) or a Nissen fundoplication (see Chap. 19) may be done. The choice of procedure depends on the experience of the surgeon and the operative findings.

Documentation Basics

Findings

Operative Technique

Incision and Exposure

With the patient supine, elevate the head of the operating table 10–15°. Make a midline incision from the xiphoid to a point 5 cm below the umbilicus. Insert an Upper Hand or Thompson retractor to elevate the lower sternum about 8–10 cm. Insert a self-retaining retractor of the Balfour type without excessive tension to separate the margins of the incision. Depending on the patient's body habitus, use a Weinberg or a Harrington retractor to elevate the left lobe of the liver above the esophageal hiatus. On rare occasions this exposure is not adequate, and the triangular ligament of the left lobe of the liver may have to be divided, with the left lobe retracted to the patient's right.

Identification of Right and Left Vagal Trunks

Expose the peritoneum overlying the abdominal esophagus, and transect it transversely using long Metzenbaum scissors and DeBakey forceps. Extend the peritoneal incision to uncover the muscular fibers of the crura surrounding the esophageal hiatus (see Figs. 29.1, 29.2, and 29.3). Separate the anterior two-thirds of the circumference of the esophagus from the adjacent right and left crux of the diaphragm using scissors and peanut-sponge dissection under direct vision (see Fig. 29.4). Then encircle the esophagus with the right index finger.

The right (posterior) vagus nerve is frequently 2 cm or more away from the esophagus. To avoid leaving the posterior vagus behind, pass the finger into the hiatus at the groove between the left branch of the crux and the left margin of the esophagus. Pass the fingernail along the anterior wall of the aorta, and curve it anteriorly along the posterior aspect of the right side of the diaphragmatic crux, entering the operative field adjacent to the right crux. As a result of this maneuver, the index finger almost invariably contains both vagal trunks in addition to the esophagus. The right vagus generally is considerably larger than the left and is almost always a single trunk. The left (anterior) vagus can be identified generally at the right anterior surface of the *lower* esophagus. Separate each vagal trunk gently from the esophageal wall, pulling the vagal trunk toward the right and the esophagus to the left. Encircle each vagal trunk with a Silastic loop, brought out to the right of the esophagus.

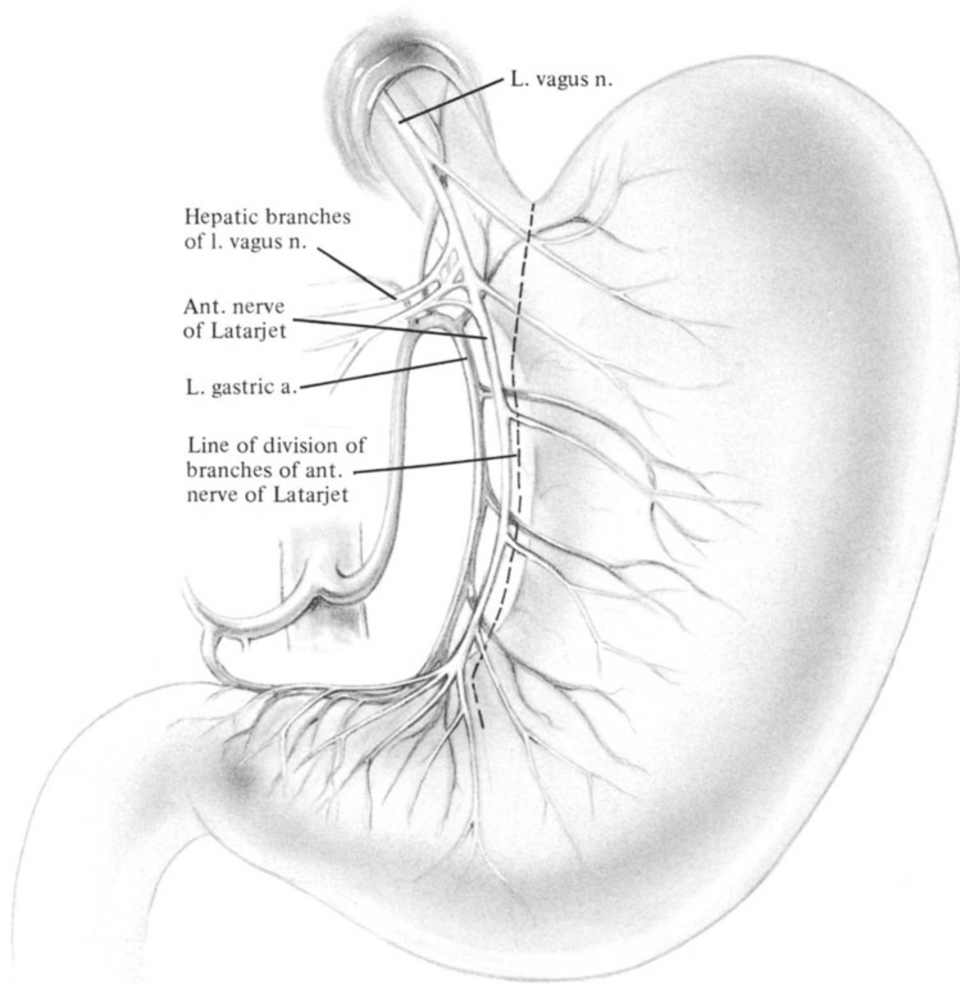
Identification of Crow's Foot

Pass the left index and middle fingers through an avascular area of the gastrohepatic omentum and enter the lesser sac. This enables the nerves and blood vessels along the lesser curvature of the stomach to be elevated and put on stretch. The anterior nerve of Latarjet, which is the termination of the left vagus trunk as it innervates the anterior gastric wall, can be seen through the transparent peritoneum adjacent to the lesser curvature of the stomach. It intermingles with terminal branches of the left gastric artery, which also go to the lesser curvature. As the nerve of Latarjet reaches its termination, it divides into four or five branches in a configuration that resembles a crow's foot. These terminal branches innervate the distal 6–7 cm of the antrum and pylorus and should be preserved (Figs. 30.1 and 30.2a).

Dissection of the Anterior Nerve of Latarjet

After identifying the crow's foot, insert a Mixter right-angle clamp underneath the next cephalad branch of the nerve and the accompanying blood vessels (Fig. 30.2b). This branch is 6–7 cm cephalad to the pyloric muscle. After the clamp has broken through the peritoneum on both sides of these structures, divide them between Adson hemostats and carefully ligate with 4-0 silk (Fig. 30.2c). Alternatively, each branch may be double-ligated before being divided. Repeat the same maneuver many times, ascending the lesser curvature of the stomach and taking care not to include more than one branch in each hemostat. To preserve the innervation of the antrum, the hemostats must be applied close to the gastric wall so as not to injure the main

Fig. 30.1



trunk of the nerve of Latarjet. Take great care not to tear any of these small blood vessels, as they tend to retract and form hematomas in the gastrohepatic ligament obscuring the field of dissection. This is a particular hazard in obese patients. Avoid trauma to the musculature of the gastric wall, as this area of the lesser curvature is not protected by a layer of serosa.

Continue dissection of the anterior layer of the gastrohepatic ligament until the main trunk of the left vagus nerve is reached. Retract this trunk toward the patient's right by means of the umbilical tape. At the conclusion of the dissection, the left vagus nerve should be completely separated from the wall of the esophagus for a distance of 6–7 cm above the esophagogastric junction. Any small nerve branching from the vagus nerve to this portion of the esophagus should be divided. In this fashion all the branches from the left vagus to the stomach are interrupted, with the exception of those innervating the distal antrum and pylorus. Preserve the hepatic branch of the vagus trunk also because it leaves the left vagus and goes to the patient's right on its way to the liver.

Dissection of Posterior Nerve of Latarjet

Delineate the posterior leaflet of the gastrohepatic omentum as it attaches to the posterior aspect of the lesser curvature of the stomach. Again, the crow's foot should be identified and preserved. Each branch of the left gastric artery and vein, together with each terminal branch of the *posterior* nerve of Latarjet, should be individually isolated, double clamped, divided, and ligated (Fig. 30.3). Take care to make this division close to the gastric wall to preserve the main nerve of Latarjet. Continue this dissection in a cephalad direction until the previously identified right vagal trunk can be seen alongside the distal esophagus. When this dissection has

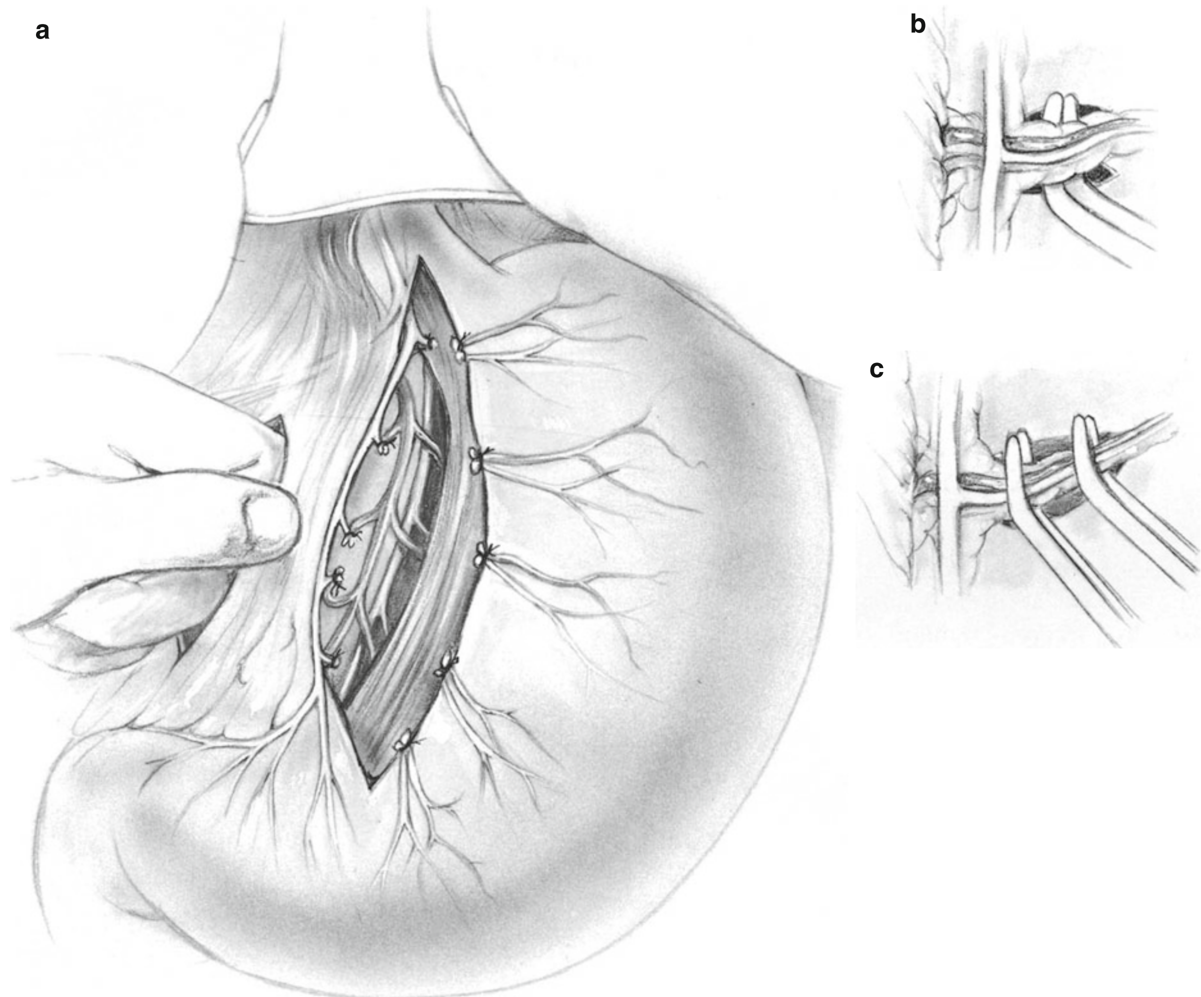


Fig. 30.2

been properly completed, it becomes evident that the right vagus nerve and the gastrohepatic ligament are situated far to the right of the completely bare lesser curvature. Now dissect away the posterior aspect of the esophagus from the posterior vagus nerve for a distance of 7 cm above the esophagogastric junction so no branches from this trunk can reach the stomach by way of the distal esophagus.

Pay special attention to the criminal nerve of Grassi, which is a branch of the posterior vagal trunk passing behind the esophagus to the posterior wall of the gastric cardia. If the surgeon's left hand can be passed between the freed vagal trunks and the distal esophagus as well as the gastric fundus, it helps ensure that the extent of the dissection has been adequate. In addition, carefully inspect the longitudinal muscle fibers of the distal esophagus. Any tiny fibers resembling nerve tissue should be divided or avulsed from the musculature throughout the circumference of the lower 7 cm of esophagus (Fig. 30.4).

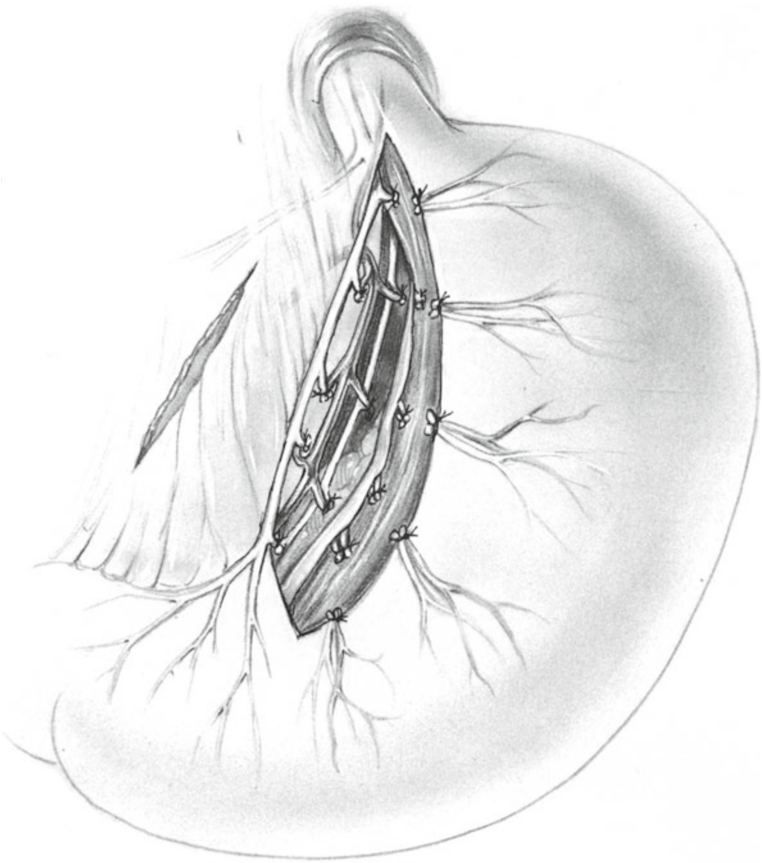


Fig. 30.3

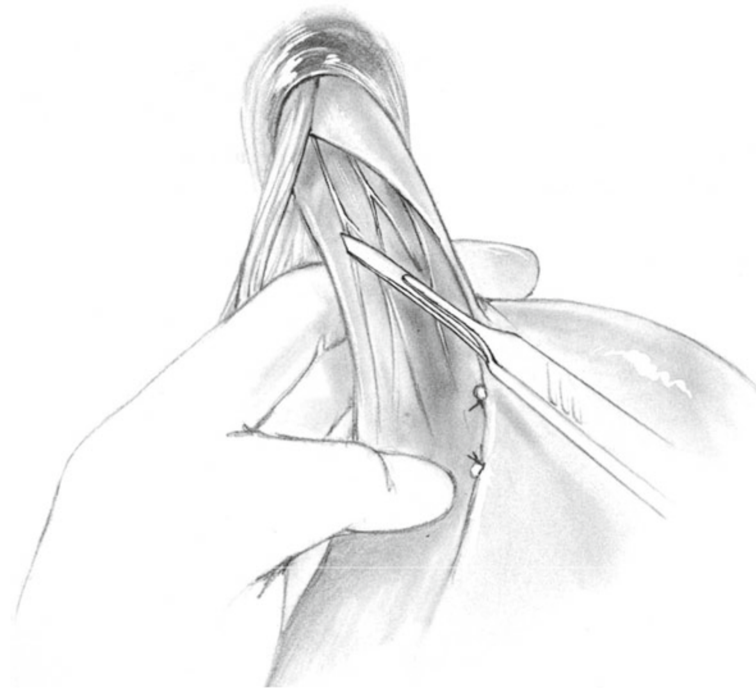


Fig. 30.4

Repair of the Lesser Curvature

Use interrupted 4-0 silk Lembert sutures to approximate the peritoneum over the gastric musculature, thereby reperitonealizing the lesser curvature (Fig. 30.5). Close the abdominal incision in the usual fashion, without drainage.

Postoperative Care

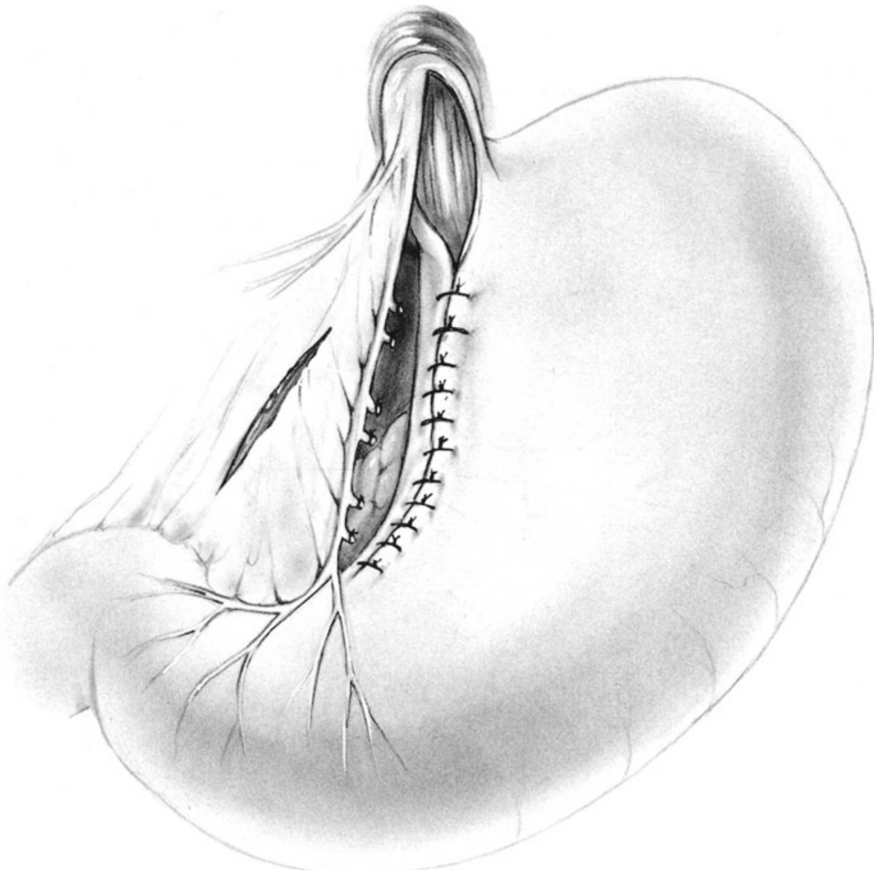
Continue nasogastric suction and intravenous fluids for 48 h. At the end of this time the patient generally is able to be advanced to a normal diet. Usually the postoperative course is uneventful, and undesirable postoperative gastric sequelae, such as dumping, are distinctly uncommon.

Complications

Recurrent Ulceration. Inadequate vagotomy results in recurrent ulceration.

Necrosis. Unique to proximal gastric vagotomy is necrosis of the lesser curvature. Although rare (0.3 % of all proximal gastric vagotomy operations), it is often fatal. It probably results from trauma or hematoma of the gastric wall in an area that lacks serosa. Prevention requires accurate dissection assisted by reperitonealization of the lesser curvature by suturing (Fig. 30.5). Treatment requires early diagnosis and resection.

Fig. 30.5



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Pyloroplasty (Heineke-Mikulicz and Finney), Operation for Bleeding Duodenal Ulcer: Surgical Legacy Technique

31

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Pyloroplasty is now primarily used in patients undergoing emergency surgery for massive hemorrhage from duodenal ulcer, when other methods of control (e.g., endoscopic) have failed. A vagotomy may be added if the patient is noncompliant with medical therapy (see Chaps. 29 and 30).

Preoperative Preparation

Nasogastric suction
Esophagogastroduodenoscopy (endoscopic control of hemorrhage is frequently possible, obviating the need for operation)
Perioperative antibiotics
Resuscitation
Close communication with the Blood Bank

Pitfalls and Danger Points

Suture line leak
Inadequate lumen
Failure to control hemorrhage

Operative Strategy

Control of Bleeding

Expose the ulcer through a generous gastroduodenotomy. This incision begins on the distal antrum, crosses the pylorus, and continues several centimeters down onto the duodenum. The bleeding site must be positively identified. If the ulcer is not seen, determine whether blood is coming from proximal or distal and extend the incision as needed. In case of doubt, do not hesitate to insert a gloved finger into the stomach and palpate for the ulcer crater.

The arterial anatomy of the stomach is shown in Fig. 31.1. The most common situation is a posterior duodenal ulcer eroding into the gastroduodenal artery. Occasionally, a gastric ulcer erodes into the left or right gastric artery, the gastroepiploic arcade, or (rarely) posteriorly into the splenic artery. Identify the bleeder and suture ligate it.

Choice of Pyloroplasty

Even if fibrosis and inflammation of the duodenum are present, as they may be with severe ulcer disease, in most cases a Heineke-Mikulicz pyloroplasty is feasible. When the duodenum appears too inflexible to allow performance of this procedure, or when the gastroduodenotomy has extended too long to allow easy transverse closure, the Finney pyloroplasty or gastrojejunostomy should be elected. The latter two operations, although slightly more complicated than the Heineke-Mikulicz, ensure production of an adequate lumen for gastric drainage. Because the gastroduodenal incision is optimally positioned slightly differently for the two types of pyloroplasty, it is ideal to decide which type is to be performed before the incision is made. In the emergency situation this consideration is secondary to the need for swift, adequate exposure.

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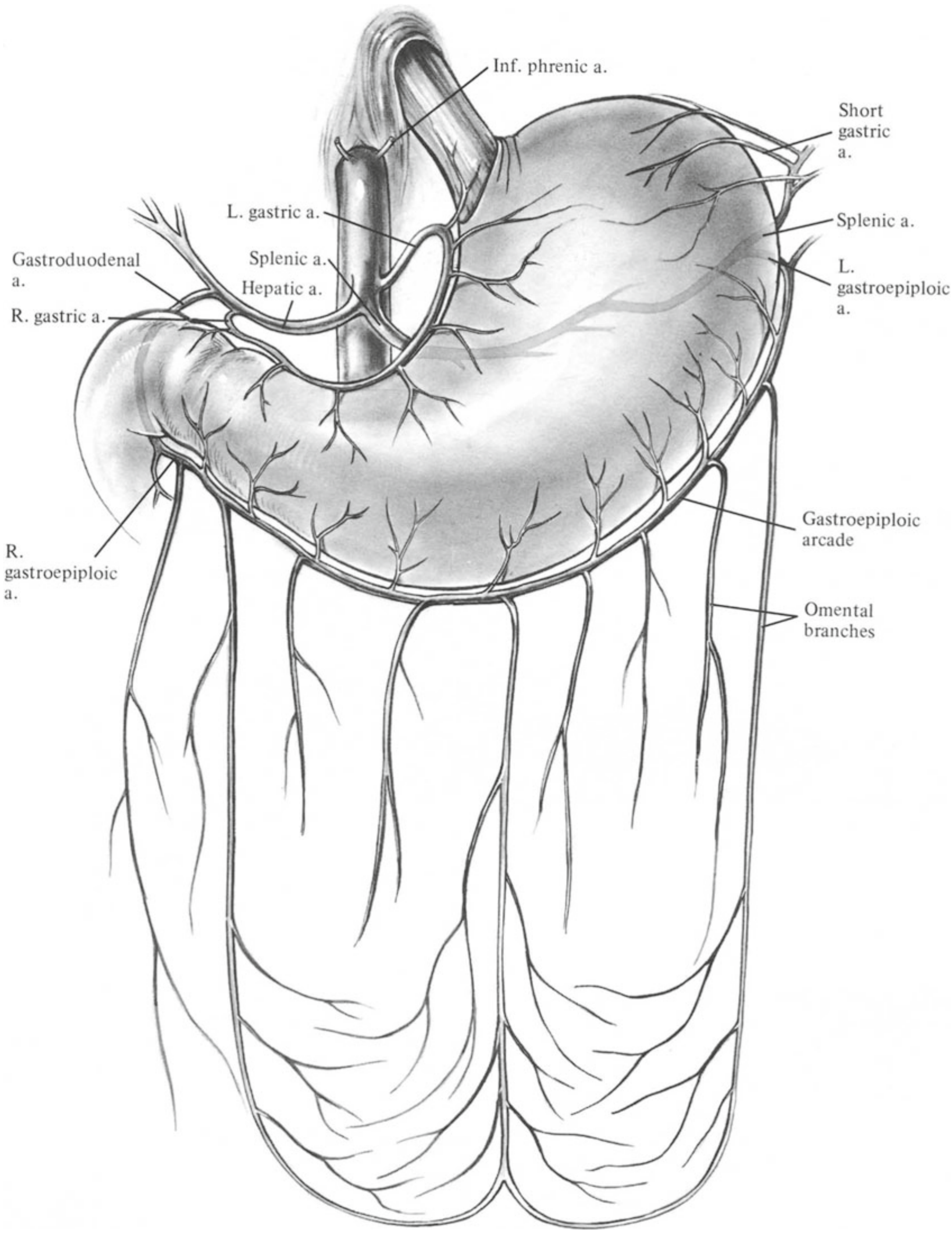


Fig. 31.1

Documentation Basics

- Findings, including location of ulcer and appearance
- Nature of pyloroplasty
- Vagotomy or not? If so, which type?

Operative Technique

Kocher Maneuver

In most cases, pyloroplasty requires a Kocher maneuver (see Figs. 14.14, 14.15, and 14.16) to provide maneuverability of the tissues: Grasp the peritoneum lateral to the duodenum with forceps and make an incision in this peritoneal layer. Alternatively, in many patients the surgeon's index finger may be insinuated behind the common bile duct and portal vein, pointing toward the ampulla of Vater. The finger then slides toward the patient's right. Overlying the fingertip is not only a thin layer of peritoneum but also an avascular lateral duodenal ligament that attaches the duodenum to the underlying retroperitoneal structures.

Incise the peritoneal layer with scissors or electrocautery and then stretch the lateral duodenal ligament with the fingertip and divide it similarly.

Pyloroduodenal Incision for Heineke-Mikulicz Pyloroplasty

Make a 5 cm incision across the lower antrum, pyloric sphincter, and proximal duodenum, with the incision centered on the pyloric muscle (Fig. 31.2). Apply Babcock clamps to the cephalad and caudad cut ends of the pyloric sphincter, and draw them apart to open the incision. Transfix any bleeding points with 4-0 PG or PDS suture-ligatures or with careful electrocoagulation. Close the incision transversely, providing a patulous lumen for gastric drainage.

Emergency Procedure for Bleeding Ulcer

The longitudinal incision across the pylorus and into the proximal 3 cm of the duodenum described above generally provides good visualization of a posterior duodenal ulcer that has eroded into the gastroduodenal artery (Fig. 31.2).

If you do not see an ulcer crater, ascertain whether the blood is coming from proximal or distal and extend the incision as needed for adequate exposure. In a difficult situation, do not hesitate to insert your gloved finger into the incision and carefully palpate for an ulcer crater.

As previously noted, the most common source of duodenal ulcer bleeding is posterior erosion into the gastroduodenal artery (Fig. 31.1). Transfix this artery with 2-0 silk sutures proximal and distal to the bleeding point. Place a third suture on the pancreatic side and deep to the bleeding point (Figs. 31.3 and 31.4) to occlude a hidden posterior branch of the gastroduodenal artery. This branch, generally the transverse pancreatic artery, may produce retrograde bleeding following apparently successful proximal and distal ligation of the gastroduodenal artery. Pluck the thrombus from the lumen of the ulcerated artery to determine if hemorrhage control is complete.

The incision in the stomach and duodenum is then closed as a pyloroplasty. If the incision is relatively short, as shown in Fig. 31.2, a Heineke-Mikulicz closure is appropriate. A longer incision, or a fibrotic duodenum, may require closure by a Finney pyloroplasty. Both are described in the sections that follow. A Kocher maneuver (see Figs. 14.14, 14.15, and 14.16) greatly facilitates closure and should be done, if not previously completed.

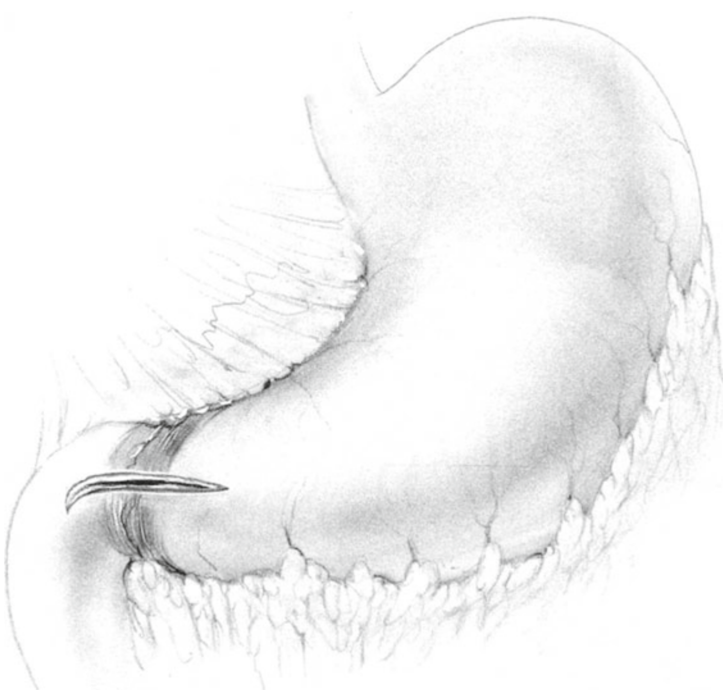


Fig. 31.2

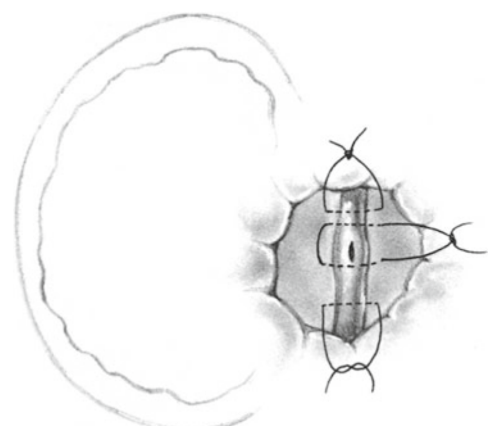


Fig. 31.3

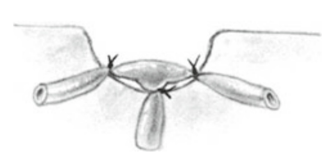
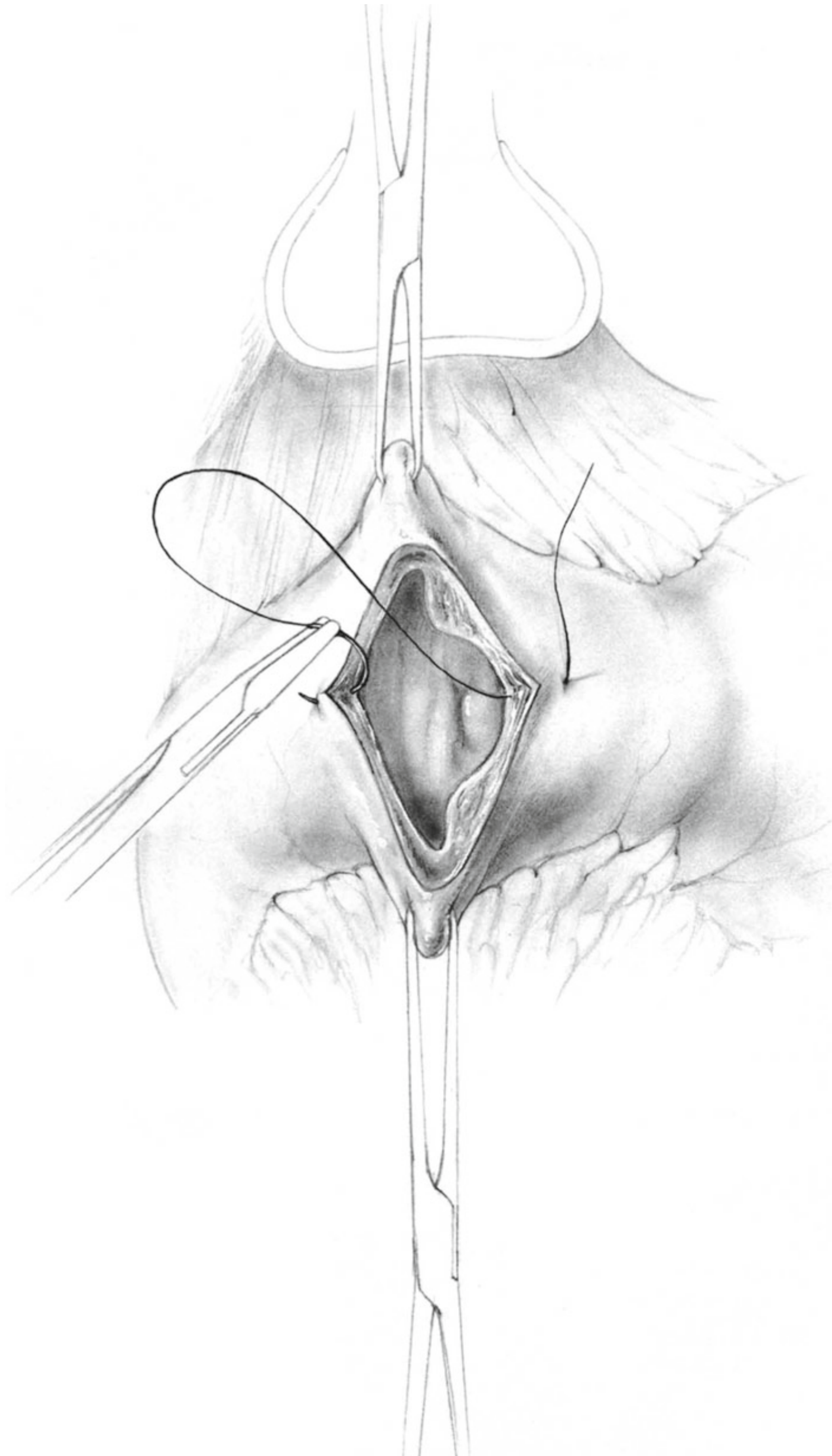


Fig. 31.4

Fig. 31.5



Heineke-Mikulicz Pyloroplasty

Sutures

Use one layer of sutures to prevent excessive tissue inversion. Most techniques call for a through-and-through suture. As the gastric wall is much thicker than the duodenal wall, it is difficult with this technique to prevent eversion of mucosa between the sutures. Consequently, we prefer deep "seromucosal" sutures (see Fig. 4.13) or interrupted Lembert sutures of 4-0 silk. Insert the first suture at the midpoint of the suture line (Fig. 31.5). Proceed with the closure from one corner to the midpoint and then from the other corner to the midpoint,

Fig. 31.6

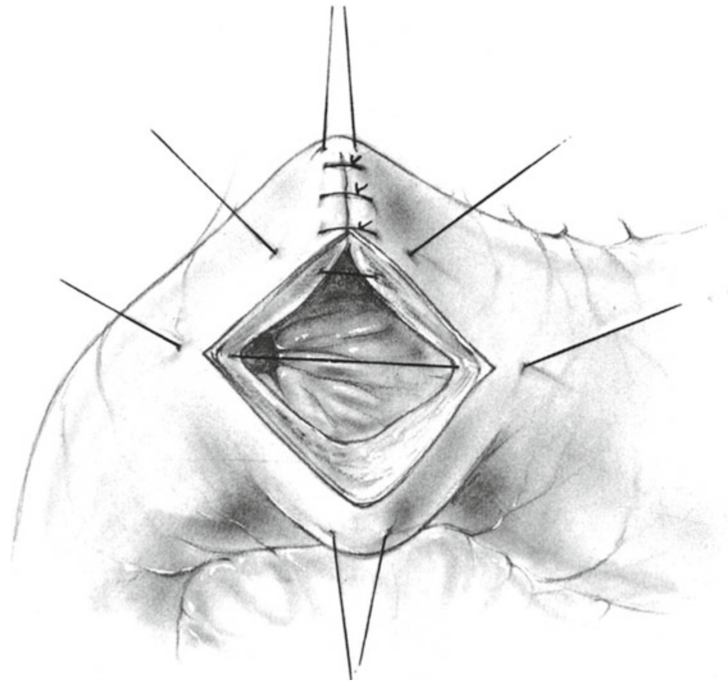
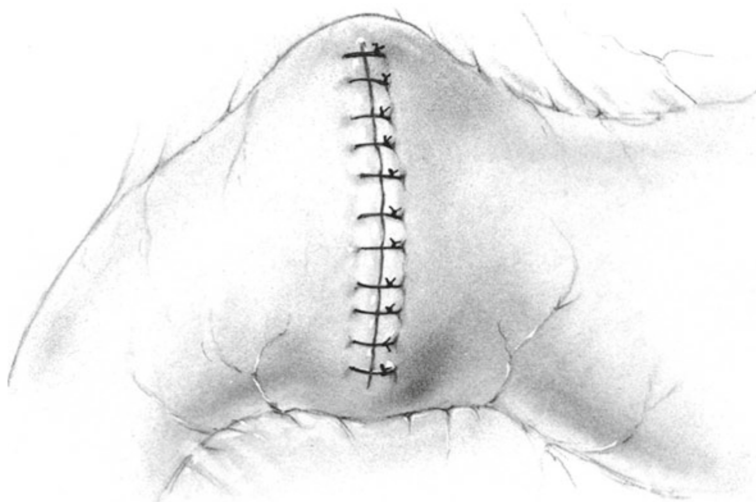


Fig. 31.7



inverting just enough of the seromuscular coat to prevent outpouching of mucosa between the sutures (Figs. 31.6 and 31.7).

Then suture omentum loosely over the pyloroplasty. This prevents leakage from the one-layer suture line and adhesions between the suture line and the undersurface of the liver, which may cause angulation and partial obstruction.

Stapling

Instead of suturing the pyloroplasty incision as described above, apply Allis clamps to the incision, approximating the tissues in eversion, mucosa to mucosa. Then apply a 55/4.8 mm linear stapling device to the everted tissues just deep to the line of Allis clamps (Fig. 31.8) and fire it. Excise redundant tissue with a scalpel, lightly electrocoagulate the everted mucosa, and remove the stapler. Carefully inspect the staple line to be sure satisfactory B formation has been carried out (Fig. 31.9). Control bleeding points by conservative electrocoagulation or 4-0 PG sutures. Place omentum over this stapled closure.

Finney Pyloroplasty

Unlike the anterior midline gastroduodenotomy incision previously described, for the Finney pyloroplasty the gastroduodenal incision is kept close to the greater curvature side of the stomach and the pancreatic side of the proximal duodenum (Fig. 31.10) to avoid excessive tension on the anterior suture line. Ideally, the first row of sutures is placed before the incision is made.

Insert a layer of interrupted 4-0 silk Lembert sutures to approximate the greater curvature of the stomach to the superior portion of the proximal duodenum. Place these sutures

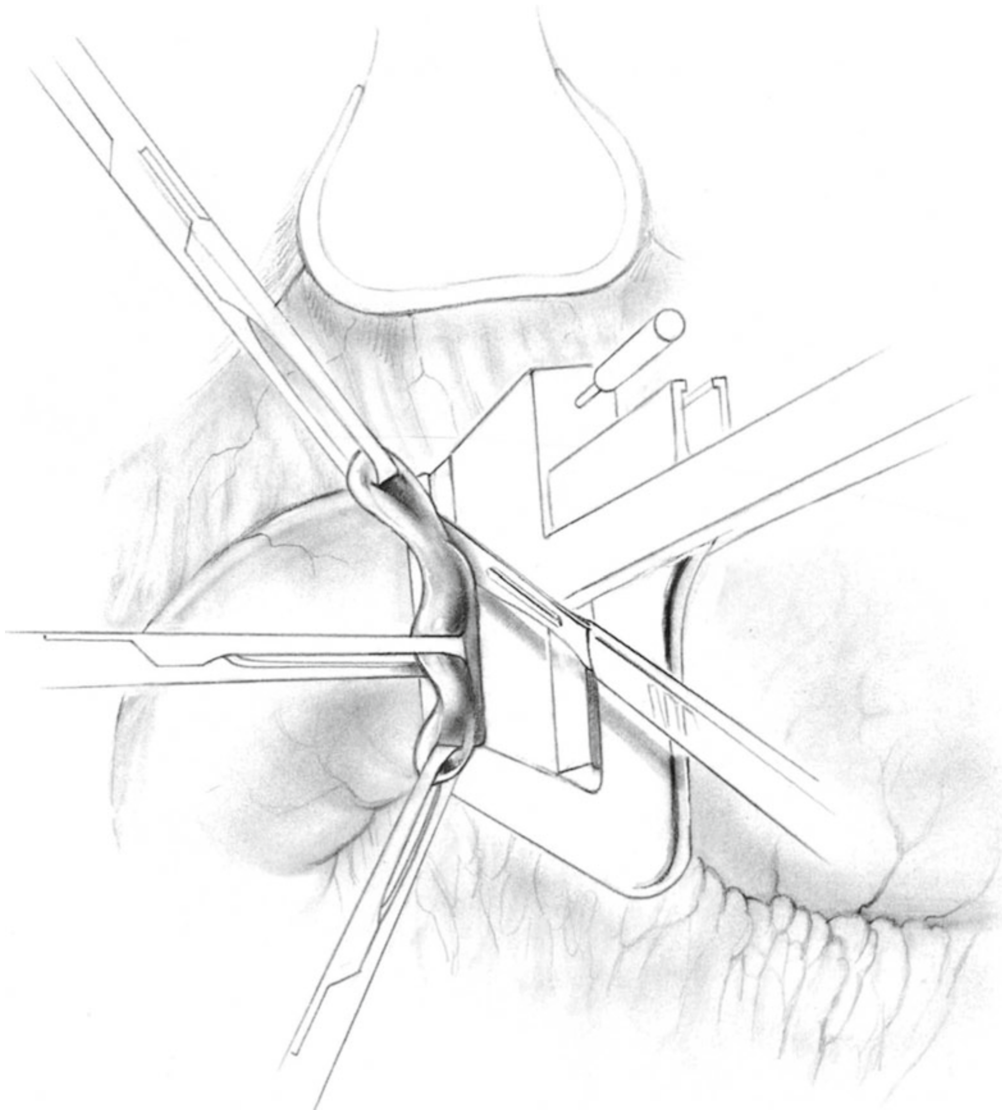


Fig. 31.8

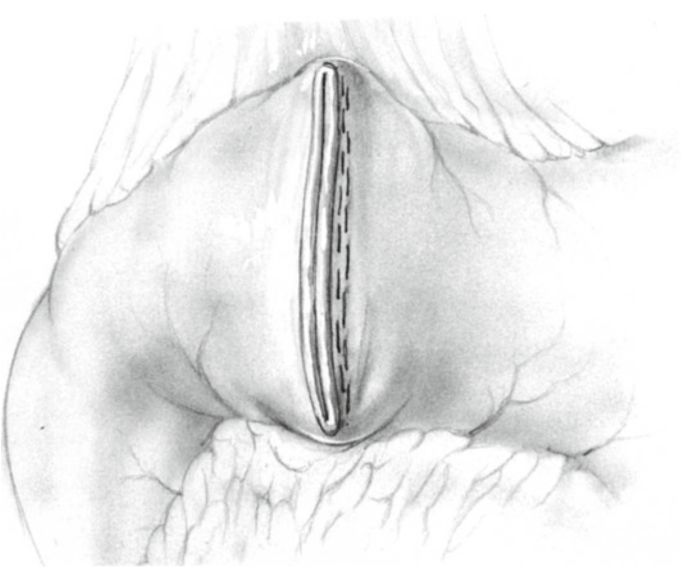


Fig. 31.9

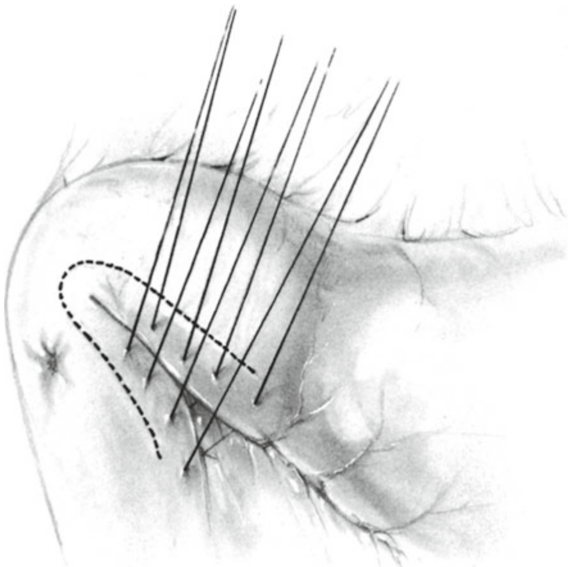


Fig. 31.10

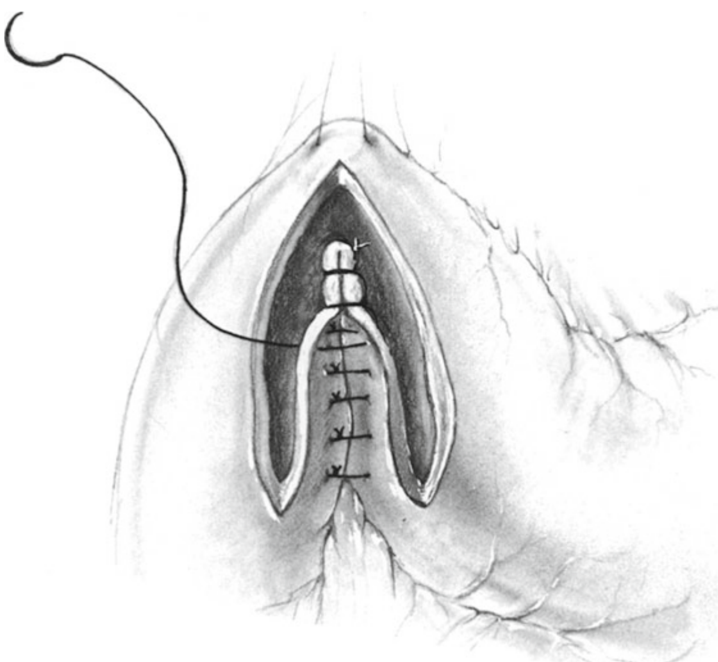


Fig. 31.11

fairly close to the greater curvature of the stomach and to the junction of the duodenum and pancreas. Continue this suture line for a distance of 5–6 cm from the pylorus (Fig. 31.10).

When the sutures have been tied, make an inverted U-shaped incision along a line 5–6 mm superficial to the suture line (Fig. 31.10). Carry this incision through the full

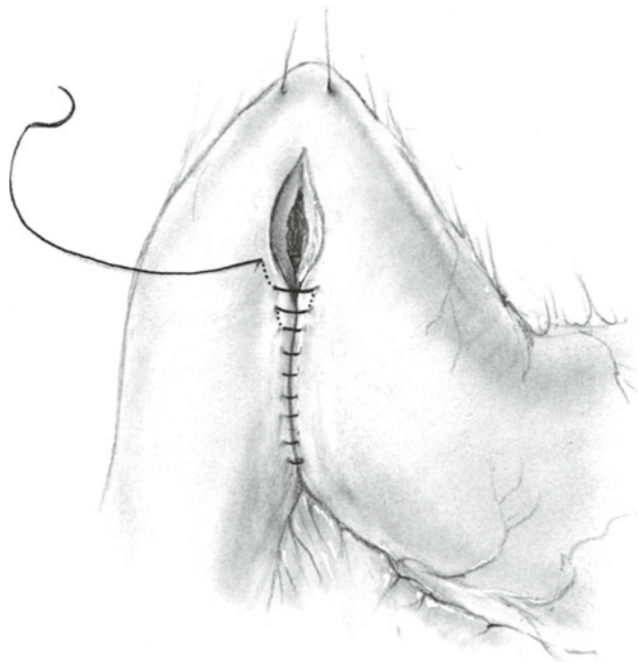


Fig. 31.12

thickness of the pyloric sphincter. After the incision has been made, the mucosal surface of both the gastric antrum and duodenum can easily be seen.

Begin the mucosal suture at the inferior surface of the divided pyloric sphincter. Pass a needle armed with 3-0 atraumatic PG through the full thickness of stomach and duodenum at the pyloric sphincter and tie it (Fig. 31.11). Continue the suture in a caudal direction as a continuous locked stitch until the lowermost portion of the incision is reached. Then pass the needle from inside out on the stomach side. Approximate the anterior mucosal layer by means of a continuous Connell or Cushing suture (Fig. 31.12), which should be terminated when the cephalad end of the incision is reached. Close the anterior seromuscular layer by means of interrupted 4-0 silk Lembert sutures (Fig. 31.13). At the conclusion the lumen should admit two fingers.

Postoperative Care

Administer nasogastric suction for 1–3 days.

Complications

Complications following this operation are rare, although delayed gastric emptying occurs occasionally, as does suture line leakage. Dumping symptoms may occur.

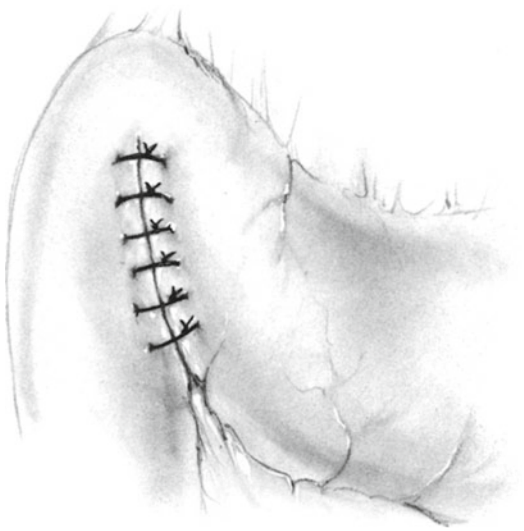


Fig. 31.13

Reversal of Pyloroplasty or Gastrojejunostomy

About 1–2 % of patients who have undergone truncal vagotomy and pyloroplasty or gastrojejunostomy develop severe symptoms of dumping, diarrhea, or bilious vomiting of such severity that surgical correction may be indicated. Reconstruction of the pylorus is required in rare circumstances. Martin and Kennedy described reconstruction of the pylorus in nine patients who underwent a Heineke-Mikulicz pyloroplasty and three with a Finney pyloroplasty. There was marked improvement in three-fourths of the patients whose complaints were dumping and diarrhea.

One can surgically reverse a pyloroplasty by reopening the transverse incision, identifying both cut ends of the pyloric sphincter, reapproximating the sphincter by interrupted sutures, and closing the incision in a longitudinal direction, thereby restoring normal anatomy.

Further Reading

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Gastrojejunostomy

32

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Gastrojejunostomy is performed for duodenal or gastric outlet obstruction when other procedures such as resection or endoscopic stenting are not possible.

Preoperative Preparation

See Chap. 28.

Pitfalls and Danger Points

Postoperative gastric bleeding
Anastomotic obstruction
Functional outlet obstruction

Operative Strategy

Traditionally, gastrojejunal anastomoses have been placed on the posterior wall of the antrum to improve drainage. However, posterior drainage is dependent drainage only when the patient is lying in bed flat on his or her back, and it is questionable whether the average patient spends enough hours in this position to warrant the additional difficulty of placing the gastrojejunostomy in a posterior location. We prefer to perform an anterior gastrojejunostomy along the greater curvature of the antrum, situated no more than 5–7 cm from the pylorus. Unfortunately, emptying problems (function obstruction) are common and there are no sure ways to prevent this complication.

Documentation Basics

Findings
Vagotomy?

Operative Technique

Incision

Make a midline incision from the xiphoid to the umbilicus.

Freeing the Greater Curvature

Beginning at a point about 5 cm proximal to the pylorus, double clamp, divide, and individually ligate the branches of the gastroepiploic vessels on the greater curvature of the stomach, separating the greater omentum from the greater curvature of the stomach for a distance of 6–8 cm.

Gastrojejunal Anastomosis: Suture Technique

Identify the ligament of Treitz and pass the jejunum in an antecolic fashion, so that the bowel runs from the patient's left to right. Make a 5 cm longitudinal scratch mark with the back of a scalpel blade on the antimesenteric border of the jejunum, beginning at a point no more than 12–15 cm from the ligament of Treitz. This point marks the eventual incision into the jejunum for the anastomosis.

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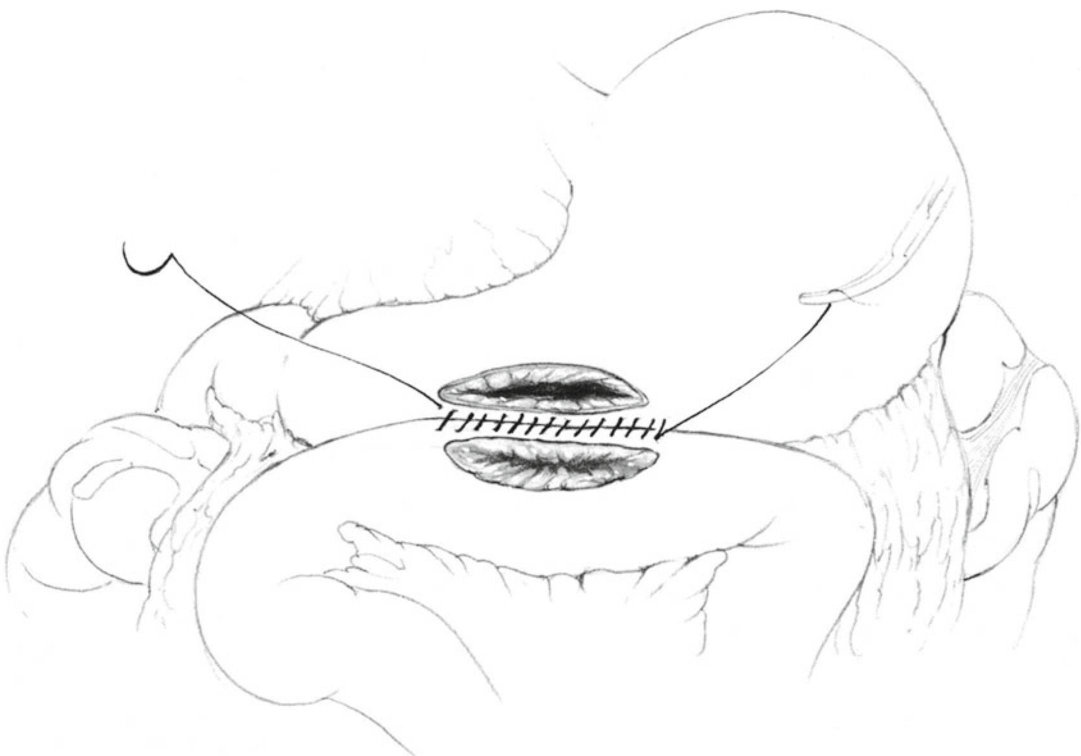
Because of the large size of the anastomosis, a continuous suture technique is satisfactory. After freeing a 6 cm segment of the greater curvature from the omentum, initiate (close to the greater curve) a continuous Lembert suture of atraumatic 3-0 PG on the left side of the anastomosis and approximate the seromuscular coats of the stomach and jejunum for a distance of about 5 cm (Fig. 32.1). Lock the last posterior Lembert suture. Then make incisions, 5 cm long, on the antimesenteric border of the jejunum and along the greater curvature of the stomach. Begin approximating the posterior mucosal layer at the midpoint of the incision using a double-armed suture of 3-0 PG. Insert and tie the first suture.

Fig. 32.1



a

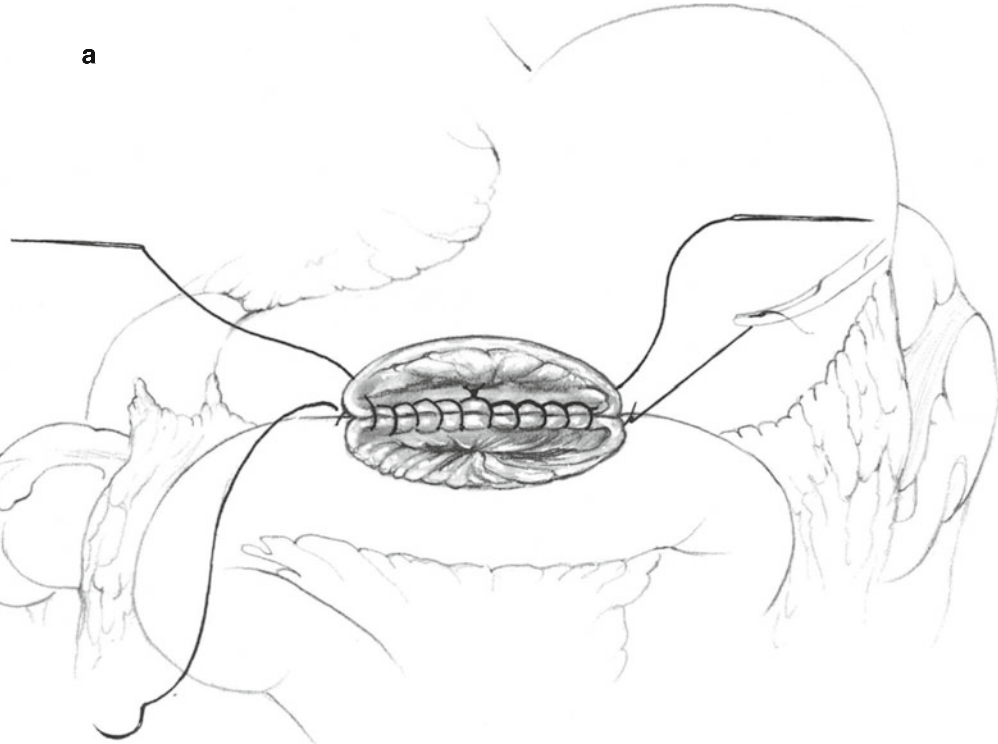
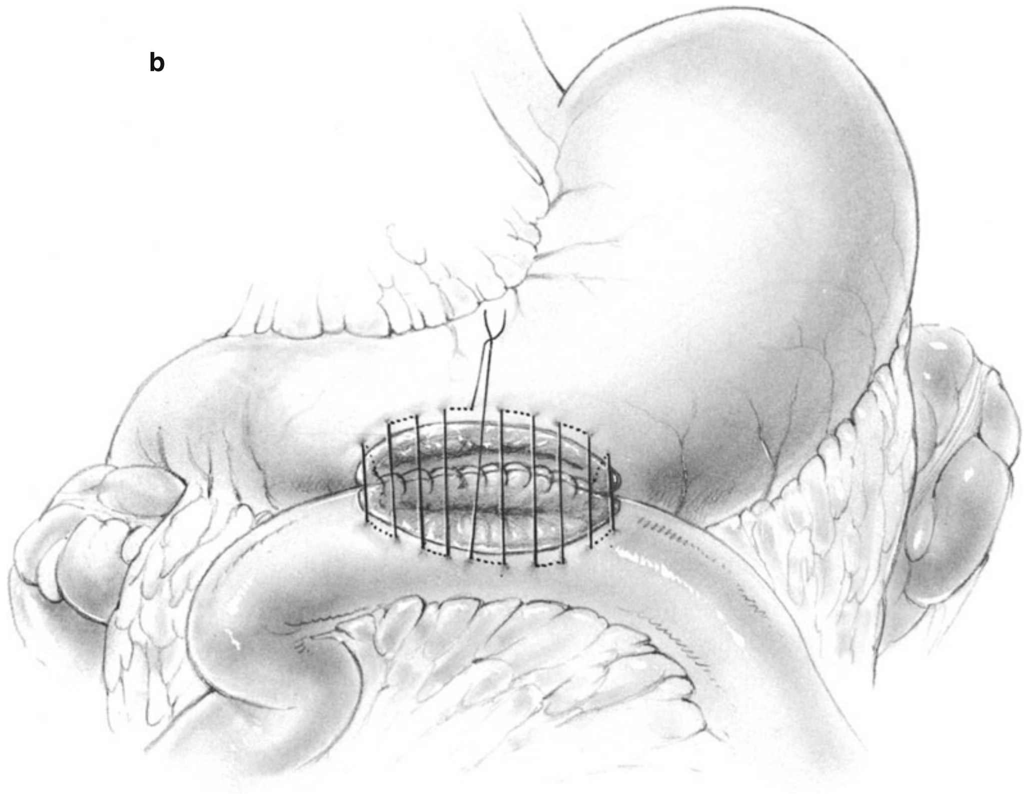


Fig. 32.2

Fig. 32.2 (continued)

b



Continue the suture toward the patient's left as a continuous locked suture, penetrating both mucosal and seromuscular coats. Terminate it at the left lateral margin of the incision. At this time, with the second needle initiate a similar type stitch from the midpoint to the right lateral margin of the incision (Fig. 32.2a). Approximate the anterior mucosal layer by means of a continuous Connell or continuous Cushing-type stitch. The two sutures should meet anteriorly near the midline and be tied to each other (Fig. 32.2b).

Close the anterior seromuscular layer with the same curved needle utilized for the posterior layer. It should progress as a continuous Lembert suture (Fig. 32.3) from the right lateral margin of the anastomosis toward the left lateral margin. Terminate the suture by tying it to itself (Fig. 32.4). The anastomosis should admit two fingers.

Stapling Technique

Identify the proximal jejunum and bring it to an antecolic position as described above. With electrocautery make a stab wound on the antimesenteric side of jejunum at a point 12–15 cm from the ligament of Treitz. Make a second stab wound along the greater curvature of the stomach at a point about 10 cm from the pylorus. Insert one fork of the cutting linear stapling device into the jejunum and one fork into the stomach (Fig. 32.5). Align the jejunum so its antimesenteric border is parallel to the fork of the stapler and lock the device. Check the proposed gastrojejunal staple line to ensure that the forks of the stapler include no tissue other than stomach and jejunum. Fire the stapler and remove it.

Apply Allis clamps to the anterior and posterior terminations of the staple line. Inspect the staple line carefully for bleeding, and control any bleeding point by cautious electrocoagulation or insertion of 4-0 PG atraumatic suture ligatures.

Closure of Stab Wound

Approximate the remaining defect in the anastomosis in an everting fashion by applying several Allis clamps. Apply a 55 mm linear stapler deep to the Allis clamps. If the gastric wall is of average thickness, use 3.5 mm staples; otherwise a larger size is necessary. Fire the stapler and excise the redundant tissue with Mayo scissors. Lightly electrocoagulate the everted mucosa and remove the stapling device. The lumen should admit two fingers without difficulty. Place a 4-0 seromuscular Lembert suture to fix the stomach to the jejunum on the right lateral margin of the newly stapled anastomosis (Fig. 32.6).

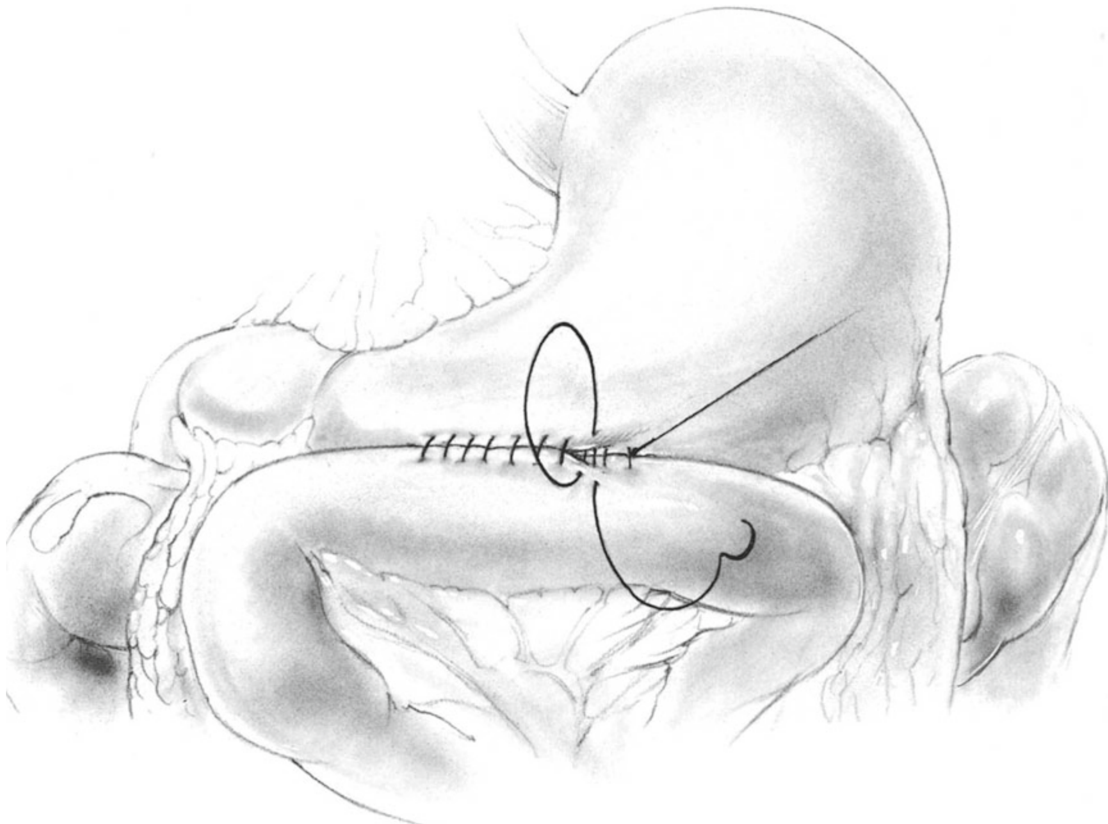


Fig. 32.3

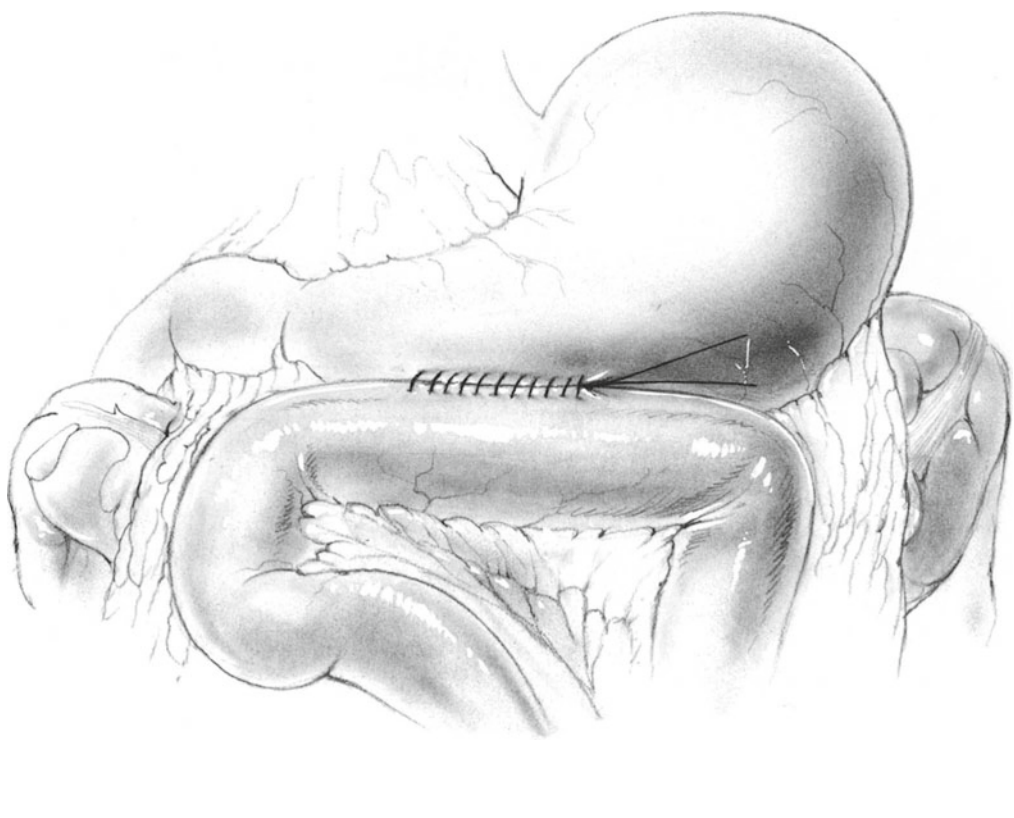


Fig. 32.4

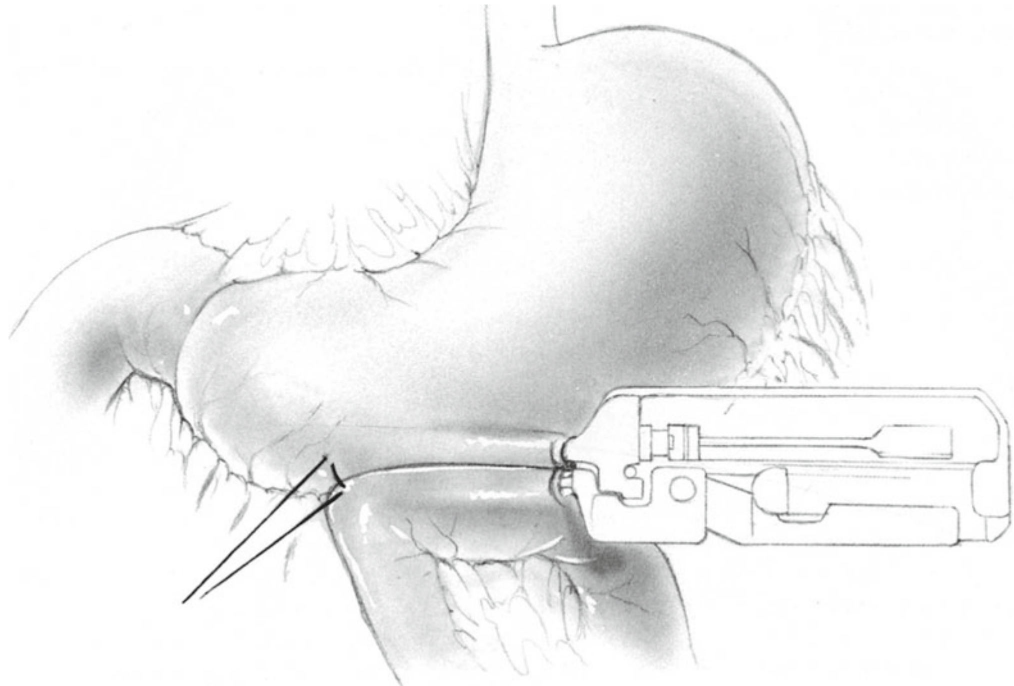


Fig. 32.5

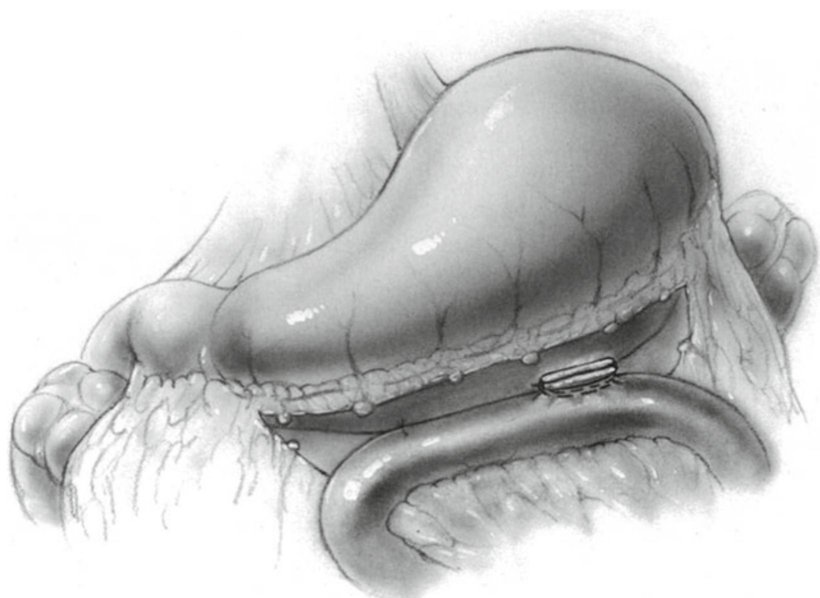


Fig. 32.6

Postoperative Care

Administer nasogastric suction for 1–3 days.

Complications

Gastric bleeding is a rare complication, occurring in 1–2 % of cases. *Anastomotic leakage and obstruction* are even less common than gastric bleeding. At times an apparently satisfactory gastrojejunostomy is anatomically patent but *fails to empty* well.

Further Reading

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Partial Gastrectomy Without Lymphadenectomy

33

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

See Chap. 28.

Preoperative Preparation

See Chap. 28.

Pitfalls and Danger Points

Inadequate duodenal stump closure
Trauma to pancreas resulting in postoperative acute pancreatitis
Incomplete removal of distal antrum (if done for control of acid peptic disease)
Splenic trauma
Injury to common bile duct or ampulla of Vater during ulcer dissection
Inadequate lumen in gastroduodenal anastomosis (Billroth I) with postoperative obstruction
Inadvertent gastroileostomy (Billroth II)
Excessive length of afferent limb (Billroth II)

Operative Strategy

Choice of Reconstruction

There are three basic ways to reconstruct the upper gastrointestinal tract after partial gastrectomy: Billroth I, Billroth II, and roux-en-Y. Although each reconstruction has its proponents, it has been difficult to demonstrate convincing evidence of the superiority of one method over the other. Successful completion of a Billroth I reconstruction requires pliable duodenum that can be brought to the gastric remnant without tension. The Billroth II reconstruction avoids tension by creating a duodenal stump and an end-to-side gastrojejunostomy. The Roux-en-Y diverts bile from the gastric remnant and avoids the potential problem of bile reflux gastritis, but does not always open well. This chapter shows Billroth I and Billroth II reconstructions.

Billroth II: Duodenal Stump

Most of the serious postoperative complications of gastric surgery involve failure of the duodenal stump closure. This leads to disruption and duodenal fistula or trauma to the pancreas, which results in acute pancreatitis. Because these complications result from persistent efforts to dissect the duodenum away from the pancreas when there is advanced fibrosis surrounding a penetrating duodenal ulcer, the simplest means to prevent trouble is for the surgeon to become aware early in the operation that the duodenal dissection is fraught with danger. It is not necessary to excise the ulcer if there is pliable duodenum proximal to the ulcerated area.

When a difficult duodenum is identified early during the operation, perform either vagotomy with a drainage procedure or proximal gastric vagotomy instead of attempting resection. If as a result of poor judgment the surgeon gets into difficulty after having broken into a posterior penetrating duodenal ulcer, the Nissen technique, the Cooper modification of it, or catheter duodenostomy may prove lifesaving. A successful Nissen maneuver requires that the anterolateral wall of the duodenum be pliable and of fairly normal thickness. If this wall is shrunken and contracted with fibrosis or is acutely inflamed, it may not be suitable for inversion into the pancreas by the Nissen-Cooper method.

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Catheter Duodenostomy

If there is any doubt about the security of the duodenal stump suture line, insert a catheter into the duodenum for postoperative decompression. It provides a valuable safety valve and prevents disruption of the duodenal suture line in most instances.

Marginal Ulcer Following Billroth II

Among the causes of postoperative marginal ulcer is erroneous transection of the antrum proximal to the pylorus, leaving antral mucosa in contact with the alkaline bilious secretions. Although an error of this type is not committed in the presence of normal anatomy, this mistake is indeed possible when the area is obscured by inflammation and fibrosis. When the landmarks of the pyloric sphincter are obscured, use frozen section biopsy to confirm the absence of antral mucosa and the presence of Brunner's glands at the cut end of the duodenal stump.

Splenic Trauma

Traction on the greater curvature of the stomach is the most common cause of splenic injury, which results in avulsion of a portion of the splenic capsule adherent to the greater omentum. If downward traction on the stomach is needed, apply it to the lesser curvature. These minor capsular avulsion injuries can generally be managed by direct pressure over a sheet of topical hemostatic agent.

Ligating the Bleeding Point in Duodenal Ulcers

The most common source of bleeding in patients who undergo emergency surgery for massive hemorrhage is a posterior duodenal ulcer eroding into the gastroduodenal artery (see Fig. 31.1). See Chap. 31 for details on proper management of this problem.

Avoiding Postoperative Wound Infection

Patients who undergo gastric resection for an ulcer in the presence of chronic obstruction or massive hemorrhage are more prone to develop postoperative wound infection than are patients who undergo elective surgery for a duodenal ulcer. Perioperative antibiotics help decrease the incidence of this complication.

Documentation Basics

- Findings
- Extent of resection
- Reconstruction

Operative Techniques: Billroth I and II

Incision

The incision should be midline, from the xiphoid to a point 5 cm below the umbilicus. Use an Upper Hand or Thompson retractor to elevate the lower margin of the sternum and a Harrington retractor to elevate the lower surface of the liver. Perform a vagotomy when indicated (see Chap. 29).

Evaluation of Duodenal Pathology

It is not easy to evaluate the potential difficulty of dissecting the posterior wall of the duodenum off the pancreas by simple inspection. Just how difficult the procedure may be is not known until the posterior dissection is initiated. Pay attention to the quality and flexibility of the anterior wall of the duodenum. If the wall is soft and maneuverable, it can be useful should a Nissen-type stump closure become necessary. A markedly fibrotic, rigid, or edematous anterior wall indicates that closing the stump will be difficult. Marked edema or scarring in the region of the pylorus, pancreas, and hepatoduodenal ligaments is a relative contraindication to gastrectomy.

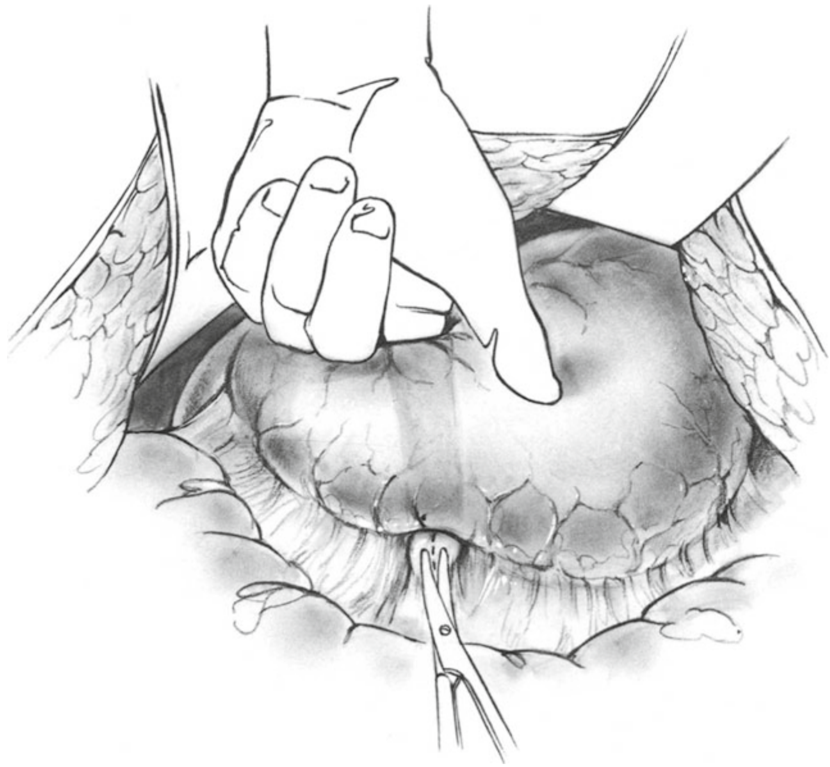
When the surgeon is uncertain of the nature of the pathology, a short incision may be made in the proximal duodenum to visualize ulcer pathology. This enables the surgeon to make a more accurate estimate of the technical expertise required to perform the resection. When in doubt, when operating for refractory ulcer disease, it is better to perform a vagotomy and drainage procedure or a proximal gastric vagotomy than a heroic duodenal dissection, as fatal duodenal leakage or acute pancreatitis may follow the dissection.

Dissection of Greater Curvature

Incise the avascular portion of the gastrohepatic ligament to the right of the lesser curvature, and pass the left hand behind the lesser curvature and antrum of the stomach, emerging deep to the gastroepiploic arcade along the greater curvature of the stomach (Fig. 33.1). This maneuver elevates the greater omentum from the underlying mesocolon, which contains the middle colic artery. Isolate the branches going from the gastroepiploic arcade to the greater curvature of the stomach, then double clamp and divide each. Continue this process up along the greater curve of the stomach until the halfway point between the pylorus and the diaphragm is reached (Fig. 33.2).

Next dissect the distal segment of the gastroepiploic arcade from the antrum. Perform the distal 4 cm of this dissection with care, as a number of fragile veins in the vicinity

Fig. 33.1



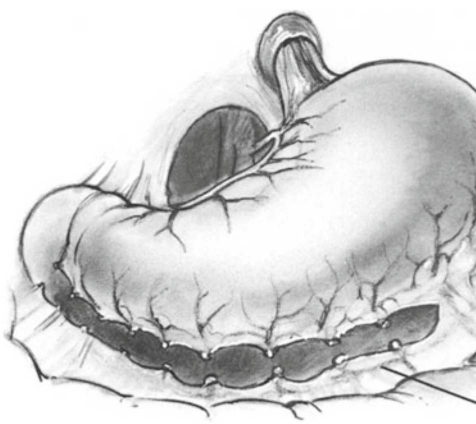


Fig. 33.2

of the origin of the right gastroepiploic vessels are easily torn. As this dissection progresses, divide the congenital avascular attachments between the back wall of the antrum and the pancreas. Completion of this dissection frees the entire distal half of the gastric greater curvature.

Division of Left Gastric Vessels

Select a point on the lesser curvature about halfway between the esophagogastric junction and the pylorus. This point serves as a reasonably good approximation of the upper margin of the antral mucosa. Insert a large hemostat between the lesser curvature and the adjacent vascular bundle, which are divided between additional hemostats. Place two ligatures, consisting of 0 silk or a double strand of 2-0 silk, on the proximal side and another on the specimen side (Fig. 33.3a, b). Preferably there is at least a 1 cm stump of left gastric artery beyond these ties. Inspect the pedicle carefully for hemostasis, as occasionally the bulky ligature permits a trickle of blood to continue through the lumen of the artery. Several additional small venous branches to the lesser curvature may require individual ties, as they are easily torn during insertion of these mass ligatures.

Division of Stomach

If vagotomy is adequate, no more than 50 % of the stomach need be removed (Fig. 33.4). This is accomplished by applying Allen clamps for a distance of 3–4 cm at an angle of 90° to the greater curvature of the stomach. The amount of stomach in the Allen clamp should equal the width of the gastrojejunal or gastroduodenal anastomosis to be performed in a subsequent step.

After the gastric wall has been incised midway between these two clamps, apply a 90/4.8 mm linear stapler at a somewhat cephalad angle to close the lesser curvature portion of the residual gastric pouch (Fig. 33.5). Fire the stapler. Place another Allen clamp opposite the stapler and divide the gastric tissue flush with the stapler. Lightly electrocauterize

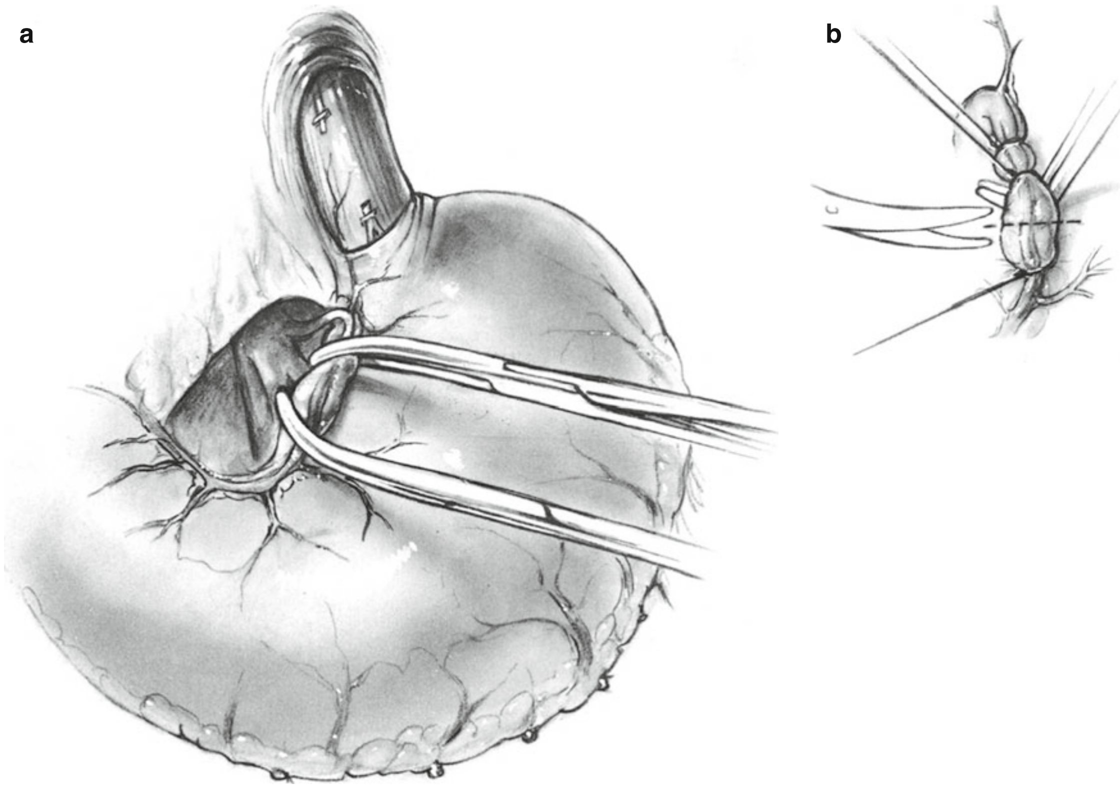


Fig. 33.3

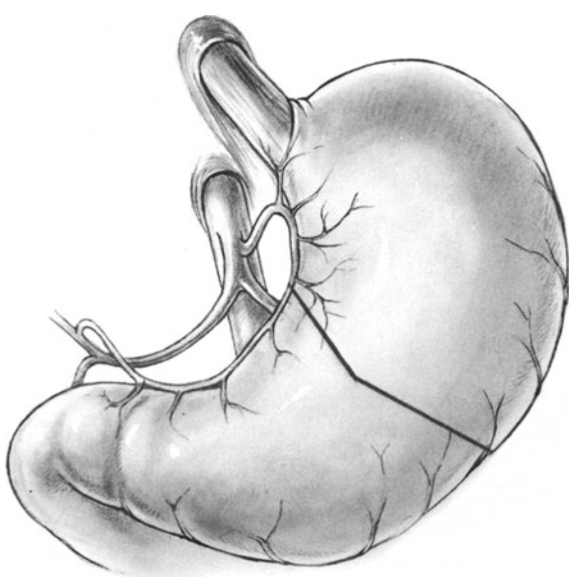


Fig. 33.4

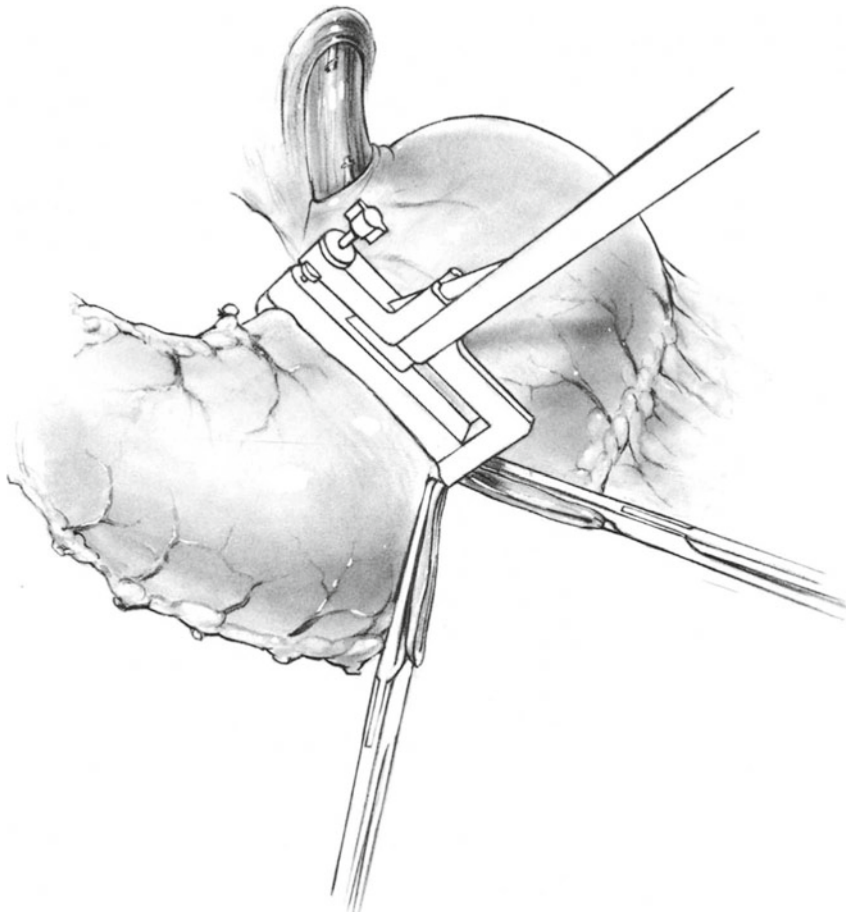
the gastric mucosa before removing the stapling device (Fig. 33.6a). Invert the stapled portion of the gastric pouch using a layer of interrupted 4-0 silk Lembert sutures (Fig. 33.6b). Apply a gauze pad over the exposed mucosa on the specimen side and fix it in place with umbilical tape ligatures, leaving the Allen clamps in position.

When a stapling device is not used, the lesser curvature should be divided between Allen clamps (Fig. 33.7) and then closed in several layers. For the first layer use 3-0 PG on a straight intestinal needle. Initiate this suture on the lesser curvature of the gastric pouch just underneath the Allen clamp. Then pass the straight needle back and forth underneath the Allen clamp to make a basting stitch, terminating it at the base of the Allen clamp (Fig. 33.8). After trimming excess gastric tissue (Fig. 33.9), remove the Allen clamp, return the same suture to its point of origin as a continuous locked suture (Fig. 33.10), and tie it to its point of origin. This completes hemostasis of this suture line. Then invert the mucosa using one layer of interrupted 4-0 silk Lembert sutures (Fig. 33.11).

Duodenal Dissection in the Absence of Advanced Pathology

Identify, ligate, and divide the right gastric artery (Fig. 33.12). Apply traction to the specimen in an anterior direction to expose the posterior wall of the duodenum and the anterior surface of the pancreas. Five or six small blood vessels can usually be identified proceeding from the pancreas to the back wall of the duodenum. Divide each between Crile hemostats and ligate each with 3-0 or 4-0 silk. If there has

Fig. 33.5



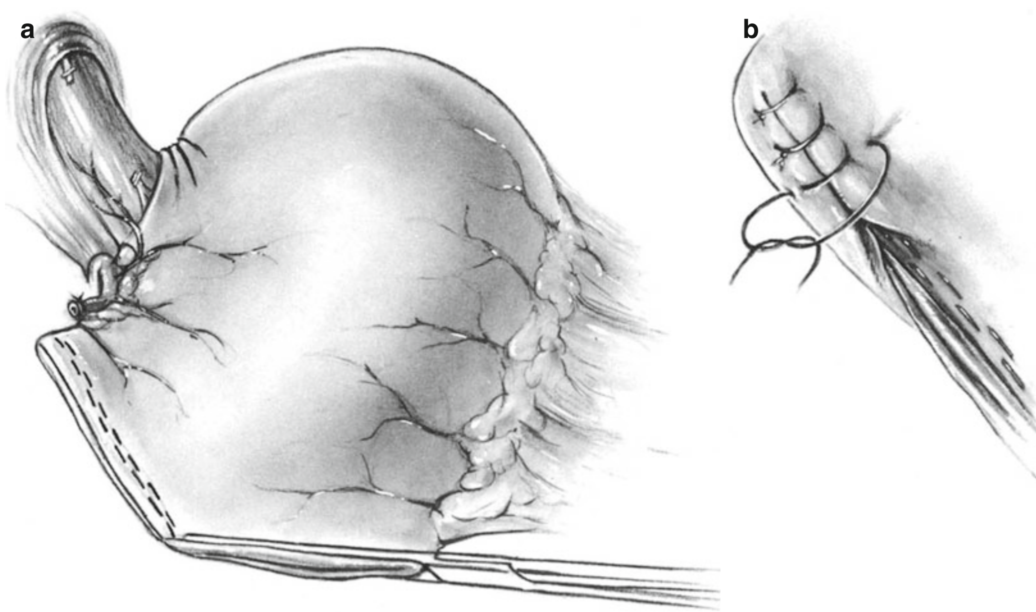


Fig. 33.6

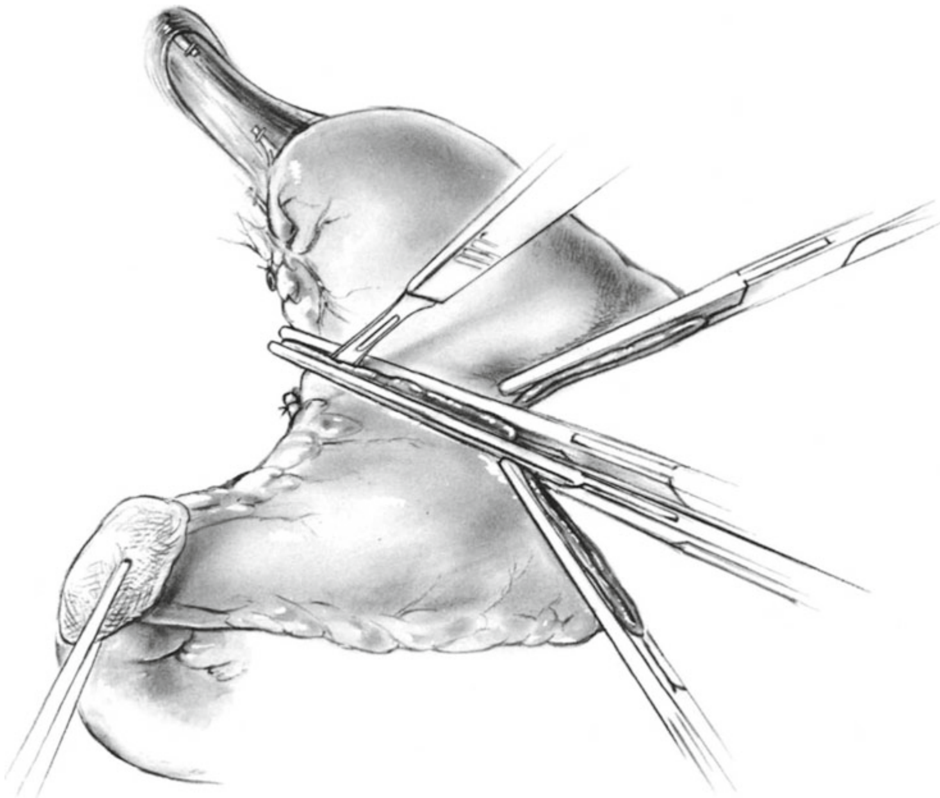


Fig. 33.7

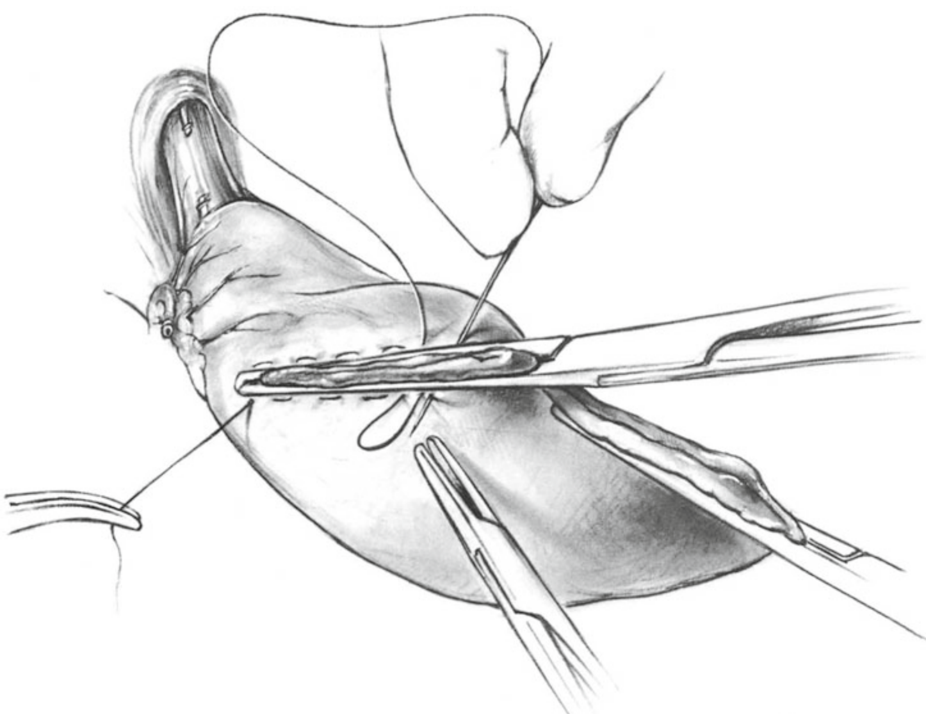


Fig. 33.8

been some scarring in this area, the stump of a small artery may retract into the substance of the pancreas. In this case, control the bleeding with a mattress suture of 4-0 silk. No more than 1.5 cm of the posterior duodenal wall should be freed from the underlying pancreas, as this amount is adequate for turning in the duodenal stump or for gastroduodenal end-to-end anastomosis. Keep the dissection in a plane close to the posterior wall of the duodenum.

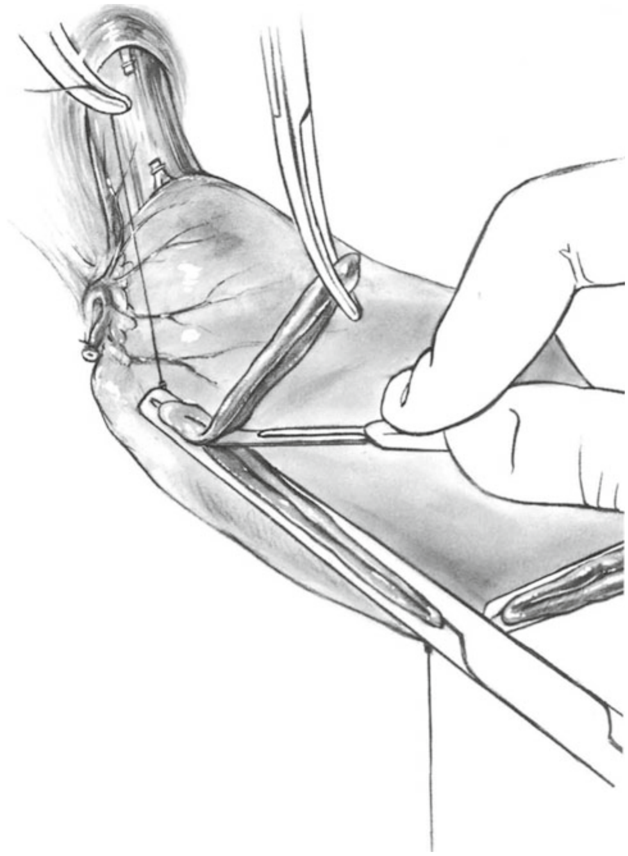


Fig. 33.9

Division of Duodenum

Apply an Allen clamp immediately distal to the pylorus, and transect the duodenum flush with the clamp, which should be left on the specimen (Fig. 33.13). Before discarding the specimen, remove the clamp and inspect the distal end of the specimen to ascertain that a rim of duodenal mucosa has been removed. This ensures that there is no remaining antral mucosa left behind in the duodenal stump. If there is still a question, the presence or absence of the antrum should be confirmed by frozen section examination of the distal end of the specimen.

Insert an index finger into the duodenal stump to check the location of the ampulla of Vater. The ampulla is situated on the posteromedial aspect of the descending duodenum at a point approximately 7 cm behind the pylorus. Occasionally, the orifice of the duct of Santorini can be palpated along the back wall of the duodenum. If the duodenal dissection has not continued beyond the gastroduodenal artery, there need be no concern about damage to the duct of Santorini or the main pancreatic duct. When the dissection continues beyond this point, special attention must be paid to these structures. If the duct of Santorini is divided, close the open duct with a fine nonabsorbable suture ligature. If the ampulla has been divided inadvertently and is separated from the duodenum, replant it into the duodenal stump or into a Roux-en-Y segment of the jejunum.

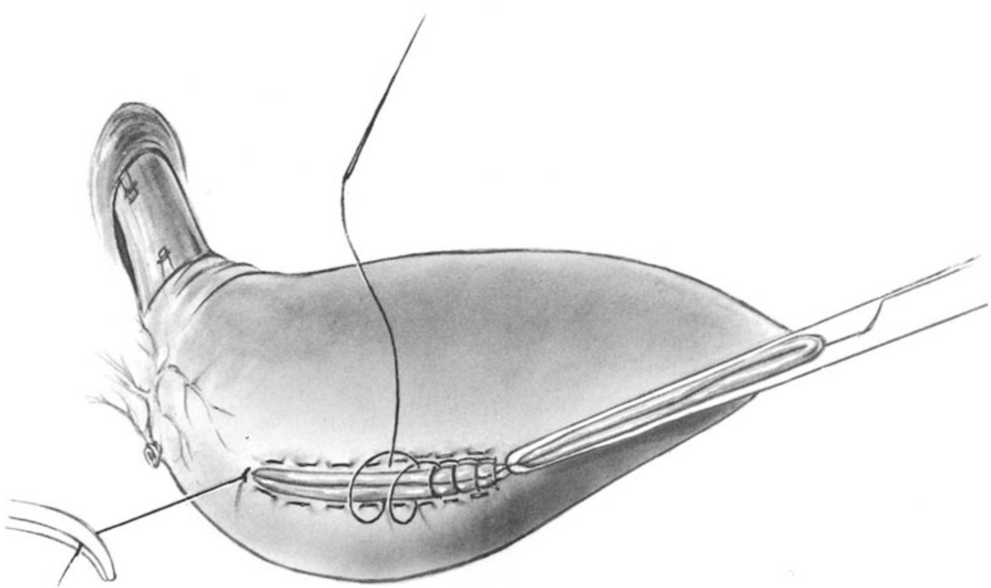
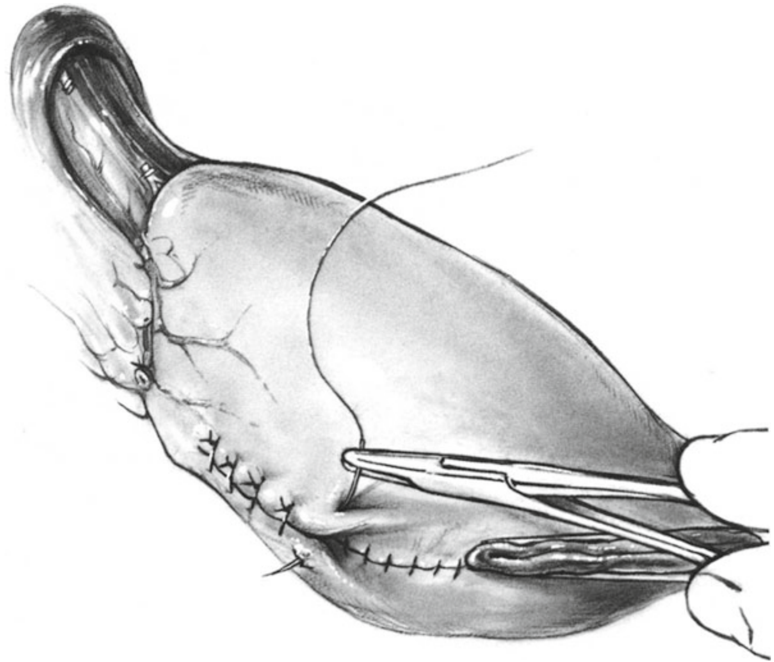


Fig. 33.10

Fig. 33.11



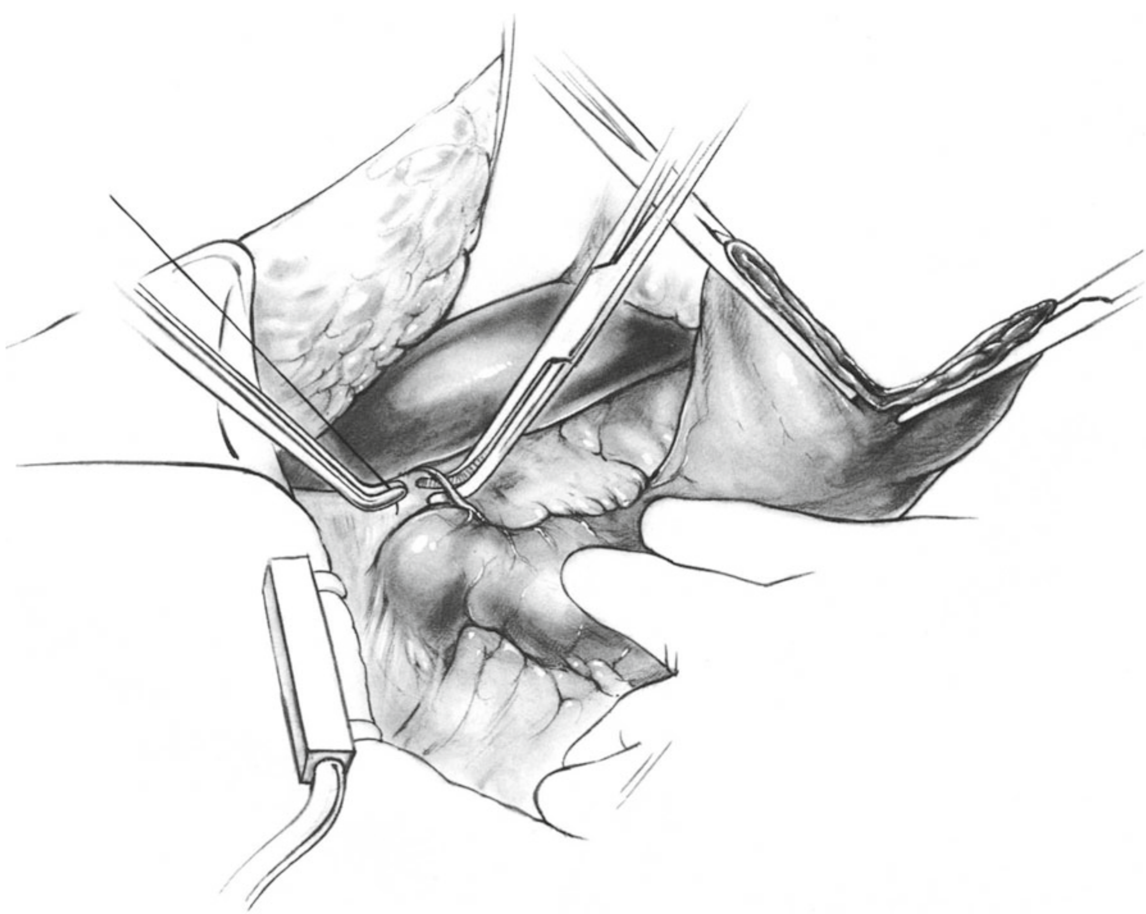


Fig. 33.12

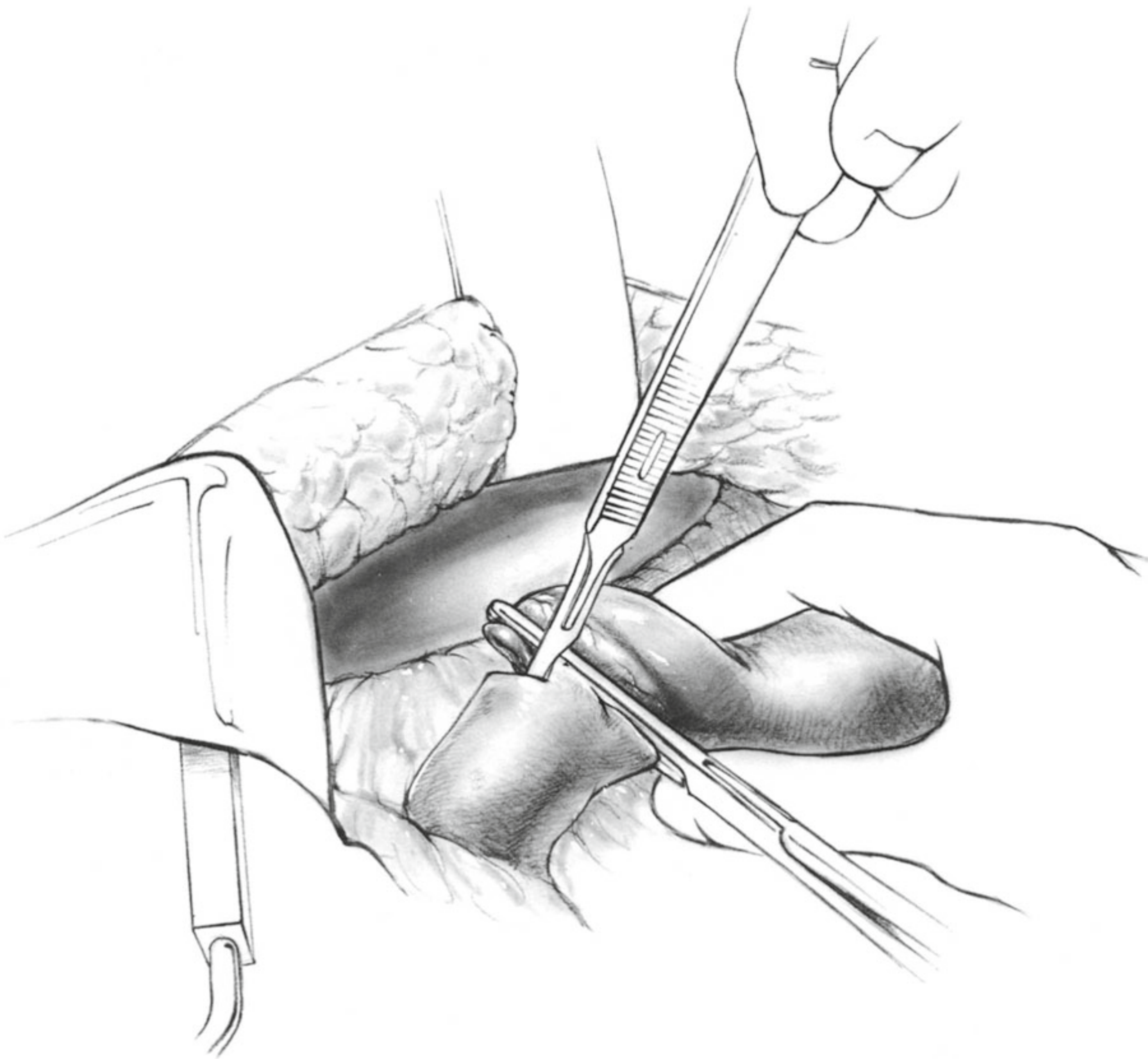


Fig. 33.13

Billroth I Gastroduodenal Anastomosis

When at least 1 cm of healthy posterior duodenal wall is available, a routine gastroduodenal anastomosis is constructed. The Allen clamp previously applied to the unsutured portion of the gastric pouch should contain a width of stomach approximately equal to the diameter of the duodenal stump. Insert the corner sutures by the Cushing technique. Complete the remainder of the posterior layer with interrupted 4-0 silk seromuscular Lembert sutures (Fig. 33.14). To prevent postoperative obstruction, take care not to invert an excessive amount of tissue.

Remove the Allen clamp and approximate the mucosal layer using a double-armed 4-0 PG suture, initiating it at the midpoint of the posterior layer where the knot is tied (Fig. 33.15). Take small bites as a continuous locked suture is inserted (Fig. 33.16). Control any bleeding points by absorbable suture ligature or electrocautery. Approximate the anterior mucosal layer with a continuous Connell or Cushing suture, which should be terminated at the midpoint of the anterior layer (Fig. 33.17). Reinforce this suture line by a seromuscular layer of interrupted 4-0 silk Lembert sutures (Fig. 33.18). At the "angle of sorrow," where the Hofmeister shelf of the gastric pouch meets the duodenal suture line at its lateral margin, insert a crown stitch by taking seromuscular bites of the anterior wall of the gastric pouch and then of the posterior wall of the gastric pouch, returning to catch the wall on the duodenal side (Fig. 33.19). If the sutures have been properly inserted, the lumen should admit the tip of the surgeon's thumb. Loosely suture omentum over the anastomosis.

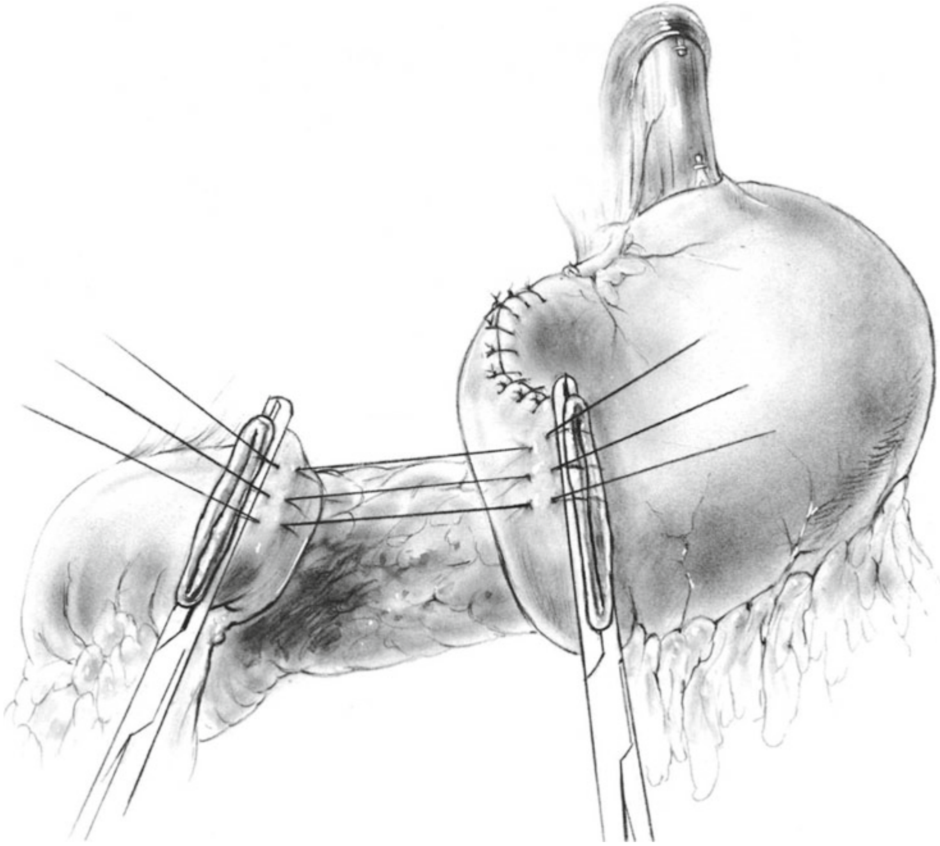


Fig. 33.14

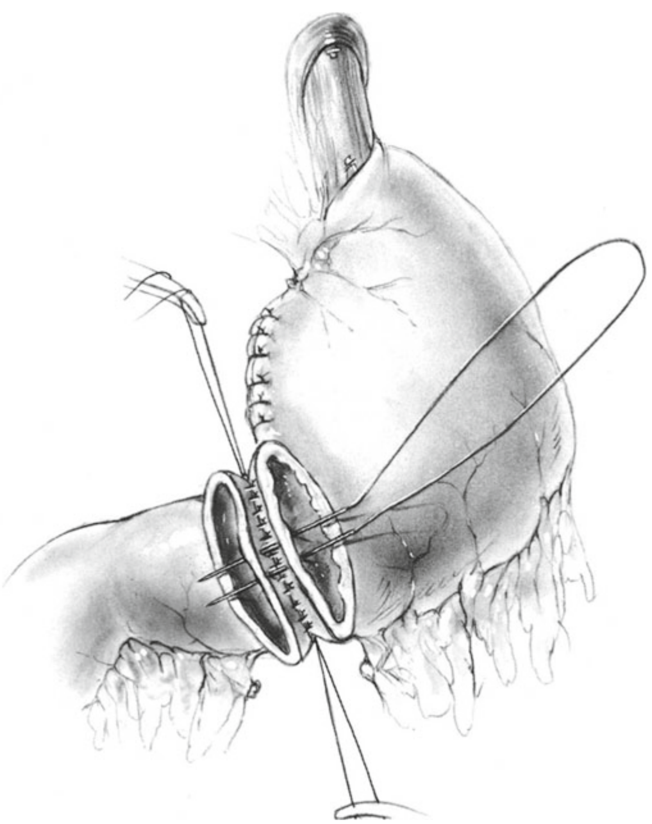


Fig. 33.15

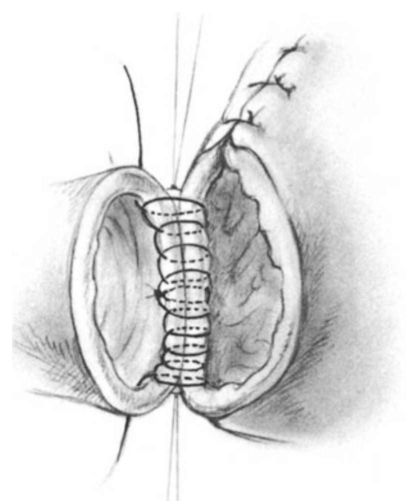


Fig. 33.16

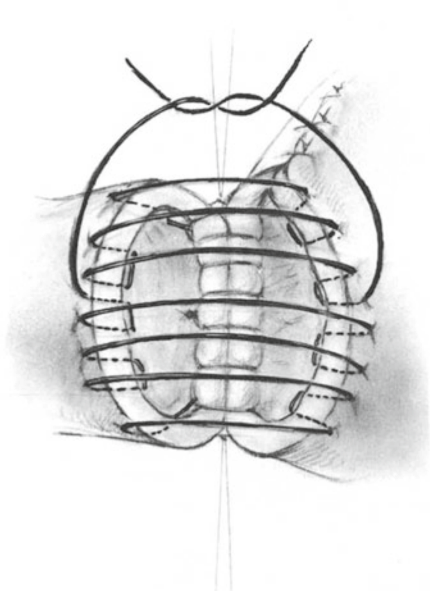


Fig. 33.17

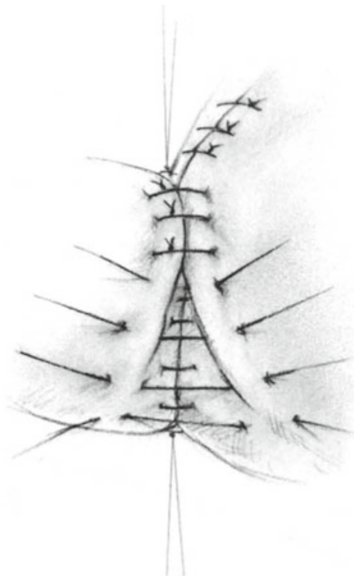


Fig. 33.18

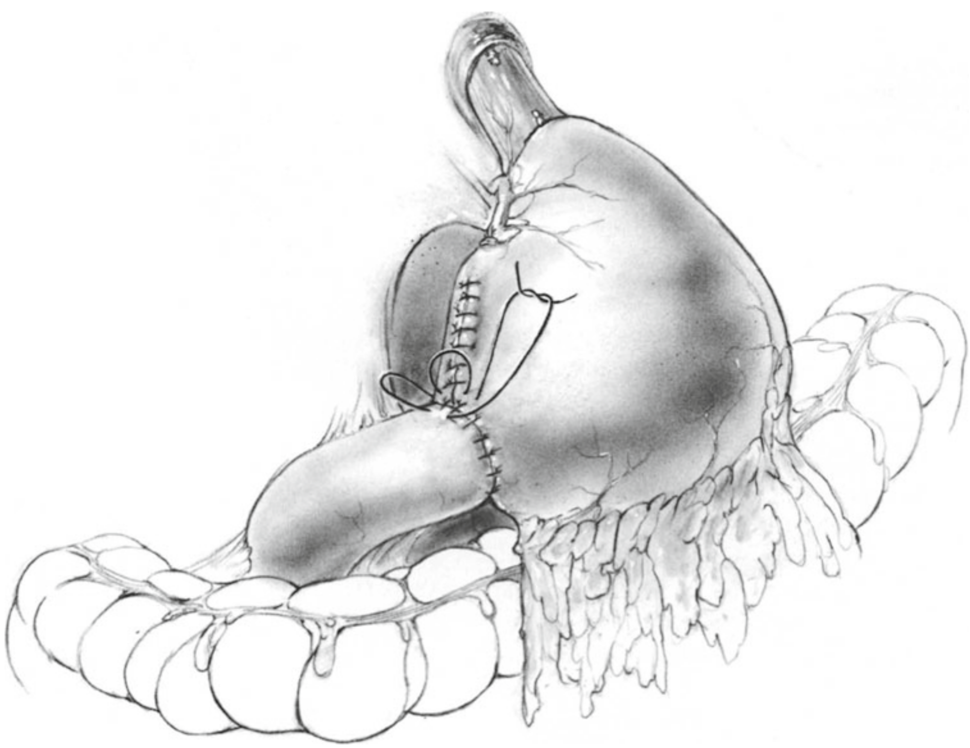


Fig. 33.19

Billroth II: Closure of Duodenal Stump

Close the healthy duodenal stump with an inverting Connell suture of 4-0 PG supplemented by a layer of interrupted 4-0 silk Lembert sutures. Initiate the Connell suture by placing a half purse-string stitch at the right lateral margin of the duodenum. Continue this strand to the middle and initiate a second strand of 4-0 PG at the left margin of the duodenal stump. Continue this also to the middle of the stump, and terminate it by tying it to the first strand (Fig. 33.20).

Though it is simple to insert a layer of interrupted Lembert seromuscular sutures as a second layer when the tissues are not thickened (Figs. 33.21 and 33.22), suturing the fibrotic duodenum requires judgment and skill. If the stitch is placed deep through the mucosa and then tied with strangulating force, a fistula may result. Once a small leak occurs, the powerful duodenal digestive juices may erode the adjacent tissue with *disastrous* results.

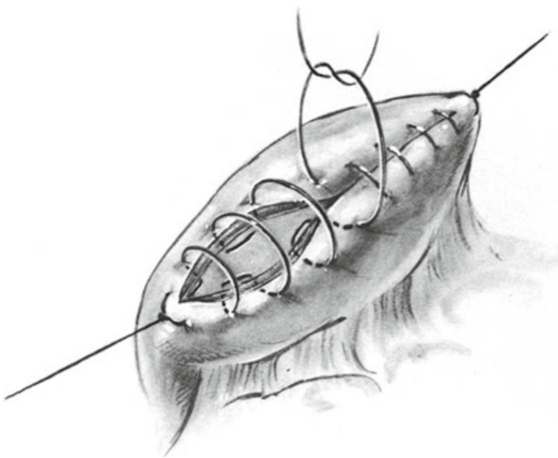


Fig. 33.20

After the Connell suture has been completed, use forceps to test the flexibility of the tissue by pushing down tentatively on the suture line. Manipulating the tissue in this manner increases the accuracy of one's judgment about the best place for the Lembert sutures. A common error is to insert the seromuscular Lembert stitch too close to the Connell suture line. If this is done with a pliable duodenum of normal thickness, no harm results. However, sewing thick, fibrotic tissue into apposition without first sufficiently inverting the Connell suture line creates a lateral shearing force that causes a small tear when the suture is tied (Fig. 33.23a). If the suture also penetrates the mucosa of the duodenum, this mishap, combined with excessive shearing force, may produce a duodenal fistula. The fistula can be prevented if the surgeon inverts the Connell suture line for a distance of 2–3 mm before placing the Lembert suture (Fig. 33.23b). If the duodenal serosa has a small tear after the Lembert suture is tied, the above error (Fig. 33.23a) was committed or the suture was tied too tightly.

Billroth II: Dissection of Difficult Duodenum

If the posterior duodenal wall and adjacent pancreas are replaced by fibrosis, a scalpel dissection, rather than scissors dissection, should be used (Fig. 33.24). It is not necessary to

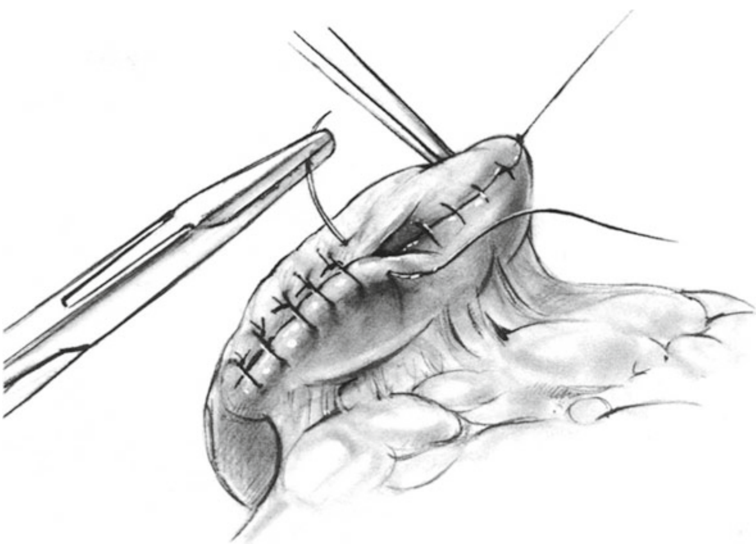


Fig. 33.21

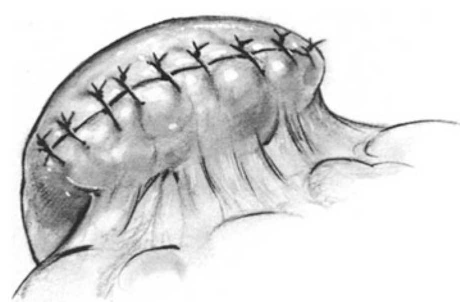


Fig. 33.22

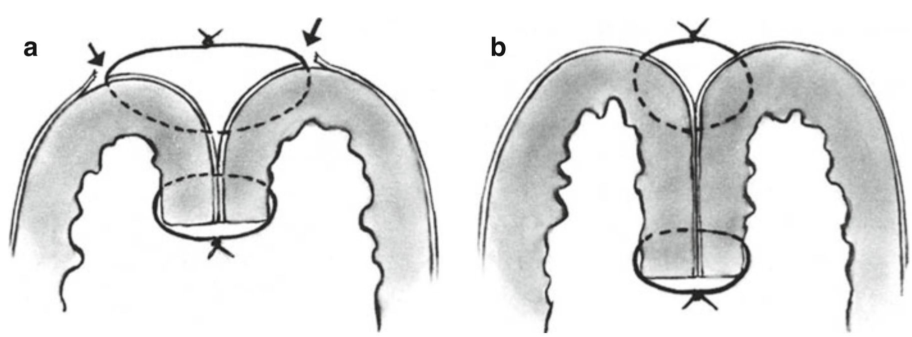


Fig. 33.23

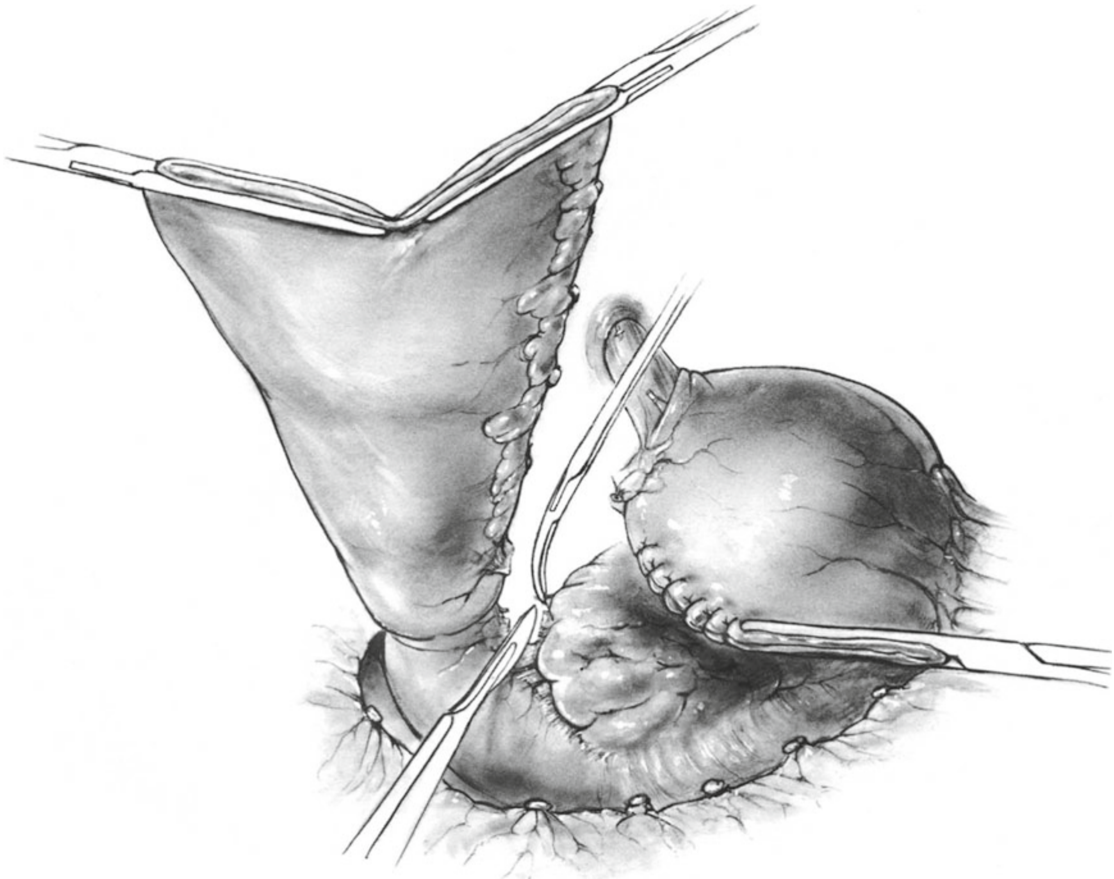


Fig. 33.24

apply hemostats when incising dense scar tissue, but it is important to keep the plane of dissection close to the posterior wall of the duodenum, thereby avoiding trauma to the pancreas. When the dissection enters the posterior duodenum at the site of the penetrating ulcer, this "window" in the duodenum should be enlarged by an incision extending proximally from the ulcer toward the pylorus. The incision permits the surgeon's index finger to be inserted into the duodenal lumen. With the finger as a guide, dissection around the borders of the ulcer may be resumed.

It is obviously not necessary to remove the *base of the ulcer* during this dissection. The base of the ulcer is really the anterior surface of the pancreas, which should not be disturbed. When the duodenum is dissected from the pancreas beyond the dense scar tissue, small hemostats may again be applied to the vessels on the pancreatic side. The vessels are then divided, and any bleeding from the duodenum, which is generally minimal in the presence of fibrosis, can be ignored. If the dissection is successful, the caudal lip of the ulcer is dissected away from the duodenum, and after a few more millimeters of dissection, the posterior duodenal wall may assume a fairly normal appearance. Liberate 1.5 cm of posterior duodenal wall. If at any point it appears that liberating the caudal lip of the ulcer is becoming dangerous, terminate the dissection and close the stump using the Nissen-Cooper technique (see below).

Another contraindication to further dissection of the caudal lip of the ulcer is proximity to the ampulla of Vater. Check this possibility by frequently palpating with the index finger in the duodenal lumen. After an adequate segment of posterior duodenum has been liberated, closure may be performed as described above (Figs. 33.20, 33.21, and 33.22).

When a posterior duodenal or pyloroduodenal penetrating ulcer involves the hepatoduodenal ligament, it may be necessary to identify the course of the common bile duct. Make an incision in the proximal common bile duct, and pass a 16F catheter or no. 4 Bakes dilator through the ampulla. Palpate this guide to confirm the position of the duct and avoid damaging it.

Closure of Difficult Stump by Nissen-Cooper Technique

When it is deemed hazardous to free the posterior duodenum beyond a callous ulcer, perform a Kocher maneuver to gain

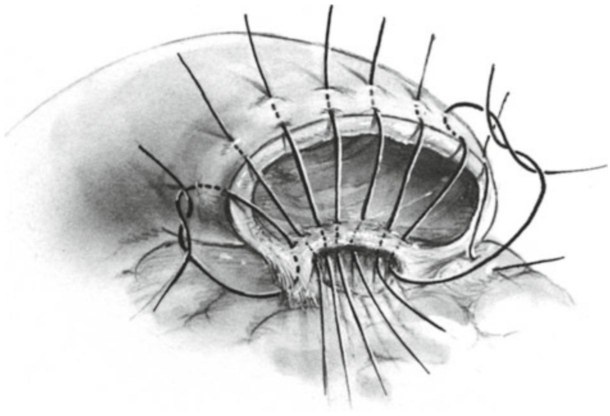


Fig. 33.25

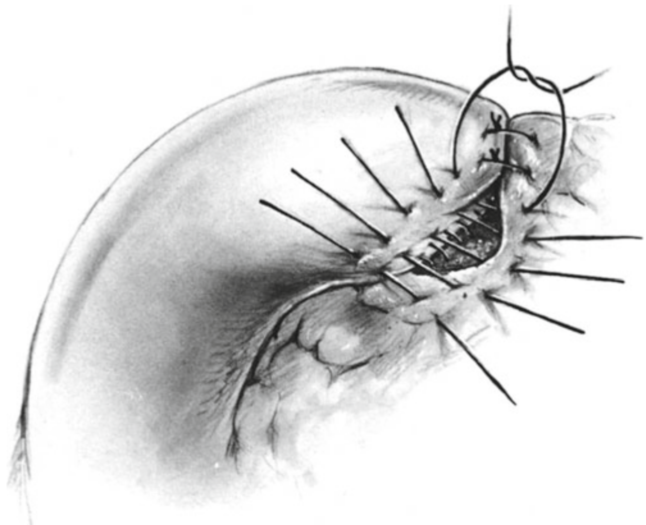


Fig. 33.26

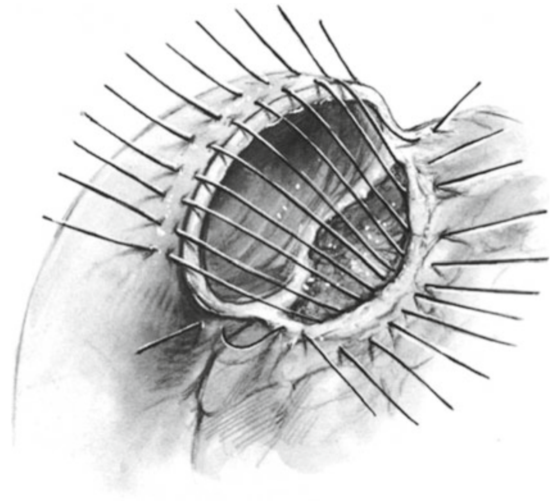


Fig. 33.27

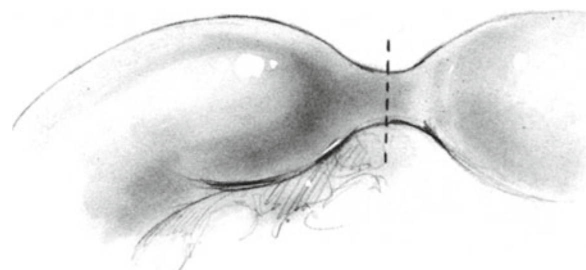


Fig. 33.28

additional mobility of the duodenum. Then accomplish closure by inserting interrupted 4-0 silk Lembert sutures to attach the free anterior and anterolateral walls of the duodenum to the distal lip of the ulcer (Fig. 33.25). Use a second layer of Lembert suture to invert the first suture line by suturing the pliable anterior wall to the proximal lip of the ulcer and to the adjacent pancreatic capsule (Fig. 33.26). Devised by Nissen and Cooper, this technique was used extensively by Harrower. A variation of it (Fig. 33.27) involves inserting the first layer of sutures to attach the free anterior wall of the duodenum to the proximal lip of a large ulcer crater. This may be reinforced by a layer of Lembert sutures between the duodenum and adjacent pancreatic capsule. It is *essential* that the anterior wall of the duodenum be soft, pliable, and long enough for use in the Nissen-Cooper maneuver without causing tension on the suture line. A Kocher maneuver must be performed to liberate the duodenum for this type of closure.

Closure of Difficult Duodenal Stump

Duodenal Stenosis

Occasionally, chronic duodenal ulcer disease produces an annular stenosis at some point in the proximal 3–4 cm of the duodenum. If there is no active bleeding, it is safe to close a healthy duodenum proximal to an ulcer. On the other hand, it is unwise to attempt inversion of the duodenal stump proximal to an area of marked stenosis. There simply is not enough room to invert the normal diameter of proximal duodenum into a stenotic segment. In such cases the duodenum should be dissected down to the point of stenosis and perhaps 1 cm beyond (Fig. 33.28). It is then a simple matter to turn in the stenosed area. Usually only three or four interrupted Lembert sutures of 4-0 silk are required for each of the two layers because of their narrow diameter (Fig. 33.29).

Catheter Duodenostomy

Catheter duodenostomy is designed to protect the integrity of a difficult duodenal stump closure. Properly performed this technique, which prevents buildup of intraluminal pressure against the newly sutured stump, has been surprisingly

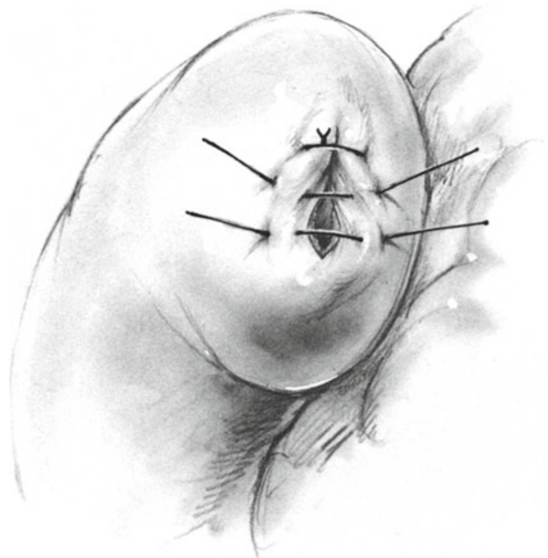


Fig. 33.29

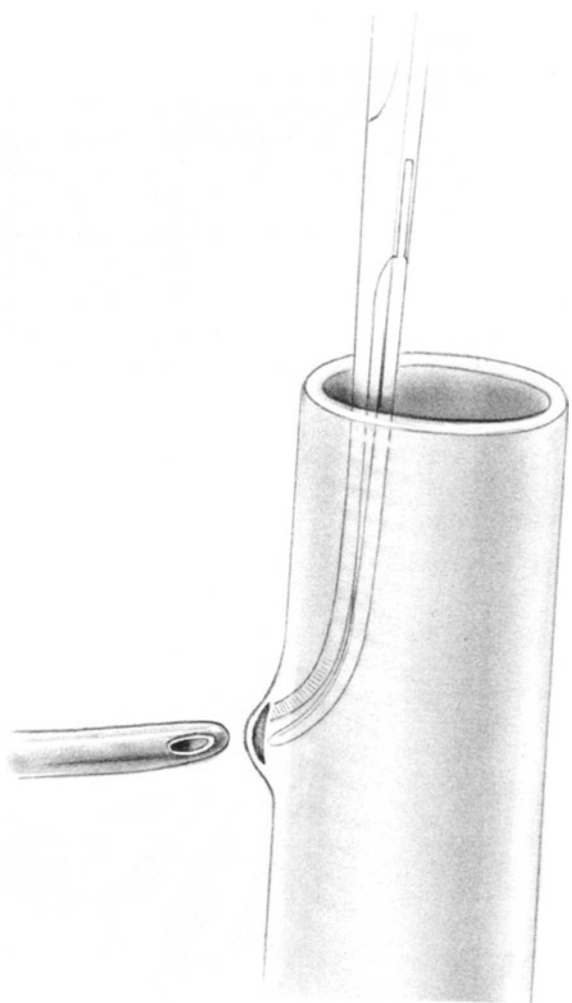


Fig. 33.30

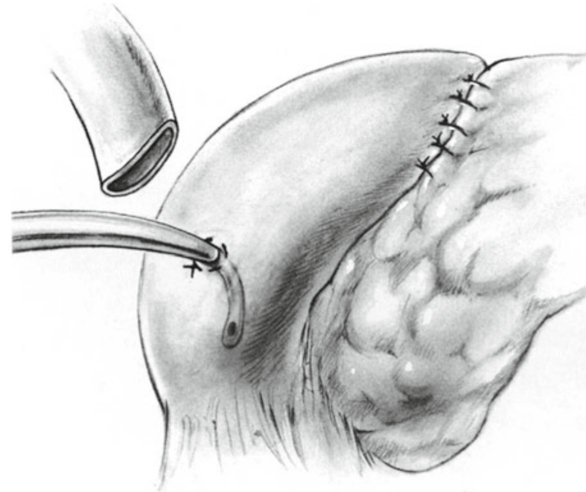


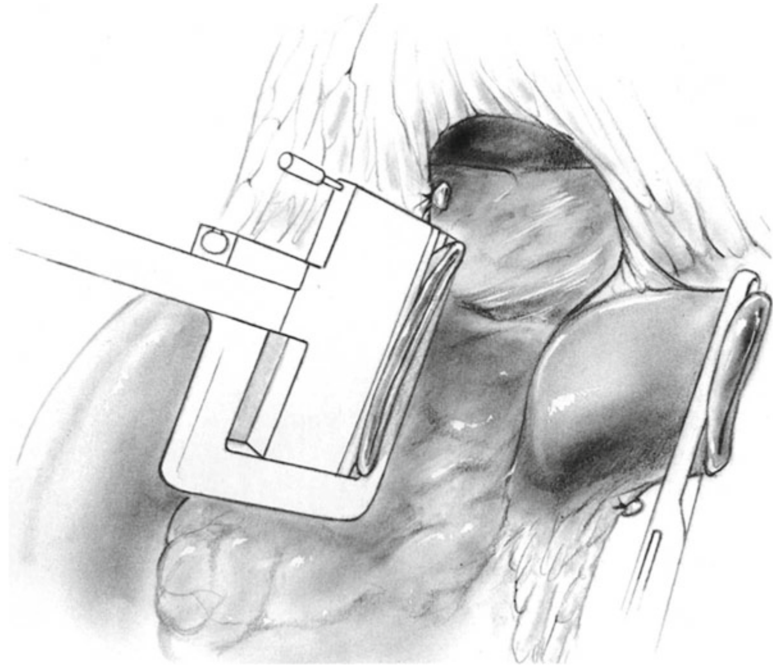
Fig. 33.31

safe. If there is doubt about the integrity of the duodenal stump suture line, place a 14F whistle-tip or Foley catheter through a tiny incision in the lateral wall of the descending duodenum. This maneuver is easier to perform before the duodenal stump is closed. Pass a right-angled (Mixter) clamp into the open duodenum, press the tip of the clamp laterally against the duodenal wall, and make a 3 mm stab wound to allow the tip of the clamp to pass through the duodenal wall. Use the Mixter clamp to grasp the tip of the catheter, and draw it into the duodenal lumen (Fig. 33.30). Close the incision around the catheter with a 4-0 silk purse-string suture. Wrap the catheter with omentum and bring it out through a stab wound in the abdominal wall, *leaving some slack* to allow for postoperative abdominal distension. Suture the catheter to the skin with heavy silk. In addition, bring a latex Penrose drain from the area of the duodenotomy out through a separate stab wound in the lateral abdominal wall (Fig. 33.31).

There may be some occasions when the surgeon finds it impossible to invert the duodenal stump, even with the techniques described earlier. This happens rarely, but if it does occur, the catheter may be placed directly in the stump of duodenum, which should be closed as well as possible around the catheter. The lateral duodenostomy is much preferred, however.

Following the operation, place the catheter on low suction until the patient passes flatus, then connect the catheter to a plastic bag for gravity drainage. Irrigate the catheter twice each day with 5 ml sterile saline. If the patient does well, remove the drain by the eighth postoperative day. Three days later partly withdraw the duodenostomy catheter so its tip lies just outside the duodenum. Apply low suction. If the volume of drainage does not exceed 100 ml per day, gradually withdraw the catheter over the next day or two.

Fig. 33.32



Duodenal Closure with Surgical Staples

If the duodenal wall is not thickened markedly with fibrosis or edema, and if an 8–10 mm width of duodenum is available, the stump may be closed safely using a 55 mm linear stapling device. Apply the stapler to the duodenal stump before dividing the specimen. After the stapler has been fired, apply an Allen clamp on the specimen side, and, with a scalpel, transect the stump flush with the stapling device (Fig. 33.32). Lightly electrocauterize the everted mucosa of the duodenal stump before removing the stapling device. There is no need to invert this closure with a layer of sutures. Experimental and clinical evidence shows that despite the eversion of duodenal mucosa seen with this closure, healing is essentially equal to that seen with the sutured duodenal stump. Generally, we cover the stapled stump with omentum or the pancreatic capsule with a few sutures, but we do not invert the mucosa.

When the duodenal wall is at all thickened, use large (4.8 mm) staples to reduce the degree of compression applied to the tissues by the stapling device. There should be blood circulation to the narrow rim of tissue that lies distal to the staple line, which generally manifests as slight oozing from the tissues despite the staples. It must again be emphasized that if the duodenal wall is so diseased it probably would not heal if closed by sutures, stapling will fail as well.

Closure of Difficult Duodenal Stump by Billroth I Gastroduodenostomy

In the hands of an expert such as Nyhus, "If one can close the duodenum, one can anastomose to it." Although it is not always necessary to liberate the distal tip of the ulcer crater, the duodenum should be dissected away from the pancreas at least to this point. The usual technique of gastroduodenal anastomosis, as described in Figs. 33.14, 33.15, 33.16, 33.17, 33.18, and 33.19, must be modified. In the region of the ulcer crater only, one posterior layer of interrupted 4-0 silk sutures should be inserted, taking a bite of stomach, underlying fibrosed pancreas, and the distal lip of the ulcer crater and duodenum, with the knot tied inside the lumen (Fig. 33.33). If the ulcer crater is so deep, the posterior anastomotic suture line cannot be buttressed by the underlying pancreatic bed of the ulcer; use of this technique may be hazardous. Because surgery for duodenal ulcer declined during the 1990s, fewer surgeons have had the opportunity to develop experience and judgment in managing the difficult duodenum. It is not wise for the inexperienced surgeon to perform a Billroth I anastomosis unless the above precautions are followed.

Billroth II Gastrojejunal Anastomosis

Although there are many variations of the technique for constructing Billroth II anastomoses, we have preferred a short-loop antecolic anastomosis of the Schoemaker-Hofmeister type. It does not seem to matter whether the afferent segment of the jejunum is attached to the greater curvature of the gastric pouch or to the lesser curvature. The distance from the ligament of Treitz to the gastric pouch should be no more than 12–15 cm. The major portions of the transverse colon and omentum should be brought to the patient's right for the antecolic anastomosis.

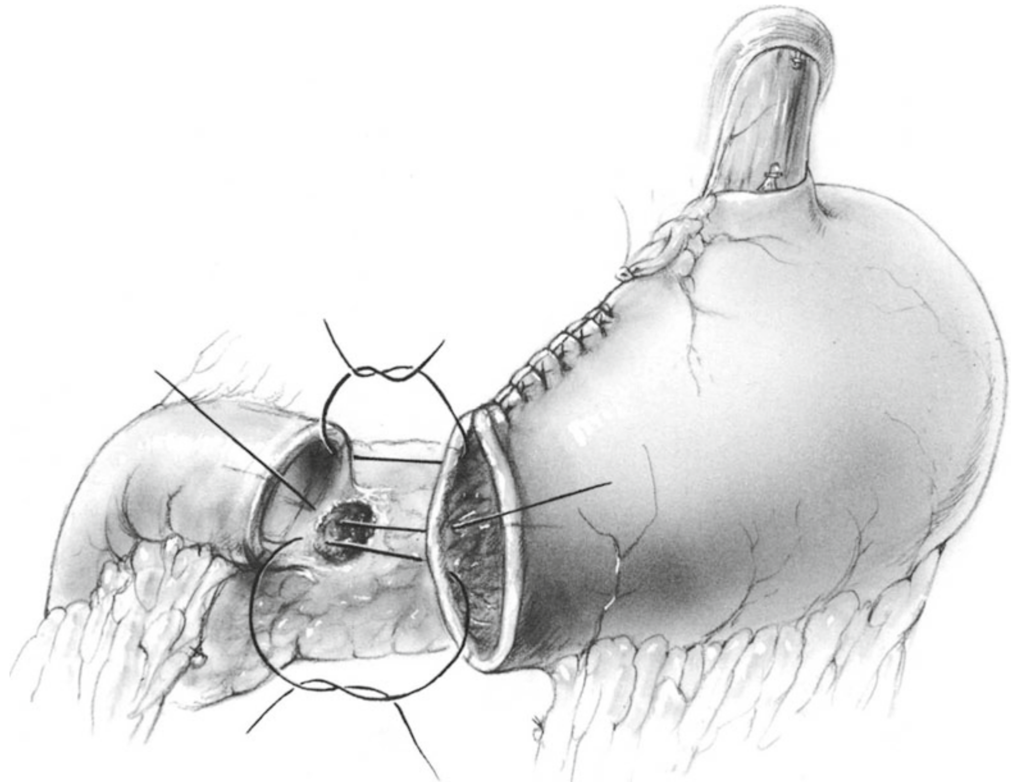
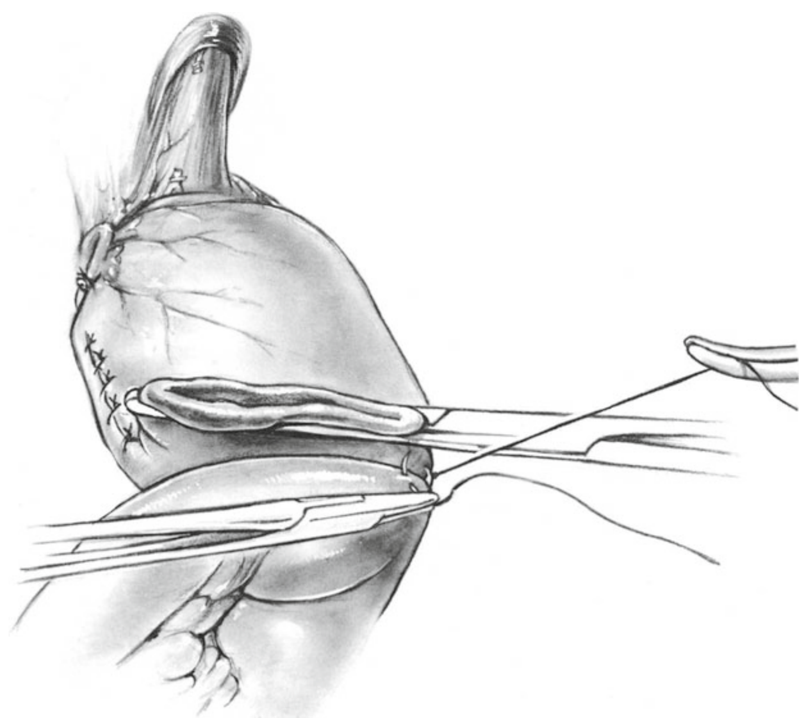


Fig. 33.33

Fig. 33.34



Score the antimesenteric aspect of the jejunum with the back of a scalpel blade. Place the first posterior suture line posterior to but parallel with this scratch line. This maneuver ensures that the stoma is placed accurately and may help prevent postoperative obstruction of the gastric outlet. Attach the jejunum to the gastric pouch with interrupted 4-0 silk seromuscular Lembert sutures placed about 5 mm apart (Fig. 33.34). Leave the first and last

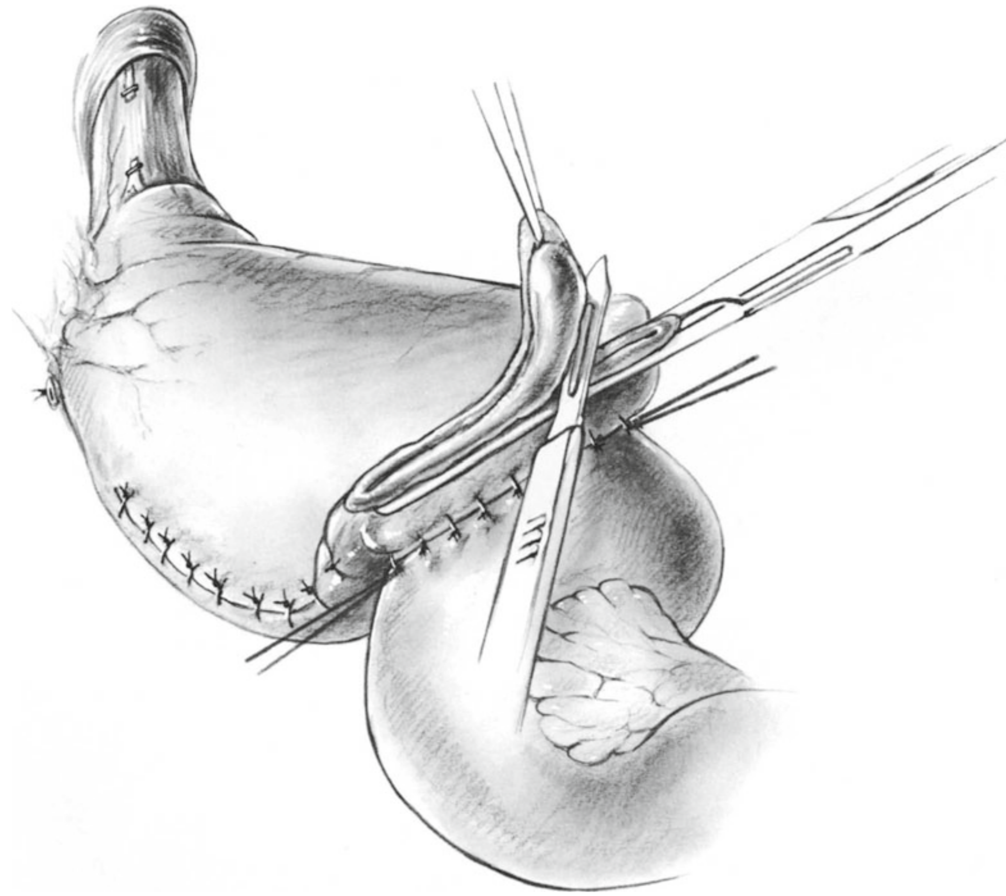


Fig. 33.35

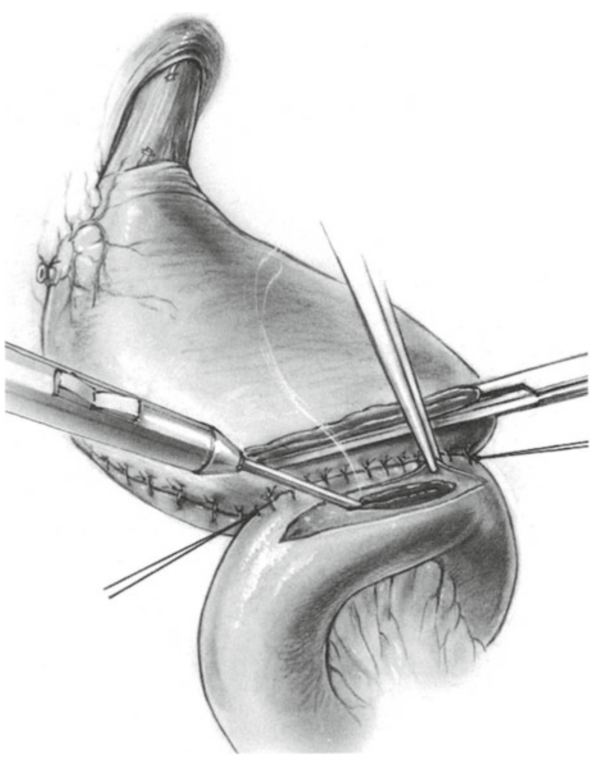


Fig. 33.36

stitches long and tag them with a hemostat. Cut all the remaining silk tails.

If any gastric wall protrudes from the Allen clamp, remove the excess with a scalpel incision flush with the clamp (Fig. 33.35). Then use electrocautery to make an incision along the antimesenteric scratch line in the jejunum. Open the mucosa of the jejunum (Fig. 33.36). Control bleeding points with electrocautery. The incision in the jejunum should be a few millimeters shorter than the diameter of the opening in the gastric pouch.

Remove the Allen clamp and open the gastric pouch. Carefully control any bleeding points on the anterior aspect of the gastric pouch by means of 4-0 PG suture ligatures. The posterior wall is controlled by the mucosal-locked suture. Initiate this suture at the midpoint of the posterior layer with a double-armed 3-0 PG suture, which should be inserted through the full thickness of the gastric and jejunal walls and tied (Fig. 33.37a, b, c). Start a continuous locked suture from the midpoint, and go first to the right and then to the left. Complete the anterior mucosal layer with a continuous Connell or Cushing suture. Initiate the suture line first at the right-hand margin of the anastomosis (Fig. 33.38a) and then on the left (Fig. 33.38b), working both needles toward the midpoint, where the two strands should be tied to each other (Fig. 33.38c). Complete the anterior layer with

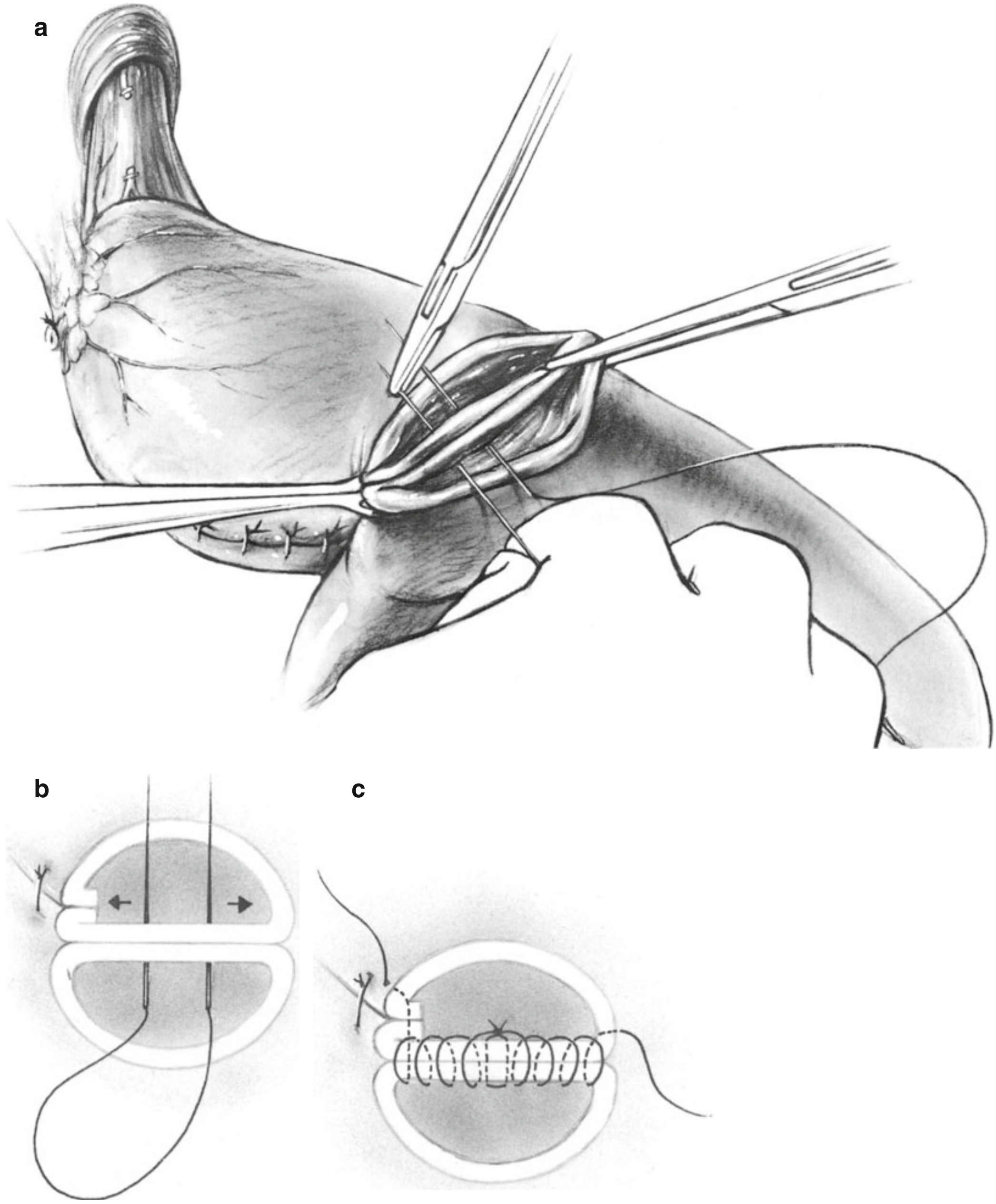


Fig. 33.37

a row of interrupted 4-0 silk seromuscular Lembert sutures (Figs. 33.38d and 33.39) on curved needles. At the medial margin of the anastomosis (the "angle of sorrow"), insert a crown stitch (Fig. 33.40). Occasionally, two crown sutures are inserted for added security.

For the poor-risk patient, minimize anesthesia time by inserting the seromuscular suture layer in over-and-over continuous Lembert fashion using 3-0 PG instead of interrupted silk. The mucosal layer may be closed using the same technique as described above. When this anastomosis is performed with care, there seems to be no disadvantage to using continuous PG seromuscular suture.

Billroth II Gastrojejunal Anastomosis by Stapling Technique

Isolate the vasa brevia along the greater curvature individually by passing a Kelly hemostat behind the vessels. Tie them or secure them with a clipping and dividing instrument that divides the vessels and applies stainless steel clips to both cut ends simultaneously (Fig. 33.41). When stapling is used, it is not necessary to close the lesser curvature as a separate step. Instead, apply a 90/4.8 mm linear stapler across the entire stomach, tighten it, and fire (Fig. 33.42). Apply a large Payr clamp to the specimen side of the stomach, and divide the

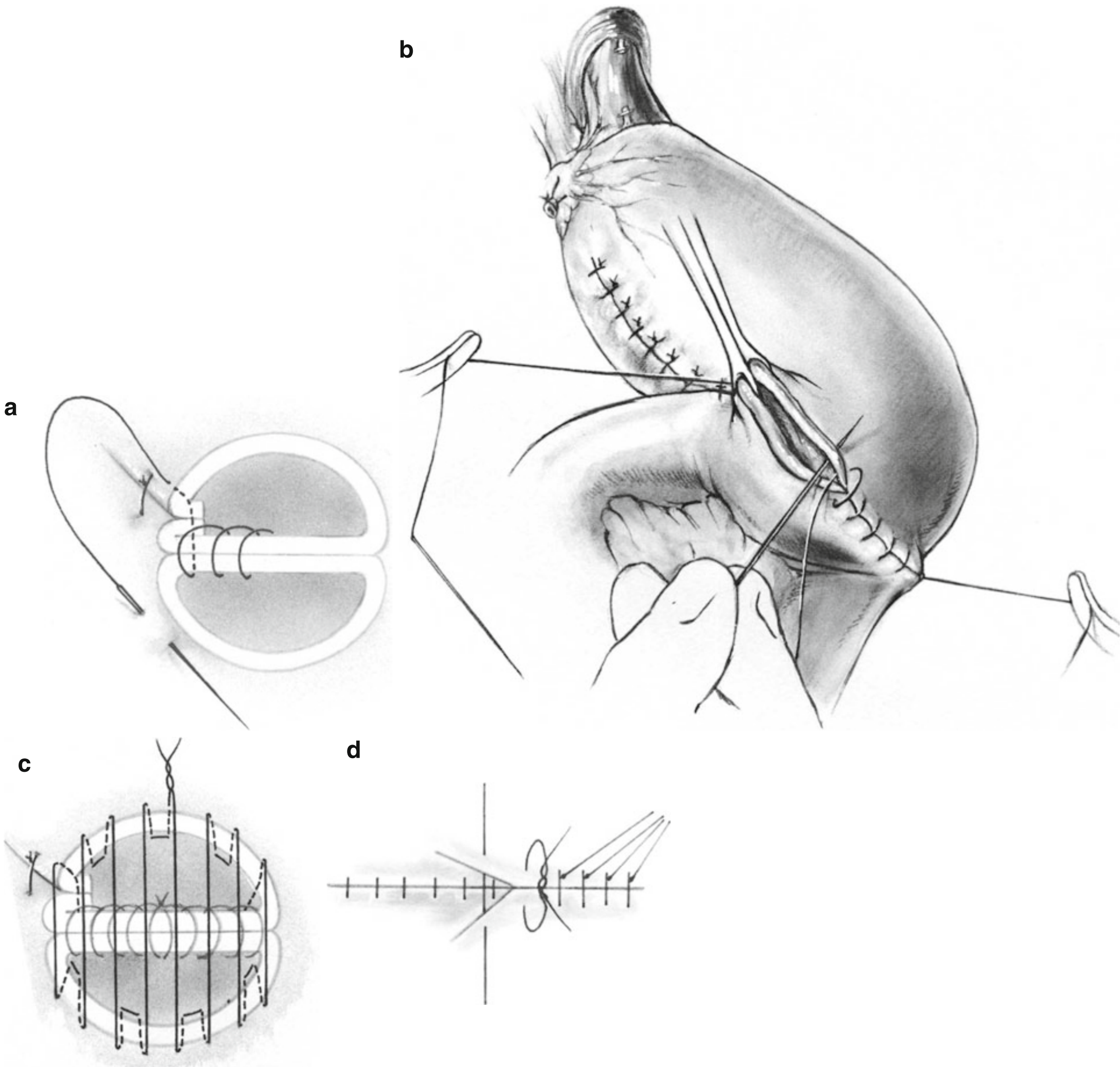


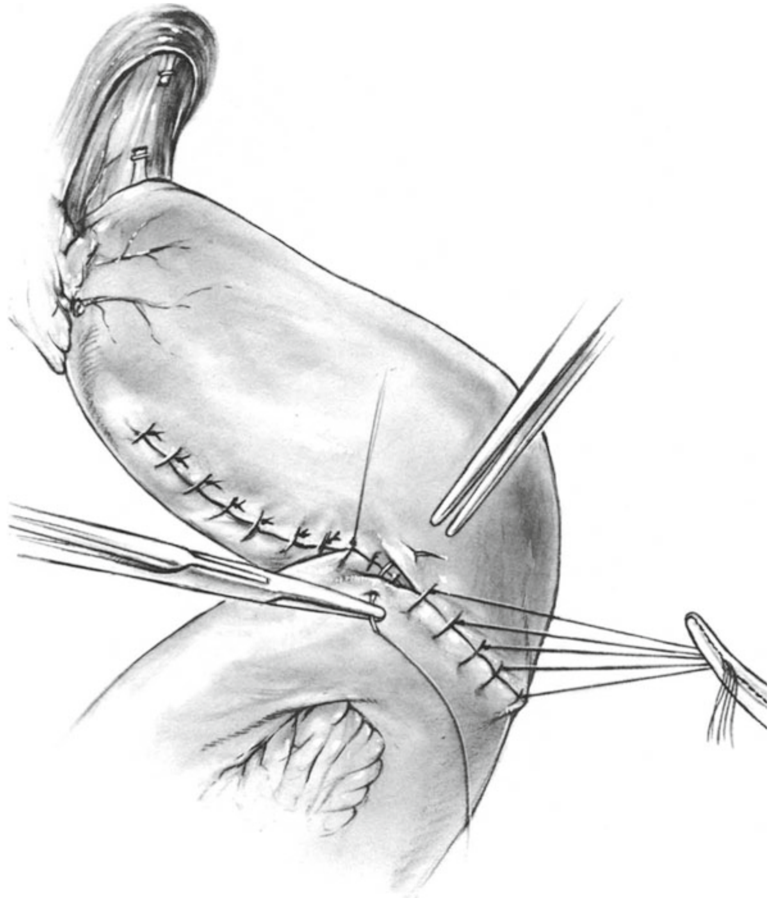
Fig. 33.38

stomach flush with the stapling device by a scalpel. Lightly electrocauterize the everted mucosa and remove the stapler. Close the duodenal stump with the 55 mm linear stapler as previously described and remove the specimen (Fig. 33.43).

It is imperative that the nasogastric tube not be permitted to lie anywhere in the vicinity of the staple line during this step. If the nasogastric tube becomes trapped in the gastric staple line, it cannot be removed without another laparotomy.

Next identify the ligament of Treitz and bring a segment of proximal jejunum in antecolic fashion to the greater curvature side of the gastric pouch. Approximate the antimesenteric border of the jejunum with a 4-0 silk suture to a point on the greater curvature of the stomach about 2 cm proximal to the staple line. Make small stab wounds in the gastric pouch and jejunum adjacent to this suture and just deep to it. Then insert the cutting linear stapling device so one fork enters the gastric pouch parallel to the staple line and the other fork enters the jejunum and is placed exactly along the antimesenteric border (Fig. 33.44). Take care not to allow any other organ or tissue to intrude between the stomach and jejunum being grasped by the stapling device. When this stapler has been inserted to the 4 or 5 cm mark, close and lock it (Fig. 33.44). Then reinspect the area. There should be a 2 cm width of posterior gastric wall between the staple line and the proposed anastomotic staple line. Also, the gastric and jejunal tissues should be exactly apposed to each other in the hub of the stapling device. At this point fire and remove the stapler.

Fig. 33.39



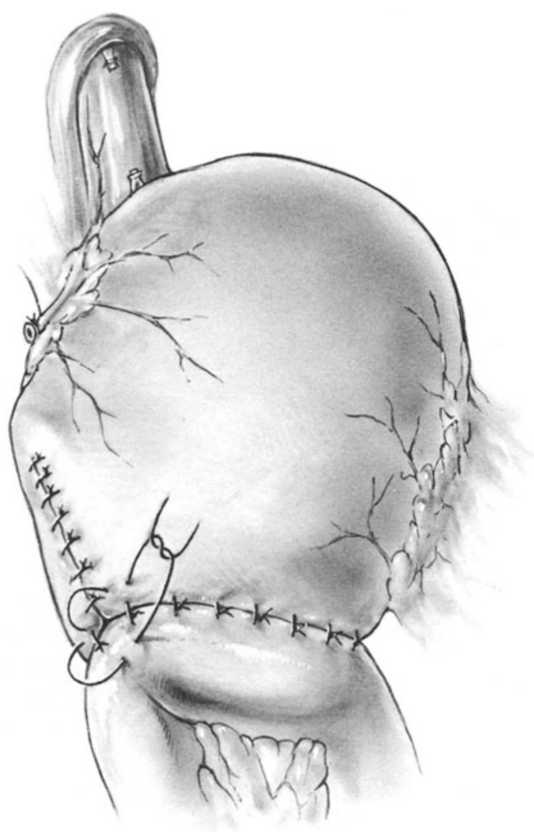


Fig. 33.40

Apply Allis clamps to the anterior and posterior terminations of the staple line, and carefully inspect the mucosal surface of the stapled anastomosis for bleeding. Arterial spurting from the gastric wall occurs occasionally. When it does, transfix the vessel with a fine PG suture ligature.

Control lesser bleeding by cautious electrocoagulation. Multiple bleeding points are seen on rare occasions. The entire mucosal suture line should then be oversewn with a locked continuous suture of 4-0 PG. The needle must be inserted deep to the staples when performing this maneuver. It should be necessary in no more than 1–2 % of all cases.

After hemostasis is ensured, approximate the gastric and jejunal layers of the open stab wounds in an everting fashion with several Allis or Babcock clamps. Close the defect with one application of a 55 mm linear stapler deep to the line of Allis clamps (Fig. 33.45). *This staple line must include the anterior and posterior terminations of the anastomotic staple line*, guaranteeing that there is no defect between the two lines of staples. Excise the redundant tissue, lightly electrocoagulate the everted mucosa, and remove the stapler. Alternatively, close the stab wound defect in an inverting fashion by various suturing techniques. Then place a single 4-0 silk seromuscular suture at the right termination of the stapled anastomosis (Fig. 33.46). The gastrojejunal stoma

Fig. 33.41

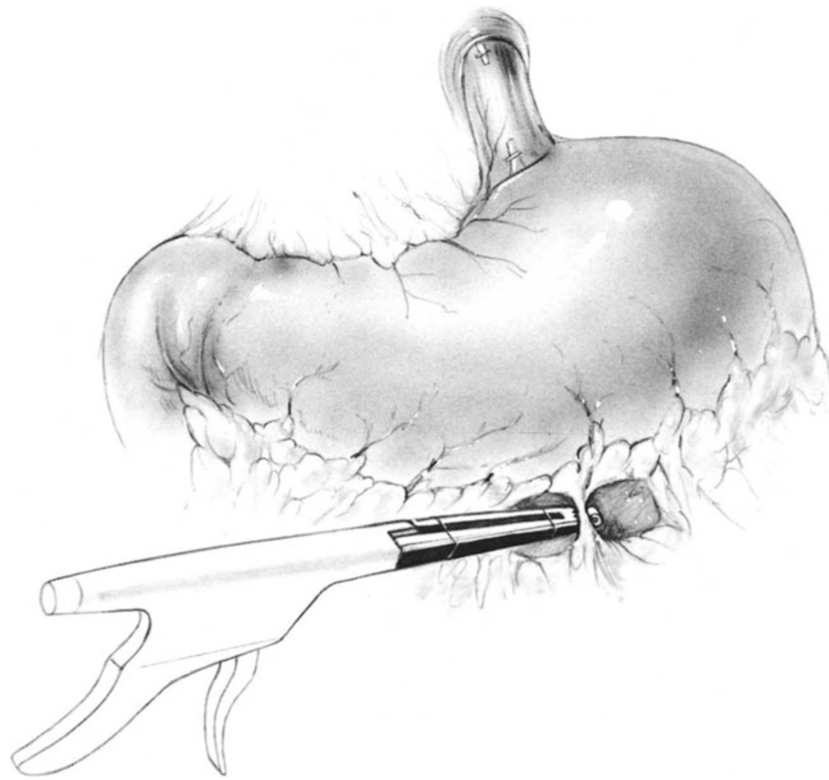
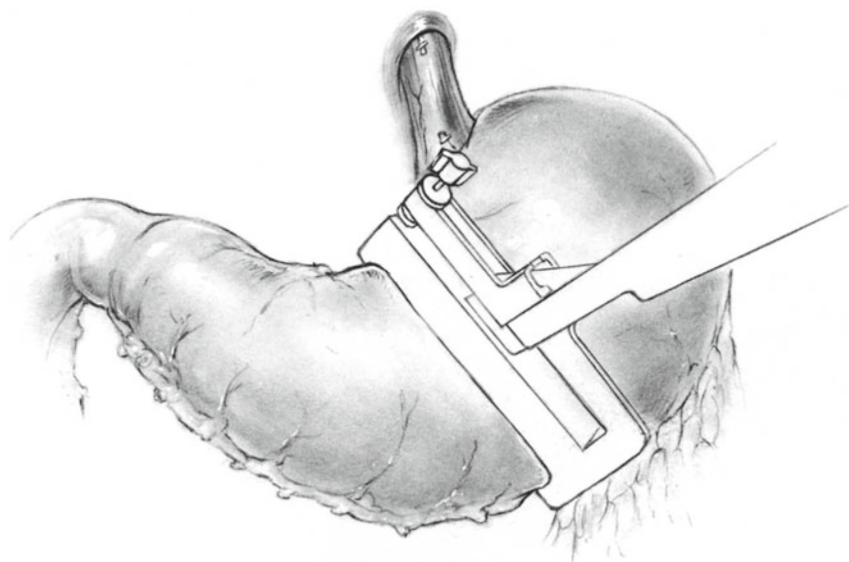


Fig. 33.42



should admit two fingers. A three-dimensional representation of the anastomosis is shown in Fig. 33.47.

Drainage and Closure

Whenever the surgeon thinks the duodenal closure is less than perfect after a Billroth II operation, a closed suction drain should be brought out from the vicinity of the duodenal stump through a stab wound in the right upper quadrant. The drain should be separated from the duodenal suture line by a layer of omentum. Accomplished this way, drainage does no harm to the patient. Close the abdominal wall in the usual fashion after taking pains to ensure that the efferent limb of the jejunum descends freely and without kinks.

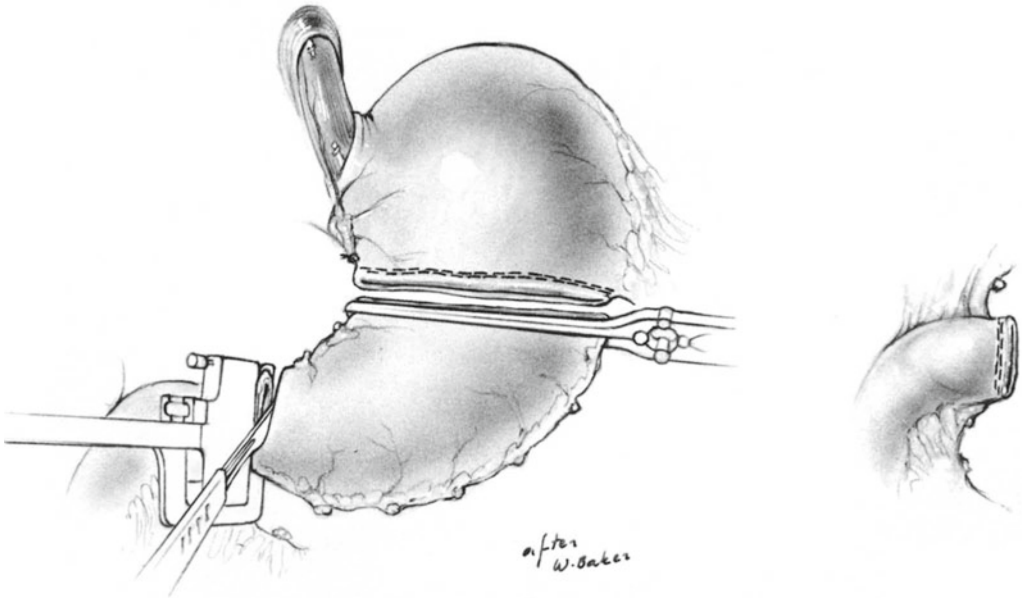


Fig. 33.43

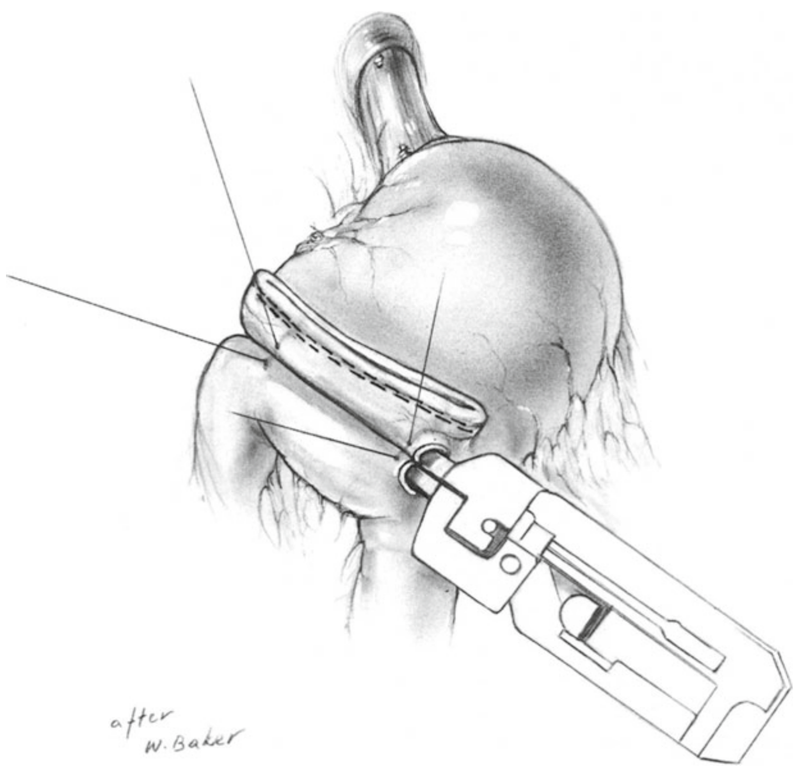


Fig. 33.44

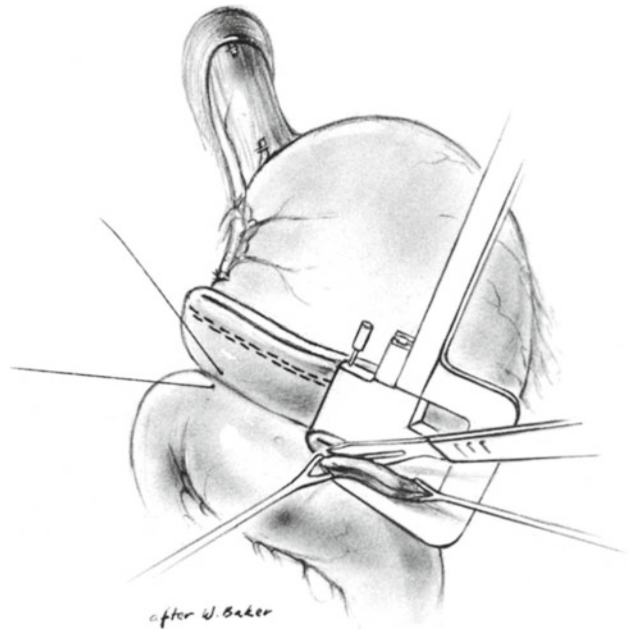


Fig. 33.45

Fig. 33.46

Postoperative Care

Nasogastric suction should be continued for several days. Oral intake can be resumed when there is evidence of bowel function. For the first 4–6 weeks following gastric resection, the diet should be low in carbohydrates and fluids and high in protein and fat to reduce the osmolarity of the meals. Liquids should largely be eliminated from meals and be consumed beginning 1 h after meals. Sweet drinks should be avoided. If this course is followed, the transitory dumping symptoms, which many patients experience during the early postgastrectomy period, are avoided. Generally, after 4–6 weeks patients can enjoy an unlimited diet.

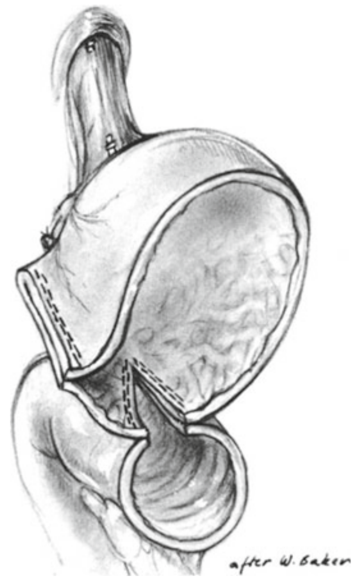


Fig. 33.47

Complications

Duodenal Fistula. In the presence of an adequate drain, the appearance of duodenal content in the drainage fluid with no other symptoms may not require vigorous therapy. On the other hand, if there are signs of spreading peritoneal irritation, prompt relaparotomy is indicated. If no drain was placed during the initial operation, immediate relaparotomy is undertaken whenever there is reason to suspect duodenal leakage. On rare occasions relaparotomy can be performed before there is intense inflammatory reaction of the duodenal tissues, and the defect may be closed by suture. This is seldom possible, however. If suturing the virgin duodenum at the first operation was not successful, an attempt at secondary suturing fails unless considerable additional duodenum can be freed from the pancreas for a more adequate closure. In most cases the operation is done to provide excellent drainage. A small sump-suction drain should be inserted into the fistula and additional latex and sumps placed in the area. If a controlled duodenocutaneous fistula can be achieved, it generally closes after a few weeks of total parenteral nutrition. Prescribing a somatostatin analog to reduce duodenal and pancreatic secretion is also helpful.

Leaks from Billroth I gastroduodenal anastomoses, though rare, are even more serious than from duodenal stump (Billroth II) procedures. Generally they are treated by the Graham technique of closing a perforated duodenal ulcer with a segment of viable omentum (see Figs. 31.3 and 31.4). Multiple sump drains should also be inserted.

Fig. 33.48

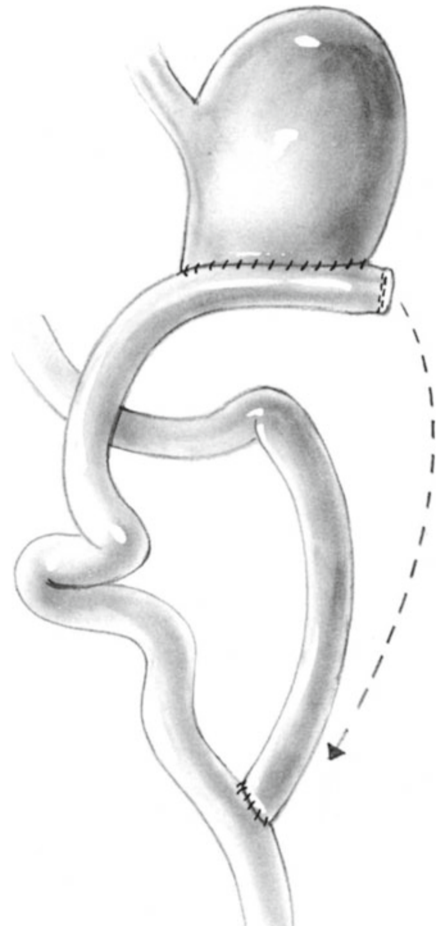


Fig. 33.49

Acute Pancreatitis. Acute pancreatitis is a serious complication that is best avoided by preventing trauma to the pancreas during the initial operation. Therapy is identical to that for acute pancreatitis in the patient who has not undergone an operation.

Gastric Outlet Obstruction. Obstruction in the gastroduodenal anastomosis is generally due to inversion of too much tissue, which produces a mechanical block. If this condition does not respond after a period of conservative treatment, reoperation to convert to a Billroth II anastomosis is probably necessary.

Be aware that the Billroth II gastrojejunal anastomosis occasionally develops an outlet obstruction that appears due to malfunction of the efferent loop of the jejunum. This diagnosis can be confirmed by inserting a gastroscope well into the efferent and afferent limbs of the jejunum, which demonstrates the absence of any mechanical stomal obstruction. Relaparotomy in these cases is of no value. Generally, several weeks of conservative treatment with nutritional support is successful. Passage of a small feeding tube into the efferent limb allows direct enteral support until function recovers.

Alkaline Reflux Gastritis. Alkaline reflux gastritis may require conversion of the Billroth II to a Roux-en-Y reconstruction (Figs. 33.48 and 33.49). Transect the afferent limb of jejunum at its point of entry into the gastric pouch. Use a TA-55 stapler to close the gastric side of the jejunum, then anastomose the open end of the afferent segment to the side of the efferent segment of the jejunum. This anastomosis should take place at a point 60 cm distal to the gastrojejunostomy. It converts the efferent limb of the jejunum to a Roux-en-Y configuration. Vagotomy is necessary to prevent marginal ulceration following this type of Roux-en-Y anastomosis. Although some surgeons routinely use a Roux-en-Y reconstruction for all gastric surgery, severe hypomotility (Roux stasis syndrome) occasionally follows this procedure and can be difficult to manage. Miedema and Kelly described an alternative reconstruction using an uncut Roux limb as a prophylactic measure.

Afferent Loop Obstruction, *Afferent Loop Syndrome*. Acute mechanical blockage of the afferent stoma, often accompanied by jejunogastric intussusception or internal hernia, causes an acute closed loop obstruction that manifests as excruciating upper abdominal pain and retching. Gastrointestinal radiography reveals complete block at the afferent stoma, which can be confirmed by endoscopy. This situation is a surgical emergency because if the distended afferent loop bursts, lethal peritonitis results. Obviously, emergency surgery for correction of the obstruction is essential.

Intermittent afferent limb obstruction causes postprandial pain that is relieved by bilious vomiting. Because the efferent limb is patent, the vomitus may not contain food. Exploration and jejunojejunostomy allow drainage of the afferent limb into the efferent limb.

Most afferent loop symptomatology can be prevented by ensuring that the distance between the ligament of Treitz and the gastric pouch is never more than 12–15 cm. These problems do not occur after a Billroth I reconstruction.

Dumping syndrome. The "dumping syndrome" may occur in any patient whose pylorus has been rendered nonfunctional. It is more common in patients of asthenic habitus who have never achieved normal body weight, even before surgery. Dietary alteration generally controls dumping. Slow introduction of concentrated carbohydrate loads, particularly in liquid form (e.g., apple juice), may help avoid the problem.

Marginal ulcer. One cause of recurrent ulcer is the surgeon's having left behind gastrin-secreting antral mucosa on the duodenal stump following a Billroth II gastrectomy. Unrecognized Zollinger-Ellison syndrome also can cause recurrent ulcer after what would otherwise be an adequate ulcer operation.

Malabsorption. Anemia may be due to inadequate iron absorption. Folic acid and vitamin B_{12} deficiencies develop on rare occasions following gastrectomy. Another late complication is osteomalacia or osteoporosis caused by poor calcium or vitamin D absorption. Steatorrhea and diarrhea develop in some cases and may contribute to malnutrition. These patients should be studied for the presence of gluten enteropathy, which may be unmasked by the gastrectomy. Although almost all the early complications are manageable, malabsorption and malnutrition many years after a gastrectomy are difficult to treat. These complications seem rare, however, following a 40–50 % gastrectomy.

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34 Perforated Peptic Ulcer

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Perforated Gastric Ulcer

Not all free perforations of gastric ulcers are susceptible to simple plication techniques. Often the ulcer is large and surrounded by edema. When the perforation occurs on the posterior surface of the antrum, adequate repair by plication techniques is generally not possible. Gastric ulcers have a high rate of recurrence. For these reasons, in a good-risk patient in whom the diagnosis of perforation has been made reasonably early, gastric resection is *preferred* to simple plication. If for technical reasons a sound plication cannot be constructed, gastric resection is *mandatory*, regardless of the risk, as a recurrent gastric leak into the peritoneal cavity is almost always fatal.

Perforated Duodenal Ulcer

As with gastric ulcers, plication works best for small perforations. Large perforations may be incorporated in a pyloroplasty type closure. Beware the large duodenal ulcer which curves over the edge of the duodenum to become confluent with a posterior ulcer. These may be associated with upper gastrointestinal bleeding. They are difficult to plicate because there is no easy way to completely close the perforation.

Effective medical therapy has significantly diminished the role for vagotomy in this setting. Laparoscopic plication (see Chap. 35) is an option in properly selected patients.

Preoperative Preparation

Fluid and electrolyte resuscitation, primarily with a balanced salt solution
Nasogastric suction
Systemic antibiotics
Monitoring of hourly urine output, central venous pressure, or pulmonary artery wedge pressure, as indicated

Pitfalls and Danger Points

Inadequate fluid and electrolyte resuscitation
Inadequate closure of perforation

Operative Strategy

The most important initial step of the operative strategy is to determine, on the basis of the principles discussed above, whether the patient should be treated by plication or resection. On technical grounds alone, large defects in the stomach or duodenum are better handled by resection than by attempted plication. If it appears that plication of a duodenal ulcer would produce obstruction, resection is safer. An alternative is excising the perforation as part of a pyloroplasty incision (see Chap. 31).

For most perforated duodenal ulcers, an attempt to close the defect by sutures alone often results in the stitch tearing through the edematous tissue. It is preferable to place a plug of viable omentum over the defect and use

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through-and-through sutures to hold the omentum in contact with the wall of the duodenum. This practice avoids tension on the sutures. It is important to irrigate the abdominal cavity thoroughly with large quantities of saline to remove the contamination.

Documentation Basics

- Findings
- Plication versus pyloroplasty versus resection

Operative Technique of Plication

Incision

A midline incision from the xiphoid to the umbilicus provides good exposure and can be made rapidly.

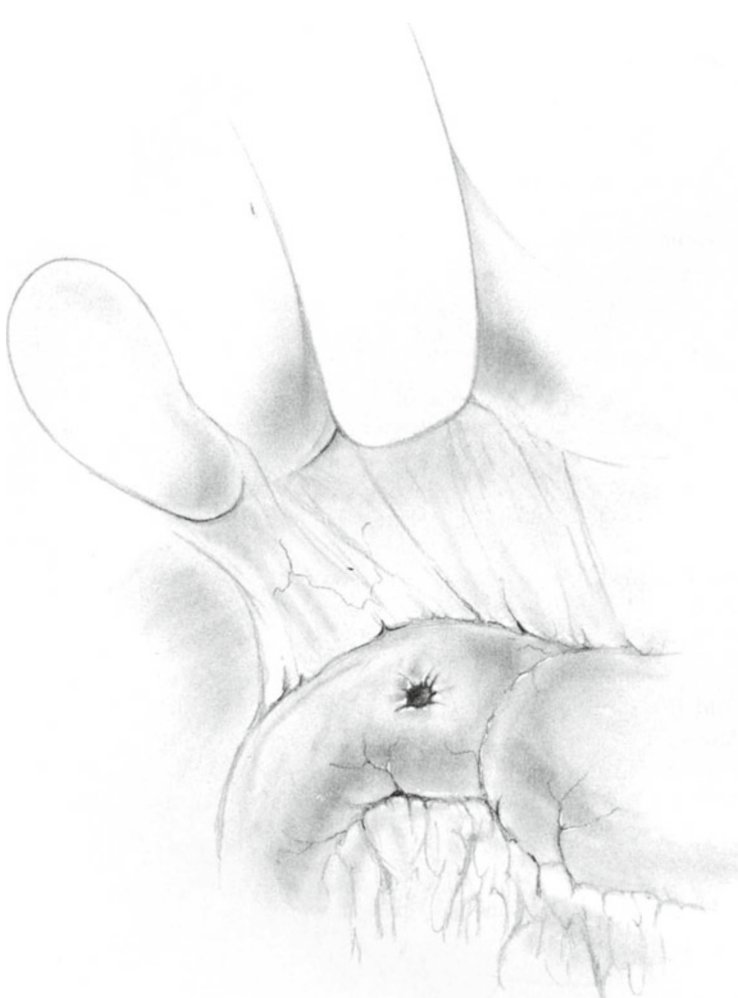

Fig. 34.1

Identification of Perforation

By following the lesser curvature aspect of the stomach down to the pylorus, the perforation along the anterior wall of the duodenum generally becomes quickly evident (Fig. 34.1). In some cases, it is sealed off by omentum or the undersurface of the liver. If this area is not the site of the perforation, search the entire stomach carefully, up to the esophagus and including the entire posterior surface of the stomach in the lesser sac. Rarely, a perforation is found somewhere in the small intestine or colon (e.g., secondary to a sharp fishbone).

Plication of Perforation

Generally, insert 3-0 silk (or PG) on an atraumatic intestinal needle beginning at a point about 5 mm above the perforation. Bring the stitch out at a point 5 mm distal to the perforation and leave it untied.

Two additional sutures of the same types are needed for the average perforation. Next, isolate a viable segment of omentum and place it over the perforation. Tie the three sutures over the plug of omentum to fasten it in place (Figs. 34.2 and 34.3). It is *not* necessary to approximate the margins of the hole in the duodenum but only to cap it with viable omental tissue.

Peritoneal Lavage

Using large volumes of warm saline, thoroughly lavage the peritoneal cavity with multiple aliquots until the gastric contents and fibrin are removed from the surfaces of the bowel and peritoneum.

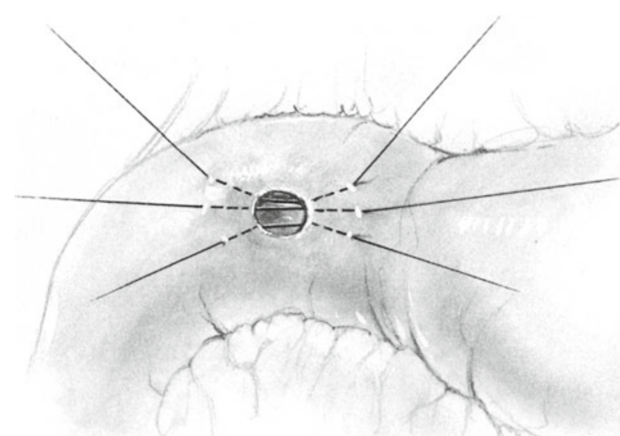

Fig. 34.2

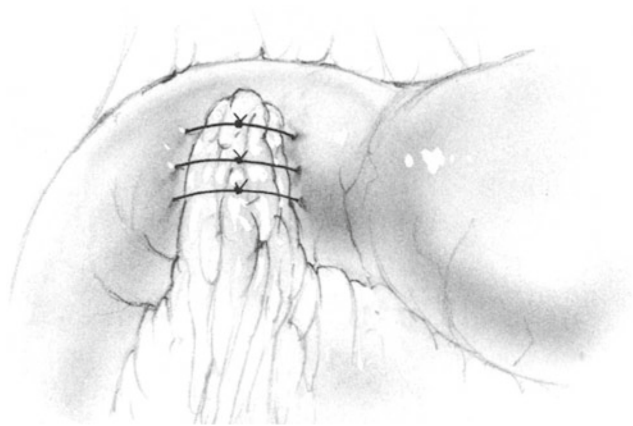

Fig. 34.3

Abdominal Closure

Consider needle catheter jejunostomy if the patient is malnourished. Close the midline incision without drainage using the modified Smead-Jones technique as described in Chap. 3. Unless the patient has advanced peritonitis, the skin may be closed in routine fashion.

Postoperative Care

Nasogastric suction
Acid-reducing therapy
Test for *Helicobacter pylori* and treat if positive
Intravenous fluids
Systemic antibiotics, guided to aerobic and anaerobic cultures obtained at surgery
Enteral feeding by needle catheter jejunostomy for malnourished patients

Complications

Subphrenic and subhepatic abscesses occur mainly in patients whose operations have been delayed more than 8–12 h after the perforation.

Duodenal obstruction, caused by the plication, should be suspected if gastric emptying has not returned to normal by the eighth or ninth postoperative day. It may be confirmed by a gastrointestinal contrast study.

Reperforation of the duodenal ulcer occurs in rare cases, and the surgeon must be alert to detect this complication. When it does occur, gastric resection is mandatory if there is to be any hope of stopping the duodenal leak.

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35 Laparoscopic Plication of Perforated Ulcer

Carol E.H. Scott-Conner

Indications

Simple anterior perforated duodenal ulcer

Preoperative Preparation

Nasogastric suction
Intravenous hydration
Antibiotics

Pitfalls and Danger Points

Incomplete closure
Duodenal obstruction
Incorrect diagnosis

Operative Strategy

Laparoscopic plication is appropriate when a simple anterior perforated duodenal ulcer is diagnosed. The operation may be conceptualized in four steps: confirming the diagnosis and peritoneal toilet, exposing the perforation, selecting the omental patch, and securing the patch in place.

This procedure is not suitable for large perforations or perforations for which the extent cannot be easily determined (e.g., large duodenal ulcers that appear to wrap around toward the posterior duodenal wall). Gastric perforations may be better handled by resection.

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Documentation Basics

- Findings

Operative Technique

Position the patient supine. The room setup and trocar placement are similar to those for laparoscopic cholecystectomy (see Figs. 9.1 and 78.4). An angled laparoscope may facilitate looking down onto the duodenal surface.

Thoroughly examine the peritoneal cavity, suctioning away any fluid or debris. Generally, the liver is adherent to the duodenum, partially or completely closing the perforation. Irrigate and aspirate the subphrenic spaces and all four quadrants of the abdomen.

Pass a closed grasper through one of the right subcostal ports and use it to tease the liver gently away from the duodenum by blunt dissection. If the perforation is relatively fresh, the gelatinous fibrin adhesions are easy to sweep away (Fig. 35.1).

Pass the grasper laterally to open the subhepatic space and elevate the liver. Pass a suction irrigator through the epigastric port and irrigate (Fig. 35.2). With sufficient irrigation and possibly some gentle rubbing with the tip of the suction irrigator, the fibrin peels away revealing the perforation (Fig. 35.3). Confirm that the perforation is amenable to omental plication (a small, anterior duodenal perforation that is easily visualized).

Choose a soft, supple piece of omentum for the patch. This may require pulling a piece up from the lower abdomen, as the omentum near the perforation may be thickened and edematous (Fig. 35.4a). Confirm that the section of omentum chosen reaches the site of perforation easily and without tension (Fig. 35.4b).

There are two methods for securing the patch: stapling and suturing. Both are described here.

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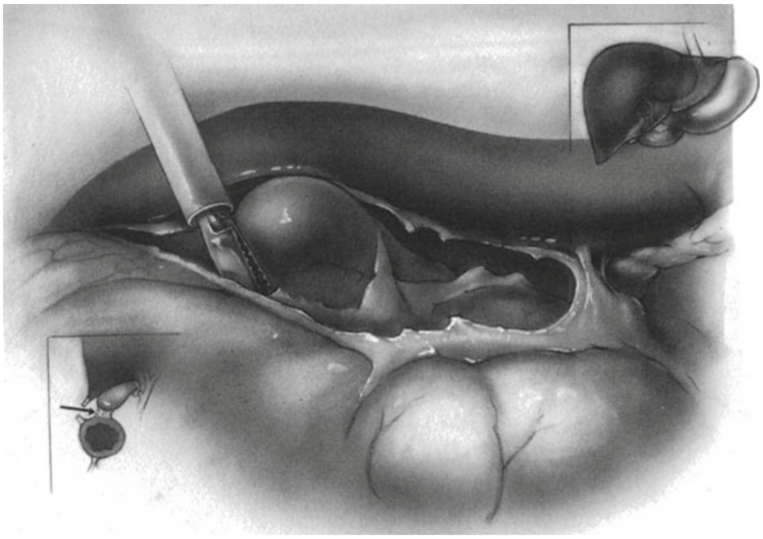

Fig. 35.1

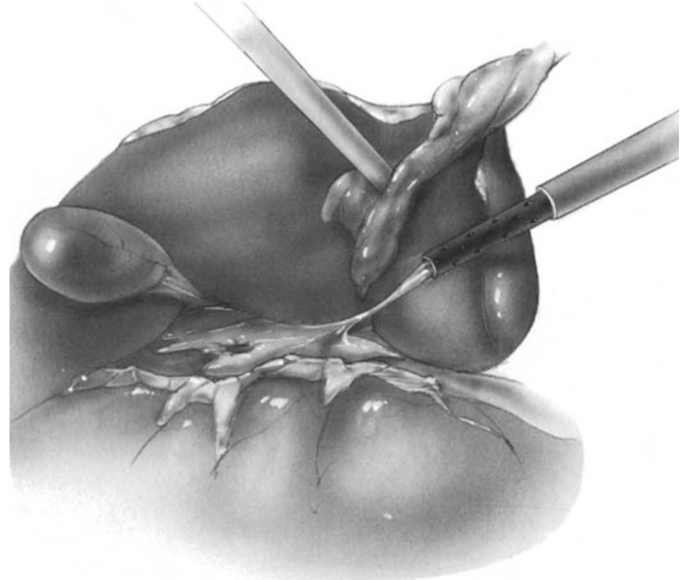

Fig. 35.3

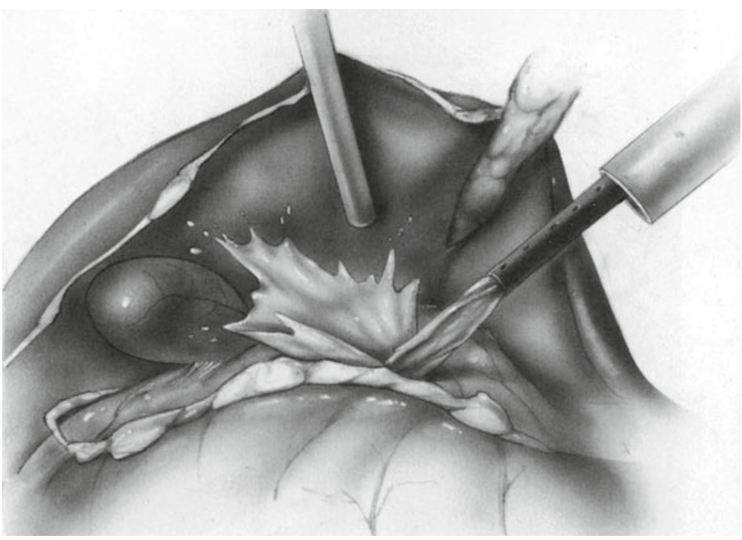

Fig. 35.2

Securing the Patch with a Hernia Stapler

When the stapler is used to secure the patch, a series of staples are placed on both sides of the patch in such a fashion that one limb of each staple goes through the omentum and the other goes directly into the duodenum. There is danger that the staple does not adequately secure a purchase in the duodenum if both limbs go through the omentum first. Close the stapler slowly. As it begins to engage the tissue, pull back slightly to prevent inadvertent injury to the back wall of the duodenum (Fig. 35.5). Place a series of staples on each side of the patch.

Suturing the Patch

Suturing the patch is relatively straightforward. Three or four sutures are placed across the perforation and tied over the omentum (Fig. 35.6). It is generally easier to take a seromuscular bite of each side of the duodenum than to attempt to place a through-and-through suture (as shown for the open procedure). It is usually easier to tie these sutures as they are placed (rather than at the end of the procedure). Begin at the apex and proceed toward the laparoscope.

Testing the Patch

Confirm the security of the patch closure by injecting air into the nasogastric tube and watching for air bubbles under saline. Place a drain in the subphrenic space if desired (Fig. 35.7).

Esophagogastroduodenoscopy

An esophagogastroduodenoscopy (EGD) scope is used by some as an adjunct. The endoscope is passed into the duodenum and the perforation visualized. A grasping forceps is passed through the perforation and used to stabilize the omentum during suturing. Visualizing the duodenum with the scope at the end ensures that staples or sutures have not been placed too deeply. Insufflation with the scope replaces injection of the air through the nasogastric tube when the patch is tested. We have not found it necessary to use an EGD scope in these cases.

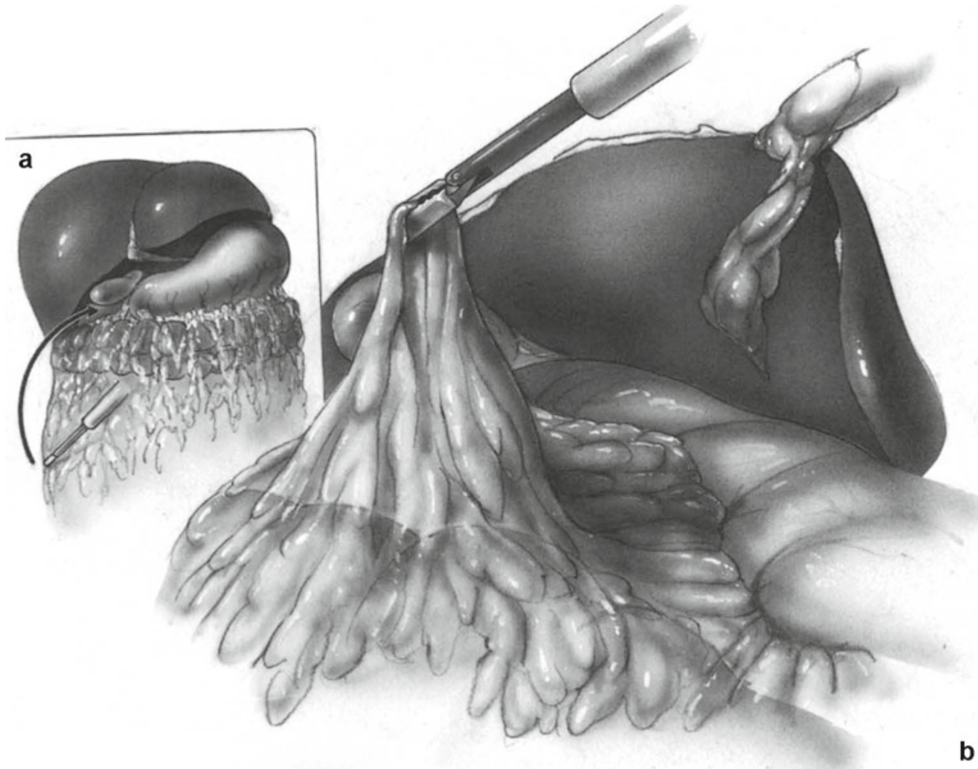

Fig. 35.4

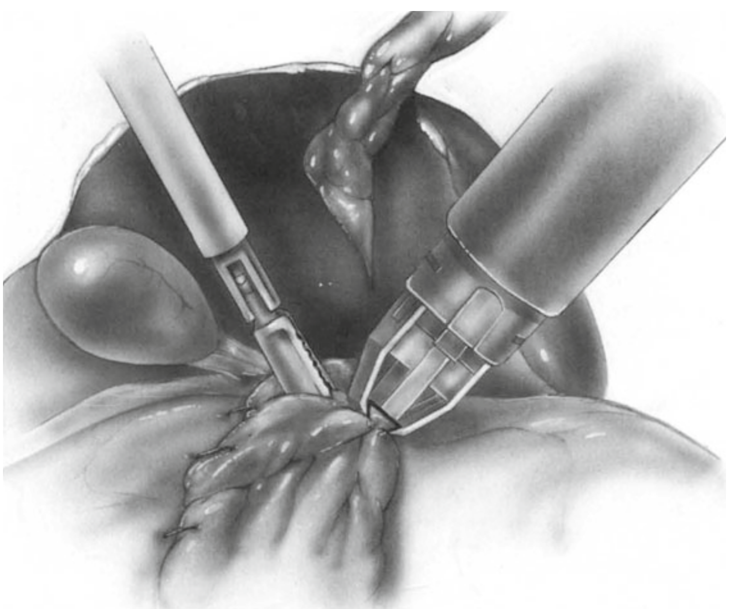

Fig. 35.5

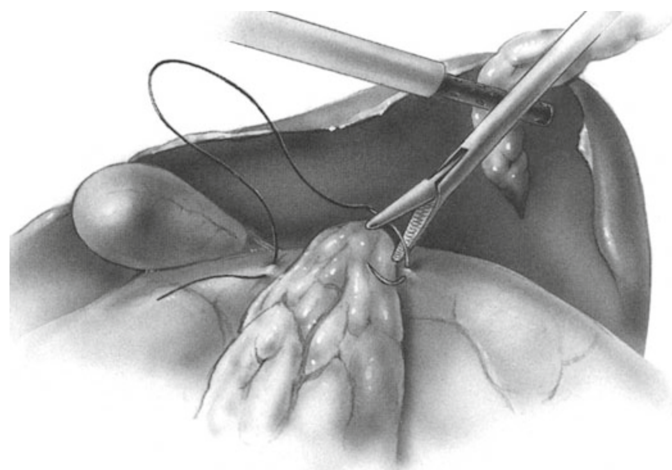

Fig. 35.6

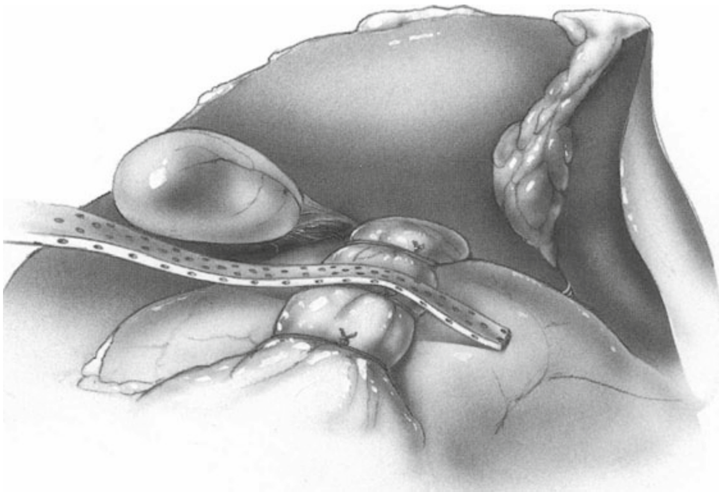

Fig. 35.7

Postoperative Care

Postoperative care is the same as that required for the open procedure. Generally a day or two of nasogastric suction is required until the gastric ileus subsides, and it allows additional time for the patch closure to become secure. Antibiotic treatment is the same as that used for an open procedure. The first postoperative week is dominated by the physiologic response to the perforation and associated peritonitis. The advantages of the laparoscopic approach generally do not become obvious until the second or third week after surgery. Evaluation for and treatment of *Helicobacter pylori* is crucial to prevent recurrent symptoms.

Complications

Failure to recognize a malignant perforation
Inadequate patch closure resulting in continuing sepsis
Subphrenic or subhepatic abscess

Further Reading

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Gastrostomy

36

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Gastric decompression without the need for a tube traversing the esophagogastric junction or the nasopharynx, when percutaneous endoscopic gastrostomy (PEG) is not an option. A tube across the esophagogastric junction renders the distal esophageal sphincter ineffective. Gastroesophageal reflux with pneumonia or esophageal stricture may result.

Gastric tube feeding with similar constraints as noted above.

Failed PEG tube insertion

Dislodged PEG tube

Pitfalls and Danger Points

Gastric leak into the peritoneal cavity

Operative Strategy

The Stamm gastrostomy is fast and relatively safe. When the gastrostomy is no longer needed, removal of the tube usually results in prompt closure of the tract. Percutaneous endoscopic gastrostomy creates a simple gastrostomy analogous to a Stamm but without the inversion of the gastric wall and additional security afforded by suturing the anterior gastric wall to the abdominal wall. See references at the end for this technique.

For patients who require long-term gastric tube feeding, the Janeway gastrostomy is more convenient than the usual Stamm gastrostomy, as the Janeway construction does not require an indwelling tube. Percutaneous endoscopic gastrostomy is an alternative for many patients. The Stamm and Janeway gastrostomies can also be performed laparoscopically (see references at the end of the chapter).

When constructing a tube gastrostomy, the gastrostomy opening must be carefully sutured to the anterior abdominal wall around the stab wound made for the exit of the tube. Otherwise, gastric contents may leak out around the tube and escape into the abdominal cavity.

Documentation Basics

- Findings
- Nature of gastrostomy performed

Operative Technique

Stamm Gastrostomy

When performed as part of another abdominal procedure, the abdominal incision has already been made. If necessary, it can be extended upward into the epigastrium to expose the stomach. When gastrostomy is performed as a single procedure, a short upper midline incision generally suffices.

Choose a location in the midportion of the stomach, closer to the greater curvature than to the lesser curvature (Fig. 36.1). Using 2-0 atraumatic PG or silk, insert a circular purse-string suture with a 1.5 cm diameter.

Grasp the left side of the incised linea alba with a Kocher clamp and elevate it. Then make a stab wound through the middle third of the left rectus muscle at the level of the purse-string suture. Pass a Kelly Hemostat through the stab wound from the peritoneum outward and use it to grasp the tip of an 18F Foley, Malecot, or mushroom catheter. Draw the catheter

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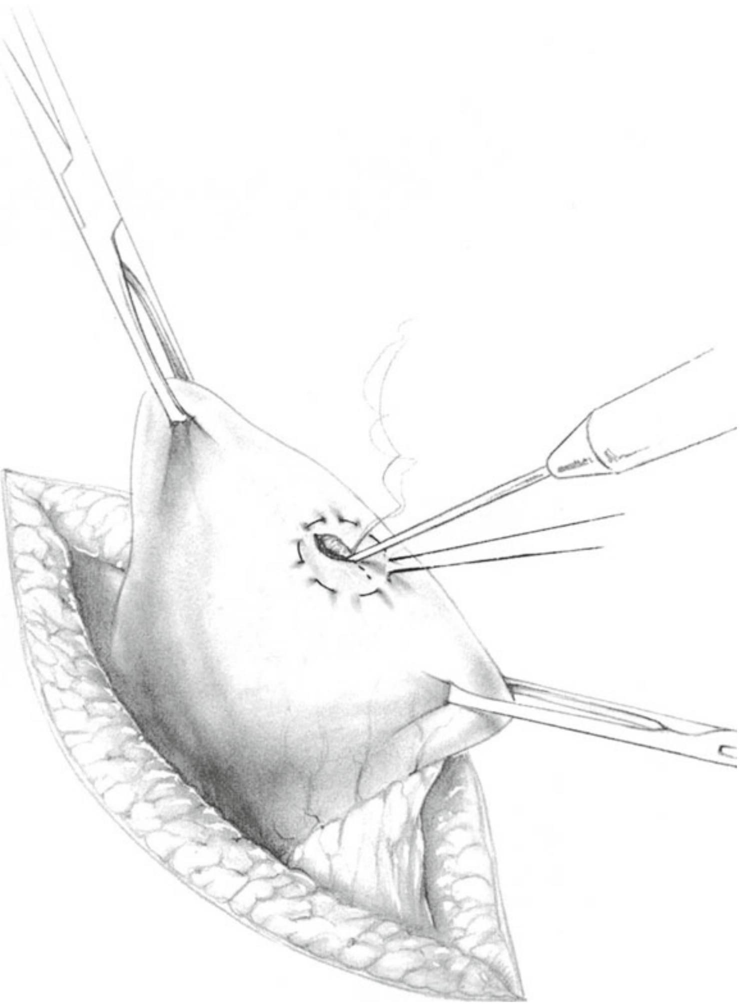

Fig. 36.1

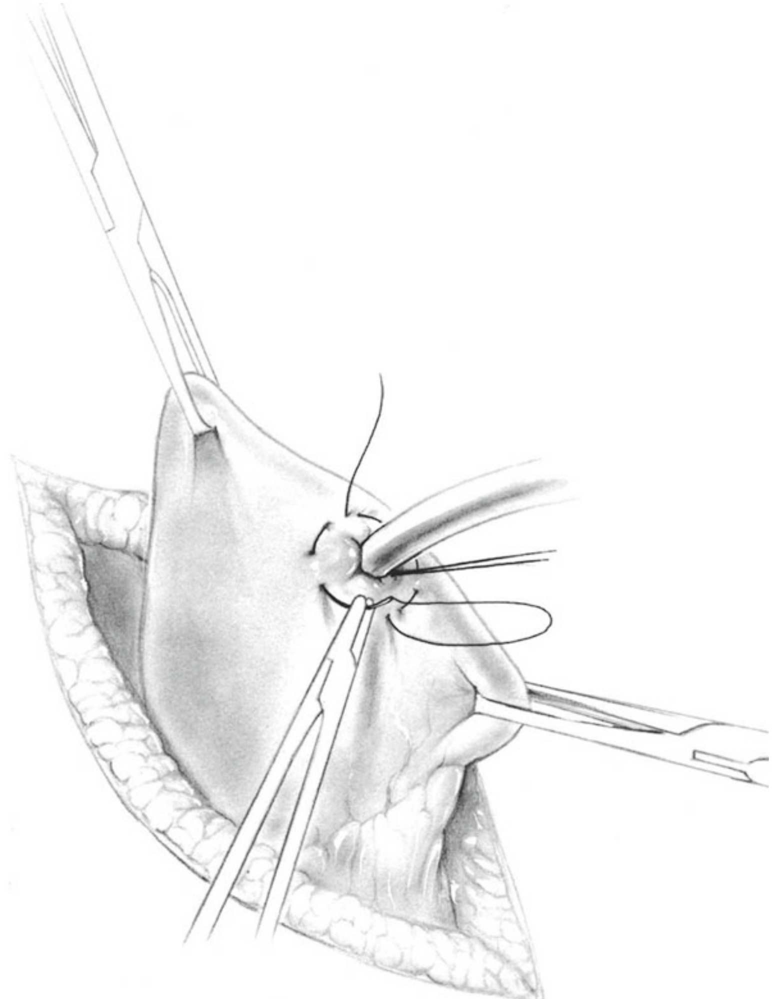

Fig. 36.2

into the abdominal cavity with the hemostat. With electrocautery make a stab wound in the anterior gastric wall in the middle of the previously placed purse-string suture (Fig. 36.1). Insert the catheter into the stomach, tighten the purse-string suture, and tie it to invert the gastric serosa (Fig. 36.2). Invert this purse-string suture, in turn, with a second concentric 2-0 PG or silk purse-string suture (Fig. 36.3). If a Foley catheter was used, inflate the balloon and draw the stomach toward the anterior abdominal wall. Insert Lembert sutures of PG or silk in four quadrants around the catheter to sew the stomach to the anterior abdominal wall around the stab wound (Fig. 36.4). When these four Lembert sutures are tied, the anterior gastric wall is firmly anchored to the abdominal wall (Fig. 36.5).

Janeway Gastrostomy, Stapled

Make a 10- to 12-cm midline incision in the midepigastrium. Local anesthesia may be used in the poor-risk patient. Apply Babcock clamps to the anterior gastric wall near the lesser

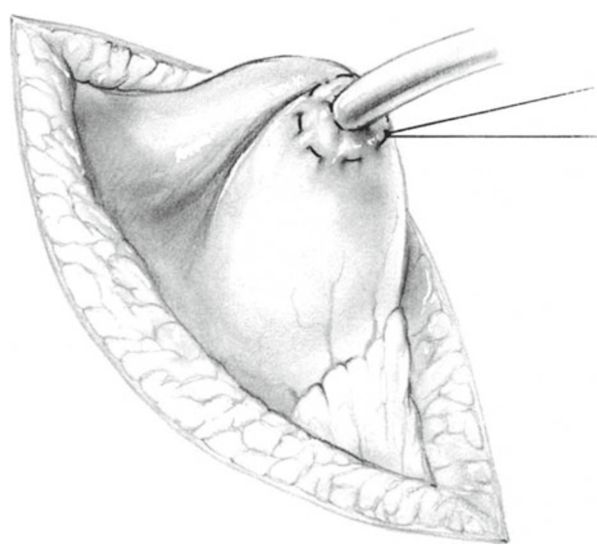

Fig. 36.3

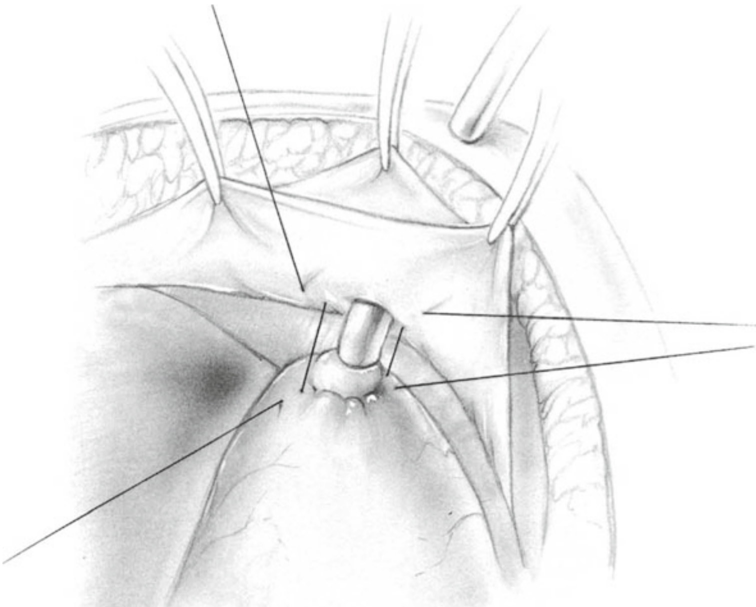

Fig. 36.4

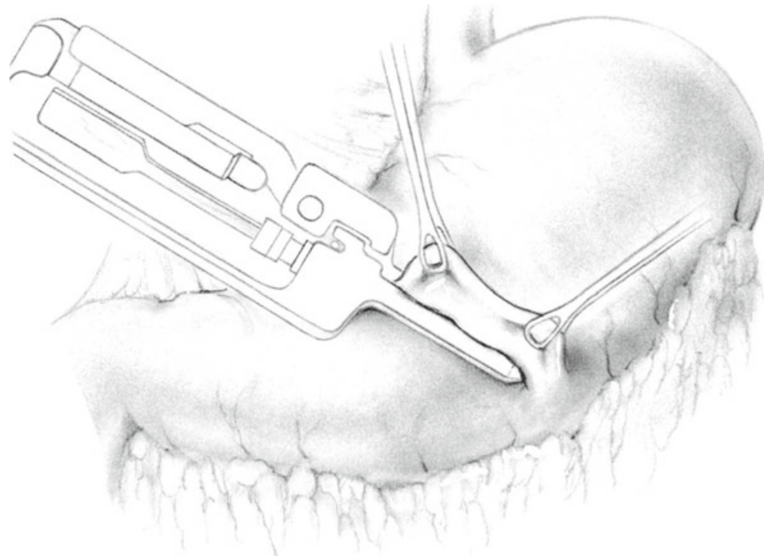

Fig. 36.6

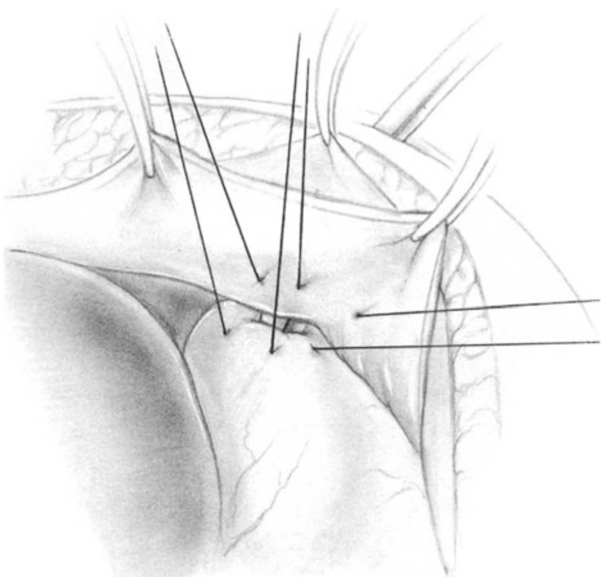

Fig. 36.5

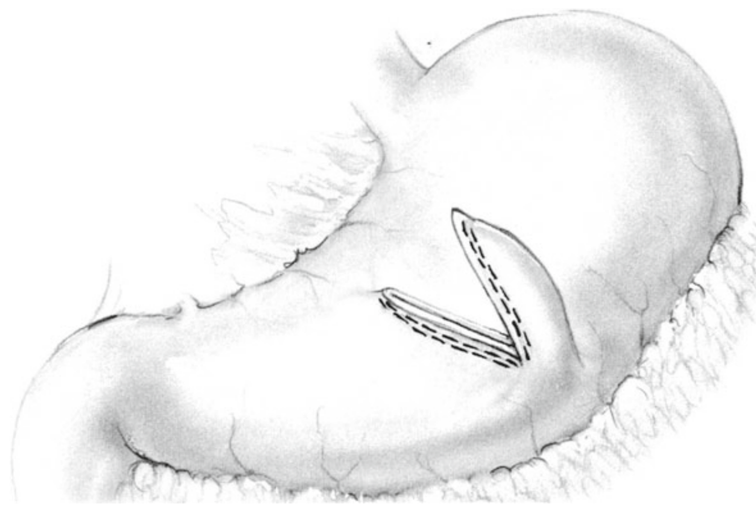

Fig. 36.7

curvature; then apply a cutting linear stapling device (Fig. 36.6). Fire the device, laying down four rows of staples, and incise for a distance of about 4 cm between the staples (Fig. 36.7). This maneuver provides a tunnel of gastric mucosa about 4 cm in length, which is sufficient to pass through the abdominal wall. Reinforce the line of staples with a layer of continuous or interrupted 3-0 atraumatic PG seromuscular Lembert sutures to invert the staples (Fig. 36.8).

Make a vertical incision about 1.5 cm long in the skin overlying the middle third of the left rectus muscle. Deepen the incision through the rectus muscle with the aid of electrocautery and then dilate it by inserting the index finger.

Grasp the gastric nipple and draw it to the outside by passing a Babcock clamp into the incision in the rectus muscle. This brings the gastric wall into contact with the anterior abdominal wall, to which it should be fixed with two Lembert sutures of 3-0 PG. Then transect the tip of the gastric nipple with Mayo scissors, leaving enough gastric tissue to reach the skin level. Insert an 18F catheter into the stomach to test the channel. Mature the gastrostomy with interrupted 3-0 PG sutures, which should pass through the entire thickness of the gastric nipple and catch the subcuticular layer of the skin.

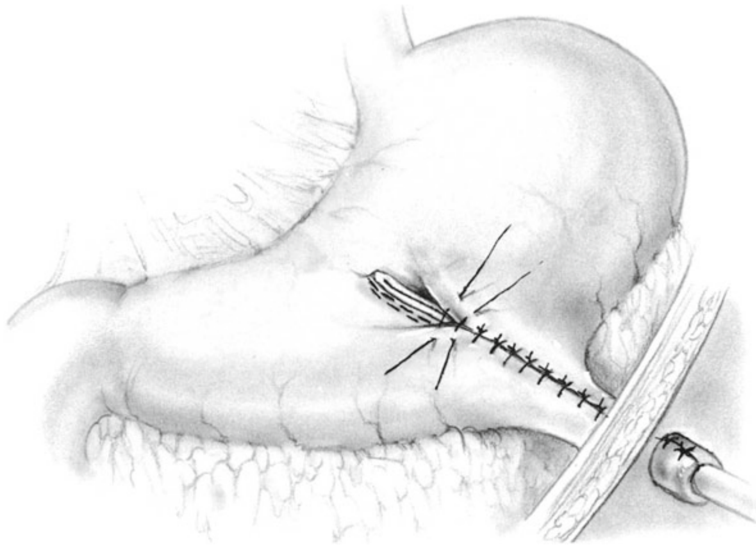

Fig. 36.8

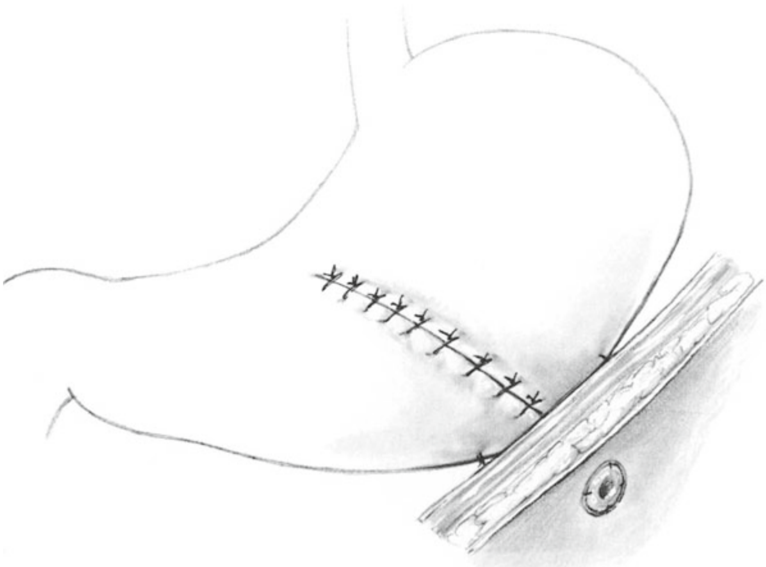

Fig. 36.9

Close the abdominal incision in the usual fashion and apply a sterile dressing (Fig. 36.9). Leave the catheter in place until the wound heals.

After healing has taken place, gastric feeding can be started by inserting a catheter into the stomach while the nutrients are being administered. The catheter is removed between meals.

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Distal Gastrectomy with D2 Nodal Dissection

37

Hisakazu Hoshi

Indications

Adenocarcinoma of the distal stomach

Preoperative Preparation

Endoscopic biopsy and ultrasonography
Computed tomography and other imaging studies as appropriate to stage
Perioperative systemic antibiotics

Pitfalls and Danger Points

Inadequate resection
Injury to pancreas, spleen
Ischemia of gastric pouch if splenectomy is performed
See Chap. 33

Documentation Basics

Document extent of disease, including presence of any metastases
Document frozen sections taken, if any, and results
Extent of lymphadenectomy
Type of reconstruction

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Operative Strategy

Extent of Resection

Distal gastrectomy with D2 nodal dissection is an en bloc resection designed to accomplish three things: (1) remove the distal stomach with adequate clean proximal and distal margins, (2) remove regional lymph nodes in continuity for staging and tumor control, and (3) in appropriate cases remove segments of adjacent organs involved by direct extension. Figure 37.1 shows the stomach lifted up to display the vascular anatomy, and Fig. 37.2 shows the regional anatomy to demonstrate the close proximity of the stomach to the pancreas, liver, and transverse mesocolon.

Frozen sections are helpful for evaluating *proximal and distal margins*. As with many gastrointestinal malignancies, gastric cancer may extend submucosally for several centimeters beyond the obvious tumor mass. Generally a well-differentiated adenocarcinoma requires at least 3 cm of gross margin, and a poorly differentiated carcinoma needs a 5-cm margin.

The nodal stations around the stomach are anatomically defined and numerically classified by the Japanese Classification of Gastric Carcinoma published by Japanese Gastric Cancer Association (JGCA) (Fig. 37.3, Table 37.1). Perigastric nodal stations are numbered 1 through 6 and regional nodal stations are 7–12. Nodal stations numbered higher than 12 are generally considered "distant" nodal stations and are not dissected for the standard D2 nodal dissection.

The level of the nodal dissection, known as the D number, is defined by the guidelines from JGCA. While the classic D1 nodal dissection is defined by complete dissection of the first tier nodal stations which are determined by the location of the primary lesion and is most compatible with current concept of the "D1 nodes, perigastric nodes (station 1–6)" in western literature, current (2010) definition of D1 nodal dissection in Japan includes left gastric artery node station (station 7) in addition to the perigastric nodal stations due to the observed high rate of metastasis in this nodal station by the early gastric cancer.

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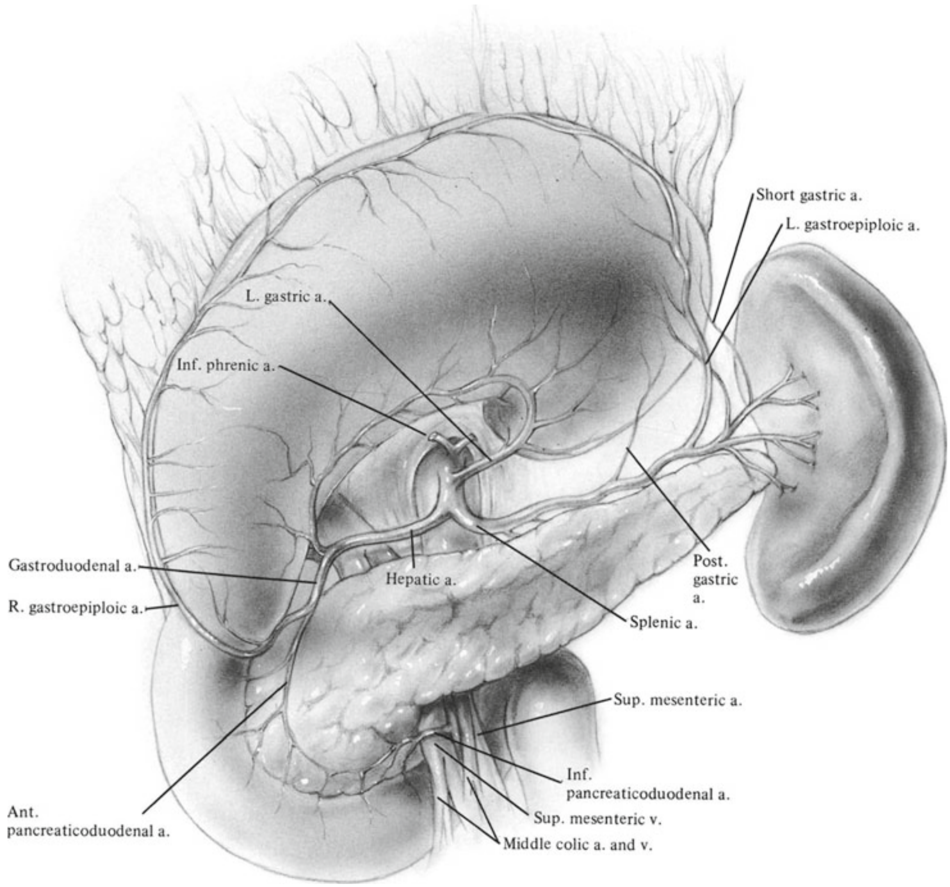

Fig. 37.1

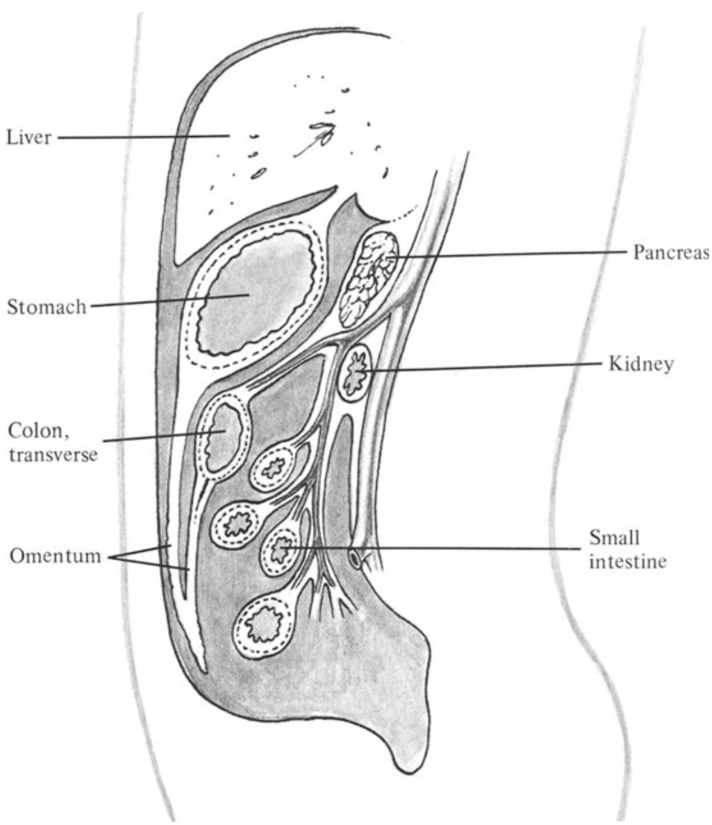

Fig. 37.2

The technique described in this chapter removes all the D2 nodal stations (stations 1–12). The survival benefit of D2 nodal dissection is still a topic of debate; however, superior locoregional cancer control has been demonstrated in large randomized trial.

Gastric cancer can involve any contiguous organ by *direct extension*. Generally such extension is obvious on the preoperative imaging studies, but the surgeon must be prepared to excise any involved adjacent organs in continuity. Posteriorly, the tumor can invade the body or tail of the pancreas, the middle colic artery, or the transverse colon; all of which can be included in the specimen. Invasion of the aorta contraindicates resection. Extension into the left lobe of the liver is amenable to resection, as is extension into the crus of the diaphragm. Generally, survival is poor when extensive tumor dictates excision of adjacent organs.

Pancreatico-Splenectomy, Splenectomy

Historically a splenectomy plus distal pancreatectomy have been an integral part of the classic D2 nodal dissection to ensure complete clearance of the splenic hilar nodal station

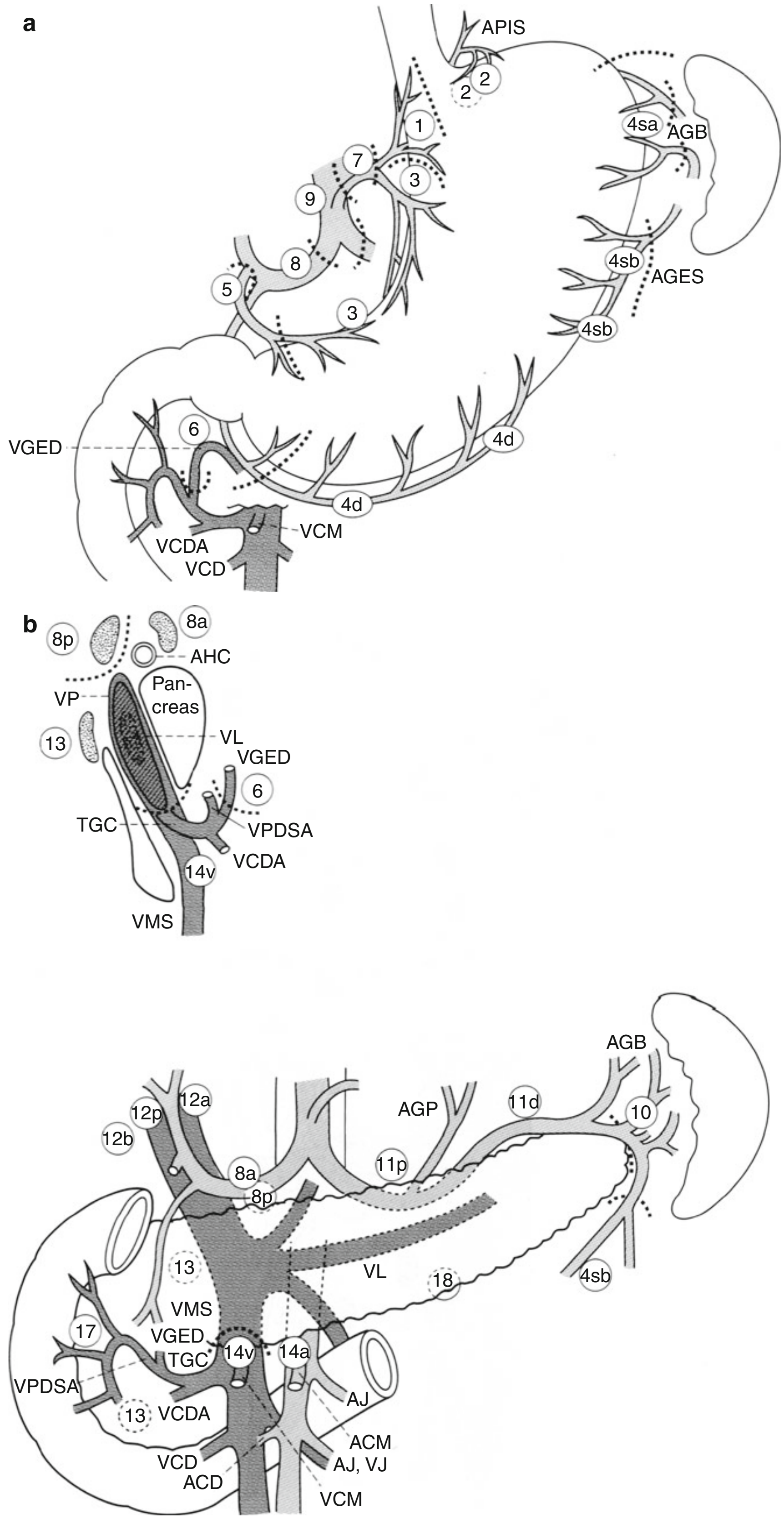

Fig. 37.3 (From Japanese Gastric Cancer Association. Japanese classifications of gastric carcinoma. 14th ed. Table 5. Tokyo: Kanehara & Co., Ltd.; with permission)

Table 37.1 Anatomical definitions of lymph node stations

No.	Definition
1	Right paracardial LNs, including those along the first branch of the ascending limb of the left gastric artery
2	Left paracardial LNs including those along the esophagocardiac branch of the left subphrenic artery
3a	Lesser curvature LNs along the branches of the left gastric artery
3b	Lesser curvature LNs along the second branch and distal part of the right gastric artery
4sa	Left greater curvature LNs along the short gastric arteries (perigastric area)
4sb	Left greater curvature LNs along the left gastroepiploic artery (perigastric area)
4d	Rt. greater curvature LNs along the second branch and distal part of the right gastroepiploic artery
5	Suprapyloric LNs along the first branch and proximal part of the right gastric artery
6	Infrapyloric LNs along the first branch and proximal part of the right gastroepiploic artery down to the confluence of the right gastroepiploic vein and the anterior superior pancreatoduodenal vein
7	LNs along the trunk of left gastric artery between its root and the origin of its ascending branch
8a	Anterosuperior LNs along the common hepatic artery
8p	Posterior LNs along the common hepatic artery
9	Celiac artery LNs
10	Splenic hilar LNs including those adjacent to the splenic artery distal to the pancreatic tail and those on the roots of the short gastric arteries and those along the left gastroepiploic artery proximal to its 1st gastric branch
11p	Proximal splenic artery LNs from its origin to halfway between its origin and the pancreatic tail end
11d	Distal splenic artery LNs from halfway between its origin and the pancreatic tail end to the end of the pancreatic tail
12a	Hepatoduodenal ligament LNs along the proper hepatic artery, in the caudal half between the confluence of the right and left hepatic ducts and the upper border of the pancreas
12b	Hepatoduodenal ligament LNs along the bile duct, in the caudal half between the confluence of the right and left hepatic ducts, and the upper border of the pancreas
12p	Hepatoduodenal ligament LNs along the portal vein in the caudal half between the confluence of the right and left hepatic ducts and the upper border of the pancreas
13	LNs on the posterior surface of the pancreatic head cranial to the duodenal papilla
14v	LNs along the superior mesenteric vein
15	LNs along the middle colic vessels
16a1	Para-aortic LNs in the diaphragmatic aortic hiatus
16a2	Para-aortic LNs between the upper margin of the origin of the celiac artery and the lower border of the left renal vein
16b1	Para-aortic LNs between the lower border of the left renal vein and the upper border of the origin of the inferior mesenteric artery
16b2	Para-aortic LNs between the upper border of the origin of the inferior mesenteric artery and the aortic bifurcation
17	LNs on the anterior surface of the pancreatic head beneath the pancreatic sheath
18	LNs along the inferior border of the pancreatic body
19	Infradiaphragmatic LNs predominantly along the subphrenic artery
20	Paraesophageal LNs in the diaphragmatic esophageal hiatus
110	Paraesophageal LNs in the lower thorax
111	Supradiaphragmatic LNs separate from the esophagus
112	Posterior mediastinal LNs separate from the esophagus and the esophageal hiatus

Adapted from Japanese Gastric Cancer Association. Japanese classifications of gastric carcinoma. 14th ed. Table 5. Tokyo: Kanehara & Co., Ltd.; with permission

(station 10) and the distal splenic artery nodal station (station 11d). Previous randomized trials examining D1–D2 nodal dissection suffered from the complications of this historical approach. Currently splenectomy and distal pancreatectomy are not recommended for nodal clearance in North America and Europe. Due to the high incidence of splenic hilar nodal involvement in advanced proximal gastric cancers, a randomized trial of D2 nodal dissections with or without a splenectomy preserving pancreatic tail is in progress for this specific group of patients in Japan.

Blood Supply to Residual Gastric Pouch

A major drawback of including the spleen in a resection that also involves ligation of the left gastric artery *at its origin* is that ischemia or necrosis of the residual gastric pouch may develop. After left gastric ligation and division of the left gastroepiploic artery, the blood supply of the residual gastric pouch is limited. About 40–97 % of patients have a posterior gastric artery supplying posterior portion of the gastric fundus that arises from the middle portion of the splenic artery. It is possible to preserve this artery if care is taken during the operation, but it is a small vessel and is easily traumatized. In addition, there are collateral branches from the inferior phrenic vessels and intramural circulation from the esophagus.

As mentioned above, whenever the left gastric artery is divided at its origin and splenectomy is performed, the blood supply to the gastric pouch may be inadequate. Thus one should avoid splenectomy in these cases unless so little gastric pouch is left behind that it may receive adequate nourishment through the intramural channels from the esophagus if the posterior gastric and inferior phrenic collaterals prove inadequate. If there is any doubt about the adequacy of the blood supply, perform a total gastrectomy.

Duct of Santorini

When carcinoma approaches the pyloric region, microscopic spread into the proximal 4–5 cm of the duodenum is possible. When as much as 5 cm of the duodenum is mobilized, the dissection has progressed beyond the gastroduodenal artery. In this area there is a risk that the duct of Santorini will be transected. Because the duodenal wall is free of inflammation in cases of this type, this structure may well be identifiable, in which case it should be divided and ligated. If the duct of Santorini communicates with the duct of Wirsung, the pancreatic juice then drains freely into the larger duct, and there should be no postoperative difficulty. In some cases the duct of Santorini does not communicate with the main duct, in which event, despite the ligature, a pancreatic fistula may well develop. This situation probably requires a secondary operation to anastomose a Roux-en-Y segment of the jejunum to the transected duct for internal drainage. Fortunately, in most cases the two ducts do communicate.

Operative Technique

Incision and Exposure

An upper midline incision extending from the xiphoid to a few centimeters below the umbilicus gives good exposure for this procedure. For patients with a high body mass index (BMI), a Chevron incision can be used as alternative. Place an Omni retractor or Thompson retractor to elevate the costal margin.

Resection

Distal gastrectomy with D2 nodal dissection differs from gastrectomy for peptic ulcer disease in terms of the dissection and the extent of resection. The reconstruction is essentially the same and is not repeated here (see Chap. 33).

Begin with a thorough exploration of the abdomen. Metastatic disease not detected on preoperative imaging studies does not preclude resection for palliation in selected patients. Evaluate the location and mobility of the tumor; determine whether adjacent structures must be resected or if a total gastrectomy (see Chap. 38) is more appropriate.

Omentectomy and Infrapyloric Nodal Dissection

Separate the entire gastrocolic omentum from the transverse colon by dissection through the avascular embryonic fusion plane, as seen in the sagittal section of the abdomen in Fig. 37.2. Be alert to the difference in texture and color of the fat in the epiploic appendices of the colon and that of the omentum. Considerable bleeding and devascularization of the transverse colon can be avoided by keeping the plane of dissection between the appendices and the omentum (Fig. 37.4). Once the lesser sac is entered through this plane, identify the fusion plane between omentum and transverse mesocolon and elevate the omentum from the transverse mesocolon (Fig. 37.5). Take care to avoid damage to the mesocolon and middle colic artery. Follow the middle colic vessels and expose the anterior surfaces of the pancreas and duodenum, along with the origin of the right gastroepiploic vessels. Ligate the latter at their origin with 2-0 silk and divide them, sweeping all soft tissue covering head of the pancreas toward the specimen (Fig. 37.6). Clear the inferior edge of the duodenal wall and connect this to previous dissection plane.

Dissection of Suprapyloric Nodes

Start the dissection by dividing the lesser omentum 1 cm from its attachment to the liver. Recognize any accessory/replaced left hepatic artery originating from left gastric artery in this area. This can be preserved if no clinically positive nodes are seen around the left gastric artery by dissection of the nodes from the left gastric artery. Extend the incision to the left border of hepatoduodenal ligament. Remove soft tissue covering the proper hepatic artery toward common hepatic artery. Identify the origin of right gastric artery, ligate with 3-0 Silk ties, and divide it. Now, change the dissection plane toward the upper border of duodenum and separate the soft tissues in the suprapyloric area from neck of the pancreas.

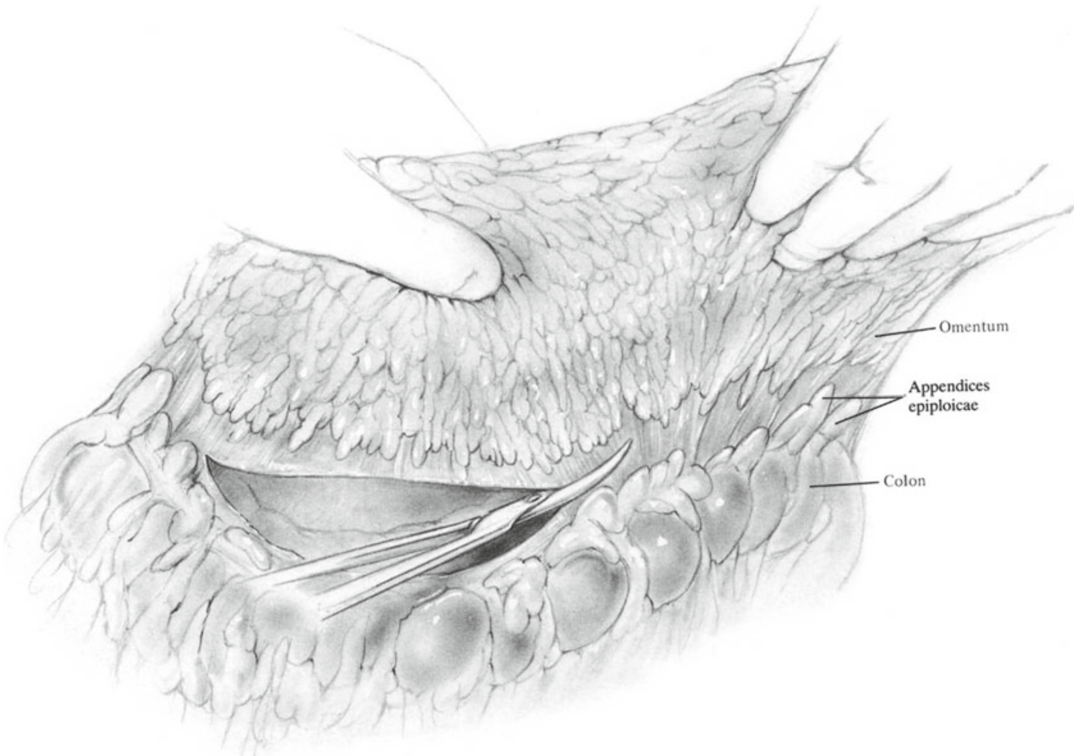

Fig. 37.4

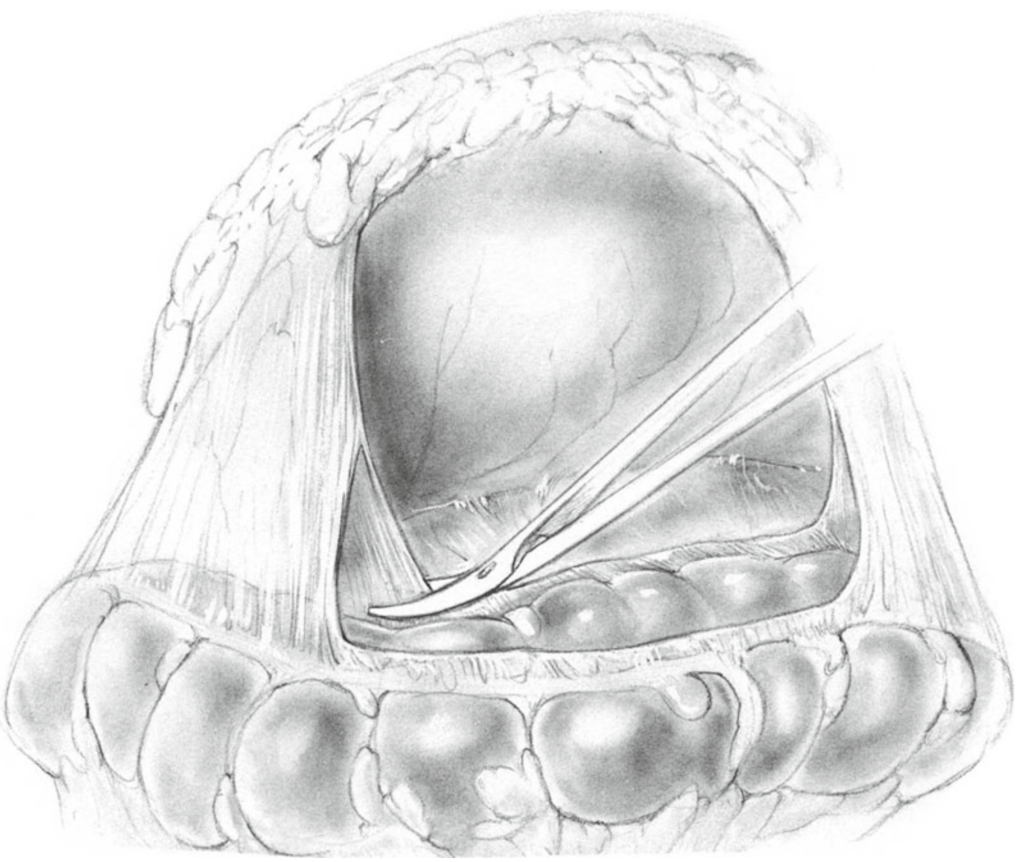

Fig. 37.5

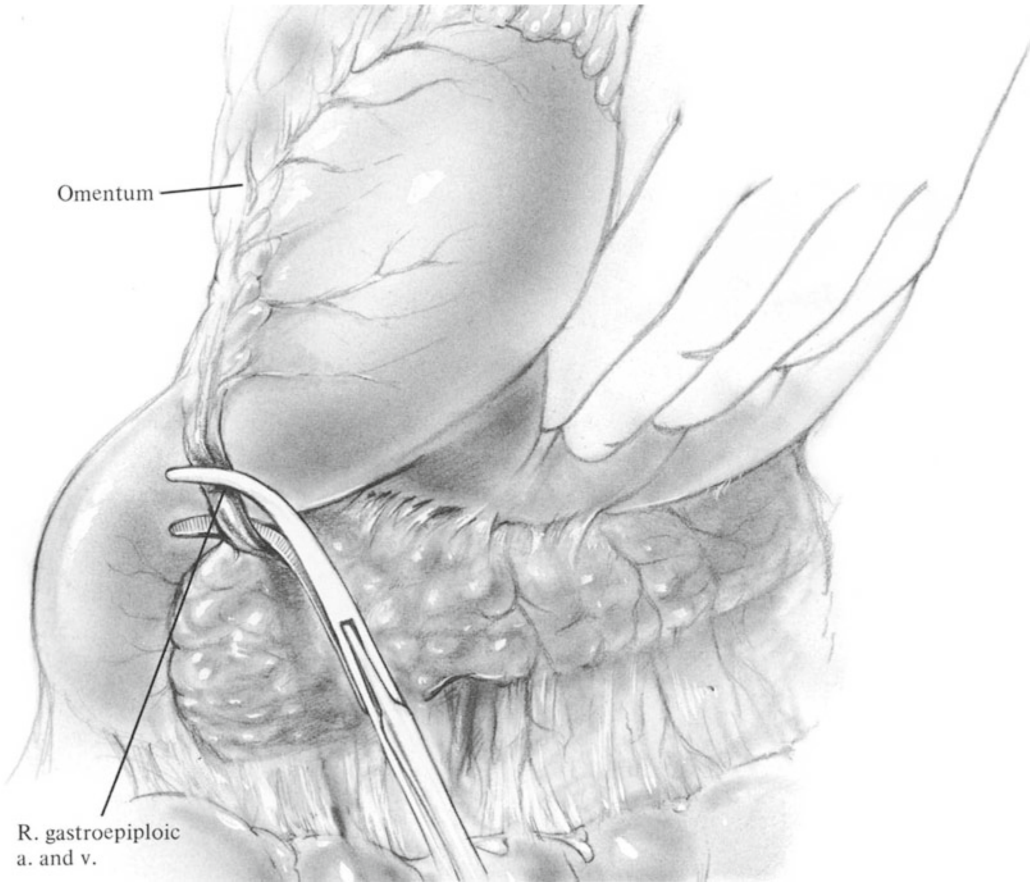

Fig. 37.6

Division of Duodenum

Perform a Kocher maneuver and dissect the duodenum from the anterior surface of the pancreas for a distance of 5 cm. If a stapled closure of the duodenum is elected, apply the blue load GIA stapler (author uses endo GIA to take advantage of 3-row staple line) to the duodenum and fire the stapler.

Hepatic Artery Node Dissection

Continue the nodal dissection along the hepatic artery. Divide the peritoneum along the superior border of the pancreas toward left and dissect away the soft tissue covering the common hepatic artery. There is a distinctive plane between the nodal tissue and the pancreas parenchyma, and this should be recognized, and the dissection should be maintained in this plane to avoid injury to the pancreas (Fig. 37.7). There are multiple small vessels present between these node and upper border of the pancreas, and these should be recognized and coagulated before transection. The dissection plane also can be maintained just outside of the perivascular nerve plexus unless gross metastatic nodes present along the artery. The left gastric vein is typically present around the common hepatic artery but may be located in front of the common hepatic artery. Injury to this vein, often referred to as the coronary vein, will create a bleeding situation that is difficult to control. Careful dissection and vessel control prior to division is recommended. The superior border of the dissection is the right crus of the diaphragm.

Celiac Axis Dissection and Division of Left Gastric Vessels

With the stomach elevated and retracted toward the patient's left, it is a simple matter to palpate the left gastric artery as it travels from the region of the aorta, anteriorly, to meet the lesser curvature of the stomach. Continuing the hepatic artery dissection leads to the celiac axis and to the origin of the left gastric artery. By dissecting the areolar and lymphatic tissue away distally, the origin of the artery can be skeletonized. After it has been double ligated, divide it. Continue the dissection along the splenic artery. Nodal tissue proximal to the origin of the posterior gastric artery should be dissected for all gastric cancers except early gastric cancers.

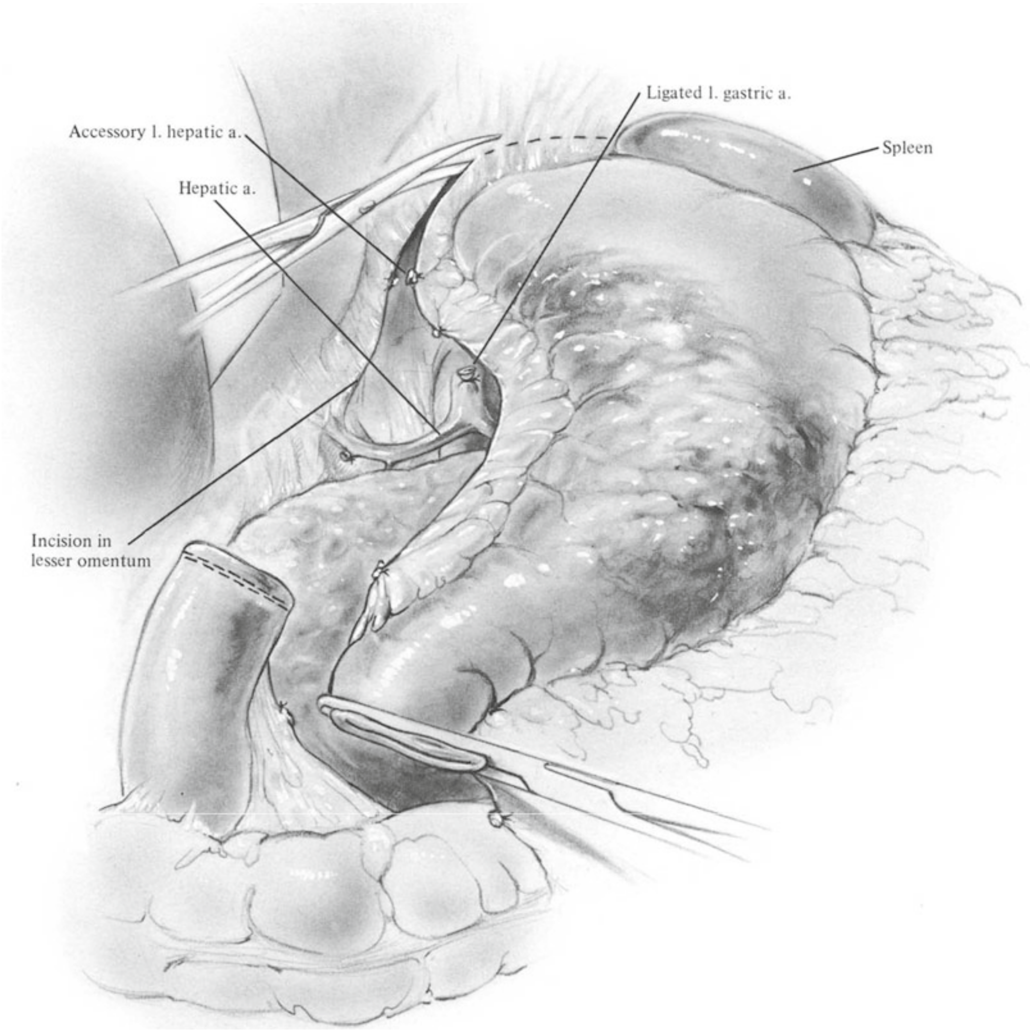

Fig. 37.7

In the retroperitoneum, the border of the right diaphragmatic crus is identified and peritoneum covering over the crus is divided. This will provide access to the space between the anterior surface of the aorta and the nodal tissue along the lesser curvature of the stomach. Dissection of this plane in right to left direction mobilizes node stations 1 (right cardiac), 3 (lesser curvature), 7 (left gastric artery), and 9 (celiac) toward the stomach. In the end, left side of esophageal hiatus will be completely exposed, and the dissection plane should connect to the previous left gastric artery and the splenic artery dissection plane.

At the conclusion of this step, the superior border of the adjacent pancreas and the anterior surface of the celiac axis and the aorta should be free of lymphatic tissue.

At the greater curvature side, separation of the greater omentum from transverse colon continues to the splenic flexure. Take care not to pull the greater omentum to expose this area until lower pole of the spleen is completely separated from the specimen as excessive traction may tear the capsule of the spleen. At the lower pole of the spleen and the tail of the pancreas, the origin of the left gastroepiploic artery and vein can be identified, and these should be ligated at this point to completely clear the left greater curvature nodal tissue.

Both lesser curvature and greater curvature of the stomach need to be cleared with nodal tissue for transection. Along the greater curvature, all the terminal branches from the left gastroepiploic artery should be ligated on the wall of the stomach starting from the first branch of the left gastroepiploic artery to planned transection point. Preserved short gastric arteries can prevent gastric remnant necrosis.

On the lesser curvature, the previously dissected nodal packet needs to be separated from the stomach wall. This can be accomplished by ligating left gastric artery terminal branches on the gastric wall from the esophagogastric junction to the transection point or vice versa. The left gastric artery has anterior and posterior branches which terminate corresponding surfaces of the stomach, thus both branches need to be ligated.

Once this portion of the dissection is completed, then the stomach should be ready to be divided to remove all the nodal tissue en bloc with the main specimen. For the clean and complete dissection of the nodes in the correct plane, en bloc resection of the celiac nodes is recommended (with the exception of preservation of the left gastric artery in cases of a replaced left hepatic artery as previously noted).

Reconstruction is generally by antecolic Billroth II anastomosis, as shown in Figs. 33.34, 33.35, and 33.36. Alternatively, a Roux-en-Y reconstruction may be preferred, as this prevents bile reflux. No drains are placed.

Postoperative Care

Postoperative care is identical to that following gastrectomy for peptic ulcer (see Chap. 33). Enteral or total parenteral nutrition is added to the regimen when indicated.

Complications

Complications are similar to those following gastrectomy for peptic ulcer (see Chap. 33), but subphrenic and subhepatic abscess is more common because of the increased bacterial contamination associated with carcinoma.

Further Reading

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38 Total Gastrectomy

Hisakazu Hoshi

Indications

Adenocarcinoma of the stomach
Gastric GIST or other malignancy (lymphadenectomy is not necessary except neuroendocrine carcinoma)
Life-threatening hemorrhage from extensive erosive gastritis (rarely – and in this case, obviously, no lymphadenectomy is performed)

Preoperative Preparation

See Chap. 37.

Pitfalls and Danger Points

Improper reconstruction of alimentary tract, which can lead to postoperative reflux alkaline esophagitis.
Erroneous diagnosis of malignancy. Patients have undergone total gastrectomy when surgeons have misdiagnosed a large posterior penetrating ulcer as a malignant tumor. Because benign gastric ulcer can be cured by relatively simple surgery, this error may have serious consequences for the patient. If preoperative endoscopic biopsy has been negative, perform a gastrotomy, and with an excision or a biopsy punch, obtain a direct biopsy of the edge of ulcer in four quadrants.
Inadequate anastomotic technique, resulting in leak or stricture.
Sepsis in wound or subhepatic and subphrenic spaces due to contamination by gastric contents or anastomotic leak.
Failure to identify submucosal infiltration of carcinoma in the esophagus or duodenum beyond the line of resection.

Documentation Basics

Document extent of disease
Frozen sections taken and results
Extent of lymphadenectomy and resection of any adjacent organs
Type of anastomosis performed
Any drains placed

Operative Strategy

Exposure

If the primary lesion is a malignancy of the body of the stomach that does not invade the lower esophagus, a midline incision from the xiphoid to a point 2–4 cm below the umbilicus may prove adequate for total gastrectomy if the Omni or Thompson retractor is used to elevate the lower sternum. If the tumor is near the esophagogastric junction, it may be necessary to include 6–10 cm of the lower esophagus in the specimen to circumvent submucosal infiltration by the tumor. In this case a left thoracoabdominal incision is indicated, as described in Chap. 15. Never attempt to construct an esophageal anastomosis without excellent exposure. For patients with a high body mass index (BMI), a Chevron incision can be used as alternative.

Esophageal Anastomosis

We prefer an end-to-side esophagojejunal anastomosis because of the ease of performing stapled anastomosis, and it permits invagination of the esophagus into the jejunum if

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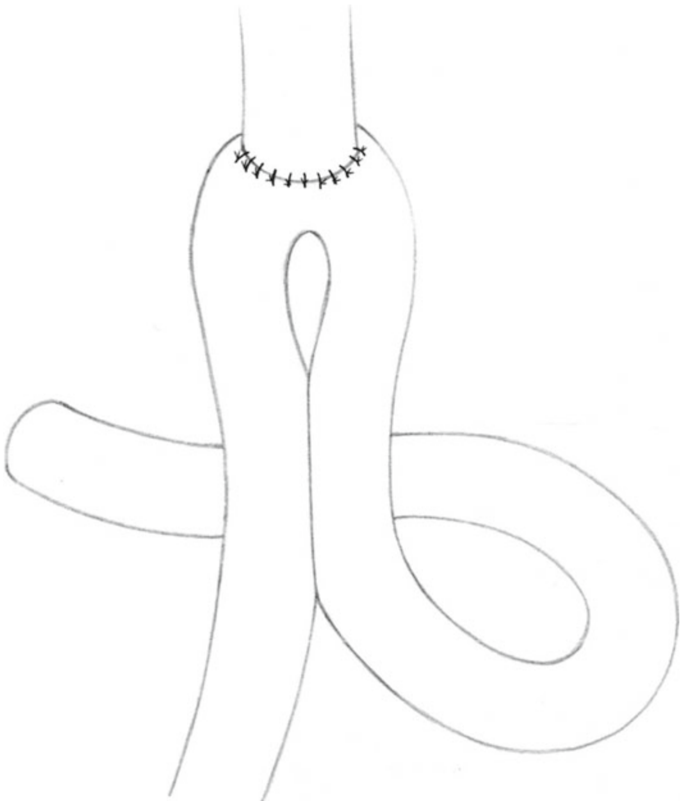

Fig. 38.1

necessary, which in turn results in a lower incidence of leakage. With an end-to-end esophagojejunostomy, invagination could result in constriction of the lumen.

Prevention of Reflux Alkaline Esophagitis

An anastomosis between the end of the esophagus and the side of the jejunum combined with a side-to-side jejunojejunostomy (Fig. 38.1) results in a high incidence of *disabling* postoperative alkaline esophagitis. *This must be prevented by utilizing the Roux-en-Y principle in all cases*. The distance between the esophagojejunal anastomosis and the jejunojejunal anastomosis must be 45 cm or more to prevent reflux of the duodenal contents into the esophagus. This is a far more important consideration than is construction of a jejunal pouch for a reservoir, and we no longer create such a pouch in these cases.

Extent of the Operation

Microscopic submucosal infiltration may occur in the esophagus as far as 10 cm proximal to a grossly visible tumor and occasionally well down into the duodenum especially with poorly differentiated adenocarcinoma. Frozen section microscopic examination of both the esophageal and duodenal ends of the specimen should be obtained to avoid leaving behind residual submucosal carcinoma (see Chap. 37).

The lymph nodes along the celiac axis should be swept up with the specimen with the left gastric artery divided at its origin. The lymphatics along the hepatic artery and splenic artery also should be removed, along with those at the origin of the right gastroepiploic artery. Whether it is beneficial to skeletonize the hepatic artery and portal vein all the way to the hilus of the liver is not clear.

Routine resection of the body and tail of the pancreas may increase the morbidity and mortality rate from this operation because pancreatic complications can occur; at the same time it has not been proved that this additional step improves a patient's long-term survival. However, if the tail of the pancreas shows evidence of tumor invasion, this portion of the pancreas should certainly be included in resection. The anatomy of the structures involved in this operation can be seen in Fig. 37.1. Due to the high incidence of splenic hilar nodal involvement in advanced proximal gastric cancers, a randomized trial of D2 nodal dissections with or without a splenectomy preserving pancreatic tail is in progress for this specific group of patients in Japan. This chapter describes a portion of D2 dissection specific for total gastrectomy. See Chap. 37 for a detailed description of the standard lymph node stations, the definitions of D level of dissection, and common portion of the D2 nodal dissection for both distal and total gastrectomy.

Operative Technique

Incision and Exposure

In many cases adequate exposure is obtained by a midline incision from the xiphoid to a point 2–4 cm below the umbilicus, along with the use of an Omni or Thompson retractor. When the carcinoma involves the lower esophagus, a left thoracoabdominal approach may be necessary.

Exploration and Determination of Operability

Tumors are considered non-resectable when there is posterior invasion of the aorta, vena cava, or celiac axis. Invasion of the body or tail of the pancreas is not a contraindication to operation, nor is invasion of the left lobe of the liver, as these structures can be included in the specimen if necessary.

When there is only a moderate degree of distant metastasis in the presence of an extensive tumor, a palliative resection is indicated *if it can be done safely*.

Invasion of the root of the mesocolon, including the middle colic artery, does not contraindicate resection if leaving

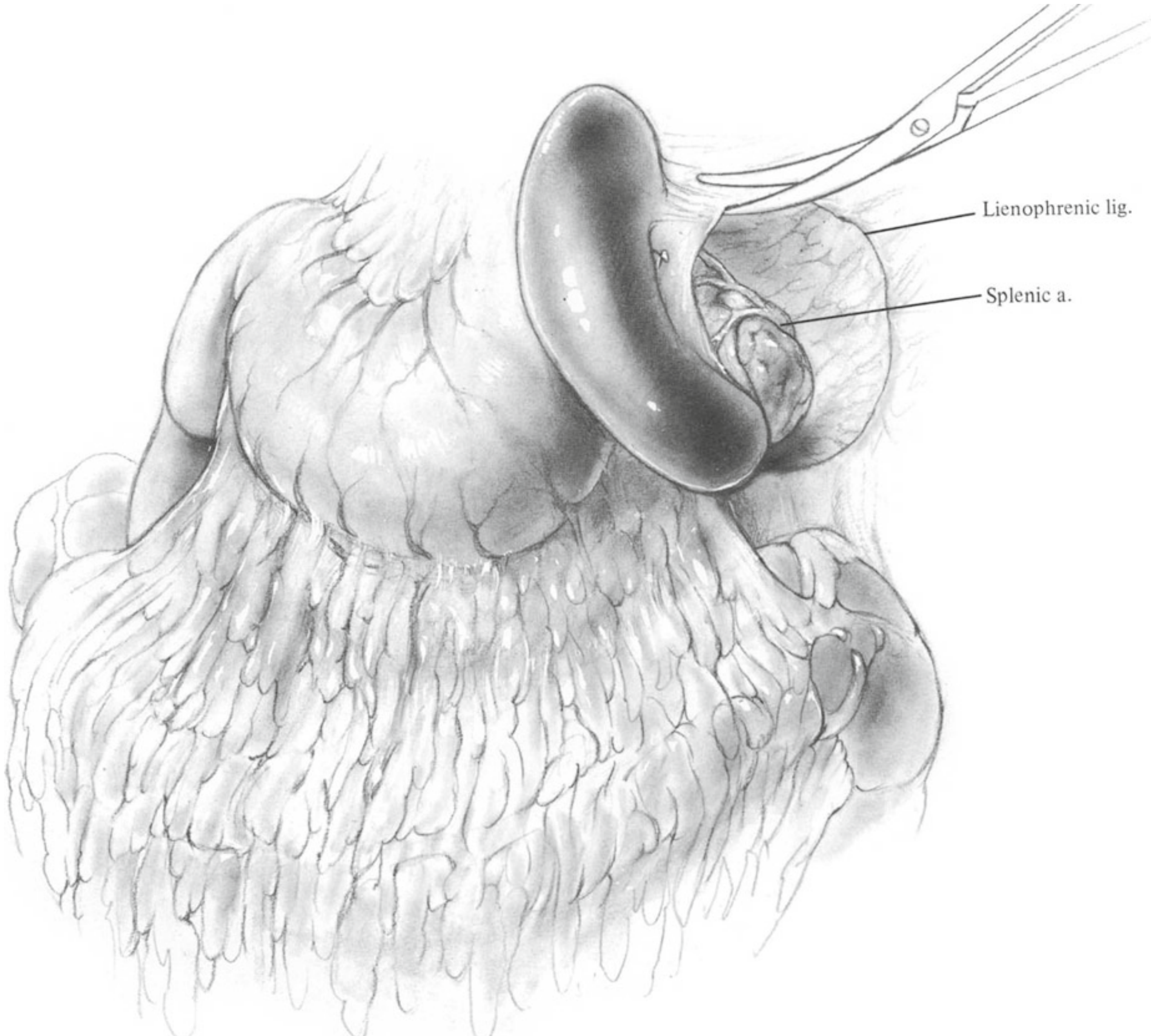

Fig. 38.2

these structures attached to the specimen removes the tumor. This often requires concomitant resection of a segment of the transverse colon. It is surprising that in some patients removing a short segment of the main middle colic artery does not impair the viability of the transverse colon so long as there is good collateral circulation.

Omentectomy, Lymph Node Dissection, and Division of Duodenum

The initial steps are performed as described in Chap. 37. The dissection begins with a complete omentectomy, ligation of the right gastroepiploic vessels at their origin, and division of the duodenum. The lesser omentum is divided up to the esophagogastric junction and the left gastric artery is ligated and divided at its origin. Nodal tissue is mobilized from retroperitoneum. If splenectomy is planned, it is frequently done as the next step.

Splenectomy

Splenectomy is performed only when tumor encroaches on the spleen or splenic hilum. Incise the avascular lienophrenic ligament that attaches the lateral aspect of the spleen to the undersurface of the diaphragm (Fig. 38.2). As this incision reaches the inferior pole of the spleen, divide the lienocolic ligament; the posterior surface of the pancreatic tail can then be seen. The tail can be elevated gently from the retroperitoneal space. Previous dissection along the splenic artery at the superior border of pancreatic tail continues until the pancreatic tail is completely dissected and splenic artery and vein clearly seen. Ligate both artery and vein and separate spleen

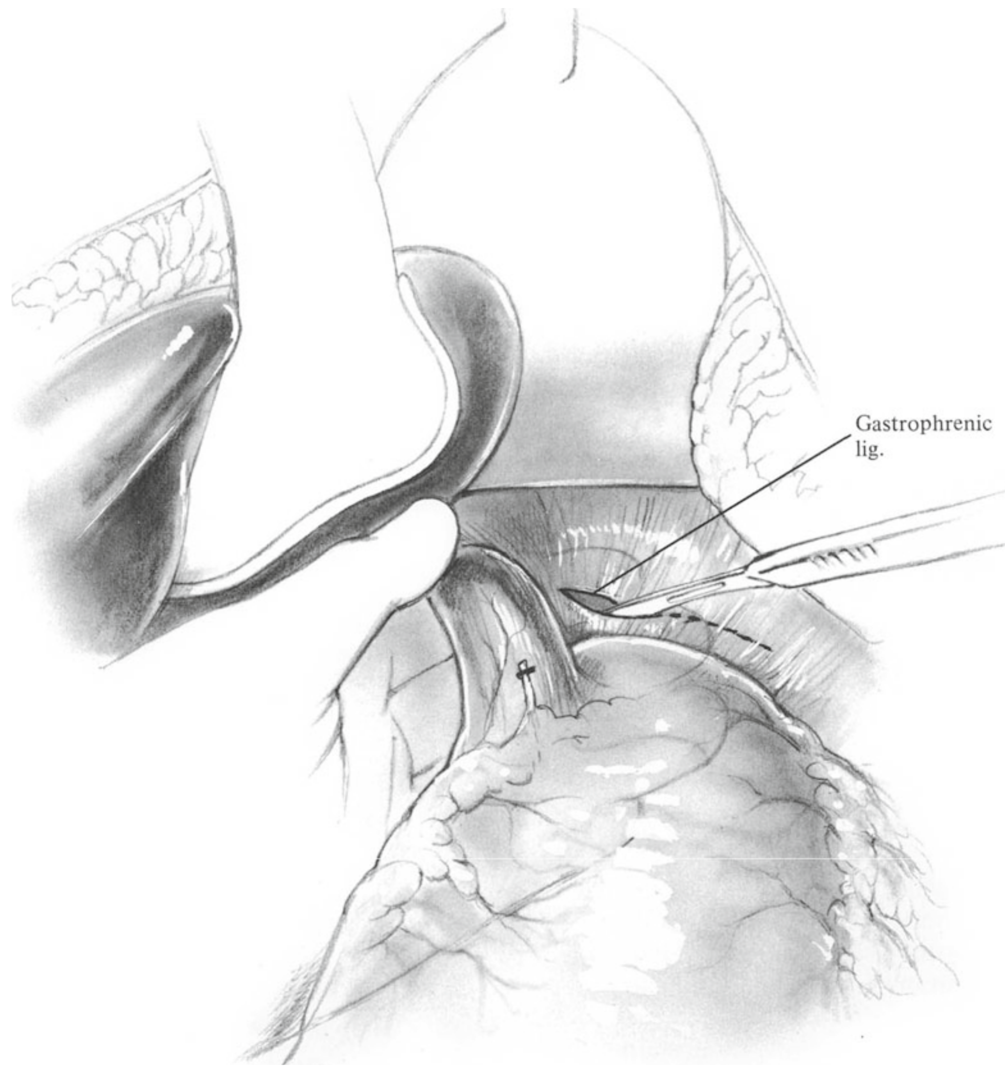

Fig. 38.3

from the tail of pancreas. For the retroperitoneal dissection, expose the fascia of Gerota and the left adrenal gland. If there is evidence of tumor invasion, include these structures in the specimen. Fundus of the stomach is attached to the diaphragm. Now divide this peritoneal attachment toward the gastroesophageal junction. Care should be exercised to avoid injury to left inferior phrenic vessels.

Splenic Nodal Dissection Without Splenectomy

After ligating the left gastroepiploic vessels, short gastric vessels need to be ligated and divided close to the splenic attachment. Once the short gastric vessels are ligated and divided, the gastric fundus can be mobilized completely from the retroperitoneum and spleen. Finally nodal tissues along the distal splenic artery (station 11d) and the hilum of spleen (station 10) are dissected. To avoid injury to the splenic vessels and tail of the pancreas, the dissection should follow the previous dissection plane identified at the celiac axis.

Dissection of the Esophagocardiac Junction: Vagotomy

Retract the left lobe of the liver to the patient's right and incise the peritoneum overlying the abdominal esophagus. Using a peanut dissector, dissect the esophagus away from the right and left diaphragmatic crura. Then encircle the esophagus with the index finger and perform a bilateral truncal vagotomy, as described in Chap. 29. Pass the left hand behind the esophagocardiac junction, a maneuver that delineates the avascular gastrophrenic and any remaining esophagophrenic ligaments, all of which should be divided (Fig. 38.3), freeing the posterior wall of the stomach.

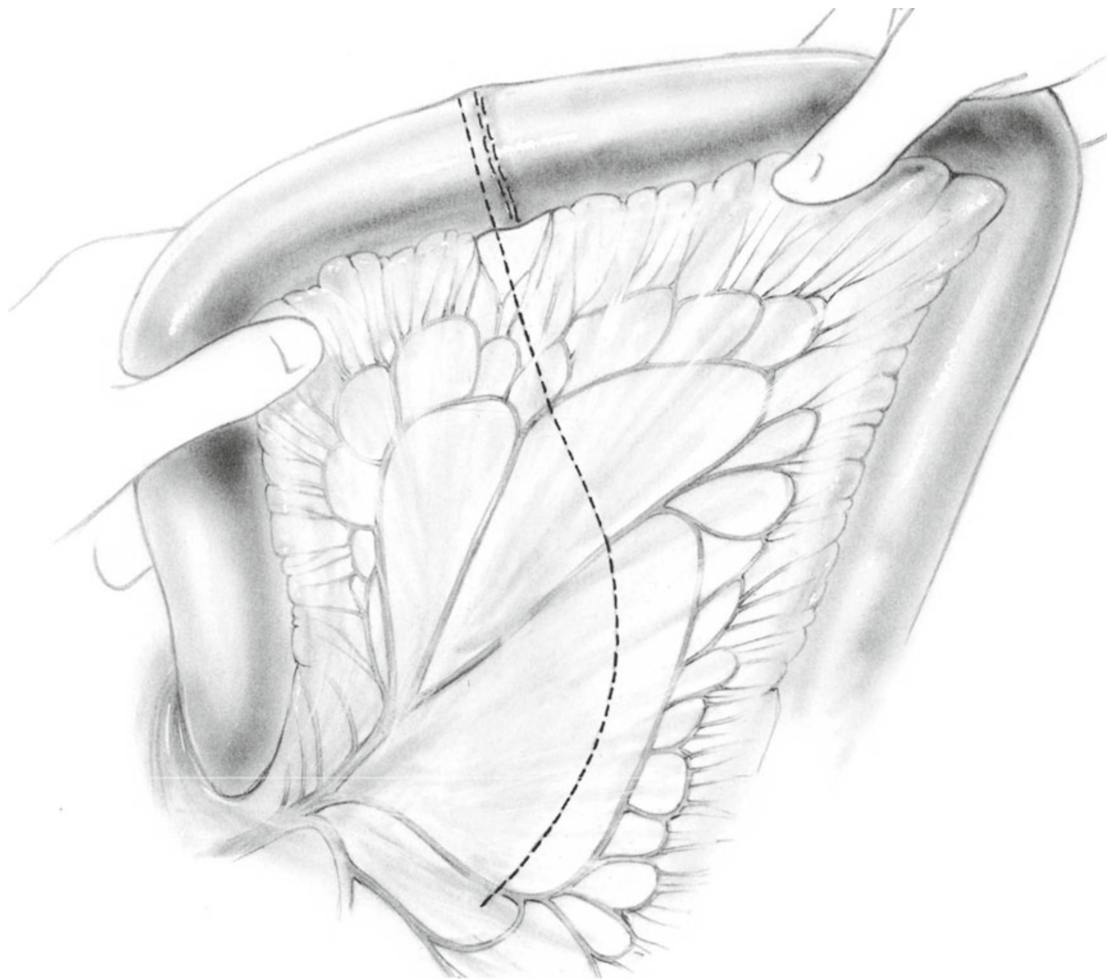

Fig. 38.4

Preparation of Roux-en-Y Jejunal Segment

After identifying the ligament of Treitz, elevate the proximal jejunum from the abdominal cavity and inspect the mesentery to determine how it can reach the apex of the abdominal cavity for the esophagojejunal anastomosis. In some patients who have lost considerable weight before the operation, the jejunum reaches the esophagus without the need to divide anything but the marginal artery. In patients whose jejunal mesentery is short, it may be necessary to divide several arcade vessels. Transillumination is a valuable aid for dissecting the mesentery without undue trauma.

Generally, the point of division of the jejunum is about 15 cm distal to the ligament of Treitz, between the second and third arcade vessels. Make an incision in the mesentery across the marginal vessels and divide and ligate them with 3-0 silk. Divide and ligate one to three additional arcade vessels to provide an adequate length of the jejunum to reach the esophagus without tension (Fig. 38.4).

Apply a GIA stapler to the point on the jejunum previously selected for division. Fire the stapler.

Next make a 3- to 4-cm incision in the avascular portion of the transverse mesocolon to the left of the middle colic artery. Deliver the stapled end of the distal jejunum through the incision in the mesocolon to the region of the esophagus. After the jejunal segment is properly positioned, suture the defect in the mesocolon to the wall of the jejunum to prevent herniation later.

End-to-Side Sutured Esophagojejunostomy

The anticipated site of the esophageal transection is at least 3–5 cm above the proximal margin of the palpable tumor depending on tumor histology.

Apply a soft Satinsky vascular clamp to distal esophagus about 2–3 cm above the transection line. Transect the esophagus and remove the specimen and ask the pathologist to perform a frozen section examination of both the proximal and distal margins. If the frozen section examination is positive for malignancy, further excision is indicated.

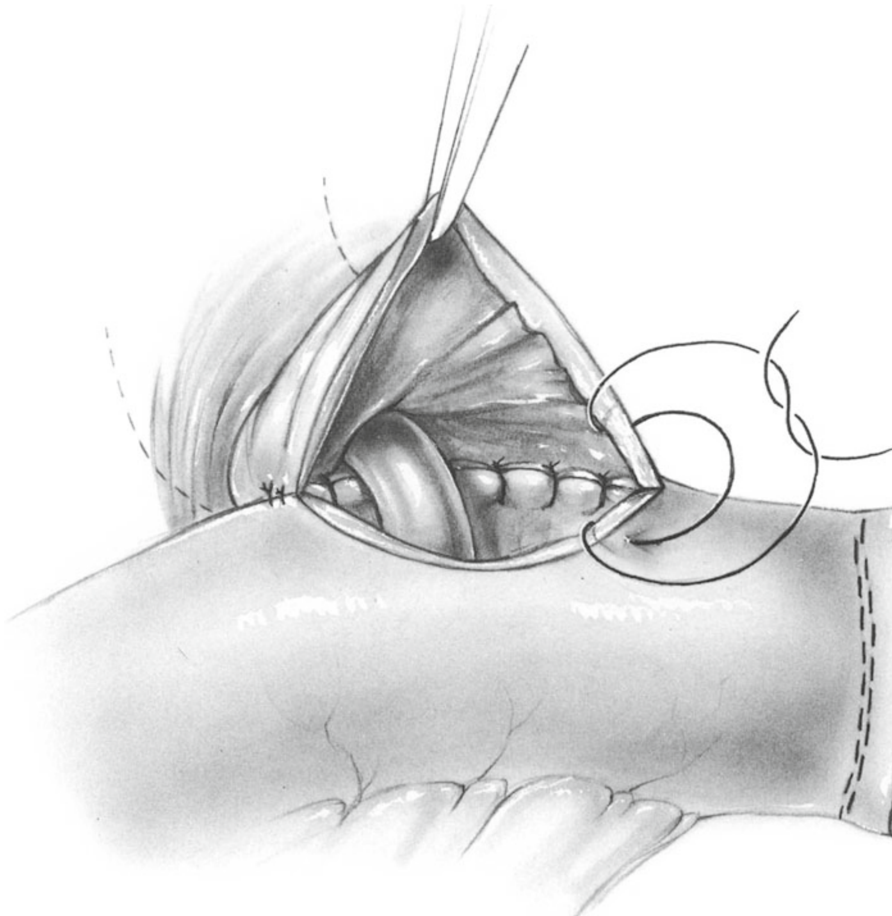

Fig. 38.5

Place a 4-0 PDS suture beginning at the right lateral portion of the esophagus with full thickness bite. With the same needle take a bite at the right lateral margin of the jejunal full thickness wall. Place a similar suture at the left lateral margins of the esophagus and jejunum. Apply hemostats to each suture, as none is tied until the posterior suture line has been completed.

Place two additional 4-0 PDS suture at the midportion of the posterior wall and close posterior layer with running full thickness bites. Once sutures reach corner then first tie the previous corner sutures and then tie running sutures to the corner sutures. Close anterior wall with interrupted 4-0 PDS full thickness sutures (Figs. 38.5 and 38.6). Inspect the anastomosis and if there is weak portion, place 4-0 PDS muscular sutures on esophagus and seromuscular bite on jejunum and invert the anastomosis.

End-to-Side Stapled Esophagojejunostomy

An end-to-side esophagojejunostomy performed with a circular stapler requires easy access to 4–5 cm of relaxed esophagus with good exposure to enable the surgeon to inspect the

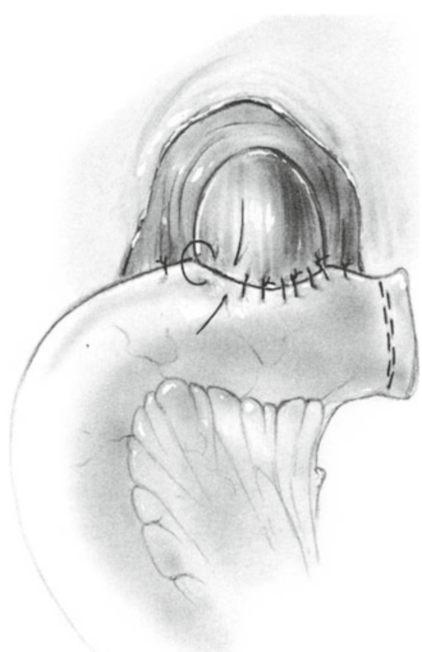

Fig. 38.6

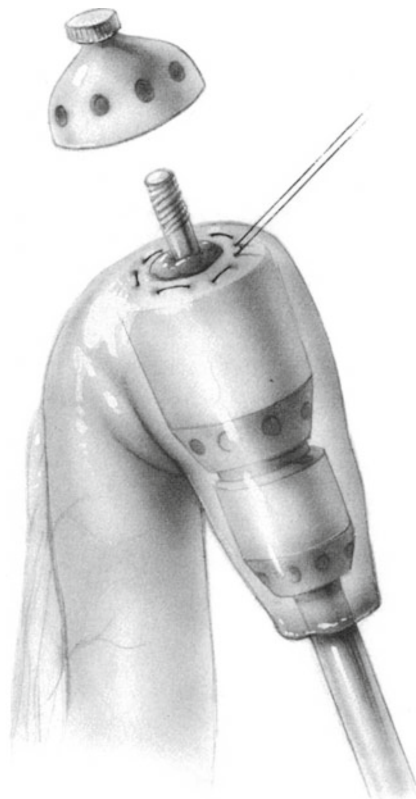

Fig. 38.7

Fig. 38.8

anastomosis carefully at its conclusion. We apply the purse-string device before transecting esophagus. Once this device is fired, then apply large right angle clamp to the esophagus 2–3 cm distal to the device to prevent spillage. Transect the anterior wall of the esophagus about 5 mm below the edge of purse-string device. Grasp just the edge of proximal edge of the anterior wall of the esophagus and release the device. The posterior wall is still attached and preventing esophageal stump retracting into mediastinum. Carefully insert EEA anvil into the proximal esophagus. We do not usually use a sizer. The 25-mm EEA is wide enough, but use 28 mm if esophagus can accommodate it without causing mucosal tear. Tie the purse-string around the post. Then transect the posterior wall with small cuff of tissue left around the post and remove specimen. Typically, the volume of housing of 25-mm EEA is small and cannot accommodate large volume of tissue. Inspect the tissue around the anvil post and if it is bulky then carefully trim it without cutting purse-string suture.

Bring the previously prepared Roux-en-Y segment of jejunum and pass it through an incision in the avascular part of the transverse mesocolon. The jejunum should easily reach the esophagus with 6–7 cm to spare. Gently dilate the lumen of the jejunum and insert the lubricated cartridge of the circular stapler into the open end of the jejunum, as in Fig. 38.7. Deploy the rod of the stapler through the elbow of the jejunum so the rod can penetrate the antimesenteric border of the jejunum.

Attach the anvil to the device and be certain the connection is tight (Fig. 38.8). Now turn the screw at the base of the stapler so the anvil is approximated to the cartridge. Watch distal portion of jejunum and make sure not to incorporate the mesenteric side of the wall in the stapler (Figs. 38.9 and 38.10). Also watch the angle and tension of stapler. Too much tension or angulation on the stapler will stretch the relatively immobile esophageal end and thus cause thin or incomplete formation of esophageal tissue ring. Carefully inspect the staple line before firing device for tissue protrusion or adjacent tissue incorporation. When this has been completed, fire the device by pulling the trigger. Then turn the wing nut the appropriate number of turns counterclockwise, rotate the device, and manipulate the anvil in such fashion as to withdraw the stapler from the anastomosis.

Inspect the excised tissue rings in the stapler. If these are satisfactory and the staple line looks intact, apply a blue GIA to the jejunal end. Apply the stapler at a point about 1–2 cm

Fig. 38.9

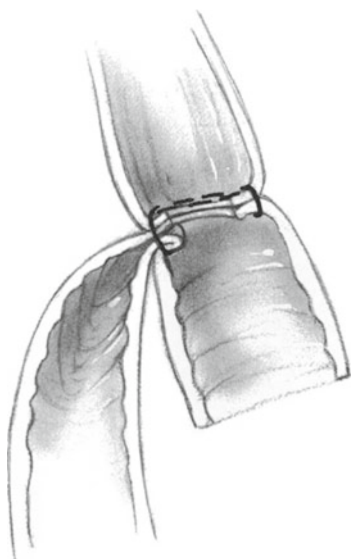

Fig. 38.10

away from the anastomosis. Close the jaws of the linear stapler and fire it. It is important to amputate the jejunum close to the anastomosis so no blind loop develops.

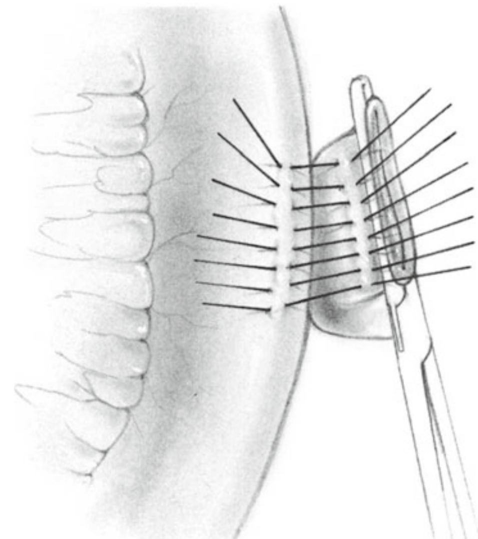

Fig. 38.11

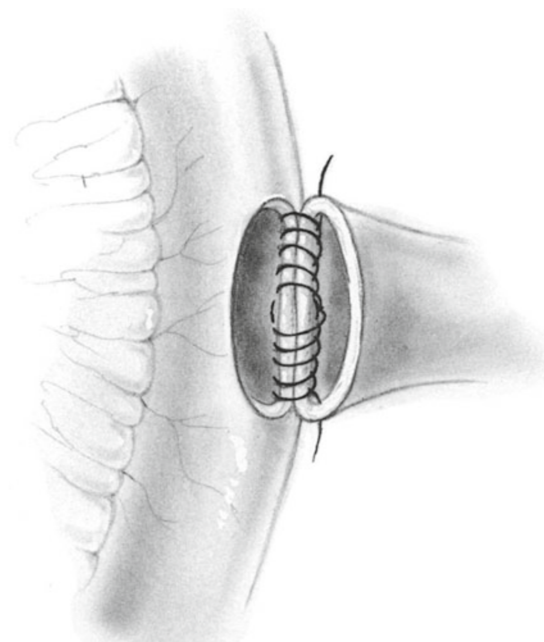

Fig. 38.12

Roux-en-Y Jejunojejunostomy

Sutured Version

Attention should now be directed to restoring the continuity of the small intestine by doing an end-to-side anastomosis between the cut end of the proximal (biliopancreatic limb) jejunum and the side of the Roux-en-Y limb. This anastomosis should be made at least 45 cm from the esophagojejunal anastomosis to prevent bile reflux. After the proper site on the antimesenteric border of jejunum has been selected, use interrupted 3-0 silk Lembert sutures for the posterior seromuscular layer of the end-to-side anastomosis (Fig. 38.11). When all these sutures have been placed, make an incision along the previously marked area of the jejunum and remove the staple line from the proximal segment of the jejunum. Approximate the full thickness layers using running 3-0 Vicryl (Fig. 38.12). Take the first stitch in the middle of the posterior layer and tie it. Close the remainder of the posterior layer with a continuous suture and transition to anterior

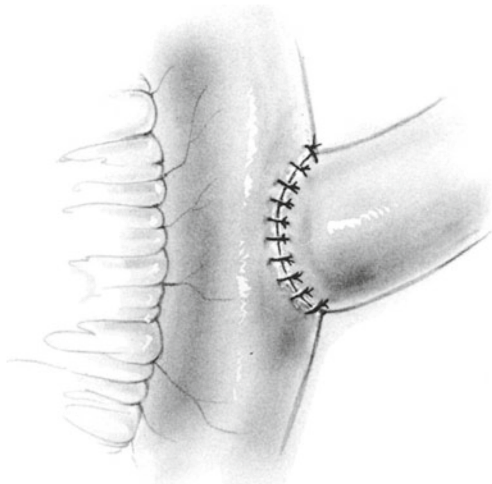

Fig. 38.13

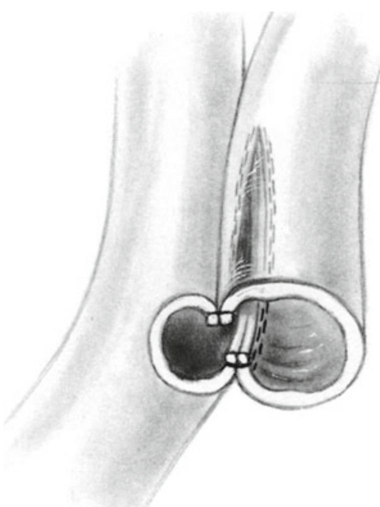

Fig. 38.14

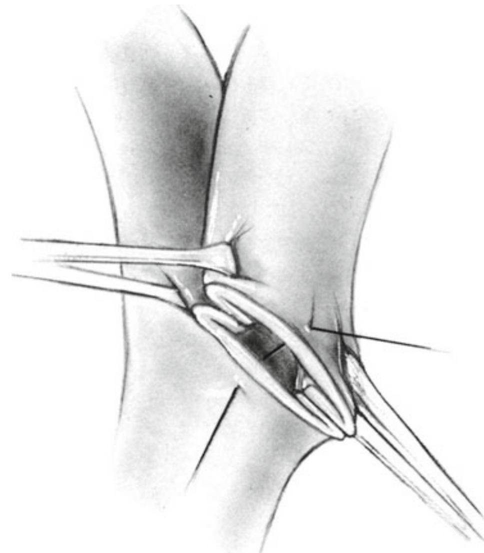

Fig. 38.15

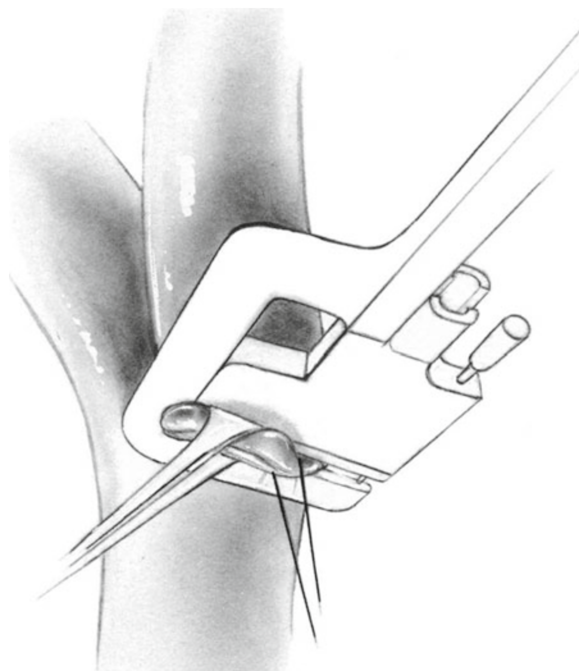

Fig. 38.16

layer. Finally approximate seromuscular layer with 3-0 silk Lembert sutures (Fig. 38.13).

Stapled Version

In most cases, we prefer to perform the Roux-en-Y jejunojejunostomy with a stapling technique. To accomplish this, the biliopancreatic limb of the jejunum is approximated to the Roux-en-Y limb with seromuscular stitches. With electrocautery make a 1-cm longitudinal incision on the antimesenteric border. Insert a linear cutting stapling device: one fork in the descending segment of the jejunum and the other fork in the open end of the proximal segment of the jejunum (Fig. 38.14). Be certain the *open end of the proximal segment of jejunum is placed so the opening faces in a caudal direction* to prevent intussusception. When the stapler is in place, lock and fire it; it can be seen that the first layer of the anastomosis has been completed in a side-to-side fashion between the antimesenteric borders of the two segments of the jejunum. Inspect the intraluminal staple line for bleeding.

To close the remaining defect in the anastomosis, apply Allis clamps to the right- and left-hand terminations of the staple line (Fig. 38.15). Then apply multiple Allis clamps in between approximating full thickness of both sides of jejunal wall. Apply the TA-55 blue stapling device deep to the Allis clamps (Fig. 38.16).

Close the remaining potential defects between the mesentery of the proximal and distal jejunum with interrupted sutures of 3-0 Vicryl to prevent internal herniation.

Modifications of Operative Technique for Patients with Benign Disease

When total gastrectomy is being performed for benign disease, several modifications are indicated. First, it is not necessary to excise considerable lengths of the esophagus or duodenum. These structures are divided close to the margins of the stomach. Second, it is not necessary to remove the spleen or omentum, and the greater curvature dissection can be carried out by dividing each of the vasa brevia between the greater curvature of the stomach and the greater omentum, leaving the omentum behind. Third, dissection of the lymph nodes in the region of the celiac axis, hepatic artery, and pancreas is not indicated. Except for the foregoing modifications, the technique is essentially the same as for cancer operations.

Wound Closure

Irrigate the abdominal cavity with saline. Consider placing a tube or needle-catheter jejunostomy in malnourished patients. If hemostasis is excellent and the anastomoses have been performed with accuracy, we do not insert drains in the abdominal cavity. Otherwise, a 6-mm Silastic Blake catheter may be brought out from the vicinity of the anastomosis through a puncture wound in the abdominal wall and attached to closed suction drainage.

Postoperative Care

Administer enteral feedings by way of the tube jejunostomy (if placed).

As with other esophageal anastomoses, nothing should be permitted by mouth until the four or five postoperative day, at which time an esophagram should be obtained in the radiography department. If no leakage is identified, a liquid diet is initiated that may be increased rapidly according to the patient's tolerance.

Long-term postoperative management requires all patients to be on a dietary regimen that counteracts dumping. The diet should be high in protein and fat but low in carbohydrate and liquids. Frequent small feedings are indicated. Liquids should not be consumed during or 1–2 h after meals to prevent hyperosmolarity in the lumen of the proximal jejunum. Some patients require several months of repeated encouragement to establish adequate caloric intake following total gastrectomy. Others seem to do well with no dietary restrictions.

Dietary supplements of vitamins, iron, and calcium as well as continued parenteral injections of vitamin B_{12} are necessary for long-term management of patients following total gastrectomy.

Complications

Sepsis of the abdominal wound or the subphrenic space is one complication that follows surgery for an ulcerated gastric malignancy. Early diagnosis and management are necessary.

Leakage from the esophagojejunal anastomosis is the most serious postoperative complication but occurs rarely if proper technique has been used. A minor degree of leakage may be managed by prompt institution of adequate drainage in the region. Nutritional support is essential, as are systemic antibiotics. In more serious cases, a diverting cervical esophagostomy may be required. Fortunately, a properly performed Roux-en-Y anastomosis diverts duodenal and pancreatic enzymes from the leak.

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Exposure of the Third and Fourth Portions of the Duodenum

39

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Tumor
Bleeding
Trauma

Preoperative Preparation

Nasogastric tube
Endoscopy and biopsy possibly for tumors of the third and fourth portions of the duodenum
Computed tomography (CT) of the abdomen

Pitfalls and Danger Points

Trauma to superior mesenteric artery or vein
Trauma to pancreas

Operative Strategy

Because the third portion of the duodenum is located behind the superior mesenteric vessels and transverse mesocolon, approaching it directly would be hazardous. Liberating the right colon and small bowel mesentery from their attachments to the posterior abdominal wall permits the surgeon to elevate the right colon and entire small bowel to a position over the patient's thorax. This changes the course of the superior mesenteric and middle colic vessels so they travel directly cephalad, leaving the transverse portion of the duodenum completely exposed. This exposure is sometimes termed the Cattell-Braasch maneuver.

After liberating the right colon by incising the peritoneum of the right paracolic gutter, the renocolic attachments are divided. Continuing in this plane, the surgeon can then free the entire mesentery of the small intestine in an entirely avascular dissection. It is important to devote special attention to the superior mesenteric vein as it emerges from the pancreas; rough traction in the area may avulse one of its branches, producing troublesome bleeding.

When planning a resection of the third and fourth portions of the duodenum, it must be noted that to the right of the superior mesenteric vessels the blood supply of the third portion of the duodenum arises from many small branches of the inferior pancreaticoduodenal arcade. These vessels must be dissected, divided, and ligated delicately, one by one, to avoid pancreatic trauma and postoperative acute pancreatitis. The distal duodenum is not attached to the body of the pancreas to the left of the superior mesenteric vessels: Its blood supply arises from branches of the superior mesenteric artery, as does that of the proximal jejunum. These branches are easily identified and controlled.

If the pancreas has not been invaded, it is possible to resect the third and fourth portions of the duodenum for tumor and then construct an anastomosis between the descending duodenum and the jejunum, so long as the ampulla is not involved. When working in this area, it is essential that the ampulla of Vater be identified early during the dissection.

Documentation Basics

Findings
Extent of procedure performed

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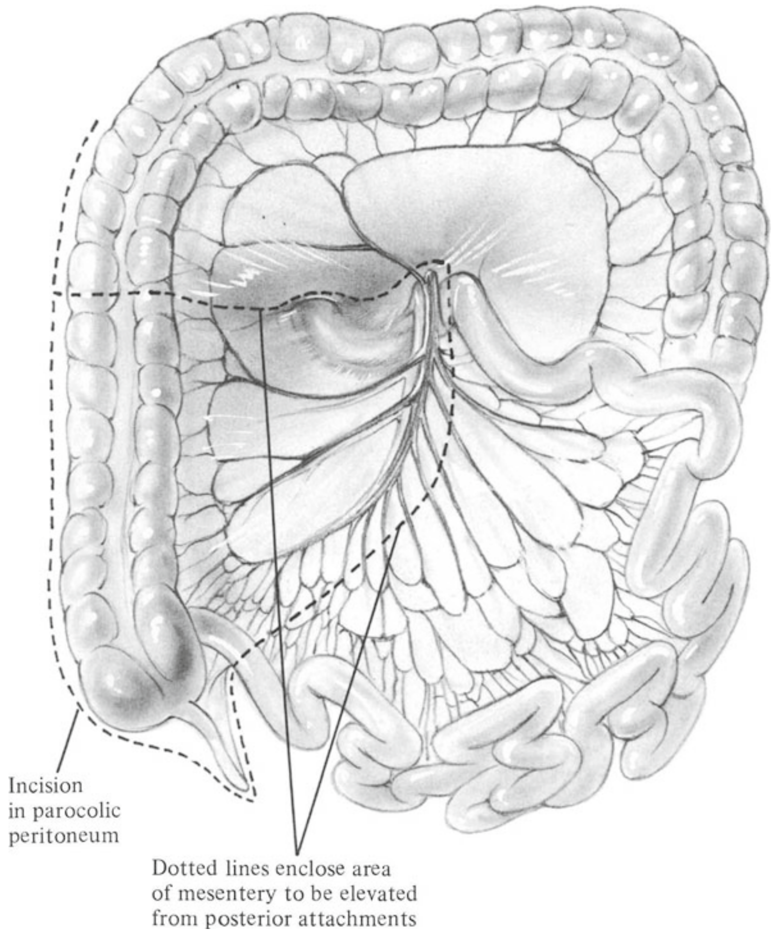

Fig. 39.1

Operative Technique

Incision

A long midline incision from the midepigastrium to the pubis gives excellent exposure for this operation.

Liberation of Right Colon

Open the peritoneum of the right paracolic gutter with Metzenbaum scissors. Insert an index finger to separate the peritoneum from underlying fat and areolar tissue, which provides an avascular plane. When the hepatic flexure is encountered, electrocautery can help control bleeding as the peritoneum is cut. It is not necessary to dissect the greater omentum off the transverse colon during this operation. It is important, however, to continue the division of the paracolic peritoneum around the inferior portion of the cecum and to move on medially to liberate the terminal ileum, all in the same plane (Fig. 39.1). Identify the renocolic ligament at the medial margin of Gerota's fascia. Division of this thin, ligamentous structure completely frees the right mesocolon.

Liberation of Small Bowel Mesentery

Insert the left index finger underneath the remaining avascular attachments between the mesentery of the small bowel and the posterior wall of the abdomen; incise these attachments until the entire small intestine up to the ligament of Treitz is free and can be positioned over the patient's thorax. This configuration resembles the anatomy of patients who have a congenital failure of rotation or malrotation of the bowel (Fig. 39.2).

Resection of Duodenum

There is no structure lying over the third and fourth portions of the duodenum or proximal jejunum at this time. If a tumor of the duodenum is to be resected, it is important to

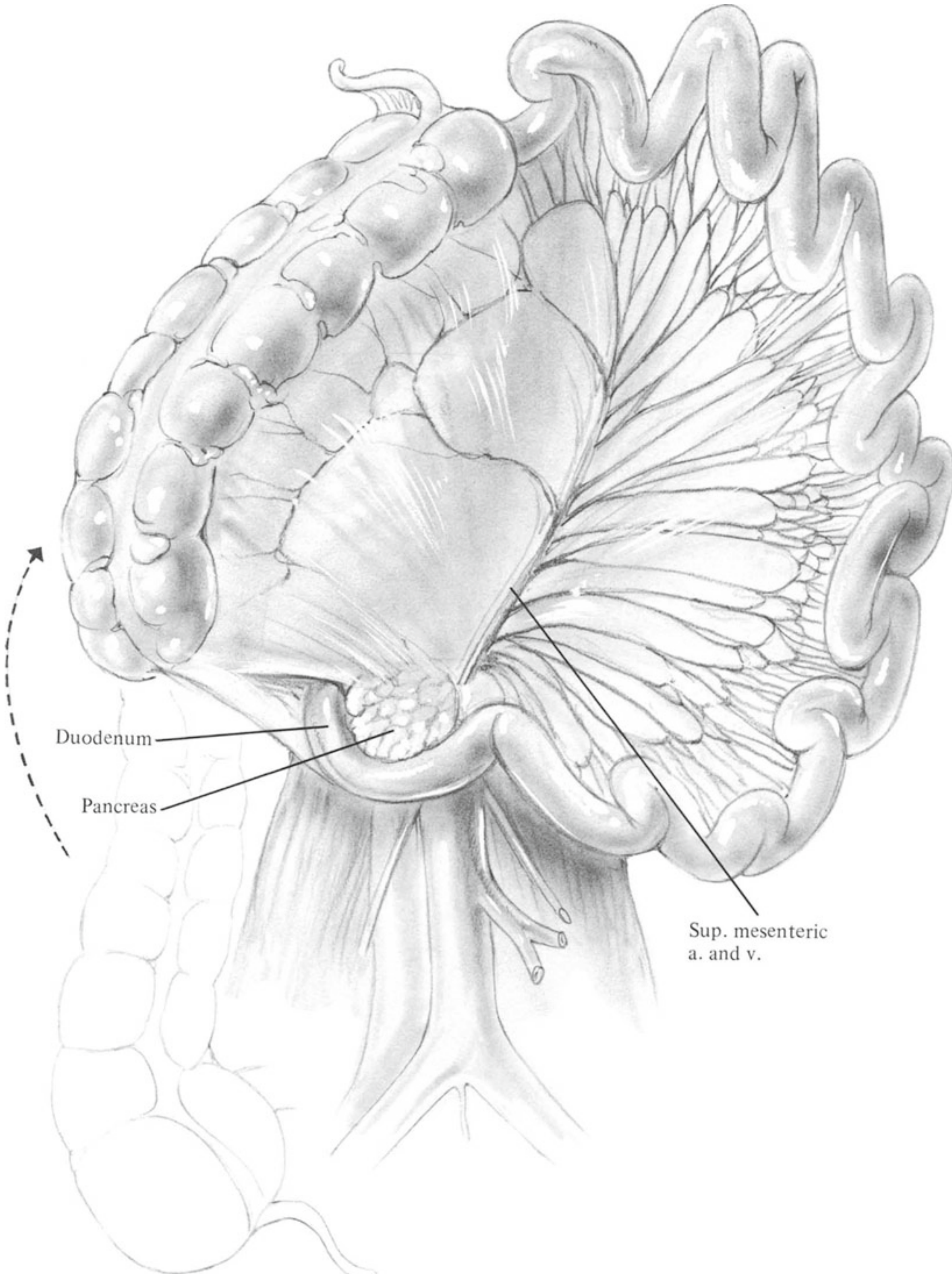

Fig. 39.2

determine now if it is safe to do so. If some portion of the pancreas has been invaded, a decision must be made whether a partial or total pancreatectomy is indicated for the patient's pathology. If the duodenum is free, dissection is best begun by identifying the blood supply of the distal duodenum, dividing each vessel between clamps, and ligating. As the pancreatic head is approached, perform this dissection with delicacy. It is possible to identify and divide each of the small vessels arising from the pancreas. This frees the duodenum and permits resection and anastomosis.

About 1 cm of the duodenum should be freed from the pancreas proximal to the point of transection. This permits an end-to-end anastomosis between the proximal duodenum and a segment of the jejunum that is brought over for this purpose. Mere closure of the distal duodenum plus a gastrojejunostomy is not a satisfactory operation, as the proximal duodenum would eventually dilate to huge proportions and form a blind loop. If for some reason the end of the duodenum is suitable for closure but not for anastomosis, a side-to-side anastomosis between the second portion of the duodenum and proximal jejunum is a good alternative.

Closure

After the anastomosis has been performed, return the right colon and small bowel to the abdomen. Make no attempt to reestablish the posterior attachments of the mesentery. Close the abdomen in routine fashion.

Postoperative Care

Aside from applying nasogastric suction until bowel function has resumed with the passage of flatus, postoperative care is routine. Acute pancreatitis is a possible complication of any dissection in the region of the pancreas. So long as the serum amylase level remains elevated and the patient shows any signs of acute pancreatitis, nasogastric suction should be continued until no danger exists.

Complications

Pancreatitis
Anastomotic leaks

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Laparoscopic Adjustable Gastric Banding

40

Gene F. Coppa, Heather McMullen, Alan Geiss, and Charles Choy

A variety of bariatric procedures, most laparoscopic, are currently available. Laparoscopic adjustable gastric banding (described in this chapter) and laparoscopic Roux-en-Y gastric bypass (Chap. 41) are two very common operations that are applicable to most cases. References at the end describe additional procedures in current use. These procedures are being adapted to single incision laparoscopic and robotic techniques.

Indications

Laparoscopic adjustable gastric banding is indicated in the treatment of morbid obesity:

- Body mass index (BMI) >40
- BMI >30 with significant obesity related comorbidities

Patients must have failed dietary attempts at weight loss and be psychologically stable and able to comply with long-term follow-up.

Preoperative Preparation

Bariatric surgery requires extensive preoperative preparation which is best conducted through a multidisciplinary team approach. All patients should undergo nutritional and psychological evaluations, as well as attend educational sessions and support groups in order to be well prepared for surgery and its aftermath. Medical workup including evaluations by cardiology, pulmonary, gastroenterology, and endocrinology is obtained as needed. Prior to surgery many patients will be placed on a 2-week liquid diet to shrink an enlarged liver and allow them to become acclimated to the post-op diet.

Pitfalls and Danger Points

- Enlarged liver
- Hepatic cirrhosis
- Enlarged fat pad
- Hiatal hernia
- Intraoperative or postoperative bleeding
- Gastric injury
- Need for long trocars and instruments

Operative Strategy

It is important that the anesthesia team be prepared for a difficult airway. Use a bariatric table with adequate padding, support, and means to secure the patient. Position the patient in the supine lithotomy position. Preoperative antibiotics are given. Deep venous thrombosis prophylaxis requires enoxaparin and sequential compression devices. Have the anesthesiologist place an orogastric tube to decompress the stomach and facilitate identification of the distal esophagus.

The operation may be conceptualized in three steps: exposure and dissection of the proximal stomach, placement of the band, and placement of the subcutaneous port.

Operative Technique

Administer the preoperative antibiotic and venous thromboembolism chemoprophylaxis in the preoperative holding area. In the operating room, apply bilateral lower extremity

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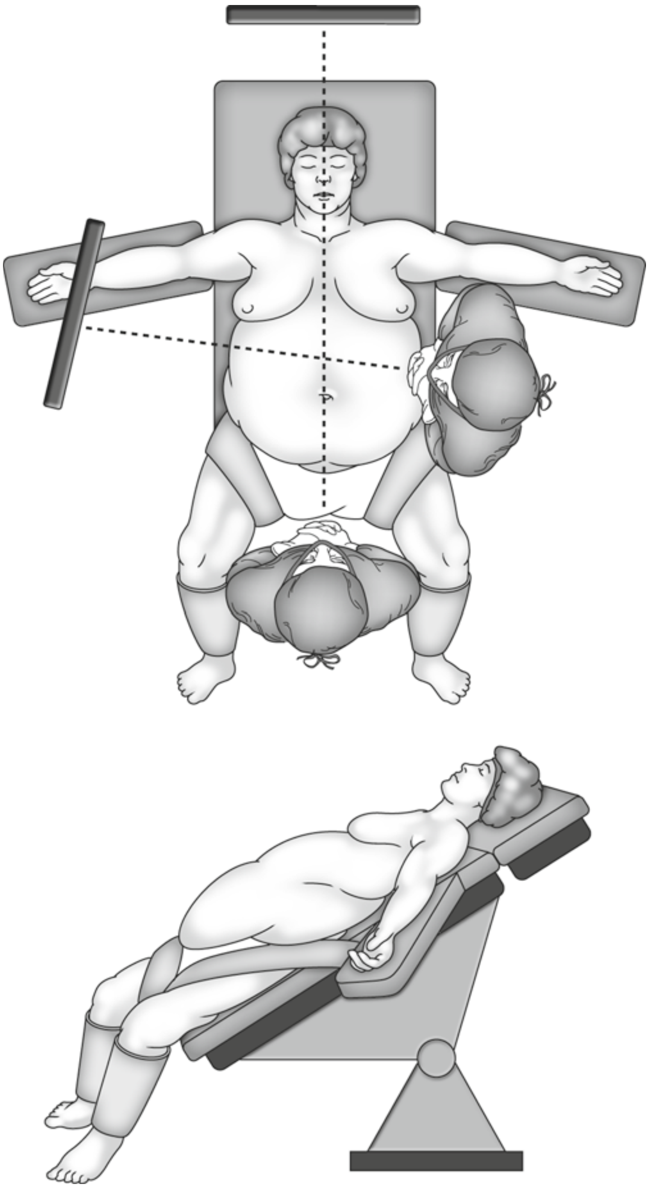

Fig. 40.1 Patient position lithotomy

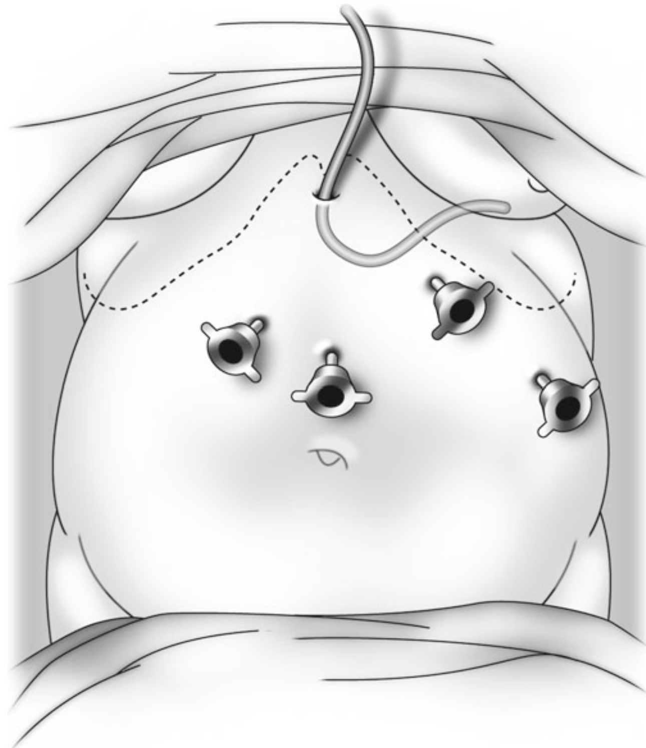

Fig. 40.2 Trocar placement

sequential compression devices. After induction of general anesthesia and endotracheal intubation, have the anesthesia team insert an orogastric tube. Position the patient in the dorsal lithotomy position and have the abdomen prepped and draped in the standard, sterile fashion (Fig. 40.1). Then adjust patient position into a reverse Trendelenburg position to facilitate exposure of the surgical site.

Begin with an incision just to the left of the midline, four fingerbreadths below the costal margin. Enter the abdomen with an optical trocar or Veress needle and establish pneumoperitoneum to 15 mmHg. Insert a 30°-angled laparoscope and explore the abdomen. Place a Nathanson liver retractor via a subxiphoid incision and secure it to the table using a fixed clamp. Next place 5 mm ports in the left subcostal region, the left flank, and the right upper quadrant (Fig. 40.2). Convert the initial entry port to a 15 mm port to allow placement of the band into the abdomen. Place all trocars under direct visualization and use alternative trocars as needed.

Exposure and Dissection of the Proximal Stomach

Atraumatically grasp the stomach and retract it inferiorly. Inspect the hiatus for evidence of a hiatal hernia and repair this if discovered (Fig. 40.3). Expose the angle of His and perform blunt dissection of the lateral aspect of the phrenoesophageal ligament with the hook cautery. Once the above dissection is completed, identify and incise the pars flaccida (Fig. 40.4). Visualize the caudate lobe and retract it laterally. Identify the inferior aspect of the right crus with the adjacent fat pad. Open this space with electrocautery and create a retrogastric window with careful blunt dissection (Figs. 40.5 and 40.6).

Placement of the Lap Band

Prepare the Lap Band for insertion by irrigating with 4–10 ml of sterile, injectable normal saline until air bubbles are

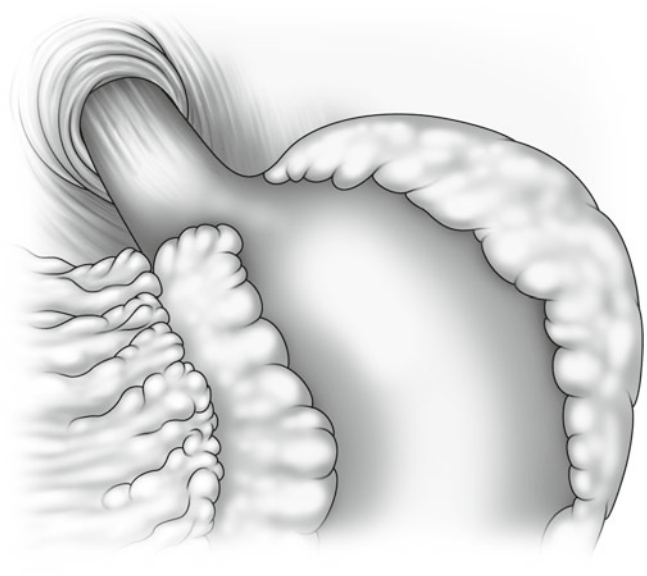

Fig. 40.3 Inspect Hiatus for hernia

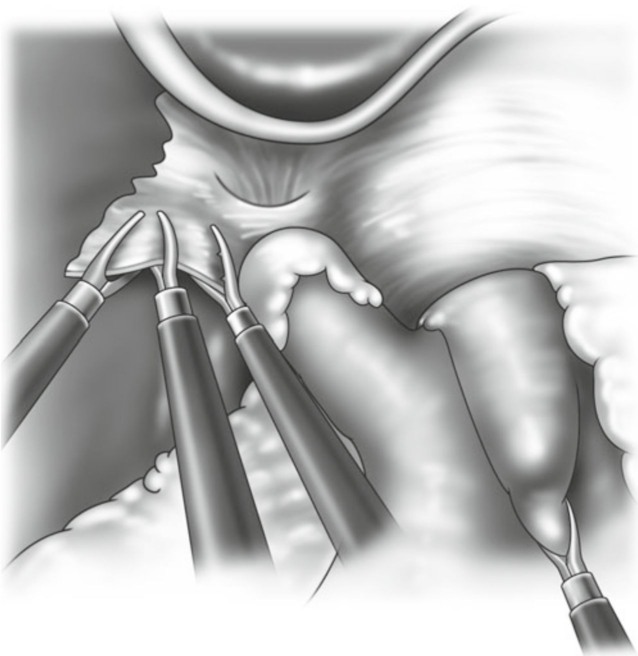

Fig. 40.4 Pars-flaccid technique

removed from the balloon and tubing. Then remove the fluid to decompress the band so that it will pass easily through the 15 mm port.

Introduce the Lap Band through the 15 mm port. Place an instrument through this newly created tunnel, grasping the tubing and then bringing it through the retrogastric window (Fig. 40.7). Have anesthesia remove the orogastric tube. Lock the Lap Band at this position (Fig. 40.8). Consider the

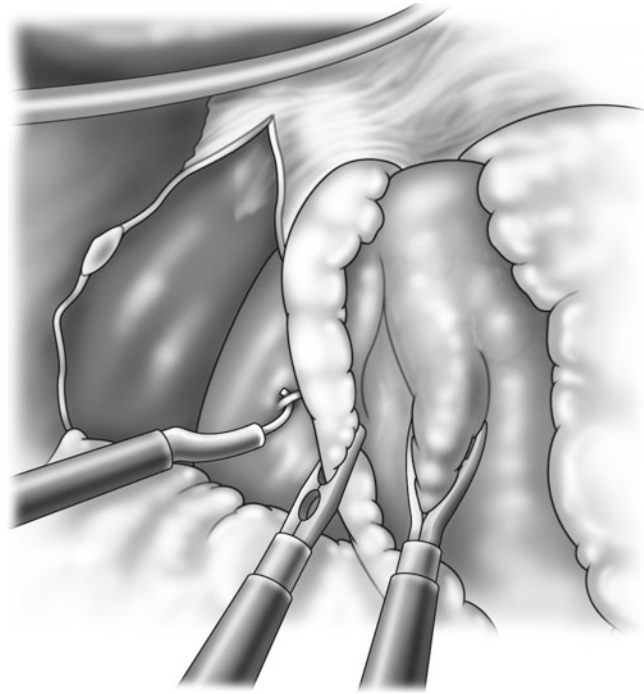

Fig. 40.5 Creation of retrogastric tunnel

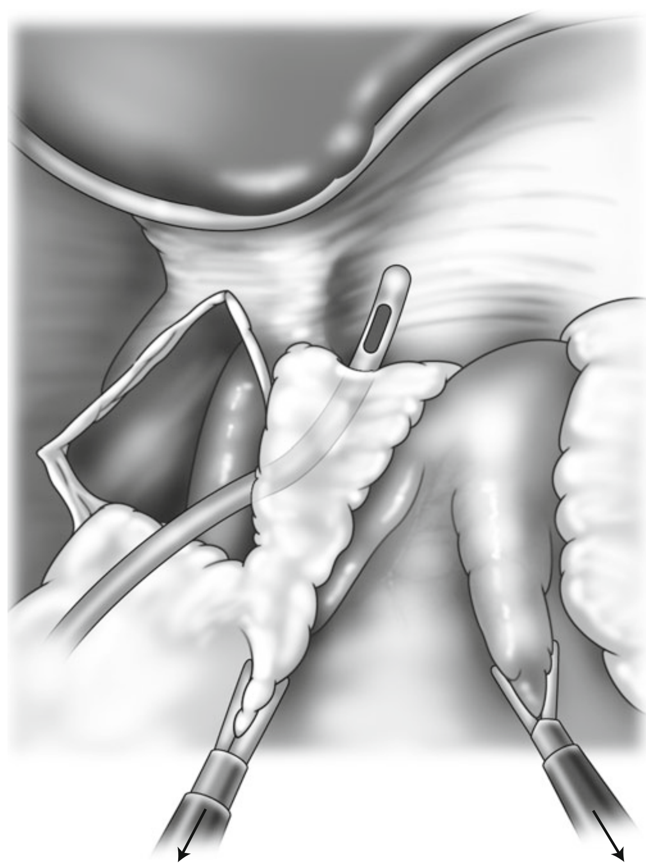

Fig. 40.6 Placement of instrument through retrogastric tunnel

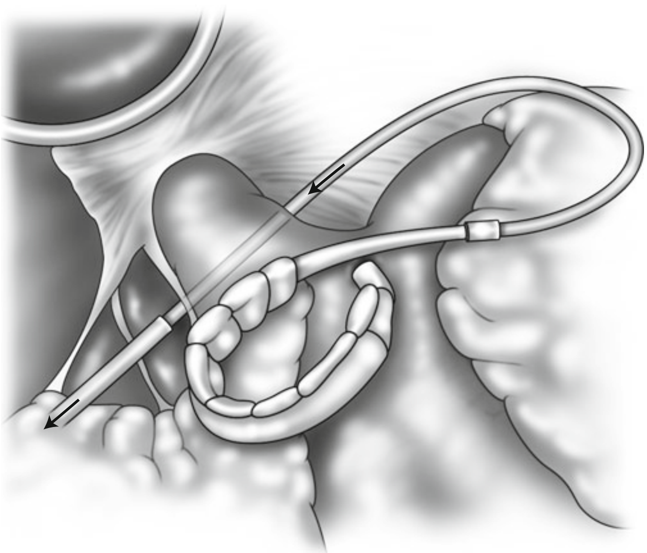

Fig. 40.7 Pull tubing through retrogastric tunnel

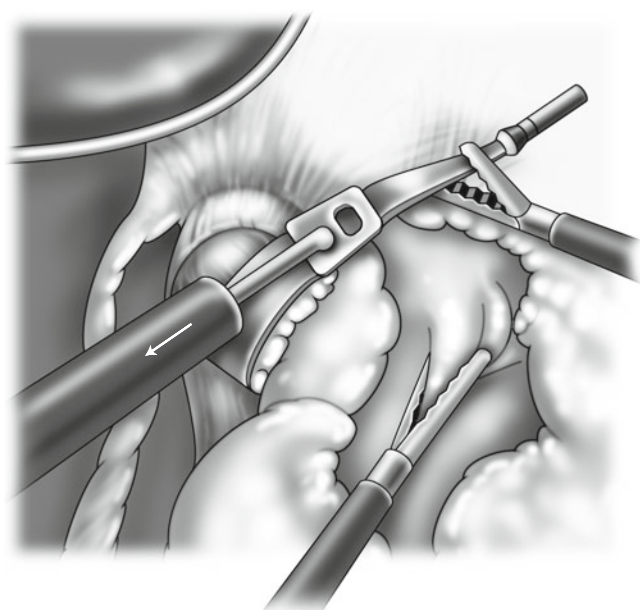

Fig. 40.8 Buckling the band

(optional) use of a calibration tube if there is any suspicion of a hiatal hernia or cardial abnormality.

Place three separate simple sutures of #0 silk to perform an anterior gastric wrap over the exposed Lap Band (Figs. 40.9, 40.10, and 40.11). Next, exteriorize the Lap Band tubing through the right upper quadrant port site.

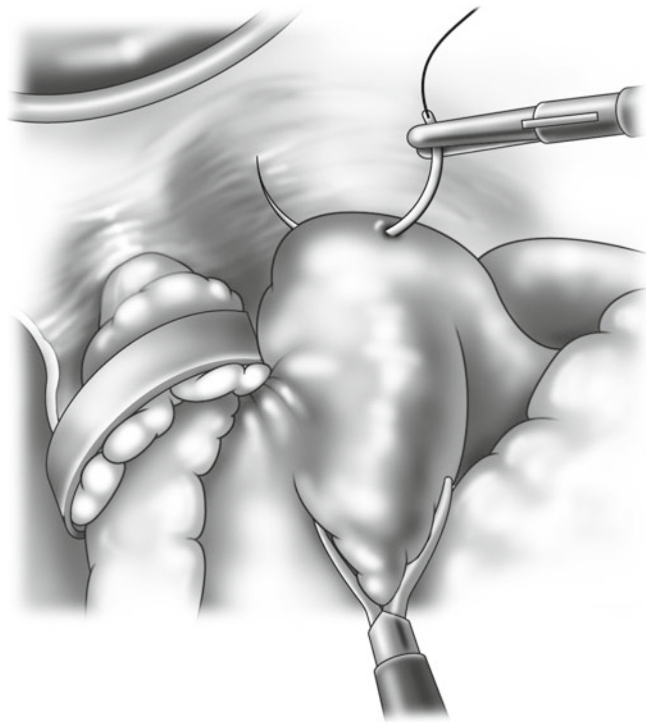

Fig. 40.9 First stitch high on greater curvature

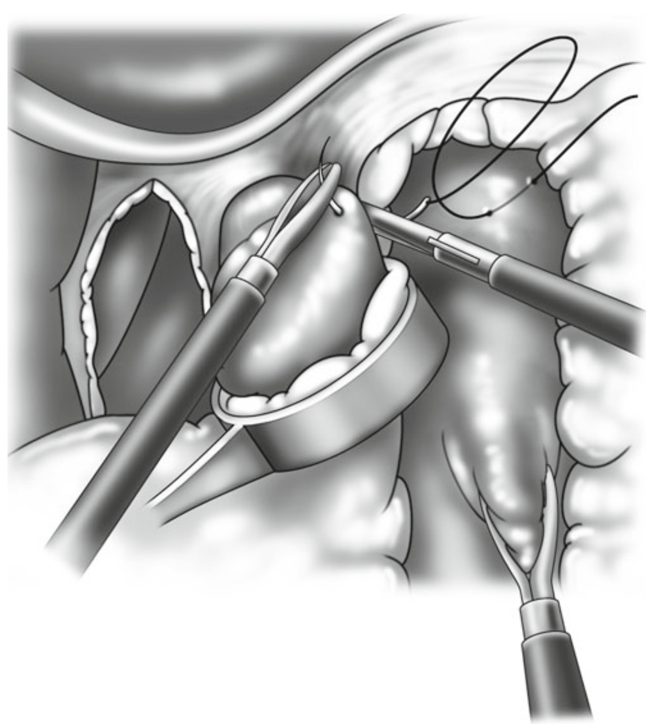

Fig. 40.10 First stitch gastric pouch

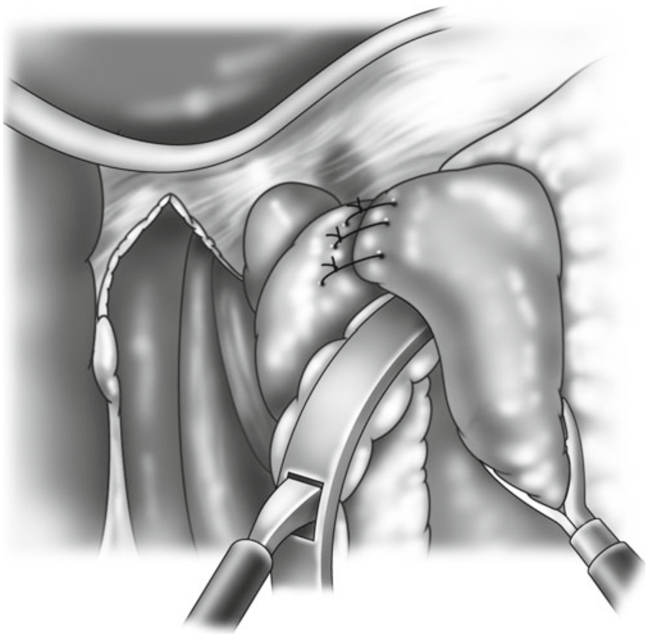

Fig. 40.11 Plication of the stomach

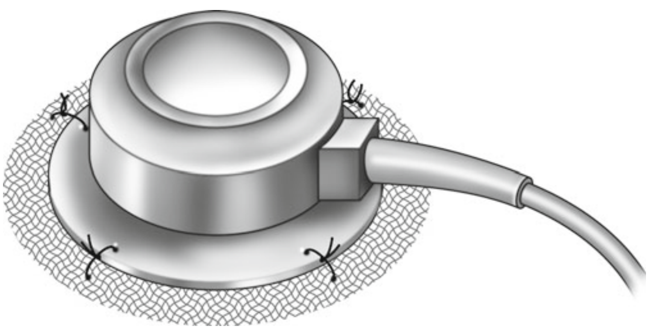

Fig. 40.12 Connecting the port to mesh

Check the operative field for hemostasis. Remove all instruments and trocars under direct visualization. Allow the pneumoperitoneum to desufflate and remove the liver retractor. Check all trocar sites for hemostasis.

Placement of the Subcutaneous Fill Port

Extend the right upper quadrant port site incision laterally and identify the abdominal wall fascia. Attach the adjustment port on a mesh platform (Fig. 40.12) to the tubing and secure it in place to the anterior rectus fascia. The band is not inflated during surgery or in the early postoperative period (see postoperative care, below).

Irrigate the port site with bacitracin solution and close the area in layers with 3-0 Vicryl and 4-0 Maxon to reapproximate the skin. Infiltrate all incision sites with 0.5 % Marcaine. Use steri-strips as the final operative dressing.

Postoperative Care

Postoperative care in the weight loss surgery patient focuses on early mobilization within hours of surgery. Patients should be out of bed, in a chair, and ambulating if at all possible. Good pulmonary toilet with use of the incentive spirometer, continued use of CPAP/BIPAP in patients with obstructive sleep apnea, and monitoring of oxygen saturation when indicated are essential aspects of postoperative care in this patient population. Pain control with combination narcotic and nonnarcotics as needed. Patients are assessed for postoperative nausea and vomiting and treated as needed. Deep venous thromboembolism prophylaxis with subcutaneous heparin or enoxaparin and sequential compression devices is continued in the postoperative period; selected patients may be sent home on a short course of enoxaparin.

Appropriately selected patients may be done on an ambulatory basis. Those kept overnight undergo a video esophagram to define the anatomy. Patients must be able to tolerate a liquid diet before discharge. Dietary guidelines are reviewed prior to discharge.

Patients are seen in follow-up 2 weeks postoperatively and then at 6 weeks when first adjustment may be performed (Fig. 40.13). Adjustments can be done in the office and/or with radiologic guidance.

Complications

Early

- Bleeding
- Pulmonary
- Deep venous thrombosis or pulmonary embolism
- Obstruction
  - Missed hiatal hernia
  - Band placed too far distal
- Wound infection
- Nausea and vomiting

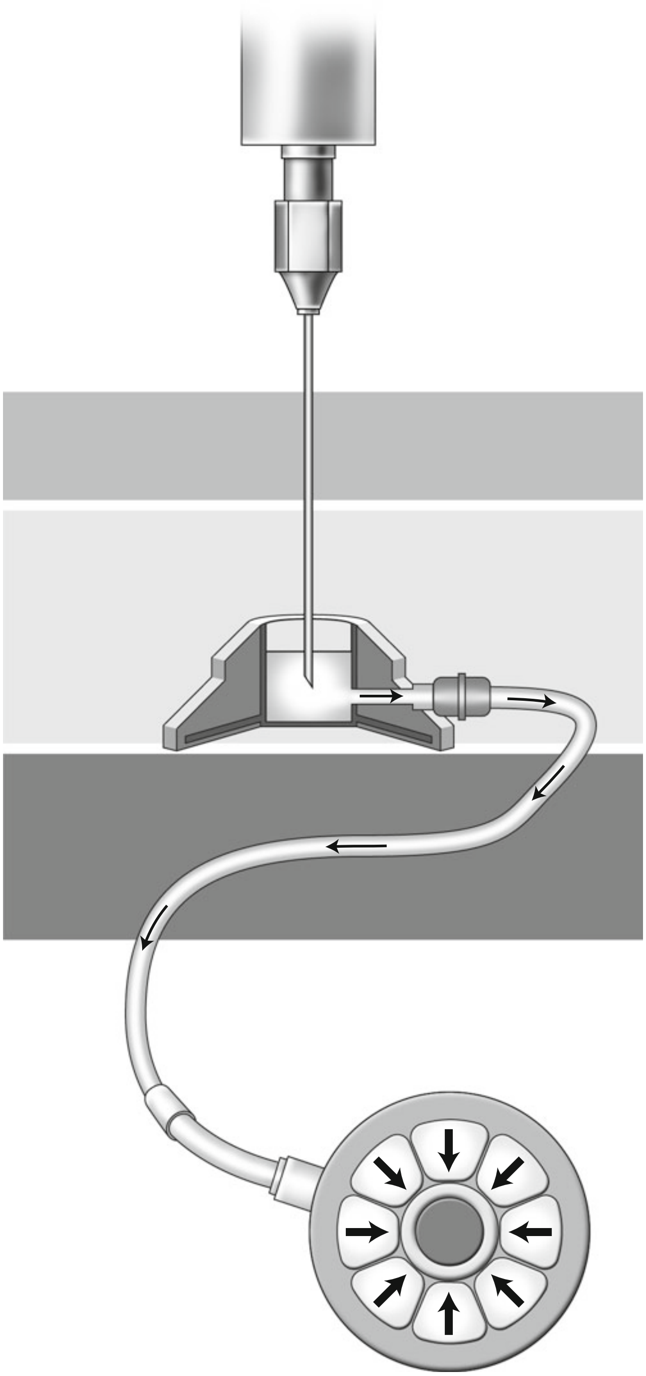

Fig. 40.13 Adjustment

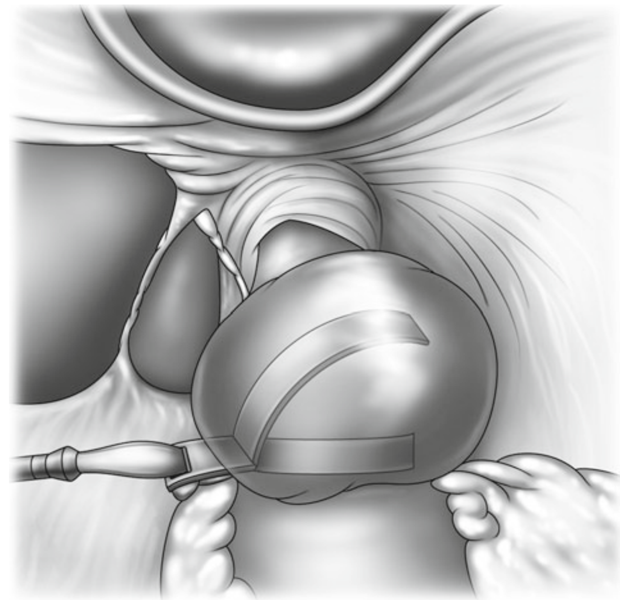

Fig. 40.14 Prolapse/slippage

Late

- Erosion
- Slippage or prolapse (see Fig. 40.14)
- Breakage of band or other defect in apparatus
- Port malposition
- Infection
- Failed weight loss
- Esophageal dilation

Further Reading

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41 Laparoscopic Roux-en-Y Gastric Bypass

Gene F. Coppa, Jeffery Nicastro, Charles Choy, and Heather McMullen

Indications

Laparoscopic Roux-en-Y gastric bypass is indicated in the treatment of morbid obesity:

- Body mass index (BMI) >40
- BMI >35 with significant obesity-related comorbidities

Patients must have failed dietary attempts at weight loss and be psychologically stable and able to comply with long-term follow-up.

Preoperative Preparation

Similar to gastric banding (see Chap. 40). Smoking cessation is mandatory.

Pitfalls and Danger Points

- Enlarged liver
- Hepatic cirrhosis
- Adhesions
- Bulky omentum

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Operative Strategy

As with laparoscopic gastric banding, it is important that the anesthesia team prepare for a potentially difficult airway. The precautions listed in Chap. 40 are important here as well.

The operation may be conceptualized in four steps: division of the jejunum and creation of the gastrojejunostomy, exposure and dissection of the proximal stomach, construction of the gastric pouch, and, finally, creation of the jejunojejunostomy.

Operative Technique

Before induction of anesthesia, ensure that the patient receives antibiotics and deep venous thromboembolism prophylaxis with Lovenox and sequential compression devices. Secure the patient in a supine position on a bariatric table with arms extended and padded and use a foot plate at the foot of the bed to prevent slippage (Fig. 41.1). After induction of general endotracheal anesthesia (with fiberoptic intubation if necessary), have a Foley catheter and orogastric tube placed. After the standard antiseptic abdominal skin preparation, use a laparoscopic drape.

Mark out the trocar sites, make a transverse incision in the left upper quadrant, and enter the abdomen with an optical trocar or Veress needle. Place a 12 mm trocar, insufflate the abdomen to 15 mmHg, and inspect the abdominal cavity. Place additional 12 mm trocars under direct vision at the left flank, right paramedian, supraumbilical, and left subcostal positions (Fig. 41.2).

Division of Jejunum and Creation of Jejunojejunostomy

First, attention is placed toward the creation of the jejunojejunostomy. Place the angled 30° laparoscope through the

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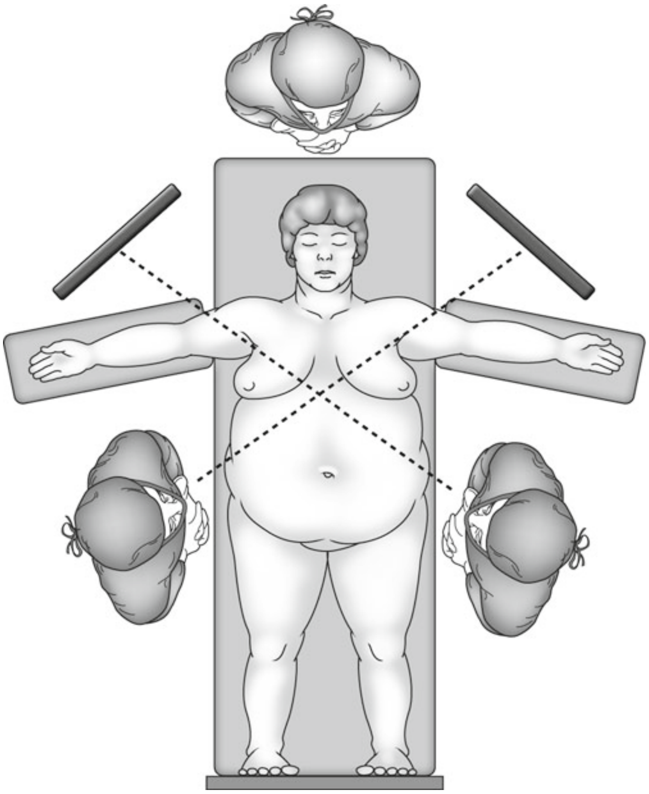


Fig. 41.1 Patient position

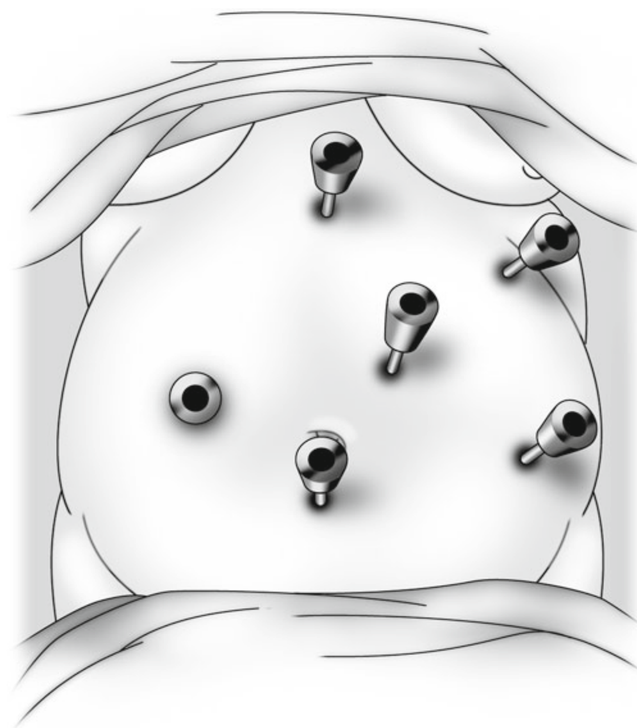
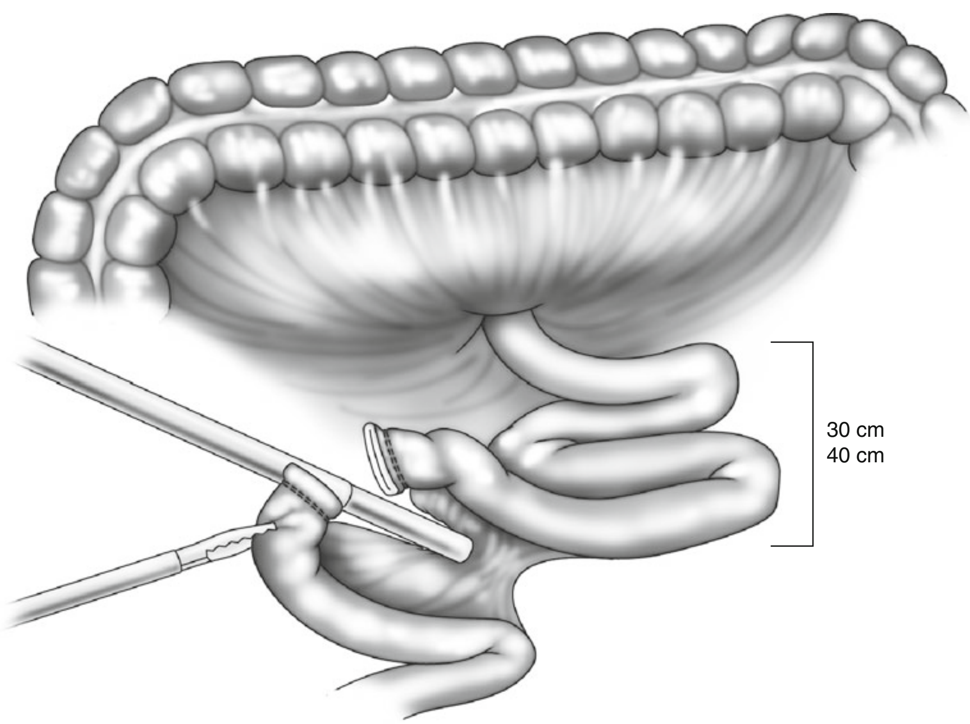


Fig. 41.2 Port placement

Fig. 41.3 Division small bowel



umbilical port, elevate the transverse colon and omentum cephalad and identify the ligament of Treitz. Run the small bowel approximately 30–40 cm distal to the ligament of Treitz. Utilizing the right-sided port, the small bowel is divided using an endoscopic stapler with a 2.5 mm cartridge (Fig. 41.3). Divide the small bowel mesentery using the

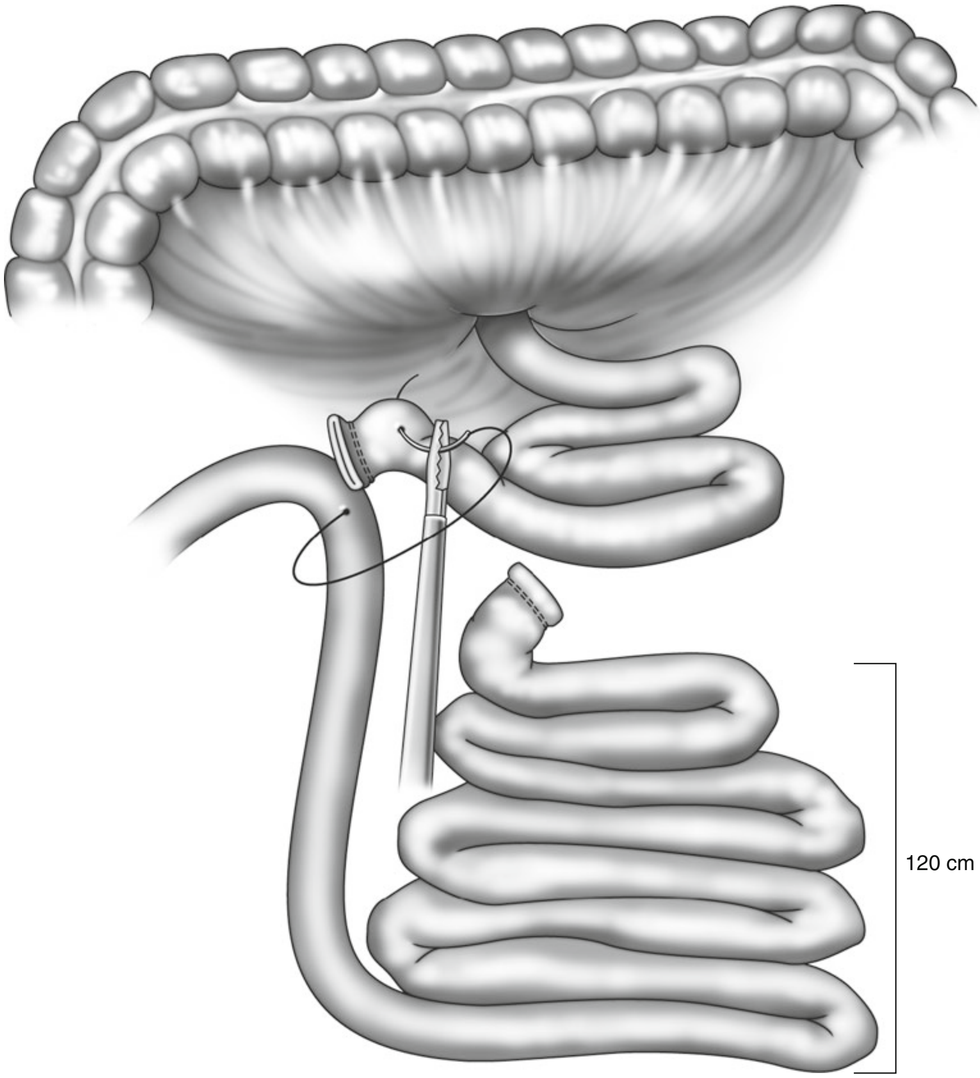


Fig. 41.4 Creation of anastomosis

endoscopic stapler with 2.0 mm cartridges. Place a clip on the staple line to mark the proximal small bowel.

Then measure the small bowel 120 cm distal to the division point, taking care to place the distal small bowel in the RUQ.

Create the anastomosis in a side to side stapled fashion. Approximate the limbs using a 3.0 Vicryl stitch via the Laprotie system (Fig. 41.4). Create two small enterotomies approximately 2–3 cm from the stapled edge with the harmonic scalpel on the antimesenteric side. Traction on the Laprotie will allow enterotomies to be made with minimal energy damage to the surrounding tissue. Pass an endoscopic stapler through the right paramedian port and place the two arms of the stapler into the enterotomies. Fire the stapler to create a side to side stapled anastomosis (Fig. 41.5). Place the laparoscope in the initial optical camera port and close the enterotomy with a 3.0 PDS suture in a running fashion

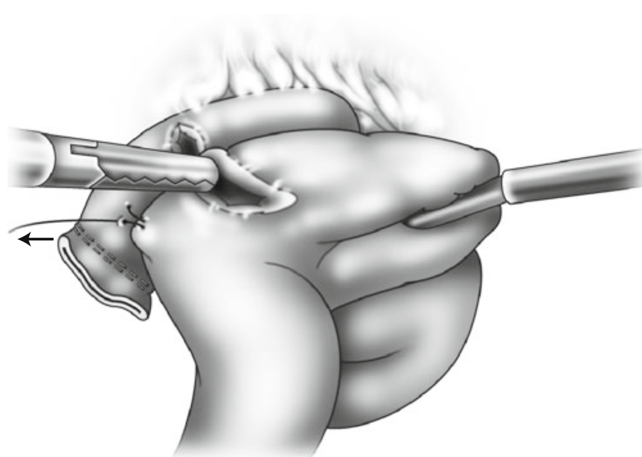


Fig. 41.5 Creation of anastomosis

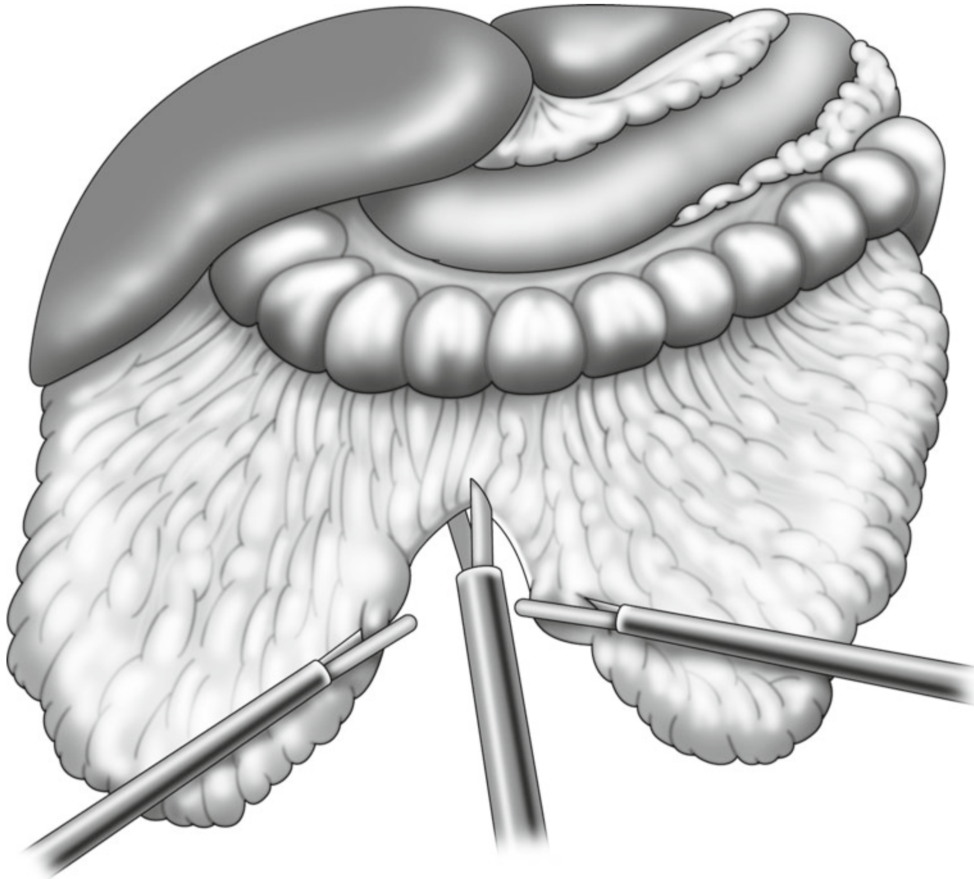


Fig. 41.6 Divide omentum (bulky omentum)

using the right paramedian and umbilical ports. (Alternatively this can be closed using an endoscopic stapler with caution not to narrow the lumen.) Close the mesenteric defect with a running suture. Before changing the patient position to perform the gastrojejunostomy, inspect the omentum and divide the omentum with the LigaSure if it is bulky (Fig. 41.6).

Exposure and Dissection of the Proximal Stomach

Next, place the patient in a steep reverse Trendelenburg position. Place a 5 mm trocar in the subxiphoid position to create a track for the medium Nathanson retractor. Pass the retractor directly through the abdominal wall (using the previously created track). Use it to elevate the left lobe of the liver away from the gastroesophageal junction. Attach the retractor to a fixed clamp on the right side of the table.

Retract the omentum inferiorly and dissect the left crus of the diaphgram. Divide the pars flaccida and retrogastric attachments in order to freely mobilize the posterior aspect of the stomach for creation of the pouch. Have the anesthesiologist remove the orogastric tube and place a Baker tube. Have 30 cc of air injected into the balloon port of the Baker tube and then have the anesthesiologist withdraw the tube until resistance by the diaphragmatic hiatus is felt. This thus approximates the size of the gastric pouch. Using a pointed electrocautery probe, mark the center of the anticipated gastric pouch, creating a full thickness penetration of the gastric wall and perforating the Baker tube balloon in the process (Fig. 41.7). Have the Baker tube withdrawn.

Construction of the Gastric Pouch

Verify with anesthesia that only the endotracheal tube remains. All other tubes and probes must be removed from the mouth and nose prior to creation of the pouch. Create a 2–3 cm distal gastrotomy with the harmonic scalpel. Pass the 25 mm EEA anvil with a ski needle (Fig. 41.8) into the abdomen using the left flank port. Grasp the pointed end of the ski needle with a needle holder. Hold it with the ski (or curved part) angled up and place it into the gastrotomy and delivered out through the cauterized hole in the planned pouch (Figs. 41.9 and 41.10). Remove the ski needle from the abdomen, leaving several cm of suture attached to the anvil spike. Close the gastrotomy with a running 3.0 PDS suture; alternatively a stapler could be utilized.

Fig. 41.7 Create proximal gastrotomy

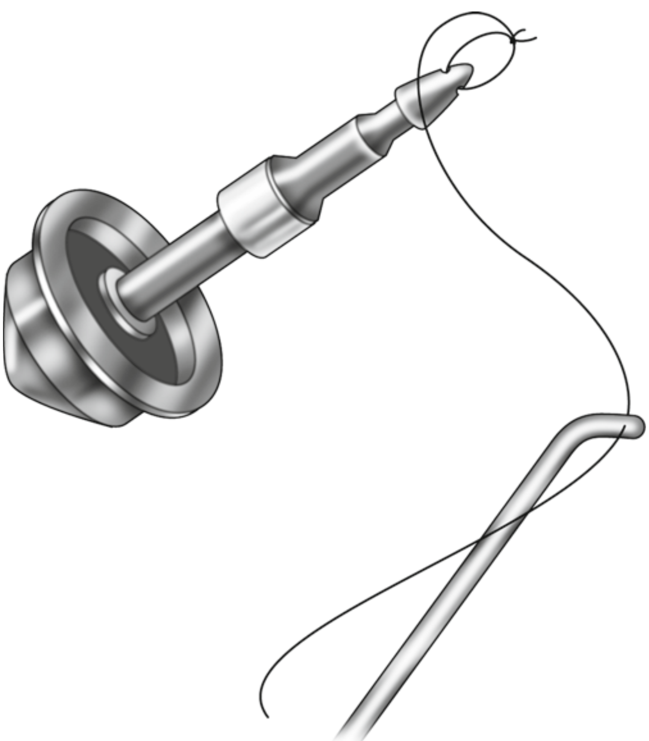


Fig. 41.8 Anvil with needle

Next, create the gastric pouch by sequential firing of an endoscopic stapler. The first load across the lesser omentum is a vascular load (Fig. 41.11), and then appropriate-sized staple cartridges are used to divide the stomach (Fig. 41.12). Once the gastric pouch is created, use an anvil grasper to hold the anvil and remove the spike with a locking grasper.

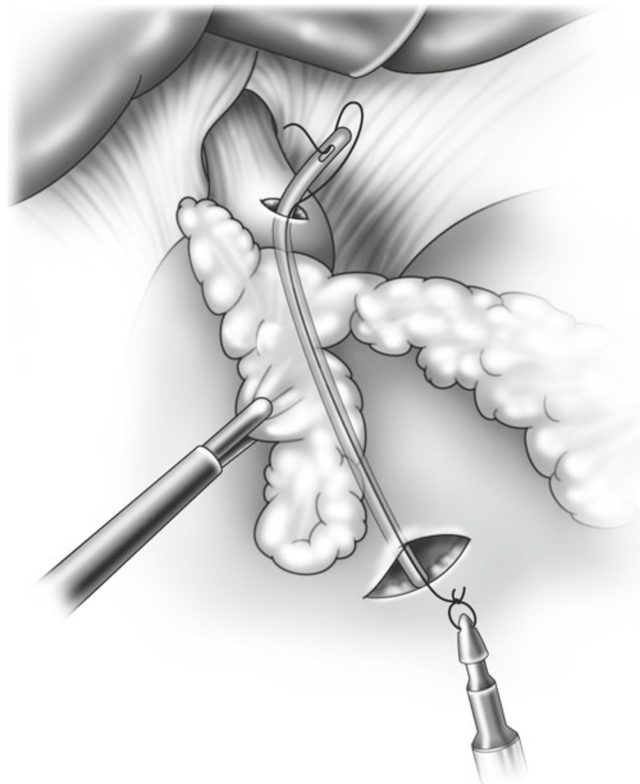


Fig. 41.9 Placement of anvil into stomach

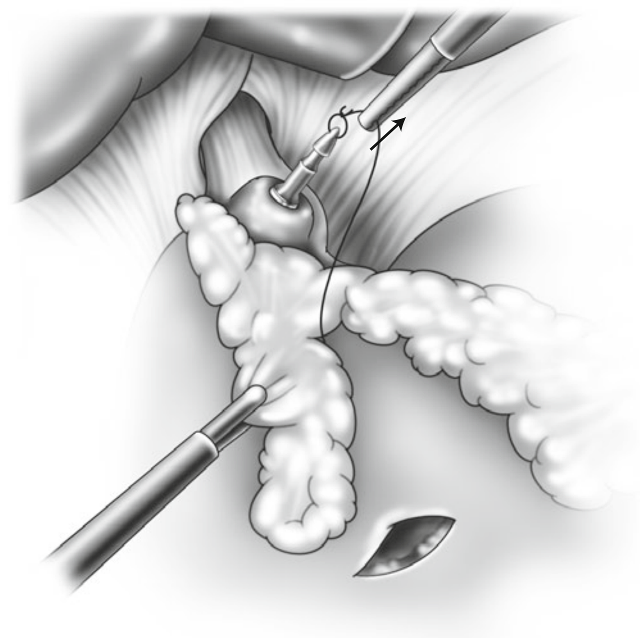


Fig. 41.10 Placement of anvil into stomach

Creation of Gastrojejunostomy

Identify the Roux limb and take care to insure there is no twist. Create an enterotomy in the small bowel approximately

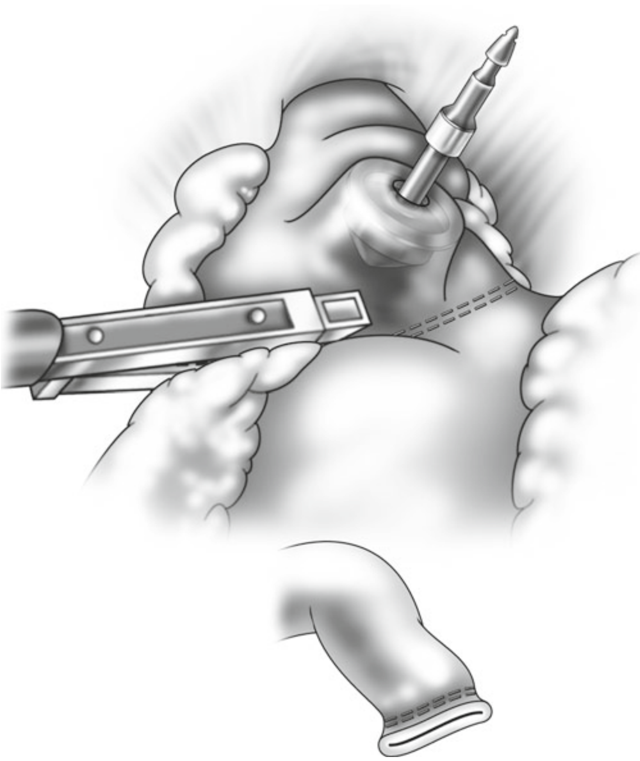


Fig. 41.11 Creation of pouch with endo GIA

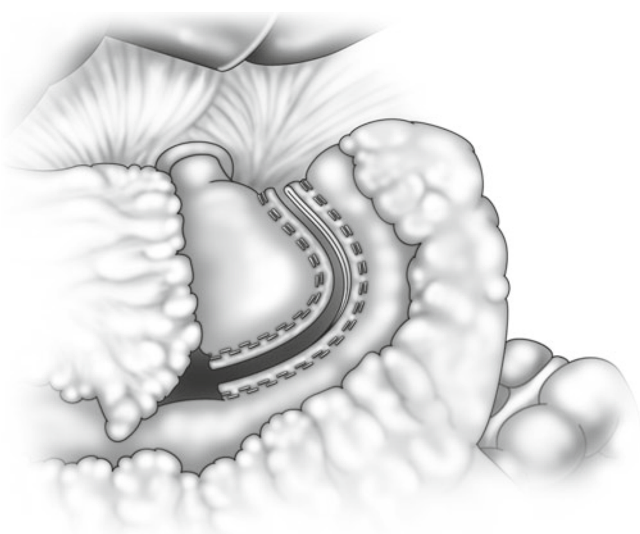


Fig. 41.12 Completed pouch

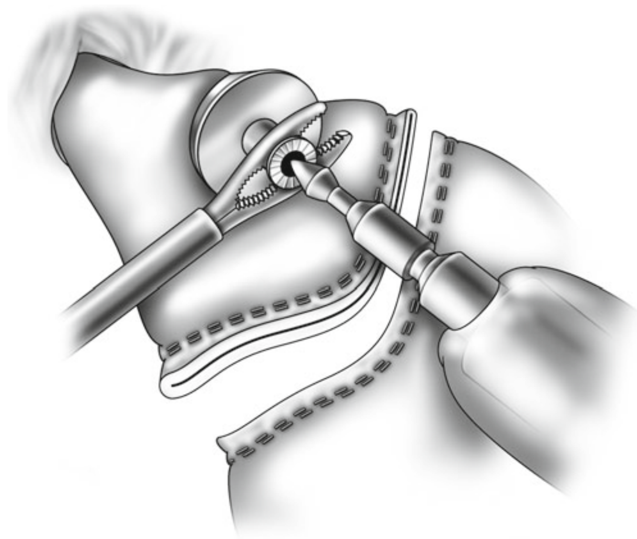


Fig. 41.13 Docking circular stapler

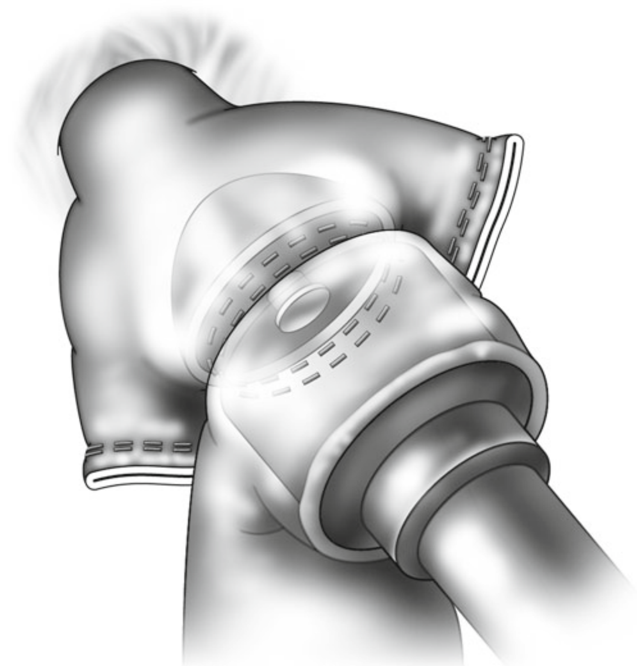


Fig. 41.14 Anastomosis with circular stapler

2 cm away from the stapled edge with the harmonic scalpel. Remove the left most lateral port and place an EEA stapler through this skin incision under direct vision. Pass the stapler into the Roux limb via the enterotomy and bring the spike through the antimesenteric side of the small bowel. Maneuver the spike toward the gastric pouch and connect it with the anvil (Fig. 41.13). Close and fire the EEA under direct vision (Fig. 41.14).

Remove the stapler and inspect the anastomosis and donuts. Divide the mesentery of the jejunum with the harmonic scalpel. Divide the jejunum proximal to the enterotomy with an endostapler. Use a laparoscopic bag to remove the small bowel remnant. Reinforce the anterior staple line with 2-0 silk sutures (Fig. 41.15).

The completed reconstruction is shown in (Fig. 41.16). Note that for clarity this is shown antecolic, but is normally constructed in a retrocolic fashion. Check the gastrojejunostomy for integrity and bleeding. Place a bowel clamp across the distal

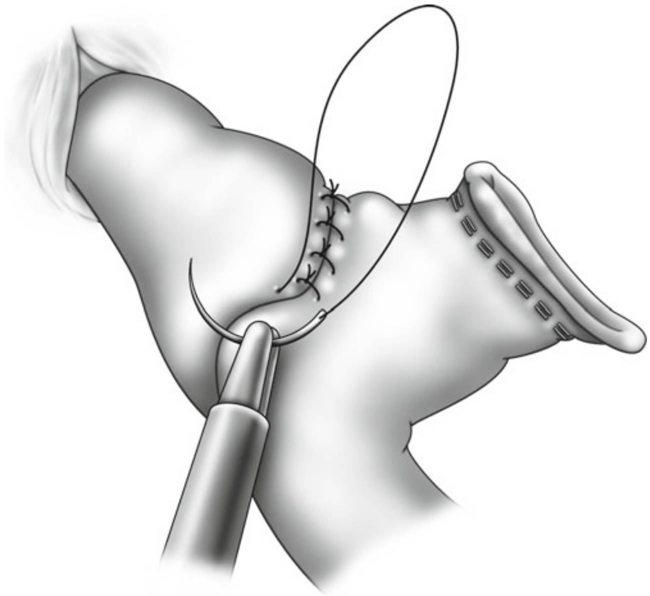


Fig. 41.15 Oversew staple line

Roux limb, fill the upper abdomen with saline, and perform an intraoperative fiberoptic gastroscopy to evaluate for air leak and intraluminal bleeding. Drain the irrigation fluid and remove the bowel clamp. Cover the anastomosis with fibrin sealant.

Close the fascial defect of the left most lateral port using a suture passer with 0 Vicryl and close other ports as needed. Place a 10 French Jackson-Pratt drain via left subcostal port and externalize it out the right lateral port. Position the drain anterior to the gastrojejunostomy, remove the liver retractor under direct vision, and deflate the pneumoperitoneum. Suture the drain in place and close all port incisions closed with running subcuticular 4-0 Monocryl stitch. Place steri-strips and dry dressings.

Postoperative Care

Postoperative care in the weight loss surgery patient focuses on early mobilization within hours of surgery. Patients should be out of bed, in a chair, and ambulating if at all possible. Good pulmonary toilet with use of the incentive spirometer, continued use of CPAP/BIPAP in patients with obstructive sleep apnea, and monitoring of oxygen saturation when indicated are the essentials of postoperative care in this patient population. Pain control with combination narcotic and nonnarcotics as needed. Patients are assessed for postoperative nausea and vomiting and treated as needed. Deep venous thromboembolism prophylaxis with subcutaneous heparin or enoxaparin and sequential compression devices is continued in the postoperative period; selected patients may be sent home on a short course of enoxaparin.

Patients have a radiographic fluoroscopic study to define the anatomy and evaluate for leaks. They are then placed on a liquid diet and must be tolerating this diet before discharge (usually by postoperative day 3).

Complications

Early

Anastomotic and Staple Line Leaks

Related to tension and/or hematomas of the staple lines that lead to tissue disruption. As described earlier, additional sutures to relieve tension on the superior border of the gastrojejunostomy and the distal corner of the stapled jejunojejunostomy are recommended routinely. Additional maneuvers such as adequate division of the Roux limb mesentery and the division of the greater omentum are sometimes necessary. The use of staple buttresses or graduated sized stapled loads (i.e., Tri-Staple) has been used to decrease staple line bleeding and hematomas.

Any postoperative patient with sudden tachycardia should be suspected to have an anastomotic leak. Fevers and abdominal pain are often absent in these patients. Large anastomotic leaks tend to cause hemodynamic instability, and reoperation may be necessary without radiologic confirmation. Often closure of a leak at the gastrojejunostomy with an omental patch is preferred than attempted suture ligation. The addition of wide drainage of the area is usually adequate to control the local inflammation. Significant postoperative systemic inflammatory response syndrome may occur, and adequate surgical intensive care management is paramount and key to recovery.

Radiologic imaging such as upper gastrointestinal studies and computer tomography may not reveal small leaks and a negative study should not be used to rule out their presence. Cranberry or grape juice given PO may confirm a suspected leak if found exiting out of the Jackson-Pratt drain. Small leaks that are controlled with the surgical drain may be managed nonoperatively in a stable nontoxic patient with TPN and NPO.

Deep Venous Thrombosis and Pulmonary Embolism

Even with aggressive prophylaxis patients may develop DVT/PE; swollen or painful calf should trigger evaluation with venous duplex; SOB may require evaluation with a spiral CT scan. High risk patients may require continuation of enoxaparin upon discharge.

Bleeding

As with any surgery, bleeding can arise from any cut surface; abdominal wall, intra-abdominal vessels, mesenteric vessels divided by staples or coagulating instruments, or the cut bowel edges. Bleeding can present with hypotension, tachycardia,

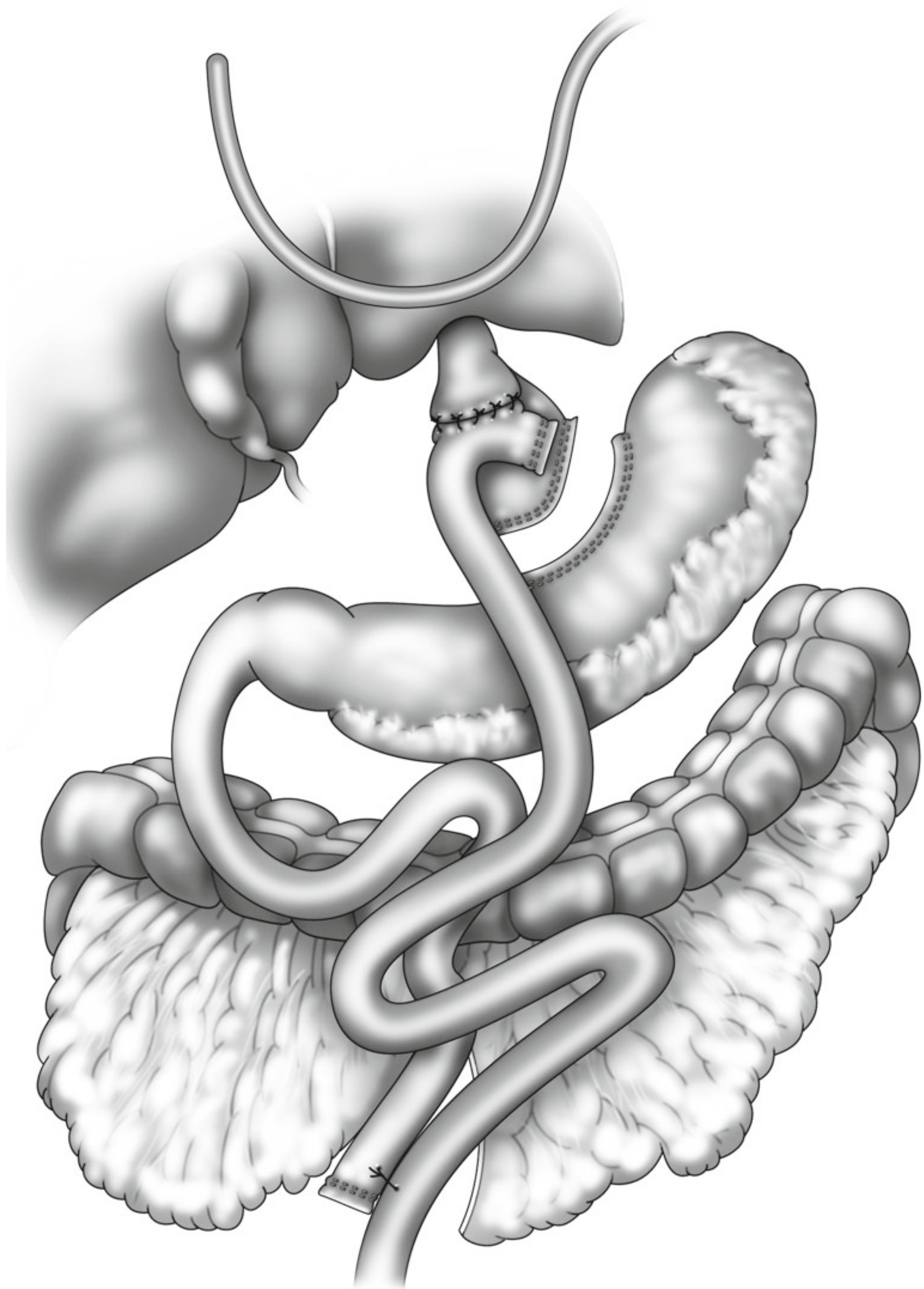


Fig. 41.16 Completed Anastomosis

abdominal distention, hematemesis, and hematochezia. Most bleeding will subside spontaneously with hydration and blood products. Persistent bleeding will require either endoscopic or surgical intervention.

Nausea

Prophylaxis should begin in the OR and then continue postoperatively; severe nausea may limit oral intake and require continued intravenous fluids and delay discharge.

Late Complications

Internal Hernias and Bowel Obstruction

Complete bowel obstruction of the enzymatic limb (the limb draining the pancreas, biliary tree, and residual distal gastric remnant) may be present despite the absence of clinical obstipation and food intolerance. Besides the usual adhesive bands that may cause bowel obstruction, two particular anatomic alterations of gastric bypass are commonly encountered. Peterson's defect describes the potential hernia behind an antecolic Roux limb. The mesenteric defect of the jejuno-jejunostomy can lead to herniation of the distal small bowel. Both hernias may demonstrate swirling of the small bowel vascular mesenteries on computer tomography with intravenous contrast. Even with normal computer tomographic studies, high index of suspicion and low threshold for diagnostic laparoscopy or laparotomy should be present to diagnose and prevent catastrophic injury to the small bowel. Abdominal pain in the postoperative gastric bypass patient should be considered an internal hernia until proven otherwise.

Stricture

Strictures may develop at the gastrojejunostomy or jejunojejunostomy and may present as progressive difficulty with solids or partial to complete bowel obstruction. Stricture at the gastrojejunostomy may be treated with endoscopic dilation, whereas those at the jejunojejunostomy are more likely to require surgical intervention.

Ulcer

Pain in the epigastric region associated with hematemesis or guaiac positive stool may be brought on by nonsteroidal anti-inflammatory drug use and recidivism of smoking. Endoscopy is diagnostic. Initial treatment is correction of inciting factors and administration of proton pump inhibitors. Ulcers may require surgery for uncontrolled bleeding or perforation.

Nutritional Deficiencies

Nutritional deficiencies may result from both decreased oral intake and malabsorption. Due to the bypass of the stomach and proximal small intestine, patients are prone to deficiencies in B_{12}, iron, folate, and calcium. Patients must take lifelong supplements of these elements as well as multivitamins. Patients with persistent emesis are at risk for thiamine deficiency.

Further Reading

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Part IV

Small Intestine and Appendix

42 Concepts in Surgery of the Small Intestine and Appendix

Danielle M. Fritze, Jessemae L. Welsh, Joseph J. Cullen, and Michael W. Mulholland

Multiple surgical diseases involve the small intestine or appendix and require knowledge relating to operations on the small bowel. This chapter introduces the concepts necessary to operate on the small bowel and appendix safely by discussing the operations in the context of common pathologic entities.

The small intestine (small bowel) begins with the jejunum at the ligament of Treitz and ends with the terminal ileum as it joins the cecum. The blood supply derives from the superior mesenteric artery, with collateral circulation of the proximal small bowel dependent upon the celiac artery and that of the distal small bowel dependent upon the inferior mesenteric artery. For convenience, the appendix is included in this section.

Procedures commonly performed on the small bowel include small bowel resection and anastomosis, enterolysis for small bowel obstruction, stricturoplasty for treatment of strictures secondary to inflammatory bowel disease, and Meckel's diverticulectomy. Other operations including ileostomy (Chaps. 59 and 60) and the use of small bowel to form pouches and conduits during reconstructive abdominal surgery (e.g., construction of a reservoir or pouch after total proctocolectomy with ileoanal pouch anastomosis – see Chap. 57) are discussed in later chapters rather than here.

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Small Bowel Resection with Anastomosis

Indications for small bowel resection and anastomosis include resection of tumor, injury secondary to blunt or penetrating trauma, mesenteric ischemia, inflammatory conditions such as Crohn's disease, and small bowel diverticula (including Meckel's diverticula).

Small Bowel Tumors

Small bowel tumors are rare. Combined, small bowel malignancies account for less than 3 % of all gastrointestinal malignancies (Han et al. 2010; Talamonti et al. 2002). They are difficult to diagnose because symptoms are usually insidious in onset and vague in presentation. They present insidiously with vague symptoms of abdominal pain, nausea, weight loss, and anemia. Often there is a delay in diagnosis as more common conditions are investigated. In the acute setting, patients with small bowel tumors may present with obstruction, perforation, or carcinomatosis at exploration (Talamonti et al. 2002).

To diagnose a small intestinal neoplasm at an early stage, the surgeon must include that possibility in the differential diagnosis. Benign tumors include adenomas, leiomyomas, lipomas, and hemangiomas. Patients may present with bright red blood per rectum or melena with resultant anemia. These tumors can also be a lead point for intussusception and cause obstructive symptoms. Primary malignant tumors include adenocarcinoma, carcinoid, lymphoma, and gastrointestinal stroma tumor (GIST). Symptoms include bleeding, obstruction, and perforation.

Often other disease processes predispose to the development of these tumors. For example, adenocarcinomas may occur in the setting of familial polyposis or Crohn's disease, while intestinal lymphoma can occur in the setting of celiac disease, chronic immunosuppression, or HIV. Melanoma is the most common tumor to metastasize to the mucosa of the gastrointestinal tract, including the small bowel.

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The poor prognosis associated with malignant tumors of the small bowel is a result of the long delay between the onset of symptoms and diagnosis of the lesion. Treatment is resection with a fan of mesentery to include the draining lymph nodes.

Trauma

The incidence of gastrointestinal injury is over 80 % in the setting of penetrating trauma, while injury to the small bowel is less frequent with blunt trauma and can be more difficult to diagnose. It is important to have a high index of suspicion and to carefully examine the entire length of small bowel during laparotomy. Injuries include perforation, contusion, mural hematoma, and mesenteric avulsion. The consequence of these injuries may range from clinically insignificant injuries to devitalized small bowel with compromised blood supply. A seat-belt sign (ecchymosis across the lower abdomen) carries a 2.4-fold increased risk for small bowel perforation and thus lowers the threshold for operative exploration. It is important to understand the limitations of currently available diagnostic modalities. CT findings most predictive for small bowel injury include pneumoperitoneum, bowel wall thickening, mesenteric hematoma, or extravasation of contrast (Fakhry et al. 2003; Butela et al. 2001).

Injuries range from simple perforation to mesenteric injury with areas of devitalized small bowel. Initial management of these injuries follows the basic principles of trauma resuscitation. Once an injury is confirmed, the patient is taken to the operating room; after a thorough exploration, an intraoperative decision is made regarding primary repair versus segmental resection, as described below. Damage control laparotomy is an important part of the management of these patients (see Chap. 8).

Mesenteric Ischemia

Small bowel resection is sometimes required in the setting of acute mesenteric ischemia. The classic presentation with severe sudden-onset abdominal pain associated with evacuation of intestinal contents, fever, and leukocytosis is seen in fewer than 1/3 of patients. Of all the symptoms, abdominal pain is the most consistent complaint, and leukocytosis and elevated serum lactic acid levels are common (Kibbe and Hassoun 2011).

The causes include: superior mesenteric embolus, thrombosis of existing atherosclerotic vessels, mesenteric venous thrombosis, and hypoperfusion (low flow). Treatment is tailored to the underlying cause but always includes resection of any areas of frankly gangrenous bowel. The prognosis is related to the underlying cause, the extent of bowel involvement, and the rapidity with which treatment is initiated. Anticoagulation is often appropriate, and the judicious use of revascularization by surgical or other means may be considered.

Because it can be difficult to ascertain the extent of nonviable bowel, liberal use of second-look procedures is warranted. The first operation is generally a form of damage control surgery (Chap. 8). In that setting, it is common to perform resection but no reconstruction, simply returning the stapled ends of small bowel into the abdomen. Anastomosis or stoma formation is then performed at the second (or even subsequent exploration) when the patient is more stable and the extent of ischemic necrosis is completely demarcated (Kibbe and Hassoun 2011).

Crohn's Disease

About 60 % of patients with Crohn's disease have involvement in the small bowel (10 % jejunum, 50 % ileum) (Duepree et al. 2002; Dasari et al. 2011; Stocchi et al. 2008; Tan and Tjandra 2007; Simillis et al. 2007; Akobeng 2008; Doherty et al. 2009; Peyrin-Biroulet et al. 2009; Regueiro et al. 2009; Fazio and Tjandra 1993). Patients may present with high-grade obstruction and sepsis, but operation is more commonly indicated for failure of medical therapy. The operative procedure of choice depends on whether the patient has had prior small bowel resection and on the location of the diseased segment. A cardinal principle is preservation of bowel length by resecting as little bowel as possible and tailoring the operation to extent of symptomatic disease. It is also important to recognize that surgery is rarely curative and radical resection does not decrease the risk of relapse. Patients who have had prior resections and are symptomatic due to chronic strictures may be treated with stricturoplasty. Because of its complexity, surgery for Crohn's disease is considered in greater detail in a separate section at the end of this chapter.

Small Bowel Diverticula

Small bowel diverticula may be divided into two kinds: acquired diverticula (usually jejunal) and Meckel's diverticulum. These will be considered separately.

Acquired small bowel diverticula have been identified in approximately 1 % of the population at autopsy (Meagher et al. 1993; Tsiotos et al. 1994). They are probably related to motility disorders and abnormalities of the intestinal wall. The diverticula are commonly located along the mesenteric border and are generally asymptomatic. These are best left alone if encountered as an incidental finding at laparotomy.

In a cohort of patients with incidentally diagnosed jejunal or ileal diverticulosis, 82 % remained asymptomatic after a mean of 4.8 years. The remaining 18 % developed a variety of symptoms and complications; more than half of these complications required operation (Peyrin-Biroulet et al. 2009). Inflammation, perforation, obstruction, intussusception, hemorrhage, and bacterial overgrowth with malabsorption have all been reported. While bacterial overgrowth and small bowel diverticulitis may be treated with antibiotics, the other complications require surgical intervention. The treatment of choice is resection of the involved segment of small bowel. In patients with long segments of small bowel involved with diverticulosis, the extent of resection is determined individually at the time of operation. Except for cases of severe inflammation, primary anastomosis is standard.

Meckel's diverticulum is the most common developmental anomaly of the small bowel, occurring in 2 % of the population (Uppal et al. 2011; Cullen et al. 1994; Zulfikaroglu et al. 2008). This diverticulum is a remnant of the attachment of the small bowel to the embryologic yolk sac. Meckel's diverticula arise from the antimesenteric border of the distal 100 cm of the small bowel. Ectopic tissue is found in approximately 50 % of diverticula, consisting of gastric tissue in 60–85 % of cases and pancreatic tissue in 5–16 %. Bleeding may occur as a result of ulceration in the presence of acid-secreting mucosa.

The diagnosis should be considered in patients with unexplained abdominal pain, nausea and vomiting, or intestinal bleeding. The clinical picture can mimic acute appendicitis, intestinal obstruction, Crohn's disease, and peptic ulcer disease. The most useful diagnostic modality is a technetium-99m pertechnetate scan, which is dependent on uptake of the isotope in heterotopic gastric tissue.

Meckel's diverticulum is encountered incidentally during elective abdominal surgery, during exploration for acute abdomen, during exploration for acute gastrointestinal bleeding, or after preoperative localization. Options for treatment in this situation include diverticulectomy (excision of the diverticulum with closure of the resulting defect with standard suture or stapled techniques), segmental small bowel resection, or simple observation (Cullen et al. 1994; Zulfikaroglu et al. 2008).

Symptomatic Meckel's diverticula are best treated by segmental resection of the diverticulum and adjacent small bowel with primary anastomosis. A diverticulectomy may also be done laparoscopically if the diverticulum is localized preoperatively or found to be the cause of symptoms during exploratory laparoscopy. If the condition is noted incidentally in association with other intra-abdominal pathology, observation may be appropriate and safe. An appendectomy is often performed in the same setting to avoid future diagnostic confusion.

Conduct of Small Bowel Surgery

In the elective setting, once a mass in the small bowel is localized or a resection is planned for a segment of bowel involved with Crohn's disease, the patient undergoes mechanical bowel preparation and is given a single dose of preoperative prophylactic antibiotics according to protocol. For open surgery, a standard midline incision is made, and systematic exploration of the abdomen is undertaken. Examination begins with palpation of the liver, gallbladder, pancreas, and retroperitoneum, with biopsy of any suspicious lesions. The small bowel is then eviscerated with meticulous visual inspection and palpation of the mesenteric and antimesenteric borders of the small bowel and mesentery from the ligament of Treitz to the terminal ileum. All the peritoneal surfaces are then inspected followed by careful palpation of the large bowel down to the rectum. Following this step, the segment of small bowel of interest is identified, and the remainder of the small bowel is carefully packed away out of the operative field. For tumors of the small bowel, a safe margin is then measured, typically about 5 cm on either side of the lesion, and that segment of bowel is resected with its associated mesentery. Malignant tumors are treated with a wide excision that includes local mesenteric lymph nodes. For patients with Crohn's disease, an isolated obstructed segment of small bowel is treated by resection. Bowel conservation is currently the goal, with resection proceeding to grossly negative margins.

For the emergency patient who presents with perforation and spillage of intestinal contents due to a malignancy, intestinal ischemia, or iatrogenic or traumatic injury, attention must be paid to rapid diagnosis and resuscitation followed by immediate exploration. The abdomen is explored systematically, and any area of hemorrhage from the blood supply to the small bowel is identified and controlled. Next, any area of perforation is identified, and spillage is controlled. The cause of the perforation or compromise to the small bowel blood supply is identified, and an intraoperative decision is made regarding primary repair versus resection of small bowel. For small perforations secondary to penetrating trauma, primary repair in the transverse direction can be performed if the perforation involves less than 50 % of the diameter of the small bowel. For larger perforations and for areas of small bowel with a compromised blood supply, a resection with primary anastomosis may be performed following the principles outlined below. The only major contraindications to small bowel resection with anastomosis are a questionable blood supply or a patient whose condition on the operating room table is precarious. In these situations, both ends of the divided bowel are exteriorized as enterostomies, and the anastomosis is completed at a later time.

Prior to dividing the segment of intestine, an adequate length of small bowel must be freed proximal and distal to the area to be resected to ensure a tension-free anastomosis. A good blood supply is required for optimal healing. This criterion is determined by noting pulsatile flow in the region where the bowel is transected. When dividing the mesentery, hematomas should be avoided, as they may impair circulation. Care must be taken to avoid excessive spillage of enteric contents after transecting the bowel and while performing the anastomosis. Control may be accomplished using nontraumatic bowel clamps that are carefully applied to the small bowel while avoiding clamping the mesentery. Once the bowel is divided, accurate apposition of the seromuscular coats is essential because optimal healing of an anastomosis requires serosa-to-serosa approximation. Care must be taken when handling the bowel wall with forceps, as improper use may cause trauma to the bowel wall. Once the sutures are placed, excessive force should not be applied when tying; otherwise, strangulation of the bowel wall can occur. Finally, when the sutures are placed, care must be taken to ensure that the bowel walls are not collapsed lest the back wall is caught by the suture, causing an obstruction. A variety of techniques exist for performing the anastomosis, ranging from hand-sewn to stapled anastomoses. Each technique is covered in detail in Chap. 43. Laparoscopic options exist for essentially all of the procedures performed on the small intestine, but there are some situations (e.g., complete small bowel obstruction with massively distended bowel) where the open approach remains best.

Enterolysis for Small Bowel Obstruction

Acute small bowel obstruction is common, and the decision to operate can be difficult. Intestinal obstruction is defined as the failure of progression of intestinal contents distally secondary to blockage of the intestinal lumen from an intrinsic or extrinsic lesion. The small bowel may become obstructed for a variety of reasons, including adhesions from prior laparotomy (60 %), benign and malignant tumors (20 %), strangulated hernia (10 %), inflammatory processes with narrowing of the lumen (5 %), volvulus or intussusception (3 %), and other miscellaneous conditions (2 %) such as gallstone ileus (Wilson et al. 1999; Bass et al. 1997; Cirocchi et al. 2010; Wullstein and Gross 2003; Khaikin et al. 2007; Ahmad et al. 2008).

Patients who present with an acute small bowel obstruction often complain of colicky pain followed by vomiting, constipation progressing to obstipation, or loose diarrhea secondary to passage of stool distal to the obstruction. Physical examination reveals a distended, tympanitic abdomen with hyperactive (early) or absent (late) bowel sounds. Abdominal radiographs reveal dilated loops of bowel, air-fluid levels, and a paucity of colonic air. Selective use of radiologic techniques, including water-soluble contrast and computed tomography (CT) studies, is helpful for characterizing the nature of the obstruction.

Despite the clinical and radiologic presentation, patients suffering from this condition are often difficult to assess and require careful evaluation and management. For patients who present with a partial intestinal obstruction, as suggested by a significant amount of air in the colon and the intermittent passage of flatus with no signs of fever, leukocytosis, systemic symptoms, or signs of peritonitis, a trial of conservative management with nasogastric suction, intravenous hydration, and close observation with serial examinations is warranted. Patients suffering from an acute complete obstruction, confirmed by the clinical and radiographic picture, should be operated on as soon as rehydration and correction of electrolytes has taken place, usually within 12–24 h from the onset of symptoms. When strangulation is suspected, rapid resuscitation is initiated and continued in the operating room.

The initial management of small bowel obstruction begins with replacement of fluid losses, correction of electrolyte abnormalities, and decompression of the bowel through nasogastric suctioning. Patients with suspected complete obstructions and those with partial obstructions that do not resolve are taken to the operating room. After administration of a dose of preoperative antibiotic that covers skin and intestinal flora, an attempt is made to enter the abdominal cavity through a scar-free area. Once the abdominal cavity is entered, the extent of adhesions in the vicinity of the incision can be determined. Through the use of gentle traction and countertraction, adhesions between loops of bowel and the abdominal wall are identified and transected with Metzenbaum scissors, freeing the small bowel from the abdominal wall on both sides. Because of dilated loops of bowel proximal to the obstruction, it is often necessary to decompress the bowel to improve exposure, preserve viability, and permit abdominal closure.

Decompression is accomplished by milking the intestinal contents proximally to a nasogastric tube placed in the stomach. It is not advisable to create a gastrotomy or an enterotomy to place a long tube for the purpose of intraoperative decompression. Care must be taken when handling dilated loops of bowel, as injury to the bowel or tearing of the mesentery can occur. It is important to have patience and proceed from easy, thin adhesions to denser adhesions. Once a segment of small bowel is freed, it is traced to the nearest loop of bowel with adhesions. This process is continued until the adhesions causing the obstruction are relieved.

Once adhesiolysis is complete, the small bowel must be reinspected along its entire length to determine if there are any serosal tears or inadvertent enterotomies and to determine viability. Small serosal tears with intact submucosa can be left unrepaired. If the mucosa is bulging, approximating the serosa on either side by interrupted Lembert stitches in a transverse direction repairs the area. Determining the viability of a segment of small bowel that has been freed can be difficult. Clues such as improved color and visible, palpable mesenteric pulsations are not reliable. Any area in question should be wrapped in warm packs and reevaluated in 15 min. If the question of viability continues, fluorescein staining and Doppler evaluation should be performed. If there are extensive areas of small bowel in question, a second-look operation should be planned in 24 h to preserve as much bowel as possible.

With the widespread use of laparoscopy for the surgical treatment of abdominal diseases, laparoscopic enterolysis has been widely reported. Several series demonstrate feasibility and surgeon acceptance; the reports also illustrate intrinsic difficulties and risk (Cirocchi et al. 2010; Wullstein and Gross 2003; Khaikin et al. 2007). In an early controlled clinical trial, 52 patients treated with standard laparotomy were compared to 52 patients treated laparoscopically (Cirocchi et al. 2010). Operative time was longer for procedures performed laparoscopically (103 vs. 84 min), but complications were more frequent (40 % vs. 19 %) and postoperative hospitalization longer (18 vs. 11 days) in the group treated by open operation. In a second controlled clinical trial published in 2007, laparoscopic enterolysis demonstrated lower morbidity, shortened postoperative hospitalization, and earlier return of bowel function (Khaikin et al. 2007). In this series, operative times were similar between the two approaches. Several retrospective reports note the frequent need for conversion from laparoscopy to open technique. Currently, there are no randomized controlled trials comparing laparotomy versus laparoscopy for the treatment of adhesive bowel obstruction in adult patients.

A vexing problem for the general surgeon is the patient who presents with recurrent bouts of obstruction secondary to adhesions. Recurrent obstructions occur in 10–15 % of cases. A number of products have been developed with the object of inhibiting the formation of adhesions in the postoperative period. Hyaluronic acid, a constituent of peritoneal surfaces and fluid, has been used in several formulations. Hyaluronic acid is a linear polysaccharide composed of repeating D-glucuronate and *N*-acetyl-D-glucosamine disaccharides. Hyaluronic acid solutions have proven efficacy in animal models for the prevention of adhesions. Cross-linking carboxylate groups on the hyaluronic acid molecule increases viscosity and is employed in several commercial applications. In a recent meta-analysis, prevalence of adhesions, judged by second-look laparoscopy, was reduced by use of hyaluronate solutions (Ahmad et al. 2008). Seprafilm (Genzyme Corporation, Cambridge, MA) is a sheeted adhesion barrier composed of sodium hyaluronate and carboxymethylcellulose. The material may be placed without suturing and is absorbed from the peritoneal cavity by 7 days and completely excreted by 28 days. Seprafilm is the only product that has been subjected to a controlled, randomized study; this trial demonstrated a reduction in the incidence, extent, and severity of postoperative adhesions (Becker et al. 1996).

Oxidized regenerated cellulose (Interceed, Johnson & Johnson, Cincinnati, OH) is a synthetic mechanical barrier that has been widely used for gynecological surgery. Interceed may be applied to raw surfaces both laparoscopically or via open surgery. The general conclusion from currently available studies is that Interceed reduces the formations of adhesions, judged by second-look laparoscopy (Ahmad et al. 2008). However, there is no solid evidence that this reduction in adhesion formation is followed long term by a decreased incidence of small bowel obstruction. Gore-Tex (W. L. Gore & Associates, Arizona, USA) is a surgical membrane composed expanded polytetrafluoroethylene. The membrane is inert and permanent. This material must be sutured in place, but most importantly, it must be removed by a second surgical procedure. This aspect has dampened enthusiasm for the use of Gore-Tex for prevention of postoperative adhesions, and it is primarily used as a prosthetic material to augment closure of hernia defects.

Several operative techniques have been used in an attempt to prevent recurrent obstruction. Two are mentioned in order to discourage their use. One strategy has been to fix the intestinal loops into a streamline configuration such that when adhesions do form, obstruction does not occur. Historically, this was done by stitch plication of the small bowel, accomplished by suturing parallel loops of bowel together, incorporating both bowel wall and mesentery. This procedure requires significantly long operating times and is associated with substantial morbidity. It has not been shown to prevent recurrent obstruction. Because of failure of suture plication, long intraluminal (Baker) tube stents were introduced. These tubes are placed through the nose or through a gastrotomy and left in place for 2 weeks (Chap. 45). Even though there are single-institution successful reports of these techniques, no prospective studies have been performed to demonstrate conclusively that long intestinal tubes prevent recurrent obstruction.

Crohn's Disease

Crohn's disease is a common inflammatory bowel disease characterized by granulomatous inflammation, by potential involvement of any portion of the gastrointestinal tract, and by the occurrence of complications that may require operative treatment. More than half of all patients afflicted with Crohn's disease require surgical therapy. For those that undergo operation, reoperation is required in 70 % and multiple procedures in 30 % (Duepree et al. 2002). Laparoscopy has been applied widely in gastrointestinal diseases with potential advantages of accelerated return to normal diet and activity, shorter hospitalization, reduced postoperative pain, smaller incisions, and fewer postoperative complications. Laparoscopic approaches are feasible for patients with Crohn's disease, but most reports are retrospective in nature and of limited scientific validity. In a recent meta-analysis comparing open and laparoscopic approaches to treatment of Crohn's disease, postoperative morbidity was affected by operative approach. Fewer patients treated laparoscopically developed wound infection. Other postoperative complications, typified by pneumonia, prolonged postoperative ileus, and urinary tract infection, were similar (Dasari et al. 2011). As with most other applications, duration of operation was shorter for procedures performed in an open fashion, but hospital stay was reduced for patients treated laparoscopically. Importantly, there was no significant difference in incidence of recurrent disease necessitating reoperation (Stocchi et al. 2008). The rate of conversion from laparoscopic approach to open operation is moderate, approximately 11 % (Tan and Tjandra 2007).

The technique of anastomosis appears to be important in surgical treatment of Crohn's disease. In a meta-analysis comparing conventional end-to-end anastomosis with other configurations (primarily side-to-side), anastomotic leak rate was increased with end-to-end technique (Simillis et al. 2007). The reasons for this observed difference are unknown.

Crohn's disease is a chronic disorder that may affect any portion of the gastrointestinal tract, with symptoms that can be disabling. Because there is currently no cure for Crohn's disease, nonsurgical therapy is focused upon the induction of remission and then upon maintenance of remission. Surgeons who treat patients with Crohn's disease must be familiar with both the power and limitations of medications used in this disorder, particularly those used for maintenance of remission. The currently available evidence does not support the efficacy of 5-aminosalicylates, corticosteroids, probiotics, cyclosporine, or antimycobacterial agents for maintenance of remission (Akobeng 2008). In contrast, strong data exist to conclude that azathioprine, infliximab, and adalimumab are effective for maintenance of long-term remission. Smaller studies suggest that enteral nutritional supplementation, enteric-coated omega-3 fatty acid preparations, and methotrexate may demonstrate efficacy.

It is tempting to extrapolate from these findings and to conclude that medications effective in maintenance of remission that is achieved by medical therapy could be used to maintain a disease-free state after surgical intervention. Such an interpretation is misleading. The definition of recurrence is important. Clinical recurrence is defined by the presence of inflammatory symptoms with or without a defined increase in the Crohn's disease activity index. Secondary outcomes include endoscopic recurrence, surgical recurrence (the need for repeat operation), or adverse treatment effects. Considered in this way, there is no evidence that probiotics have an influence on recurrence rates postoperatively (Doherty et al. 2009). Antibiotic therapy with nitroimidazole agents is more effective than placebo, but the ability of most patients to tolerate this therapy is limited due to neurological side effects. Mesalamine shows benefit for prevention of postoperative recurrence. The number of patients needing treatment to prevent one recurrence is relatively high (NNT = 12), but these agents are well tolerated and safe. Immunosuppressives such as azathioprine and 6-mercaptopurine are effective in preventing postoperative recurrence (NNT = 7) but are associated with a high rate of adverse drug effects (Peyrin-Biroulet et al. 2009). Recent data also suggests that anti-TNF therapy (infliximab) is effective in reducing postoperative Crohn's disease recurrence (Regueiro et al. 2009).

Small Intestinal Stricturoplasty

Multiple intestinal strictures are common sequelae of chronic inflammation in patients with Crohn's disease. Up to 30 % of patients who have undergone resection for Crohn's disease require another operation. Because of this high recurrence rate, radical resections for repeated bouts of intestinal obstruction secondary to strictures are inadvisable. Stricturoplasty has emerged as a useful technique for treating these narrowed segments of small bowel and serves as a valuable adjunct in the treatment of Crohn's disease (Fazio and Tjandra 1993). Stricturoplasty should be considered for patients with short, fibrotic strictures (15–35 % of Crohn's patients), a previous resection of more than 100 cm of small bowel, rapid symptomatic recurrence within 1 year of the previous resection, or evidence of short-bowel syndrome. Stricturoplasty is contraindicated in patients with peritonitis secondary to intestinal perforation, enteroenteric fistulas at the site of stricture, multiple strictures in a short segment, malnutrition, or hemorrhagic strictures.

There are several kinds of stricturoplasty, of which the Heineke-Mikulicz and Finney varieties (Figs. 42.1 and 42.2) are the most common. The Heineke-Mikulicz stricturoplasty is useful for short segments of narrowing (less than 8 cm in length), whereas the Finney stricturoplasty is useful for longer narrowed segments (more than 10 cm). The Heineke-Mikulicz stricturoplasty involves dividing the stricture longitudinally along its short course including 1–2 cm of normal bowel proximally and distally. The enterotomy is then closed transversely, as shown. When a longer segment of narrowing is found, the Finney stricturoplasty can be performed, as in Fig. 42.2. If intraluminal ulceration is seen, the bowel is biopsied to exclude malignancy. Results of stricturoplasty are favorable and reveal that it is a safe, effective procedure in selected patients with Crohn's disease. Stricturoplasty is associated with a 28 % reoperation rate, comparable to

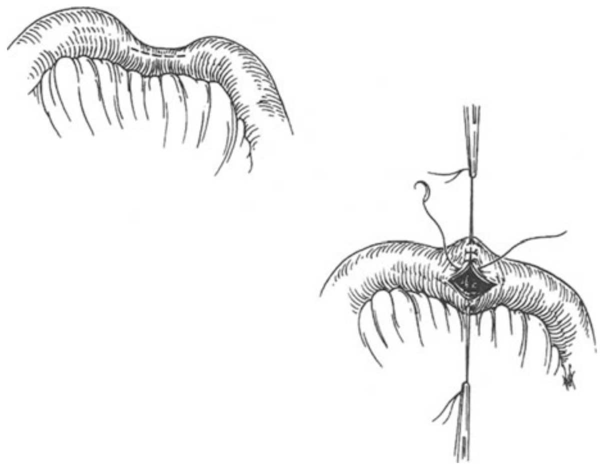

Fig. 42.1 (From Bell et al. (1996), with permission)

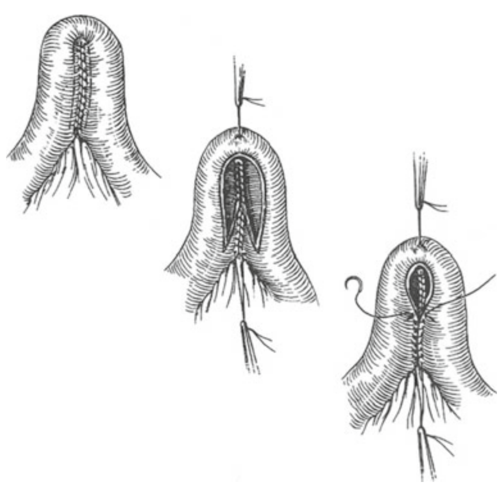

Fig. 42.2 (From Bell et al. (1996), with permission)

resection while preserving the length and function of small bowel. A very long segment isoperistaltic stricturoplasty has also been described (Michelassi and Upadhyay 2011).

Appendectomy

The evaluation and treatment of acute appendicitis has remained essentially unchanged for most individuals who present with this disease. Although advancements have been made in laboratory analysis and imaging via ultrasonography and helical CT, nothing can replace careful evaluation by an experienced surgeon. Appendicitis remains a diagnosis based primarily on history and physical examination, with further studies being useful adjuncts in atypical cases. Diagnostic uncertainty is more likely in the very young or the very old (Coursey et al. 2010; Raman et al. 2008; Flum et al. 2001).

Patients with acute appendicitis typically present with periumbilical visceral pain that migrates and localizes to the right lower quadrant. This pain can be associated with nausea, vomiting, low-grade fever, anorexia, and diarrhea. Laboratory evaluation reveals leukocytosis with a predominance of neutrophils. When the presentation is classic, the diagnosis may be made on clinical grounds alone; imaging studies may be useful in patients with an atypical presentation, obese patients, and women of childbearing age. Helical CT and ultrasonography offer the highest yield in terms of specificity, sensitivity, and predictive value when used as adjuncts to the physical examination. These studies are also useful in identifying complications of acute appendicitis – such as abscess or free perforation – which affect treatment strategy.

For patients with acute, non-perforated appendicitis, early appendectomy remains the cornerstone of therapy. All patients should receive preoperative antibiotics to cover skin and enteric organisms. After accessing the peritoneal cavity via either an open or laparoscopic approach, the appendix is mobilized from any surrounding adhesions or attachments. Should the appendix appear entirely healthy, another cause for the patient's symptoms is sought by examination of surrounding tissues. In the era of CT imaging, negative appendectomy rates of 5–15 % are reported (Coursey et al. 2010; Raman et al. 2008; Flum et al. 2001).

Both open and laparoscopic approaches are considered acceptable in treating acute appendicitis, each with benefits and limitations (Brugger et al. 2011; Sauerland et al. 2010; Oliak et al. 2000; Kaminski et al. 2005; Dixon et al. 2003). According to the National Inpatient Sample, 58 % of appendectomies performed in the USA in 2005 were laparoscopic (Sporn et al. 2009). Outcomes of laparoscopic appendectomy have improved over the past decade, with decreased rates of conversion, complications, and reoperation in 2006 as compared to 1995 (Brugger et al. 2011). Cochrane analysis of 56 randomized trials and 11 other studies related to the use of a laparoscopic versus open approach for acute appendicitis revealed significantly reduced rates of wound infection, postoperative pain, and length of hospital stay associated with laparoscopy. Even so, patients who underwent laparoscopic appendectomy also had significantly higher rates of intra-abdominal abscess, longer operative time, and greater overall cost than those treated with open appendectomy (Sauerland et al. 2010). Furthermore, evaluation of recent NIS data reveals an increased intraoperative complication rate for patients with uncomplicated appendicitis undergoing laparoscopic appendectomy as compared to the open approach (Sporn et al. 2009). Nonetheless, the laparoscopic approach may have particular benefit for patients in whom there is diagnostic uncertainty, allowing for exploration of the entire abdomen and pelvis. Studies also suggest reduced complication rates following laparoscopic appendectomy in obese and elderly patients. Generally, both laparoscopic and open appendectomy can be performed safely in the setting of acute appendicitis; the choice of approach should be informed by surgeon experience and patient characteristics.

Patients for whom physical exam or imaging studies identify complications of appendicitis require tailored care. Free perforation into the peritoneal cavity mandates broad-spectrum antibiotic therapy and prompt operative exploration with washout and drainage. For patients with contained perforation, the initial therapy is nonoperative. Broad-spectrum antibiotics and supportive therapy are accompanied by percutaneous drainage of any defined abscess to achieve source control. This nonoperative strategy is effective in 95 % of patients (Oliak et al. 2000); those who fail nonoperative management undergo exploration. For those patients who are treated successfully, interval appendectomy is traditionally performed at least 6 weeks after the resolution of symptoms. This practice has recently been called into question and evaluated in several large, retrospective studies. These studies indicate that the risk of recurrent appendicitis is similar to the risk of an initial episode and that recurrent episodes do not carry a higher risk of complications (Kaminski et al. 2005; Dixon et al. 2003). These data suggest that the decision to perform an interval appendectomy after successful nonoperative management of perforated appendicitis can be individualized to patient circumstances and preference.

Occasionally when operating for presumed acute appendicitis, the general surgeon identifies other pathology as the etiology of the patient's right lower quadrant pain. Common findings include inflammatory bowel disease or an appendiceal mass such as a carcinoid or mucocele. For patients found to have Crohn's disease at operation, an appendectomy can be performed safely so long as the base is not involved. Carcinoid tumors of the appendix are typically small, firm, circumscribed yellow tumors. When encountered, simple appendectomy with resection of the mesoappendix is adequate treatment for carcinoids less than 1 cm. For carcinoids more than 2 cm or smaller tumors with involved nodes, right hemicolectomy should be performed. Mucoceles of the appendix can be benign or malignant. An appendectomy is adequate treatment for benign tumors, but care must be taken to avoid rupture, as pseudomyxoma peritonei has been reported. Right hemicolectomy should be performed for mucous papillary adenocarcinoma.

In summary, multiple concepts must be followed for success when operating on the small bowel and appendix. Operating on the small bowel is usually safe unless the blood supply is impaired or active acute inflammation, edematous or dilated bowel, or advanced peritoneal sepsis is present. In most situations, small bowel resection with primary anastomosis for benign, malignant, or traumatic disease, an enterolysis for small bowel obstruction, a stricturoplasty for a stricture secondary to Crohn's disease, Meckel's diverticulectomy, ileostomy, and appendectomy can be safely performed when the above principles are followed. Laparoscopic alternatives to open surgery exist for most of these procedures. Both open and laparoscopic are described in the chapters which follow.

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Small Bowel Resection and Anastomosis

43

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Tumor
Trauma
Strangulation
Perforation
Crohn's enteritis with complications
Ischemic enteritis

Preoperative Preparation

Nasogastric intubation in selected cases (obstruction, perforation)
Perioperative antibiotics

Pitfalls and Danger Points

Small bowel anastomosis is generally safe unless the blood supply is impaired or advanced peritoneal sepsis is present. When a small bowel anastomosis fails because of technical errors, the leak almost invariably occurs at the mesenteric border, where the serosa has not been adequately cleared of blood vessels and fat.

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Operative Strategy

Open Versus Laparoscopic Technique

As with other abdominal procedures, laparoscopic techniques have been successfully applied to small bowel resection and anastomosis. This chapter details basic principles essential for success with either approach and stresses safe performance of small bowel anastomoses (sutured or stapled). For laparoscopic techniques, see the reference at the end of the chapter.

Successful Bowel Anastomosis Requirements

1. *Good blood supply*. Determine this by noting pulsatile flow after dividing a terminal arterial branch in the region where the bowel is to be transected. There should be no hematoma near the anastomosis, as it could impair circulation.
2. *Accurate apposition of the seromuscular coats*. There should be no fat or other tissue between the two bowel walls being sutured. The seromuscular suture must catch the submucosa, where most of the tensile strength of the intestine is situated. Optimal healing of an anastomosis requires serosa-to-serosa approximation. Devote special attention to the mesenteric border of any anastomosis. This is the point at which several terminal blood vessels and accompanying fat are dissected from the bowel wall to provide visibility for accurate seromuscular suture placement. Clear fat and blood vessels from a 1-cm-wide area of serosa around the circumference of an anastomosis. This allows increased accuracy for suture placement without causing ischemia.
3. *Sufficient mobility of the two ends of bowel*. A sufficient length of bowel must be freed proximal and distal to each anastomosis to ensure there is no tension on the healing suture line. Remember to allow for some degree of foreshortening if postoperative distension occurs.

†Deceased

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4. *No excessive force*. Force must not be excessive when tying the anastomotic sutures, as it would result in strangulation of tissue. If the suture should inadvertently have been placed through the full thickness of the bowel and into the lumen, the strangulated tissue will cause a leak. Tie sutures with no more tension than is needed to approximate both intestinal walls.
5. *No excessive force applied to the forceps*. When manipulating the ends of the bowel to be anastomosed, there must be no excessive force. If the imprint of forceps teeth is visible on the serosa after the forceps have been removed, the surgeon obviously compressed the tissue with too much force. Pass the curved needle through the tissue with a rotatory motion to minimize trauma. As discussed in Chap. 4, it does not matter whether an intestinal anastomosis is sutured or stapled so long as proper technique is employed.
6. *Learn the pitfalls*. One must learn the pitfalls (technical and conceptual) before constructing stapled intestinal anastomoses. Study the strategy of avoiding the complications of surgical stapling (see Chap. 5).
7. *Avoid common errors*. One must avoid the common errors seen among neophytes learning the art of anastomotic suturing:

   Do not insert the outer layer of seromuscular sutures with the collapsed bowel resting on a flat surface. An even worse error consists in putting the left index finger underneath the back of the anastomosis while inserting the anterior seromuscular sutures. Both errors make it possible to pass the seromuscular suture through the bowel lumen and catch a portion of the posterior wall. When the sutures are tied, an obstruction is created. Although some of these sutures may later tear out of the back wall in response to peristalsis, others remain permanently in place and produce a stenosis. To prevent this complication, simply have the assistant *grasp the tails of the anastomotic sutures that have already been tied*. Skyward traction on these sutures keeps the lumen of the anastomosis open while the surgeon inserts additional sutures.

   Another error consists in inserting anastomotic sutures while the bowel is under linear tension. This practice stretches the bowel wall, so it becomes relatively thin, making it difficult to enclose a substantial bite of tissue in the suture. *A sufficient length of intestine*, *proximal and distal*, *should be loosely placed in the operative field*. After the first seromuscular bite has been taken, the needle is ready to be reinserted into the wall of the opposite segment of intestine. At this time it is often helpful to use forceps to elevate the distal bowel at a point 3–4 cm distal to the anastomosis. Elevation relaxes this segment of the bowel and permits the suture to catch a substantial bite of tissue, including the submucosa. Each bite should encompass about 4–5 mm of tissue. These stitches should be placed about 4–5 mm from each other.

Contraindications to Anastomosis

Because of the excellent blood supply and substantial submucosal strength of the small bowel, anastomoses are often successful even in the presence of such adverse circumstances as intestinal obstruction and gross contamination of the abdominal cavity. Consequently, the only major contraindications to a primary small bowel anastomosis are peritoneal sepsis, a questionable blood supply, or a patient whose condition on the operating table is precarious. In these cases both ends of the divided small bowel may be brought to the skin as temporary enterostomies or simply stapled closed and returned to the abdomen for a planned second look.

Documentation Basics

Findings
Extent of resection
Location of resection (proximal versus distal, ileum versus jejunum)
Length of remaining bowel

Operative Technique

Small Bowel Anastomosis by Suturing

Incision

Use a midline vertical incision for the best exposure of the small bowel.

Division of Mesentery

Expose the segment of intestine to be resected by laying it flat on a moist gauze pad on the abdominal wall. With a scalpel make a V-type incision in the mesentery to be removed, carrying it through the superficial peritoneal layer only, to expose the underlying blood vessels (Fig. 43.1). Apply medium-size hemostats in pairs to the intervening tissue. Divide the tissue between hemostats and ligate each with 2-0 PG. After the wedge of mesentery has been completely freed, apply Allen clamps to the bowel on the specimen sides. Apply noncrushing intestinal clamps proximally and distally to prevent spillage of intestinal contents. Remove the diseased segment of intestine by scalpel division.

Open Two-Layer Anastomosis

Considerable manipulative trauma to the bowel wall can be avoided if the anterior seromuscular layer of sutures is the first layer to be inserted. This should be done by successive bisection (see Chap. 4). First, use 4-0 silk on an atraumatic needle, and insert a seromuscular suture on the antimesenteric border followed by a second suture on the mesenteric border (Fig. 43.2). Tie both sutures. Next, bisect the distance between these two sutures, and insert and tie the third Lembert suture at this point. Follow this sequence until the anterior seromuscular layer has been completed (Fig. 43.3a). Retain the two end sutures as guys, but cut the tails of all the remaining sutures. *Rotate the bowel by passing guy suture A behind the anastomosis* (Fig. 43.3b) so the posterior layer is on top (Fig. 43.3c).

Close the mucosal layer with a running 5-0 double-armed PG suture. Insert the two needles at the midpoint of the deep layer (Fig. 43.4). Tie the suture and close the posterior layer, which should include the mucosa and a bit of seromuscular tissue, with a continuous locked suture (Figs. 43.5, 43.6, and 43.7). Turning in the corners with this technique is simple. Bring the needle from inside out through the outer wall of the intestine (Fig. 43.8). Then, complete the final mucosal layer using the Connell technique or a continuous Cushing suture (Fig. 43.9). After this mucosal layer has been completed, insert the final seromuscular layer of interrupted 4-0 silk Lembert sutures (Fig. 43.10). The technique of successive bisection is not necessary in the final layer because the two segments of bowel are already in accurate apposition.

After all the suture tails have been cut, carefully inspect for imperfections in the suture line, especially at the mesenteric margin. Test the patency of the lumen by invaginating one wall of the intestine through the anastomosis with the tip of the index finger.

Open One-Layer Anastomosis

The first step in constructing an end-to-end anastomosis in one layer is identical to the steps in Figs. 43.2 and 43.3a. Insert interrupted 4-0 silk Lembert sutures on the anterior seromuscular layer. Cut the tails of all the sutures except the two at the end and rotate the bowel to expose the opposite, unsutured bowel (Fig. 43.3b, c). Approximate this too with interrupted 4-0 silk *seromuscular* Lembert sutures, paying special attention to the mesenteric border, where fat and blood vessels may hide the seromuscular tissue from view if the dissection has not been thorough.

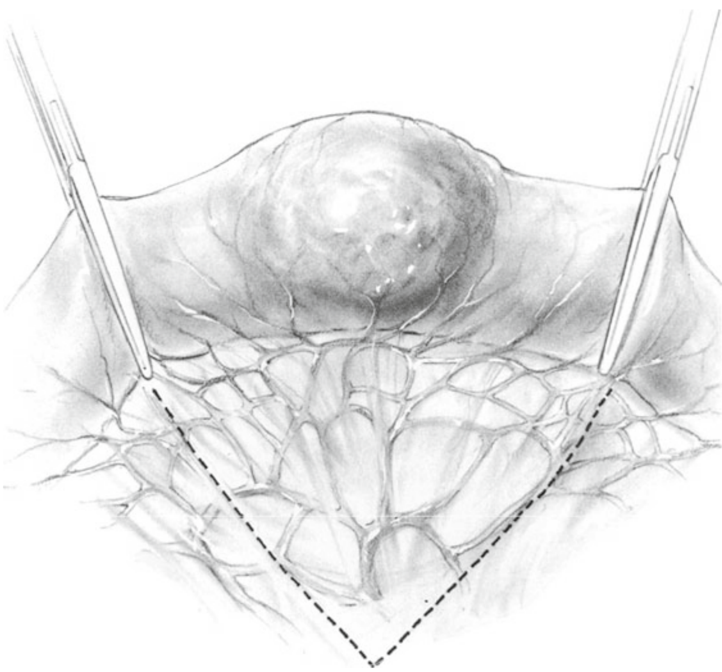

Fig. 43.1

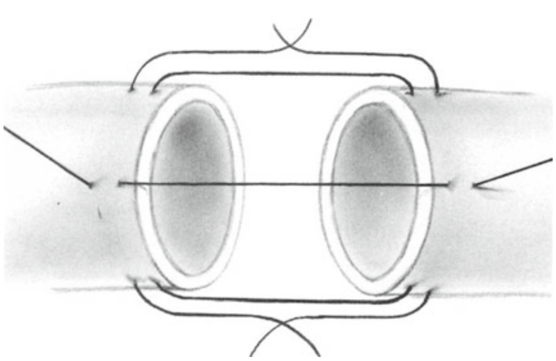

Fig. 43.2

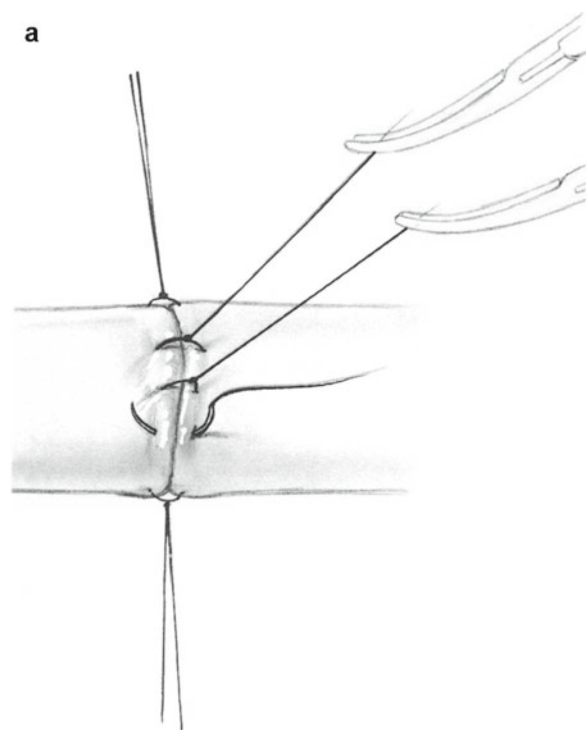

Fig. 43.3

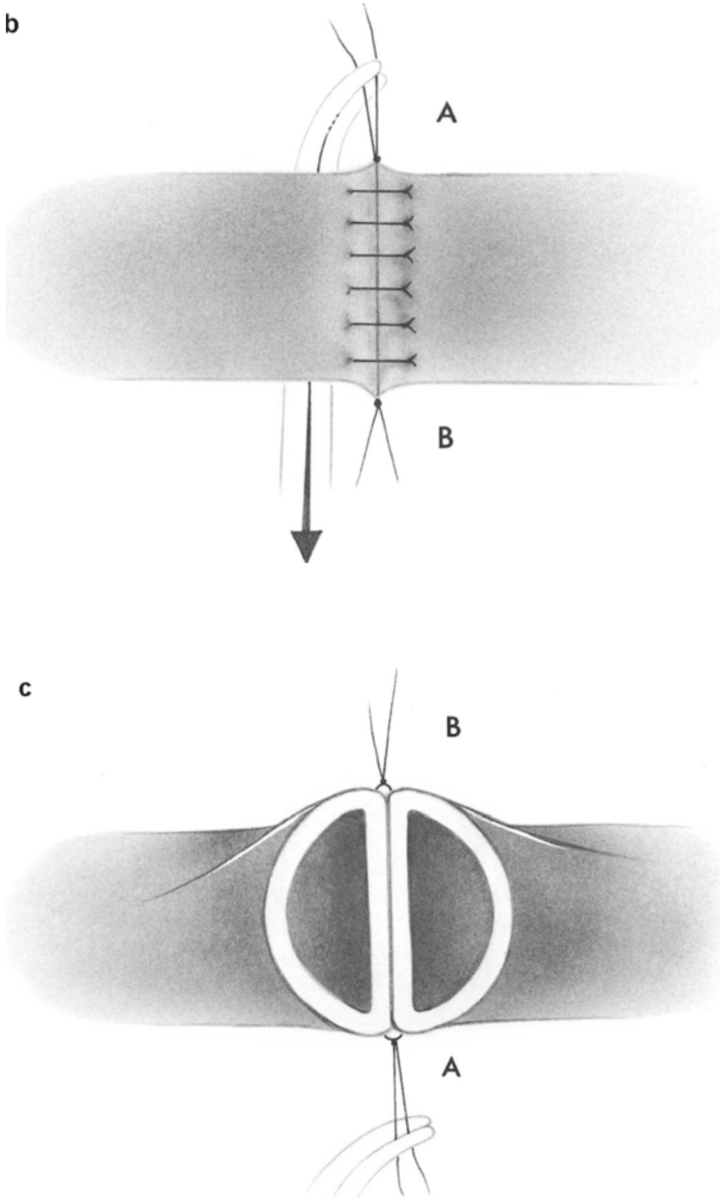

Fig. 43.3 (continued)

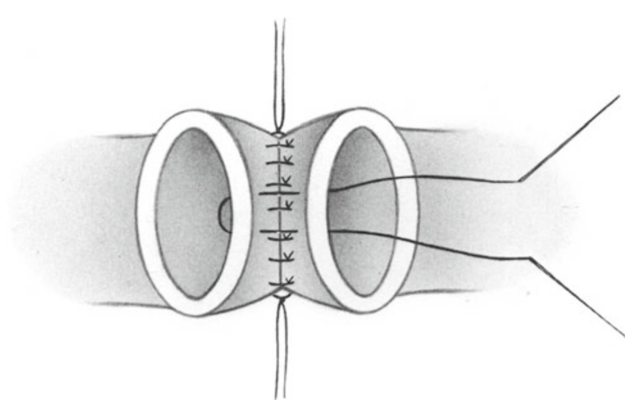

Fig. 43.4

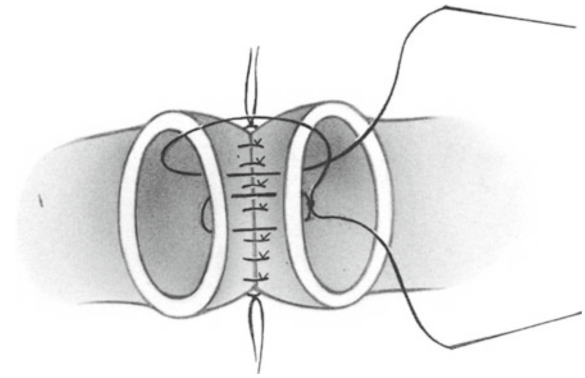

Fig. 43.5

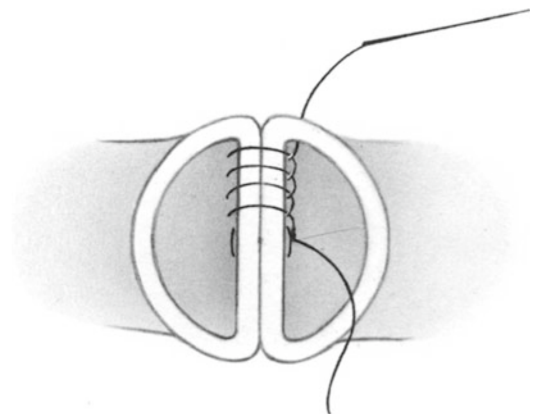

Fig. 43.6

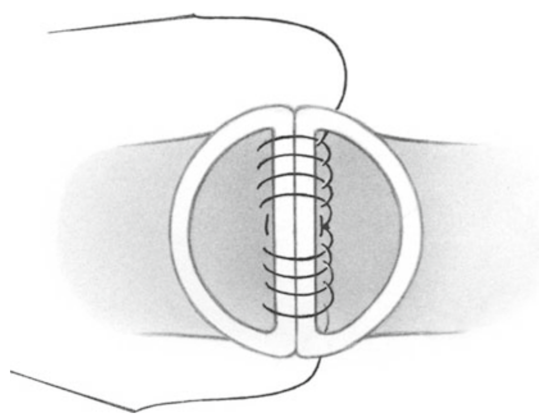

Fig. 43.7

After the anastomosis is completed, check it closely for defects. Test the size of the lumen by invaginating the wall with a fingertip.

Alternatively, instead of Lembert sutures, "seromucosal" stitches may be inserted (Fig. 43.11). This suture enters the seromuscular layer and, like the Lembert sutures, penetrates the submucosa; but instead of emerging from the serosa, the needle emerges just beyond the junction of

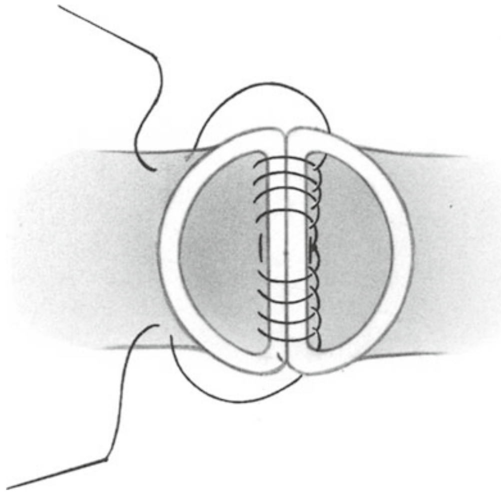

Fig. 43.8

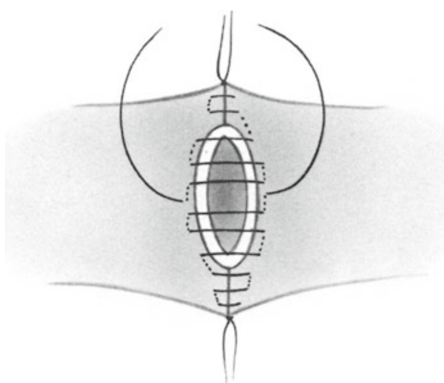

Fig. 43.9

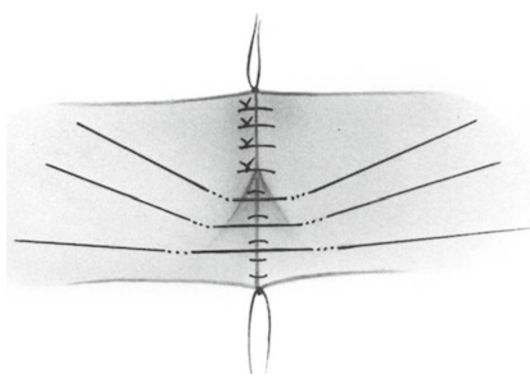

Fig. 43.10

the cut edge of the serosa and underlying mucosa. This stitch has the advantage of inverting a smaller cuff of tissue than does the Lembert or Cushing technique and may therefore be useful when the small bowel lumen is exceedingly small. When inserted properly the seromucosal suture inverts the mucosa but not to the extent seen with the Lembert stitch.

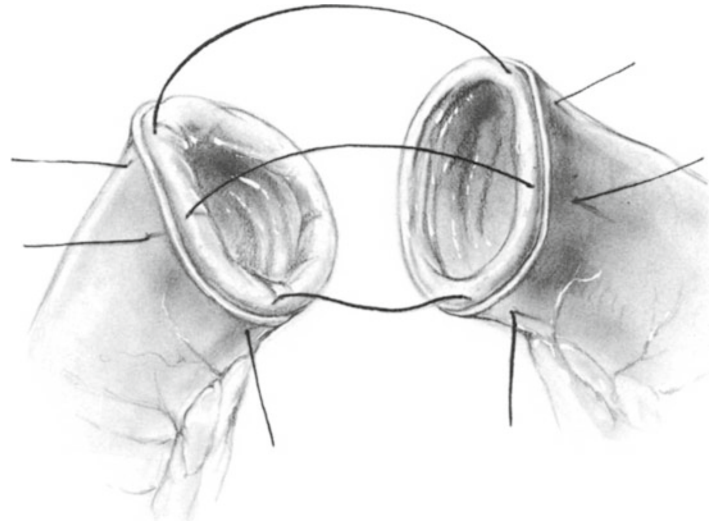

Fig. 43.11

Closure of Mesentery

Close the defect in the mesentery by a continuous suture of 2-0 PG on a large, intestinal-type needle. Take care not to pierce the blood vessels.

Small Bowel Anastomosis Using Stapling Technique

In our experience, the most efficient method for stapling the small bowel is a two-step functional end-to-end technique. It requires the two open-ended segments of the small bowel to be positioned, so their antimesenteric borders are in apposition. Insert a cutting linear stapling device, one fork in the proximal and the other fork in the distal segment of the intestine (Fig. 43.12). Fire the stapling instrument, which forms one layer of the anastomosis in an inverting fashion (Fig. 43.13). Apply Allis clamps to the anterior and posterior terminations of the staple line. Then, draw the two Allis clamps apart (Figs. 43.14 and 43.15). Close the remaining defect in the anastomosis in an everting fashion after applying four or five Allis clamps to maintain apposition of the walls of the proximal and distal segments of bowel (Fig. 43.16).

After all the Allis clamps have been aligned, staple the bowel in eversion by applying a 90/3.5 mm linear stapling device just deep to the Allis clamps (Fig. 43.16). If the bowel wall is thick, use 4.8 mm staples. It is essential that the line of staples cross both the anterior and posterior terminations of the anastomotic staple line to avoid gaps in the staple line. Fire the stapler, and excise the redundant bowel flush with the stapling device using Mayo scissors. Lightly electrocoagulate the everted mucosa.

Carefully inspect the staple line to be sure each staple has formed a proper B. Bleeding may be controlled by conservative electrocautery or by using interrupted 4-0 atraumatic PG sutures.

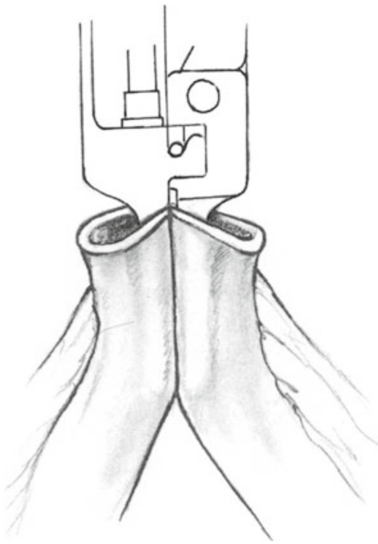

Fig. 43.12

Fig. 43.13

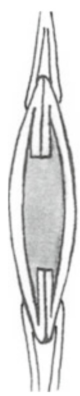

Fig. 43.14

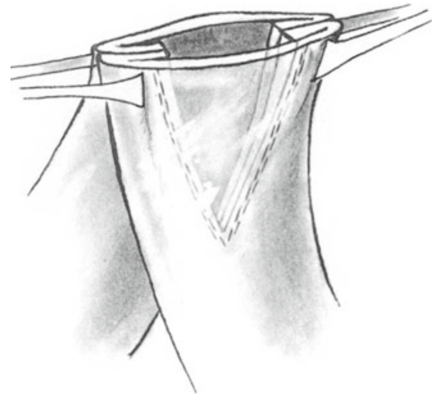

Fig. 43.15

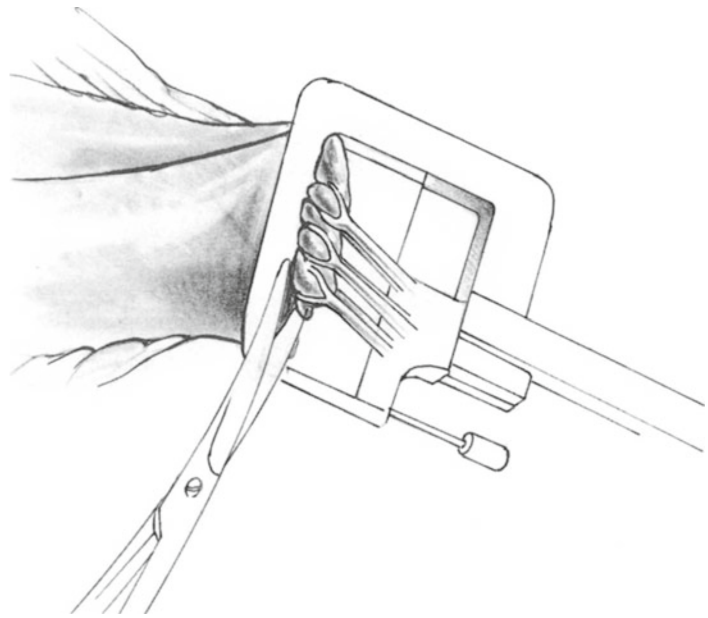

Fig. 43.16

Close the defect in the mesentery with a continuous 2-0 atraumatic PG suture. If feasible, cover the everted mucosa by the mesenteric suture line to minimize the possibility of it becoming a nidus of adhesion formation. Cover the anastomosis with a layer of omentum, whenever possible, to prevent adhesions.

Postoperative Care

Consider nasogastric suction until bowel function resumes.

Complications

Although it is uncommon for the patient to develop complications following a small bowel anastomosis, postoperative obstruction does occasionally occur. Anastomotic leaks accompanied by intraperitoneal sepsis or enterocutaneous fistula are rare except after resection in the face of sepsis or when mesenteric circulation is impaired.

Further Reading

Soper NJ, Scott-Conner CEH. The SAGES manual, vol. I. New York: Springer Science + Business Media; 2012.

44 Enterolysis for Intestinal Obstruction

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Enterolysis is indicated for acute cases of complete small bowel obstruction. It is frequently performed as an incidental procedure when the previously operated abdomen must be reentered.

Preoperative Preparation

Institute nasogastric suction promptly.
Initiate fluid and electrolyte resuscitation.
Administer perioperative antibiotics.

Pitfalls and Danger Points

Inadvertent laceration and spillage of the contents of the intestine is a hazard of this procedure. Failure to identify and relieve all points of obstruction can occur unless the entire small bowel is dissected free.

Operative Strategy

Dissect carefully and patiently to avoid spillage of intestinal contents. Bacterial overgrowth occurs rapidly when the contents stagnate. Massive distension with thinning of the bowel makes it much more likely to occur and more serious if it happens.

Enter the abdomen through a scar-free area and carefully dissect the bowel from the underside of the abdominal wall. Adhesions are commonly dense in the region of the old scar.

Separate loops of bowel, working from regions of easy dissection toward those where it is difficult. The additional exposure gained by doing the easy dissection first facilitates work in the more difficult parts. Work on the collapsed region (distal to the obstruction) first, if possible, and keep the dilated proximal bowel in the abdomen as long as possible.

After all adhesions have been freed, repair any injured segments and evaluate intestinal viability. Determine whether operative decompression is needed prior to closure.

Documentation Basics

- Note findings
- Presence or absence of obstruction

Operative Technique

Incision and Bowel Mobilization

A long midline incision is preferable. In the case of a previous midline incision, start the new incision 3–5 cm cephalad to the upper margin of the scar so the abdomen can be entered through virgin territory. If the old scar extends from xiphoid to pubis, enter through the cephalad part of the incision, where it is likely that only the stomach or the left lobe of the liver (rather than distended loops of bowel) will be encountered.

Carry the skin incision through the old scar and down to the linea alba. After opening the upper portion of the incision, identify the peritoneal cavity and then carefully incise the remainder of the scar. If entry into the peritoneum is difficult, lift up on the skin and subcutaneous tissues on both

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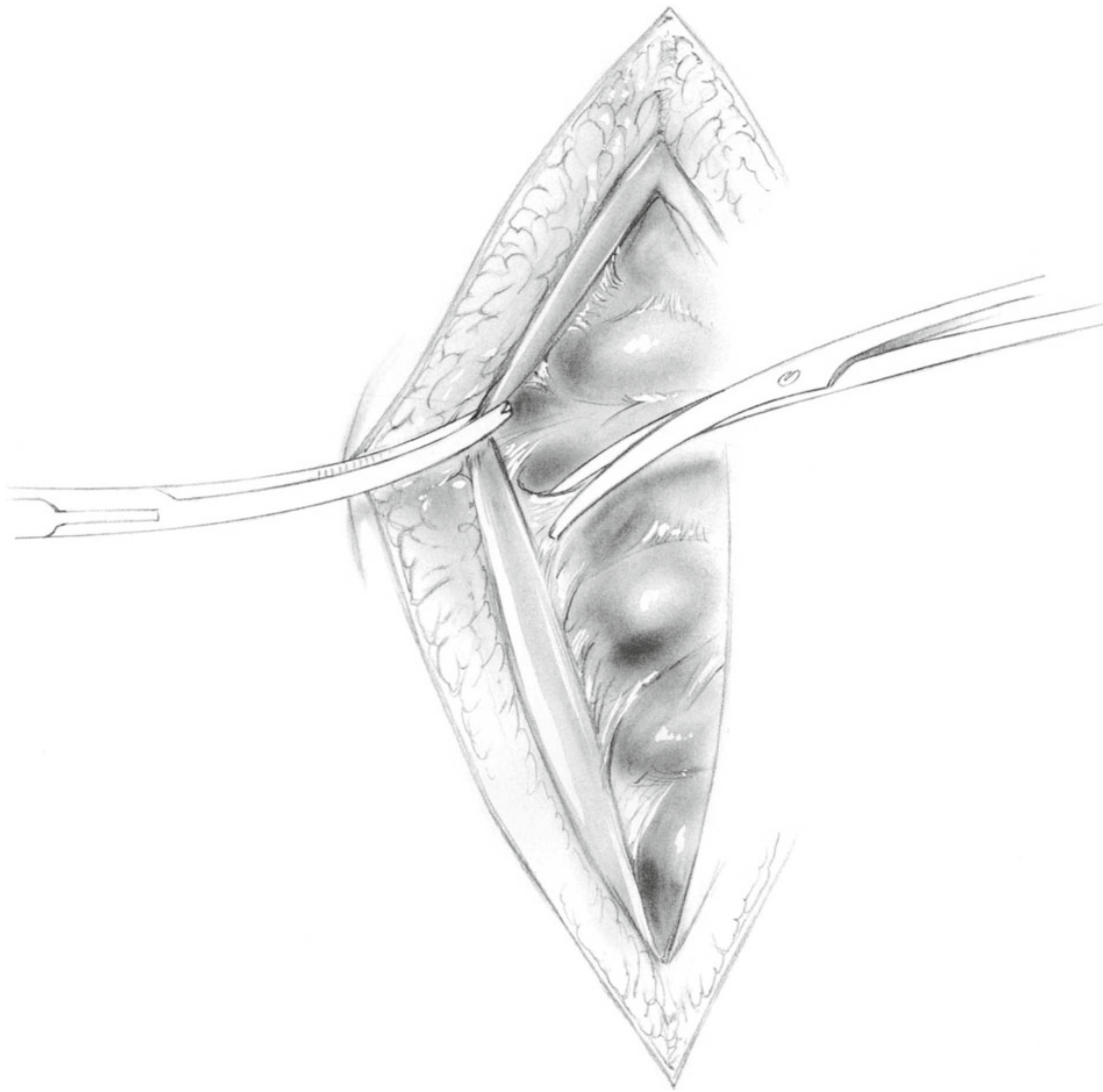

Fig. 44.1

sides of the incision to create locally negative intra-abdominal pressure, and gently continue to incise with a scalpel. As soon as the peritoneum is entered, air flows into the peritoneal cavity and creates a safe zone for continued dissection. At the same time, dissect away any adherent segments of underlying intestine (Fig. 44.1).

Approach to Densely Adherent Abdomen

Whereas the content of the normal small intestine is sterile, with intestinal obstruction, the stagnation of bowel content results in overgrowth of virulent bacteria with production of toxins. When these substances spill into the peritoneal cavity, the likelihood of postoperative mortality and infection increases significantly. To avoid this mishap, dissection should be done carefully and patiently.

The basic dissection strategy consists in entering the abdominal cavity through a scar-free area. Even though an old midline scar is frequently used to reenter an abdomen to relieve an obstruction, it is advantageous to make some part of the incision through an area of the abdomen above or below the old scar. Access to the peritoneal cavity through an unscarred area often gives the surgeon an opportunity to assess the location of adhesions in the vicinity of the anticipated incision. After the free abdominal cavity is entered and any adherent segments of intestine are freed, the remainder of the incision is carefully done.

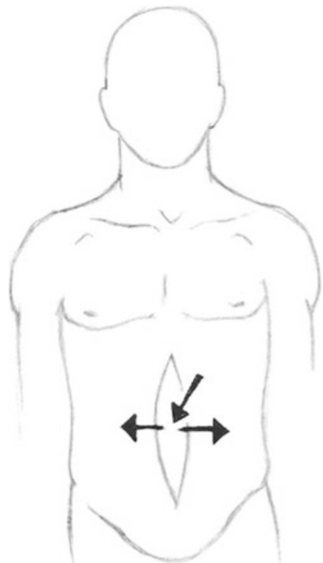

Fig. 44.2

Attach Allis clamps to the peritoneum and linea alba on one side of the incision, and have the assistant lift up on the clamps. Metzenbaum scissors can generally then be insinuated behind the various layers of avascular adhesions to incise them (Fig. 44.1). If the left index finger can be passed underneath a loop of bowel adherent to the abdominal wall, it helps guide the dissection. The aim is to free all the intestine from the anterior and lateral abdominal wall, first on one side of the incision and then on the other, so the anterior and lateral layers of parietal peritoneum are completely free of intestinal attachments (Fig. 44.2).

Once the intestine has been freed, trace a normal-looking segment to the nearest adhesion. If possible, insert an index finger into the leaves of the mesentery, separating the two adherent limbs of the intestine. By gently bringing the index finger up between the leaves of the mesentery, the adherent layer can often be stretched into a fine, filmy membrane, which is then easily divided with scissors (Fig. 44.3). In general, the strategy is to insinuate either

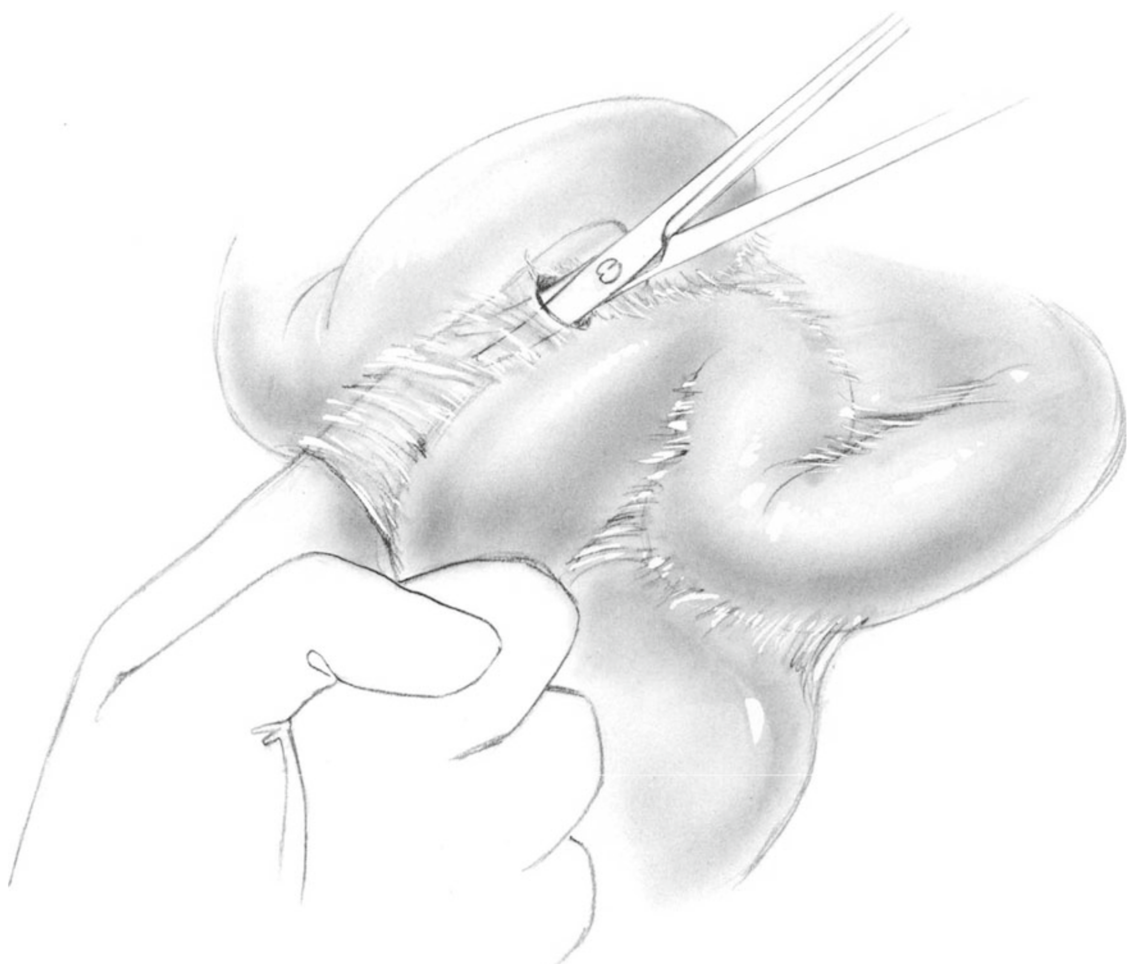

Fig. 44.3

the left index finger or closed blunt-tipped curved Metzenbaum scissors underneath an adhesion to delineate the plane and then withdraw the closed scissors and cut the fibrous layer. A guiding principle is *to perform the easy dissection first*. If this principle is always followed, the difficult portion of a dissection becomes easy. Avoid tackling a dense adherent mass directly; if the loops of intestine going to and coming from the adherent mass are dissected on their way in and on their way out of the mass of adhesions, a sometimes confusing collection of intestine can be easily untangled.

In the case of an acute small bowel obstruction, frequently there are only one or two adhesions and a markedly distended proximal bowel. When this occurs, be careful not to permit the distended bowel to leap out of a small portion of the incision, as it may be torn inadvertently in the process. If possible, first deliver the collapsed bowel (distal to the point of obstruction), and then trace it retrograde up to the point of obstruction. The adhesion can then be divided under direct vision and the entire bowel freed.

Free the remainder of the bowel of adhesions, from the ligament of Treitz to the ileocecal valve. Accomplish this task by delicate dissection with Metzenbaum scissors, alternately sliding the scissors underneath a layer of fibrous tissue to visualize its extent and then cutting the adhesion. This can be done more efficiently if the left index finger can be insinuated in such a way as to circumscribe the adherent area or if the index finger can be brought between the leaves of mesentery separating the adherent bowel, thereby placing the adhesion on stretch and making it visible (Fig. 44.3). In some cases there are adhesions of a cartilaginous nature, especially in patients whose obstruction is due to multiple malignant implants. Bold scalpel incisions should be made to divide adhesions of this type. Again, by doing the easy dissection first, the difficult parts become easier.

Relaparotomy for Early Postoperative Obstruction

We most often reenter the same incision, usually in the midline, to reexplore the postoperative abdomen. Because most relaparotomy operations are done after the eighth to tenth postoperative day, some sharp dissection may be necessary to enter the abdomen.

To divide adhesions in these cases, many of the loops of bowel can be separated by inserting the index finger between the leaves of adjoining mesentery. By elevating the finger, the adhesion can be stretched between the bowel segments. Often the adhesion can be disrupted by pinching it *gently* between the thumb and index finger without damaging the serosa of the bowel.

Operative Intestinal Decompression

If the diameter of the small bowel appears to be so distended that closing the incision would be difficult, operative decompression of the bowel makes the abdominal closure simpler and may improve the patient's postoperative course. Decompression may also lessen the risk of inadvertent laceration of the tensely distended intestine.

We prefer to use the Baker intestinal tube, which is a 270-cm-long tube with a 5 ml balloon at its tip, for this procedure. It may be passed through the patient's nose by the anesthesiologist or introduced by the surgeon through a Stamm gastrostomy. It is then passed through the pylorus with the balloon deflated. The balloon is partially inflated and the tube milked around the duodenum to the ligament of Treitz and then down the small intestine. Meanwhile, intermittent suction is applied to aspirate gas and intestinal contents. Caution should be exercised when milking the tube through the intestine, as the distended bowel has impaired tensile strength and can easily be torn. In patients who have relatively few adhesions, the Baker tube may be removed at the conclusion of the decompression and a nasogastric tube substituted for postoperative suction. In very rare situations, for example, when the patient has required multiple laparotomies for adhesions or where the bowel has sustained extensive serosal damage, the Baker tube may be left in place for 2–3 weeks to perform a "stitchless plication" (see Chap. 45).

Repair of Damage to Bowel Wall

Small areas of intestine from which the serosa has been avulsed by dissection require no sutures for repair if the submucosa has remained intact. This is evident in areas where some muscle fiber remnants remain. Otherwise, when only thin mucosa bulges out and the mucosa is so transparent that bubbles of fluid can be seen through it, the damage is extensive enough to require inversion of the area with interrupted or continuous seromuscular 4-0 PG Lembert sutures. Large areas of damage should be repaired transversely by one or two layers of Lembert sutures in a transverse manner. Extensive damage requires bowel resection with anastomosis by sutures or stapling.

If a segment of bowel is of questionable viability, replace it in the abdomen and cover the incision with warm, moist packs. Reevaluation in 10–15 min often reveals that the bowel has regained some color, tone, and peristalsis indicative of recovering perfusion.

Closure

After decompressing the bowel, replace it in the abdominal cavity. If there has been any spillage, thoroughly irrigate the abdominal cavity with large volumes of warm saline solution. Close the abdominal wall in the usual fashion (see Chap. 3).

Postoperative Care

Nasogastric suction may be required postoperatively until evidence of bowel function returns. This is manifested by active bowel sounds or the passage of flatus or stool per rectum.

In the very rare situation when a Baker tube must remain in place postoperatively because of extensive serosal damage or some other indication for a "stitchless plication" (see Chap. 45), it is generally necessary to insert a nasogastric tube in the other nostril to decompress the upper gastrointestinal tract. Our policy is to avoid filling both nostrils with intestinal tubes. It is far preferable in these cases to insert the long Baker tube through a newly constructed Stamm gastrostomy, thereby leaving one nostril free.

Antibiotics are given perioperatively.

Complications

Recurrent intestinal obstruction
Intestinal fistula or peritonitis

Baker Tube Stitchless Plication: Surgical Legacy Technique

45

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Operations for intestinal obstruction due to extensive adhesions, when the patient has already undergone numerous similar operations

Extensive serosal damage following division of many adhesions

Preoperative Preparation

See Chaps. 43 and 44.

Nasogastric suction should be initiated before the operation.

Pitfalls and Danger Points

Trauma to the bowel while passing the Baker tube

Reverse intussusception when the tube is removed

Operative Strategy

Adhesions tend to form again after enterolysis. Plication attempts to prevent multiple recurrent adhesions by holding the bowel in a prearranged orderly fashion (Fig. 45.1) during the period of adhesion formation. In this manner, any adhesions that develop presumably form between loops of intestine that are held in gentle curves, minimizing the chances of recurrent adhesive obstruction.

The Baker tube may be passed through a Stamm gastrostomy (preferred), a jejunostomy, or under rare circumstances retrograde through a cecostomy. It is not advisable to pass the tube via the nasogastric route, as the tube must remain in place for at least 10 days. A nasogastric tube may be required to decompress the stomach postoperatively.

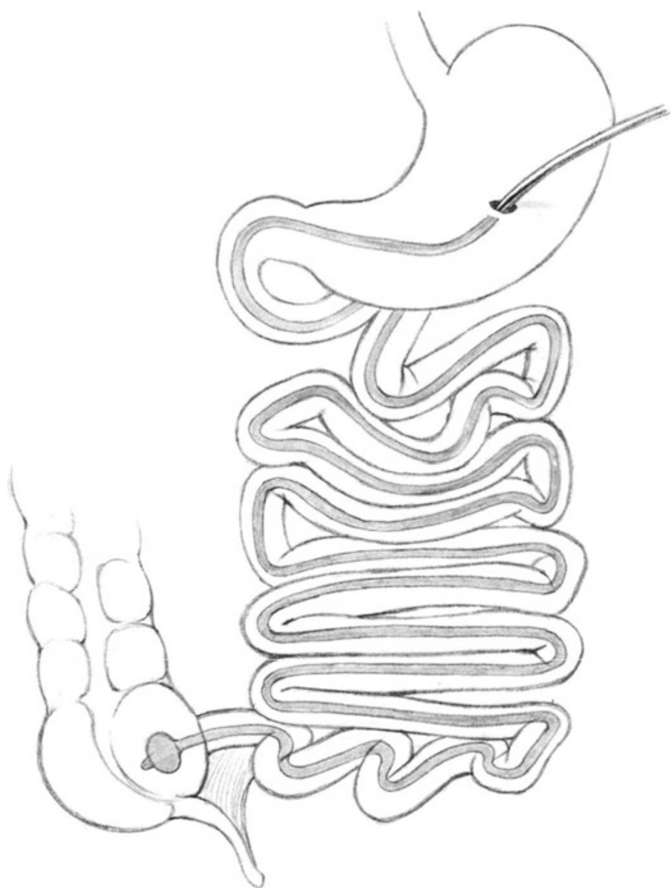

Fig. 45.1

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Operative Technique

Enterolysis of the entire small bowel should be performed as the first step of this operation. Create a Stamm gastrostomy (see Figs. 36.1, 36.2, 36.3, 36.4, and 36.5). The Baker tube is an 18F 270-cm-long intestinal tube with a balloon at the end and a dual lumen. The primary lumen may be placed for suctioning the bowel to decompress it during tube passage and during the early postoperative period. The second lumen controls inflation and deflation of the balloon.

Pass the sterile Baker tube into the gastrostomy and then through the pylorus; partially inflate the balloon. By milking the balloon along the intestinal tract, the tube may be drawn through the entire length of the intestine. Supply intermittent suction to the tube to evacuate gas and intestinal contents. Pass the balloon through the ileocecal valve and inflate it to 5 ml.

Distribute the length of the intestine evenly over the length of the tube. Then, arrange the intestine in the shape of multiple gentle S-curves as shown in Fig. 45.1. Irrigate the peritoneal cavity and close the abdomen in the usual fashion. If there has been any spillage of bowel contents during the dissection, if gangrenous bowel has been resected, or if an enterotomy has been performed for intestinal decompression, do not close the skin incision, as the incidence of wound infection is extremely high.

When local factors contraindicate a gastrostomy, a potential "bailout" maneuver is to pass the Baker tube through a stab wound near McBurney's point and construct a cecostomy by the Stamm technique. Insert a purse-string suture using 3-0 PG in a portion of the cecum near the stab wound. Make a puncture wound in the center of the purse-string suture, insert the Baker tube, and hold the purse-string suture taut. To pass the Baker tube through the ileocecal valve, make a 3- to 4-mm puncture wound in the distal ileum. Then, insert a Kelly hemostat into the wound and pass the hemostat into the cecum. Grasp the Baker tube with the hemostat and draw the tube into the ileum. Close the puncture wound with sutures.

Inflate the balloon of the Baker tube and milk the balloon in a cephalad direction until the tip of the Baker tube has reached a location proximal to the point of obstruction and to any area of bowel that has suffered serosal damage. Suction all the bowel contents through the Baker tube and deflate the balloon.

Insert a second 3-0 PG purse-string suture, inverting the first purse-string suture. Then, suture the cecostomy to the abdominal wall with one 3-0 PG suture in each quadrant surrounding the abdominal stab wound.

Postoperative Care

Connect the Baker tube to low wall suction. Deflate the balloon at the end of the Baker tube on the second postoperative day. We cut off the port after balloon deflation to ensure that the balloon is not inadvertently reinflated. The tube itself must stay in place for 14–21 days if a stitchless plication is to be achieved. An additional nasogastric tube may be required for several days. Prolonged ileus due to preoperative obstruction or the manipulation of bowel required to pass the tube is common.

When bowel function returns, remove the Baker tube from the suction and allow the patient to eat. Simply clamp the tube and leave it in place as a stent. When it is time to remove the Baker tube, do so gradually, with the balloon deflated to avoid creating (reverse) intussusception.

Antibiotics are given postoperatively to patients who have had an intraoperative spill of intestinal contents.

Postoperative Complications

Wound infection

Further Reading

Baker JW. Stitchless plication for recurring obstruction of the small bowel. Am J Surg. 1968;116:316.
Childs WA, Phillips RB. Experience with intestinal plication and a proposed modification. Ann Surg. 1960;152:258.
Noble TB. Plication of small intestine as prophylaxis against adhesions. Am J Surg. 1937;35:41.

46 Appendectomy

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Acute appendicitis.

Interval appendectomy following conservative treatment of appendiceal abscess.

Mucocele of appendix.

Adenocarcinoma and carcinoid of appendix may require right colon resection in addition to appendectomy, especially if there is suspicion of metastases in lymph nodes.

Preoperative Preparation

Diagnostic studies: ultrasonography and computed tomography (CT) of the appendix (if necessary)

Intravenous fluids

Perioperative antibiotics

Nasogastric tube if ileus is present

Pitfalls and Danger Points

Inadvertent laceration of inflamed cecum during blunt dissection

Inadequate control of blood vessels in edematous mesoappendix

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Operative Strategy

Incision

When the diagnosis is clear, use a McBurney incision, which splits the muscles along the lines of their fibers, each in a somewhat different direction. The healed scar with this incision is usually quite strong, and the cosmetic result is good. Accurate placement of this small incision over the appendix is crucial. Figure 46.1 shows how this incision is classically placed so as to allow easy access to the base of the appendix.

Recognize, however, that the cecum and appendix can vary considerably in location. Use any available information to guide incision placement. Consider available imaging studies and the point of maximum tenderness on physical examination. Gently palpate the abdomen once the patient is under anesthesia, and place the incision over any mass that might be found. If in doubt, remember that it is easier to pull the cecum and appendix up out of the pelvis into the incision than to pull a high-lying retrocecal appendix down into a low incision. Adequate exposure of a true retrocecal appendix will require mobilization of the cecum; plan accordingly.

If the exposure proves inadequate, the incision may be carried in a medial direction by dividing the rectus sheath and retracting the muscle laterally. If necessary, the right rectus muscle itself may be transected to expose the pelvic organs. If it is obvious that the exposure is inadequate, even with an extension (e.g., if a perforated ulcer is found), make a new vertical incision suitable to the pathology and close the McBurney incision. If the diagnosis is uncertain, the laparoscopic approach (see Chap. 47) or even a midline laparotomy incision may be preferable.

Management of Appendiceal Stump

In most cases acute appendicitis is the result of a closed-loop obstruction due to an appendiceal fecalith. The base of the

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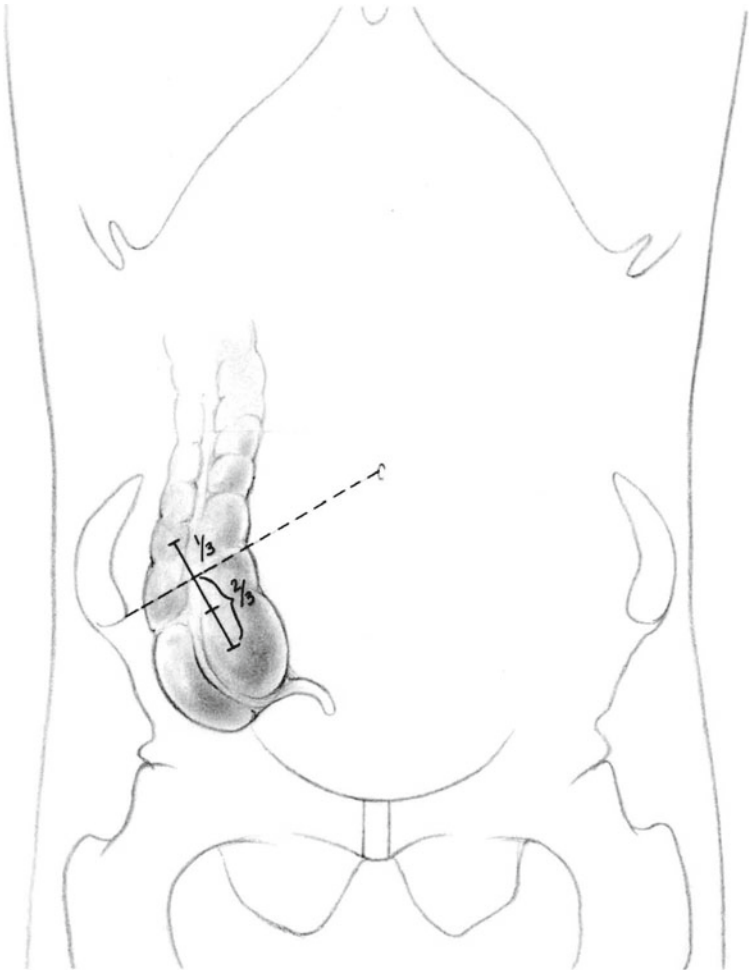

Fig. 46.1

appendix, which is proximal to the obstructing fecalith, usually is fairly healthy even in the presence of advanced inflammation or even if the remainder of the organ is gangrenous. This makes ligature or inversion of the appendiceal stump a safe procedure.

After the appendix has been removed, the stump may be managed by simple ligation or by inversion with a purse-string suture around its base. There does not appear to be proof of the superiority of either method, although a purse-string inversion may produce fewer adhesions than a simple ligation, which permits eversion of some of the mucosa. Inversion is preferable in simple cases, but if the area is edematous, making inversion difficult, simple ligation is preferable.

In some cases it may be simpler and safer to staple across the base of the appendix or even its termination on the cecum, as commonly done during laparoscopic appendectomy (Fig. 47.6).

Indication for Drainage

The presence of inflammation or even generalized peritonitis due to a perforated appendix is not an indication for external drainage. Close the abdominal wall without drainage after thoroughly irrigating the abdominal cavity and pelvis. If an abscess with rigid walls is encountered, drain the cavity with a closed-suction drain. Leave the skin wound open in cases of perforated appendix to avoid wound sepsis.

Documentation Basics

- Findings
- Perforated?
- Drains

Operative Technique

Incision

Draw an imaginary line from the right anterior superior iliac spine to the umbilicus. At a point 3–4 cm medial to the anterior spine, draw a line perpendicular to this line (Fig. 46.1). This is the general direction of the McBurney skin incision. About one-third of the incision should be above the imaginary line between the iliac spine and umbilicus and two-thirds below this line. The average length of this incision is 6 cm. Modify the location of this incision, if preoperative imaging studies or physical examination suggests. If in doubt, place the incision a bit higher rather than a bit lower.

Deepen this incision through the external oblique aponeurosis, along the line of its fibers (Fig. 46.2). Start the incision with a scalpel and extend it with Metzenbaum scissors. Then, elevate the medial and lateral leaves of the external oblique aponeurosis from the underlying muscle and separate them between retractors (Fig. 46.3).

Note that the internal oblique muscle, which is fairly thick, and the transversus muscle, which is deep to the internal oblique, run in a transverse direction. Make an incision just below the level of the anterosuperior iliac spine into the thin fascia of the internal oblique muscle. Then, insert a Kelly hemostat to separate the muscle fibers of the internal

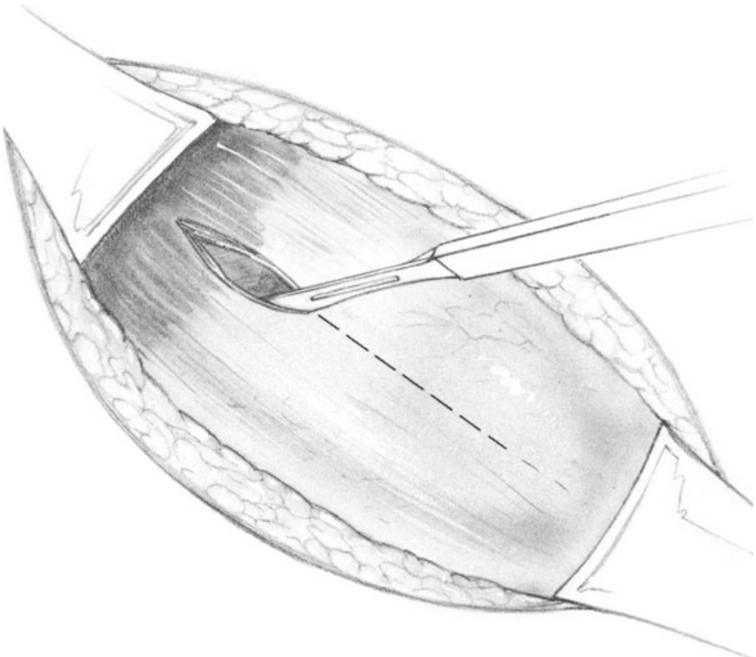

Fig. 46.2

oblique and underlying transversus muscle (Fig. 46.3). Using either two Kelly hemostats or both index fingers, enlarge this incision sufficiently to insert small Richardson retractors (Fig. 46.4).

Obtain adequate hemostasis of one or two vessels in the internal oblique muscle with electrocautery; then, note the layer of fat that adjoins the peritoneum. Tease this fat off the peritoneum lateral to the rectus muscle to identify a clear area. Elevate it between two hemostats and make an incision into the peritoneal cavity (Fig. 46.5). Enlarge the incision sufficiently to insert Richardson retractors and explore the region. Generally the cecum will be seen filling the incision.

For additional exposure in a medial direction when, for example, it is necessary to identify a woman's pelvic organs, a medial extension of about 2 cm can be made across the anterior rectus sheath, after which a similar division of the posterior sheath can be carried out and the rectus muscle retracted medially. The inferior epigastric vessels may be encountered and generally can also be retracted medially.

When the lateral extremity of the McBurney incision must be extended, the surgeon has two choices: (1) Close the

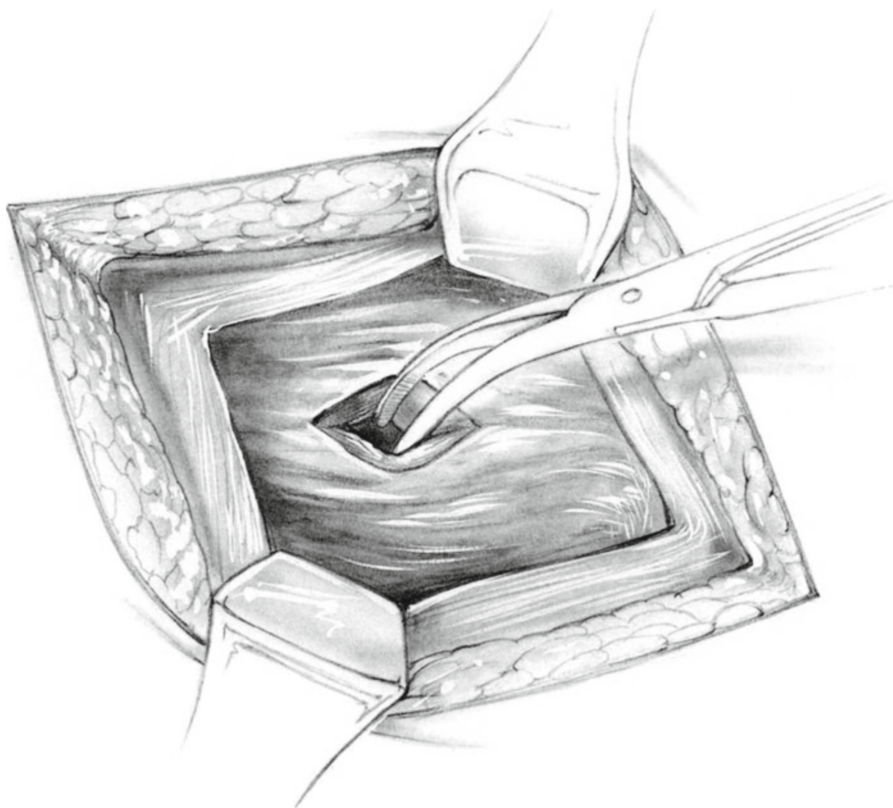

Fig. 46.3

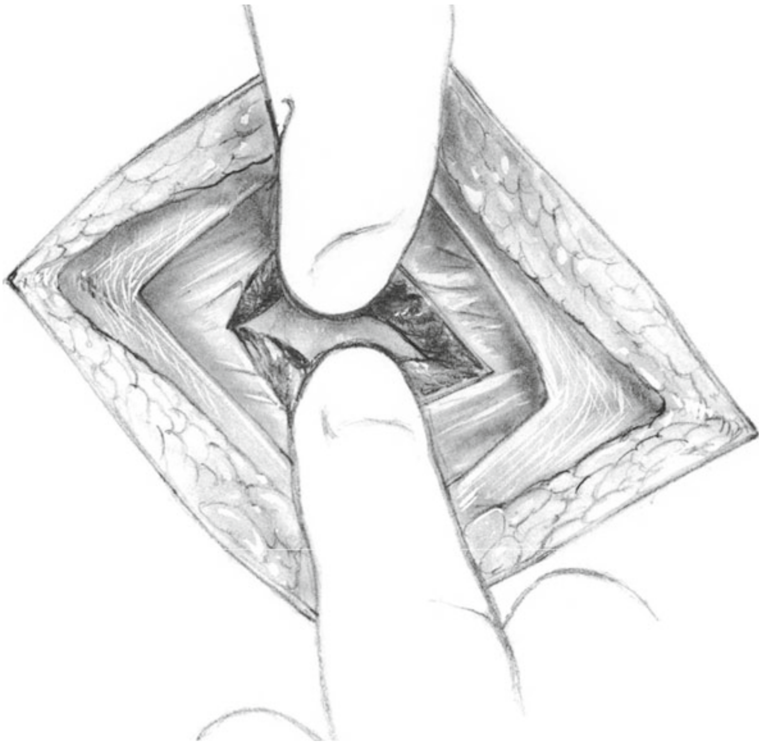

Fig. 46.4

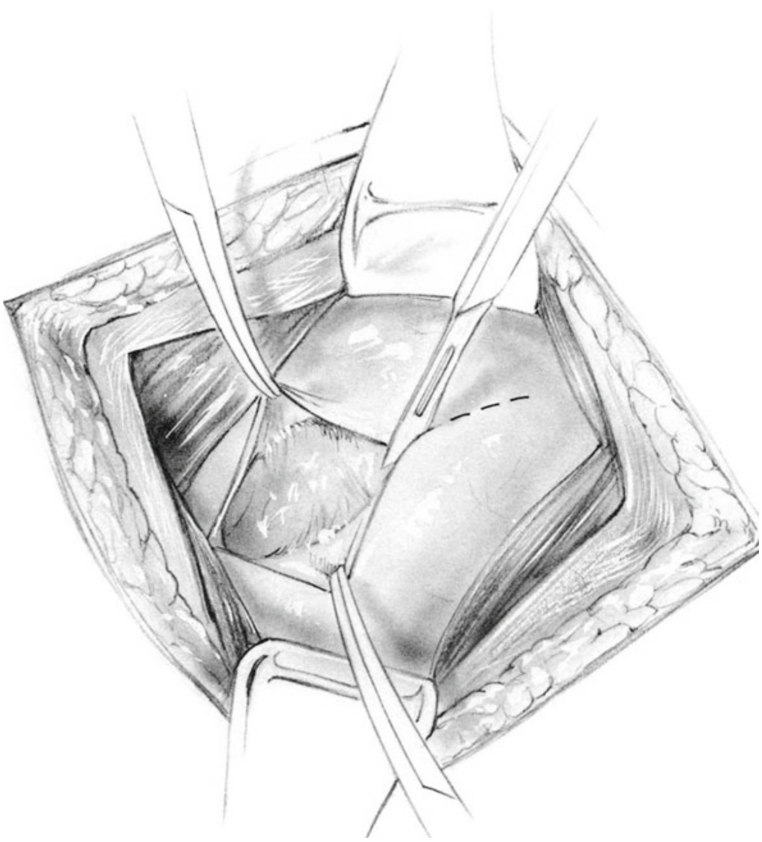

Fig. 46.5

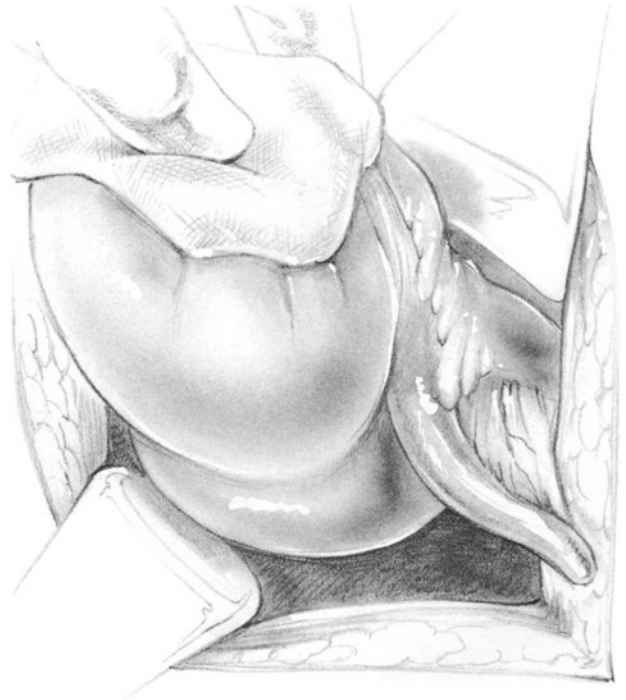

Fig. 46.6

McBurney incision and make a separate vertical incision of adequate length for exposure. (2) If additional exposure of only a few centimeters is needed, the oblique and transverse muscles may be deliberately divided with electrocautery in a cephalad direction along the lateral portion of the abdominal wall. Be aware that if this vertical extension along the lateral abdominal wall is continued for *more than* 4–5 cm, two or more intercostal nerves are likely to be divided, resulting in muscular weakness of the lower abdomen. If a 4- to 5-cm extension of the incision is closed carefully, generally no serious problems of weakness or herniation develop.

Delivery of Appendix

Insert small Richardson retractors into the peritoneal cavity and grasp the anterior wall of the cecum with a moist gauze pad (Fig. 46.6). With the cecum partially exteriorized, identify the appendix. If the appendix cannot be seen, exploration with the index finger may reveal an inflammatory mass consisting of inflamed appendix and mesoappendix. It can usually be delivered into the incision by gentle digital manipulation around the borders of the mass.

If this palpatory maneuver is not successful in locating the appendix, follow the taenia on the anterior wall of the cecum in a caudal direction. This leads to the base of the appendix, which can then be grasped in a Babcock clamp. Apply a second Babcock clamp to the tip of the appendix and deliver it into the incision.

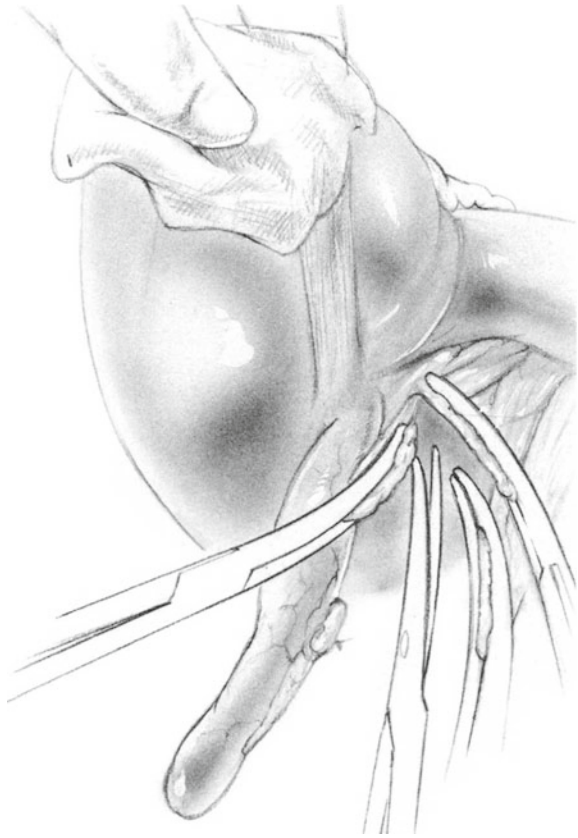

Fig. 46.7

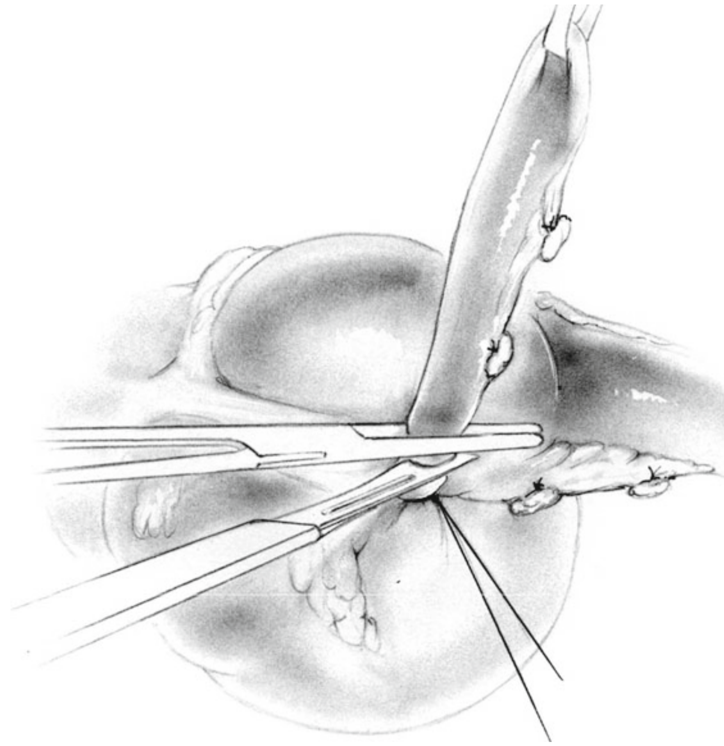

Fig. 46.8

Division of Mesoappendix

If the base of the mesoappendix is not thick, it may be encompassed by a single ligature of 2-0 PG. Otherwise, divide the mesoappendix between serially applied hemostats and ligate each with 2-0 or 3-0 PG until the base of the appendix has been dissected free (Fig. 46.7).

Ligation of Appendiceal Stump

Hold the tip of the appendix in a Babcock clamp and double-ligate the base with 2-0 PG or chromic catgut at a point 4–6 mm from the cecum. Apply a straight hemostat to the appendix 1 cm distal to the ligature; then, transect the appendix with a scalpel 5–6 mm distal to the ligature (Fig. 46.8) and remove the specimen. The appendiceal stump may be lightly sterilized by applying electrocautery to the exposed mucosa, or it may simply be returned to the abdominal cavity (Fig. 46.9).

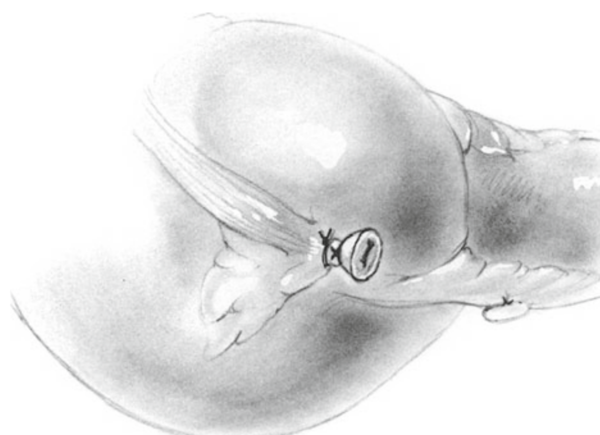

Fig. 46.9

Inversion of Appendiceal Stump

To invert the stump, insert a purse-string suture around the base of the appendix using 3-0 PG or silk on an atraumatic needle. The radius of this suture should exceed the anticipated length of the appendiceal stump to allow sufficient space for the stump (Fig. 46.10). Apply a small straight hemostat to the base of the appendix at a point 5–6 mm from the cecum. Apply a second hemostat 1 cm distal to the first. Using a scalpel, transect the appendix just distal to the first hemostat (Fig. 46.11), which should now be used to invert the stump into the previously placed purse-string suture (Fig. 46.12). As the first knot is being tied, gradually withdraw the hemostat, completing the purse-string tie. The

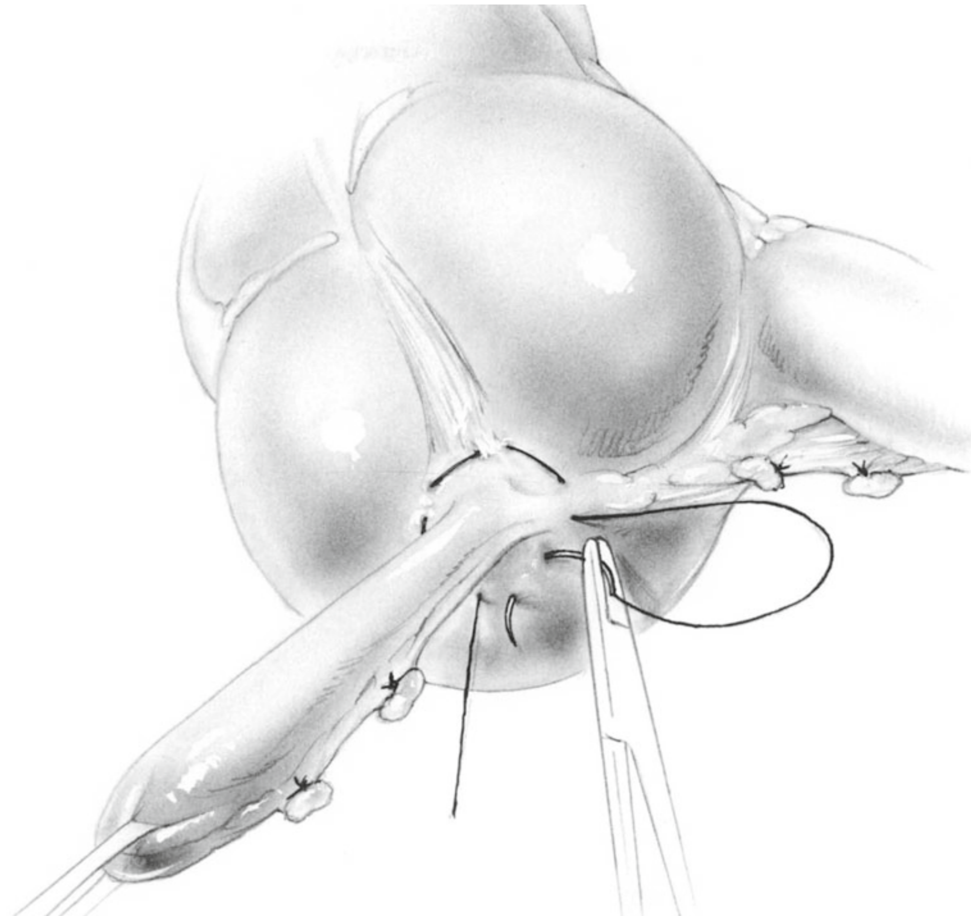

Fig. 46.10

single suture should be sufficient; if there is some doubt of its adequacy, it may be reinforced with a figure-of-eight suture of the same material. Most surgeons ligate the base of the appendix before inverting it.

Closure of Incision

Irrigate the right lower quadrant and pelvis with saline or a dilute antibiotic solution; then, apply four hemostats to the cut ends of the peritoneum to elevate it into the incision, facilitating closure. Close the peritoneum with continuous 3-0 atraumatic PG sutures (Fig. 46.13). Close the internal oblique and transversus muscles as a single layer with interrupted sutures of 2-0 PG tied loosely (Fig. 46.14). Close the external oblique aponeurosis with continuous or interrupted sutures of 2-0 PG (Fig. 46.15).

If intraperitoneal pus or a gangrenous appendix is present, do not close the skin incision. Rather, place a few vertical mattress sutures of 4-0 nylon but do not tie them. Insert just enough gauze into the incision to keep the skin edges separated.

Postoperative Care

In the absence of pus or perforation, postoperative antibiotics need not be administered beyond the operative period. Otherwise, appropriate systemic antibiotics are indicated. Most patients recover rapidly following an appendectomy and rarely require intravenous fluid for more than 1 day. If the skin wound has been packed open, change the packing daily. If the area is clean, tie the previously placed skin sutures on the fourth postoperative day or perform a delayed closure with skin tapes.

Complications

Postoperative *sepsis*, in the form of peritonitis or a pelvic abscess, is the most serious postoperative complication of an appendectomy. If the patient is febrile after the fourth or fifth postoperative day, perform a daily rectal or pelvic examination to try to detect a pelvic abscess. Often it can be discovered when the tip of the examining finger feels a fluctuant, tender mass pressing on the anterior wall of the rectum or

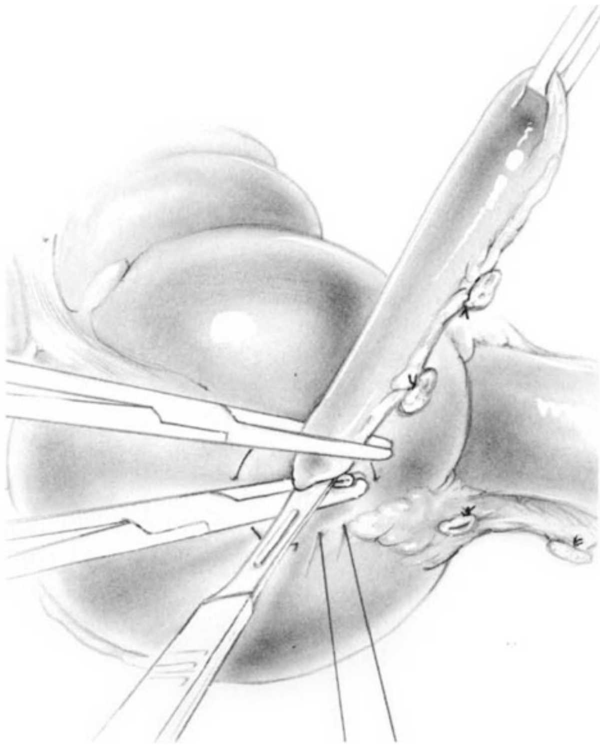

Fig. 46.11

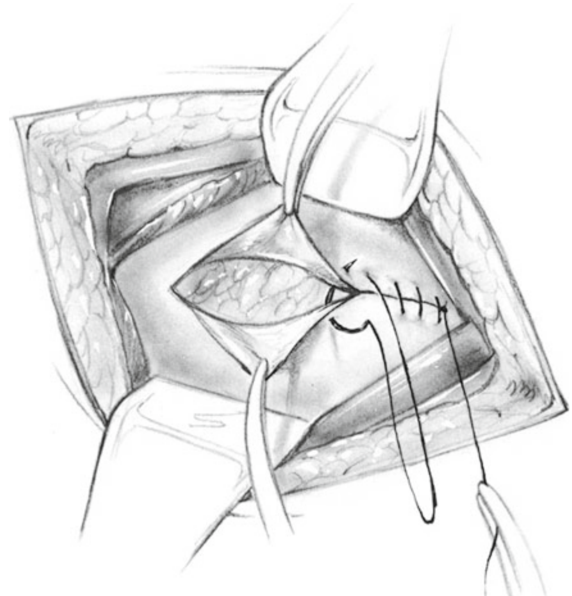

Fig. 46.13

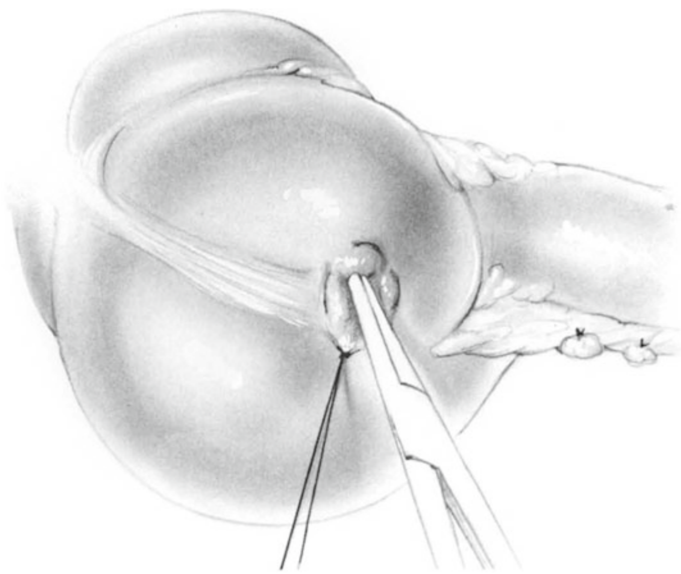

Fig. 46.12

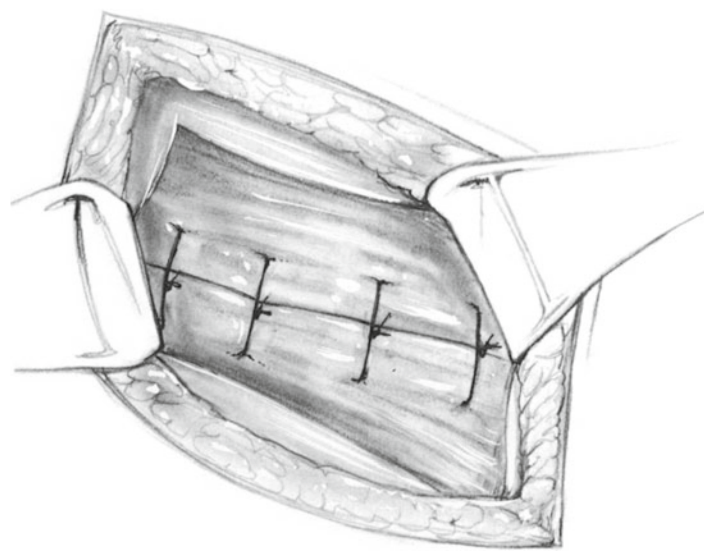

Fig. 46.14

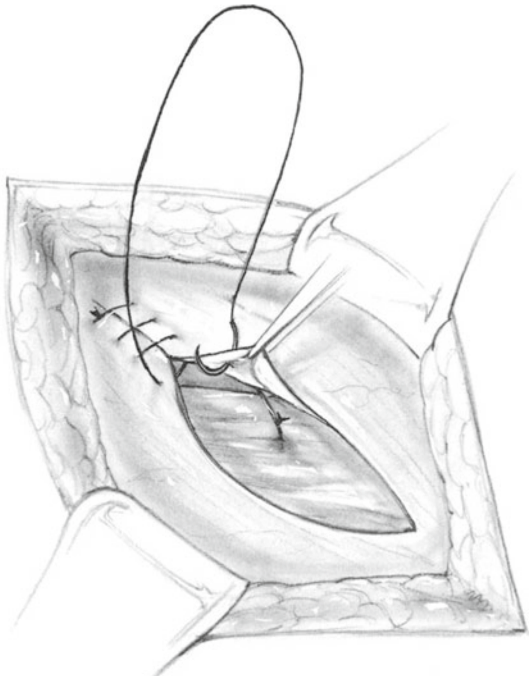

Fig. 46.15

cul-de-sac. If the abscess has progressed on antibiotic therapy, incision and drainage may be performed with general anesthesia. To do so, dilate the anus and then pass a needle into the palpable mass. Aspiration should reveal pus just deep to the rectal wall. If pus is found, insert a hemostat along the needle tract to make 1- to 2-cm opening for drainage. CT scans or sonography is useful for identifying abdominal and pelvic abscesses, which often can be drained percutaneously by the interventional radiologist.

Wound infection following an appendectomy for a perforated appendicitis is another cause of fever. It can be prevented by delaying closure of the skin. When a wound abscess is detected, open the overlying skin for drainage.

Intestinal *obstruction* due to adhesions occasionally occurs during the postoperative period, especially when there is some degree of peritonitis. Early relaparotomy is indicated for a complete obstruction.

47 Laparoscopic Appendectomy

Carol E.H. Scott-Conner

Indications

Acute appendicitis
Right lower quadrant pain of unknown etiology, especially in women of reproductive age
Interval appendectomy

Preoperative Preparation

See Chap. 46.
Place an indwelling bladder catheter for any laparoscopic procedure that involves the pelvis or lower abdomen.

Pitfalls and Danger Points

Injury to bladder from trocars or instruments.
Injury to cecum from traction or dissection.
Incomplete appendectomy, resulting in a retained stump.
See Chap. 46.

Operative Strategy

The laparoscopic approach allows the surgeon to make a thorough visual inspection of the abdominal cavity and hence is especially useful in cases in which the diagnosis is questionable. The procedure differs from open appendectomy in that the base of the appendix usually presents first and is divided first followed by the mesentery. A pretied ligature or staples are used to secure the base. The stump is generally not inverted. The choice of approach (open versus laparoscopic) should not influence the decision to drain or not to drain (see Chap. 46) or the duration of antibiotic therapy. These decisions should be based on the extent of the purulent and inflammatory process found at laparoscopic exploration. Other causes of lower abdominal pain, such as an inflamed Meckel's diverticulum or torsion of an ovarian cyst, may also be treated laparoscopically. The laparoscopic approach is not advisable if an appendiceal mucocele is found, as spillage of mucocele contents may seed the peritoneal cavity with malignant cells.

This chapter describes a standard three-trocar approach to appendectomy. Single-site laparoscopic techniques are being applied to appendectomy but are beyond the scope of this text. See the references at the end for further information on these advanced techniques.

Documentation Basics

- Findings
- Perforated?
- Drains

Operative Technique

Position the patient supine on the operating table. Tuck both arms at the sides; if the arms remain on arm boards, they limit the ability of the camera holder and the first assistant to move cephalad as needed. Position the monitors at the foot of the bed. If only one monitor is being used, place it along an imaginary line of sight from the umbilicus through McBurney's point. Decompress the bladder with a Foley catheter. A typical room layout is shown in Fig. 47.1.

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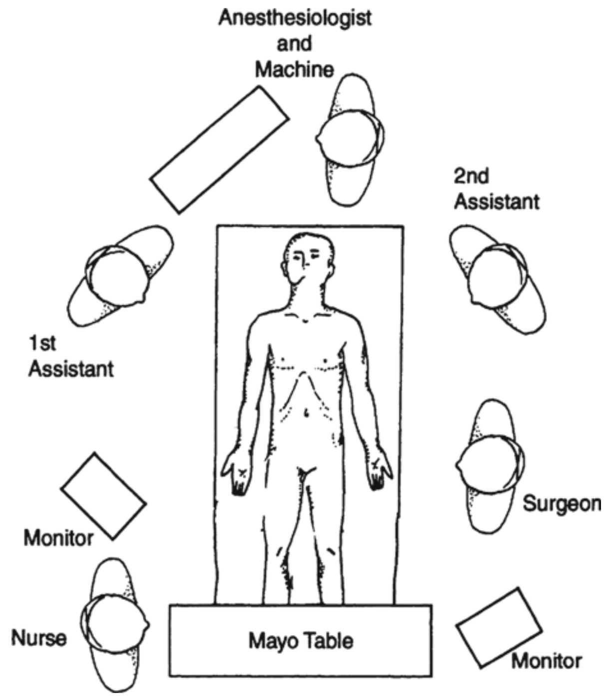

Fig. 47.1

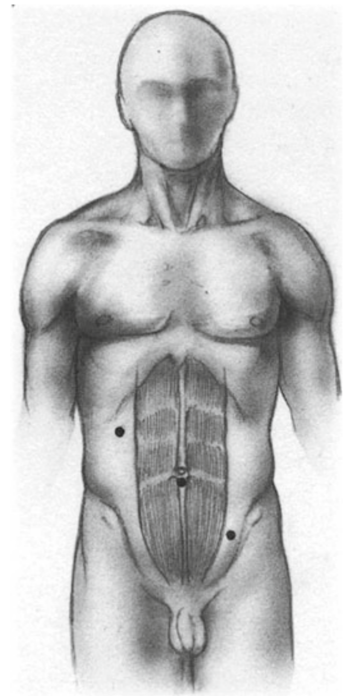

Fig. 47.2

It is important to have sufficient working distance from the right lower quadrant. Consider the location of the umbilicus relative to McBurney's point. For most patients a supraumbilical location is best for the first trocar. Place secondary trocars in the right midclavicular or anterior axillary line and left lower quadrant (lateral to the rectus muscle to avoid the inferior epigastric vessels) (Fig. 47.2).

Thoroughly explore the abdomen and confirm the diagnosis. Examination of the female adnexae is facilitated by gently sweeping up one tube and ovary to displace the uterus to one side and then the other. Use a closed grasper or Babcock clamp to push and elevate gently, rather than grasp, the adnexae (Fig. 47.3).

Exposure is enhanced by placing the patient in Trendelenburg position with the right side up. Gently sweep the omentum and small intestine medially to expose the cecum, which may be recognized by its size and white color and the presence of taeniae (Fig. 47.4a). In the most common situation, the appendix lies underneath the terminal ileum and is tethered posteriorly by its mesentery (Fig. 47.4b). Pulling the cecum cephalad causes at least part of the appendix, most commonly the base, to come into view (Fig. 47.4c). The maneuver commonly used during open surgery (pulling the cecum cephalad, toward the patient's left shoulder) may obscure the view by pulling the cecum closer to the umbilically placed laparoscope. A straight cephalad pull, toward the patient's right shoulder, avoids this problem.

Pass an endoscopic Babcock clamp through the left lower quadrant trocar and gently pull the cecum toward the patient's left shoulder in such a way as to roll the lateral aspect of the cecum toward you. The base of the appendix should come into view. Grasp the appendix near its base with a Babcock or an atraumatic grasper. Pull straight up toward the anterior abdominal wall. Identify the base and confirm its location by the convergence of taeniae on the cecum.

There are two major ways to secure the base of the appendix: with an endoscopic stapler or a pretied suture ligature. Both methods are described here.

Stapled Closure

Withdraw the Babcock clamp and replace it with a Maryland dissector or right-angle clamp. Insert the point of this dissection instrument into the groove between the fatty mesentery of the appendix and the appendix, immediately adjacent to the base (Fig. 47.5). Sometimes the appendiceal mesentery is thin or transparent at this point. Take care not to injure the cecum with the tip of the clamp. If necessary, begin creating the window just above the termination of the appendix to ensure that the tips of the clamp do not inadvertently injure the cecum behind the mesentery, where it cannot be seen. Gently open and spread, withdraw, close, and reinsert the instrument until the tip passes completely through the mesentery at this point. Enlarge this window until it is at least 1 cm in diameter. We prefer the endoscopic right-angle clamp for the task of enlarging the window once it has been established. Reconfirm that the window is exactly at the base of the appendix.

Withdraw the dissecting instrument and insert an endoscopic stapler through the 12 mm left lower quadrant port.

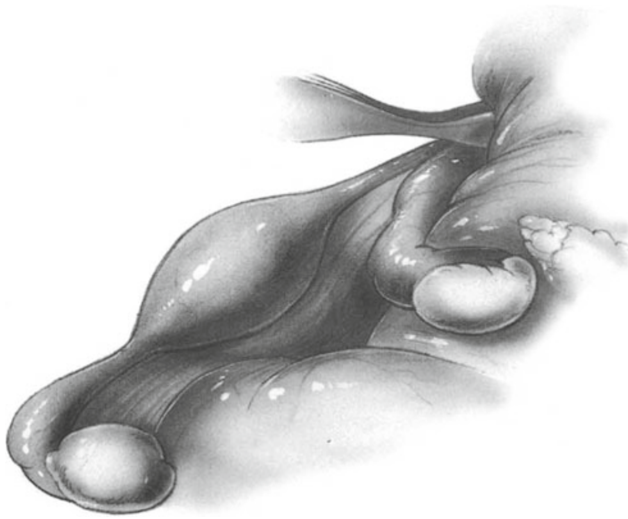

Fig. 47.3

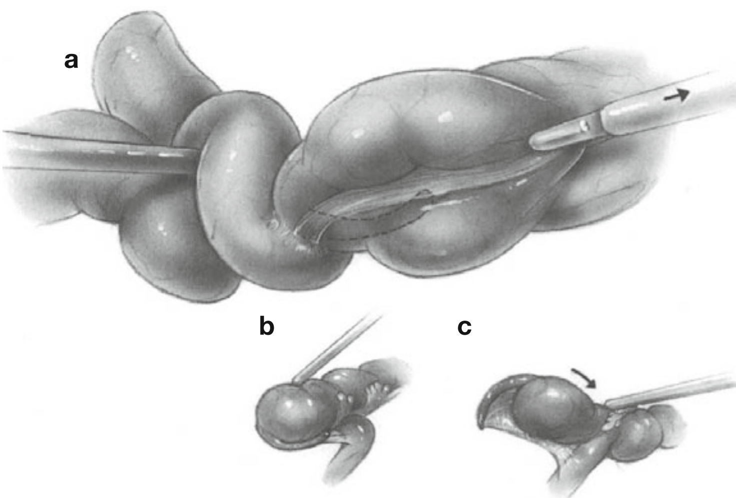

Fig. 47.4

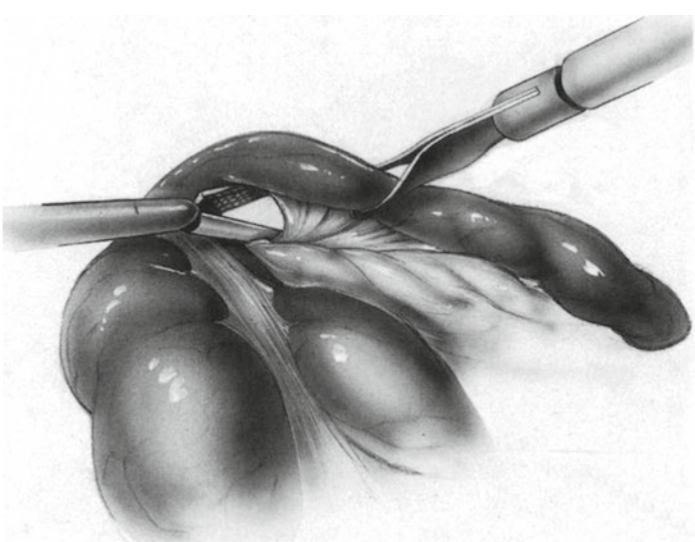

Fig. 47.5

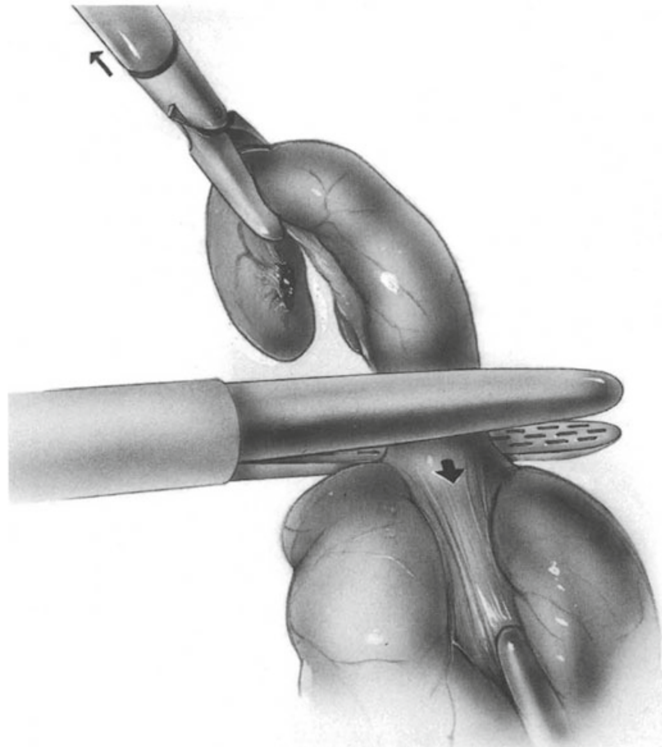

Fig. 47.6

The hinge of the stapler must be completely outside the trocar for the stapler to open properly. It may be necessary to pass the stapler behind and beyond the appendix, along the right gutter toward the right subphrenic space to have sufficient distance to open the stapler fully. Open the stapler. Withdraw the stapler (and trocar if necessary) and maneuver the narrower jaw (anvil) through the window in the mesentery. Visualize the tip of the anvil emerging on the far side of the appendix. Rotate the stapler as needed to optimize visualization of the appendix, mesentery, stapler, and cecum. Pull up on the appendix and push down on the stapler as you close the jaws of the stapler (Fig. 47.6); this move maximizes the chances of positioning the stapler properly (across the base so no appendiceal remnant is left). Close, but do not fire, the stapler. Rotate the stapler back and forth to visualize the proposed site of transection fully. Fire the stapler.

Open the stapler and release any adherent tissue. It may be necessary to divide a small amount of tissue with scissors. If this must be done, visually confirm that the staple line extends to the full length of the appendiceal base (Fig. 47.7). Move the stapler to a safe location; close and remove it.

If necessary, reposition the appendix, now tethered only by its mesentery, so the mesentery is clearly seen. Frequently the mesentery is widest at its attachment to the appendix and then narrows as the branches of the appendicular artery converge on the trunk vessel. By identifying a narrower portion of the mesentery, it may be possible to secure it with a single

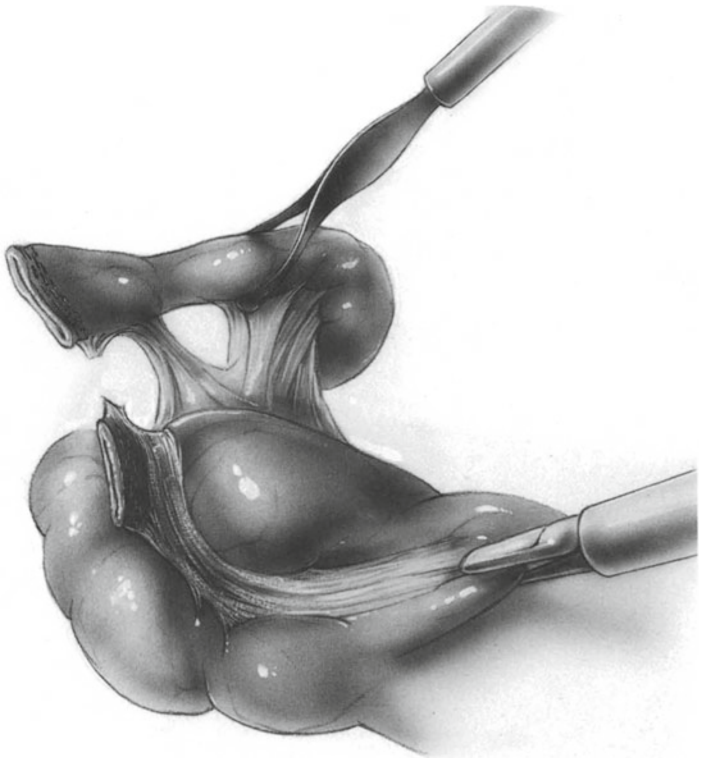

Fig. 47.7

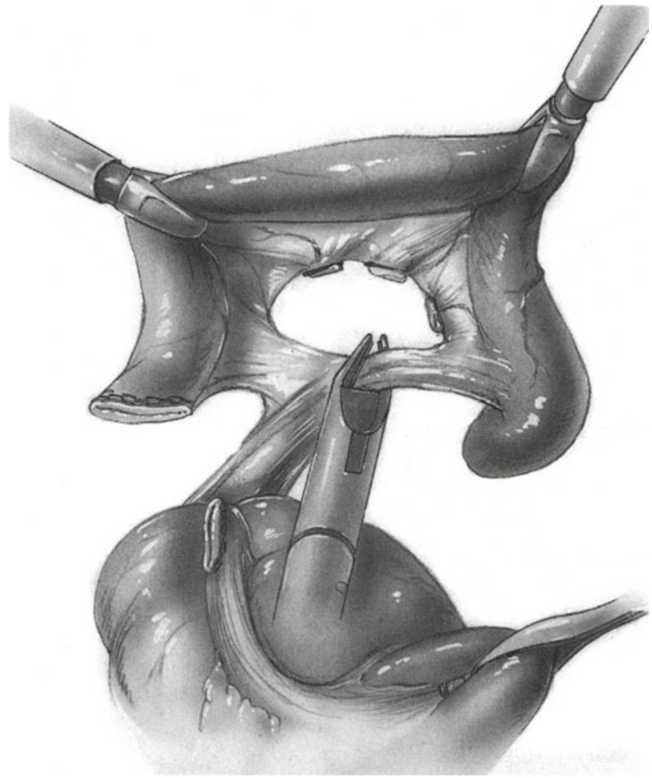

Fig. 47.8

application of the stapler. Reload the stapler and pass and fire it as previously described. Alternatively, use endoscopic clips to secure individual vessels (Fig. 47.8). Carefully inspect the staple lines for completeness and hemostasis. Control any bleeding by endoscopic clips or suture.

Ultrasonic dissection forceps may be used instead of the stapler to divide and control the mesentery.

Pretied Ligature

Alternatively, the mesentery may be divided first by clips or an ultrasonic dissecting forceps. A pretied ligature is then used to secure the base.

Identify individual branches of the appendicular artery and make windows in the mesentery between these vessels using a Maryland dissector or a right-angle clamp. Place clips on the vessels and divide them, as shown in Fig. 47.8. Do not attempt to skeletonize the vessels, as they are likely to tear. Sequentially divide the mesentery along a line from the free edge toward the appendiceal base.

After completely dividing the mesentery, pass a pretied ligature into the field through the left lower quadrant trocar. Shorten the loop slightly. Avoid letting the ligature come in contact with the viscera, as the loop is easier to manipulate while still dry and relatively stiff (rather than damp and limp).

Drop the appendix. Pass a Babcock clamp or atraumatic grasper through the loop of the ligature and grasp the appendix at its midportion. Pull the appendix through the loop while maneuvering and shortening the loop. Use the knot pusher as a finger to position the knot at the base and slowly tighten the ligature (Fig. 47.9).

We prefer to place two ligatures side by side on the base and a clip or a third ligature on the specimen side. Divide the appendix (Fig. 47.10a). Inspect the stump to verify the ligatures are in a good position (Fig. 47.10b). Cauterize the exposed mucosa lightly.

Removal of the Appendix

A small, minimally inflamed appendix may be drawn completely into the left lower quadrant trocar; the trocar (containing the specimen) can then be completely removed and replaced. A specimen bag is used for larger, more inflamed, gangrenous or perforated appendices.

Management of the Retrocecal Appendix

The appendix is occasionally completely retrocecal and cannot be visualized without mobilizing the cecum and

Fig. 47.9

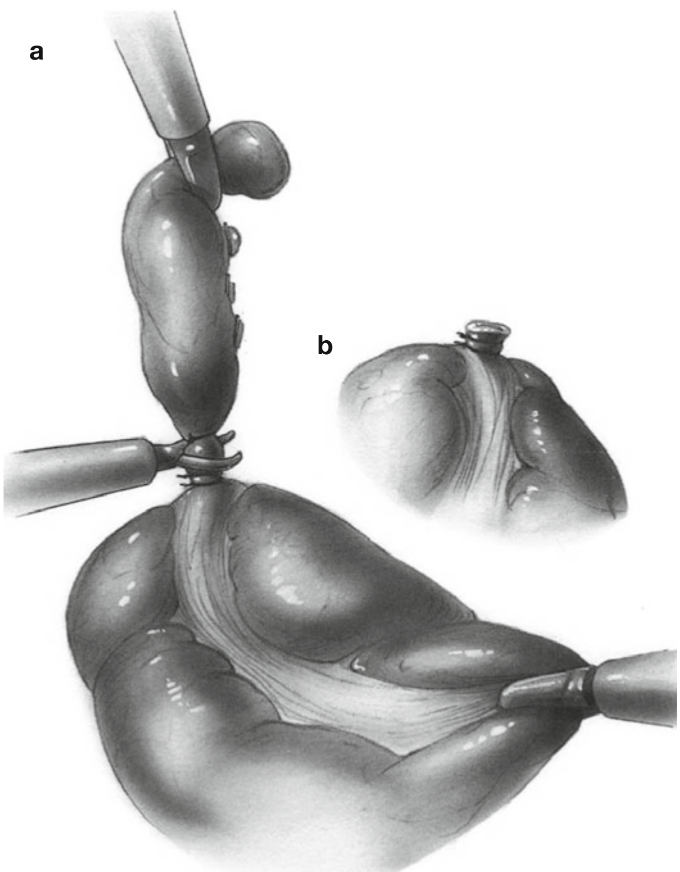

Fig. 47.10

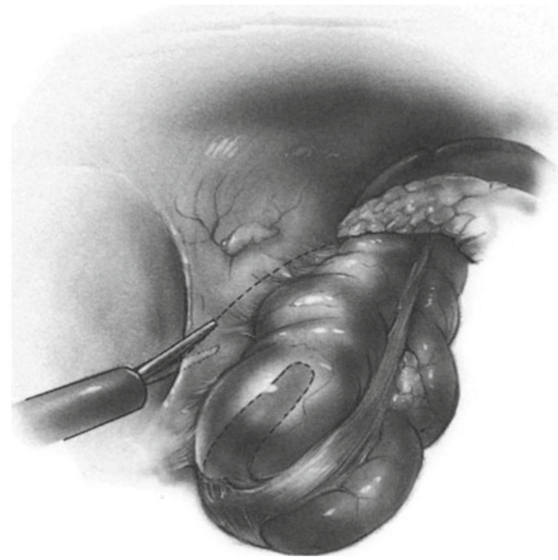

Fig. 47.11

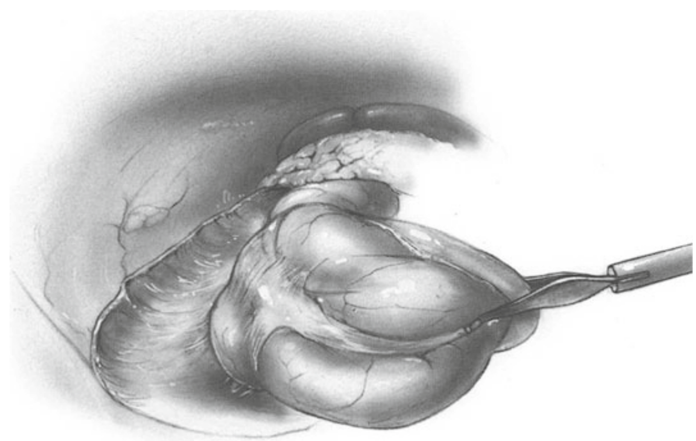

Fig. 47.12

right colon. Incise the line of Toldt from the cecum up to the vicinity of the hepatic flexure (Fig. 47.11) with hook cautery, scissors (with cautery attachment), or ultrasonic shears. Grasp the cut edge of peritoneum adherent to the right colon and pull the right colon medially while lysing any residual adhesions by sharp and blunt dissection (Fig. 47.12).

The appendix is then found on the back wall of the cecum, generally adherent to the cecum with fibrous bands. It may be so encased in fibrous tissue; it is difficult to identify at first. Tactile perception from the Babcock clamp may help identify the appendix, which feels like a small, firm cylinder compared with the softer cecum.

Grasp the appendix near its base and sequentially lyse the fibrous adhesions that tether the appendix to the cecum (Fig. 47.13). Sharp dissection with scissors or ultrasonic shears is best. Remove the appendix in the usual fashion.

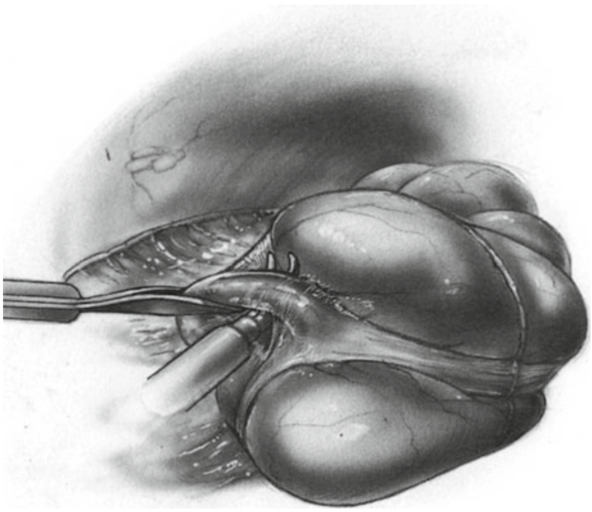

Fig. 47.13

Closure of Trocar Sites and Postoperative Care

If purulent material is encountered, close the fascia as usual but leave the skin open. Necrotizing fasciitis has been reported as a rare complication and is more likely in obese patients.

The patient may have an ileus for several days, especially if the appendix was gangrenous or perforated. Because the events of the first postoperative week are determined by the extent of the pathology, the immediate advantage of the laparoscopic approach may not be obvious.

Continue antibiotics as you would as if the operation had been performed as an open procedure. In other words, if you would have given antibiotics for 1 week following open appendectomy for perforated appendicitis with local peritonitis, follow this regimen after laparoscopic appendectomy for the same pathology.

Complications

Abdominal wall infection (discussed above)
Pelvic or abdominal abscess
Retained appendiceal stump (causing recurrent appendicitis)

Further Reading

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Part V

Large Intestine

48 Concepts in Surgery of the Large Intestine

Marylise Boutros and Steven D. Wexner

This chapter provides a comprehensive overview of essential concepts relating to the operative approach and strategy for colon and rectal surgery. Additional information is contained in the technical chapters that follow and the references at the end of the chapter.

Benign Conditions

Diverticular Disease

Diverticula may be true, containing all layers of the colon wall, or false, lacking the muscular layer of the colon wall. In North America, almost all colonic diverticula are acquired, false pulsion diverticula that most frequently affect the sigmoid colon. Thirty-five percent of patients will also have more proximal colonic diverticula, and a minority will have pancolonic diverticulosis. Prevalence correlates with age and geographic location; approximately 30 % of adults living in industrialized countries will acquire diverticular disease by age 60 while up to 80 % of those aged 80 years and older are affected (Beck et al. 2011). The majority of patients with diverticular disease are asymptomatic; only 1 % of patients will eventually require surgery (Beck et al. 2011).

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Diverticulitis, the most common complication of diverticulosis, occurs in approximately 10–25 % of patients (Ferzoco et al. 1998) and is associated with signs and symptoms of acute inflammation including left lower quadrant or suprapubic pain, fever, and altered bowel habits. If the involved segment of the colon is in contact with the bladder, urinary symptoms may occur including increased frequency, dysuria, pneumaturia, and fecaluria. A palpable mass may be noted in the lower abdomen or pelvis. Leukocytosis with a left shift is common. Computed tomography (CT) scan of the abdomen and pelvis with oral, intravenous, and rectal contrast is the examination of choice for patients with suspected diverticulitis (Rafferty et al. 2006; Fozard et al. 2011; Ambrosetti et al. 1997).

The management of acute diverticulitis depends on the patient's clinical status and the presence of any complications of disease. Acute diverticulitis may be uncomplicated (limited to the colonic wall and adjacent tissues) or complicated (with perforation, abscess, or fistula). Management of acute uncomplicated diverticulitis consists of bowel rest and administration of oral or intravenous antibiotics; this treatment is successful in 70–100 % of patients (Rafferty et al. 2006; Janes et al. 2005). If the patient fails to improve, further diagnostic evaluation, including repeat CT, is indicated. In addition to bowel rest and antibiotics, management of complicated diverticulitis may include radiologically guided percutaneous, transgluteal, or transrectal drainage of an abscess.

The indications for surgery include failure of nonoperative management, nondrainable abscess, septic shock/generalized peritonitis, and obstruction. The minority of patients who present with septic shock and/or generalized peritonitis require resuscitation and surgical management; otherwise patients are likely to respond to conservative management.

Emergency Surgery for Acute Diverticulitis

The optimal surgical procedure for acute diverticulitis depends on the patient's clinical status and the degree of inflammation encountered at the time of operation. The

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standard emergency operation for perforated diverticulitis is Hartmann's procedure: resection of the diseased segment of colon with an end colostomy and closure of the distal stump ("Hartmann's stump" or "Hartmann's pouch"). At the time of emergency Hartmann's resection, it is preferable not to enter the presacral space if possible, in order to preserve this plane for future elective resection. However, it is important to transect the distal colon in an area that is minimally inflamed in order to avoid a Hartmann's stump blowout. The Hartmann's stump may be stapled and/or sutured. Alternatively, some surgeons prefer to leave the distal stump above the fascia under the midline wound or to mature it as a mucous fistula. The left lower quadrant stoma site should be preoperatively marked ideally by enterostomal therapists at a site through the rectus abdominis muscles. Such preoperative stoma marking helps minimize postoperative stoma complications.

Although outcomes of emergency Hartmann's procedure are acceptable, up to 50 % of patients with an end colostomy never undergo a reversal, and anastomotic leak rates following reversal range from 2 to 30 % (Salem and Flum 2004; Wigmore et al. 1995; Maggard et al. 2004). Thus, alternatives to Hartmann's procedure have emerged. Primary resection and anastomosis with or without a diverting ileostomy, and with or without on-table lavage, may be performed. An anastomosis may be considered in the emergency setting if the patient is clinically stable and if the presence of pus and inflammation is limited such that the bowel resection margins are healthy and noninflamed (Fozard et al. 2011). Often, the presence of a pelvic abscess or generalized peritonitis creates inflammation and thickening of the anterior upper rectal wall that would preclude a safe anastomosis. Laparoscopic peritoneal lavage with placement of drains has been used with good results in the acute setting (Myers et al. 2008); however, debate remains regarding the need for subsequent definitive elective surgery.

Elective Surgery for Diverticulitis

After resolution of the acute diverticular attack, it is important to ensure that the patient undergoes (or has recently undergone) a colonoscopy to confirm the diagnosis and exclude underlying malignancy or inflammatory bowel disease (Fozard et al. 2011).

The indications for elective surgery for diverticulitis are continually evolving (Margolin 2009). Historically, elective resection was recommended after two documented attacks of uncomplicated diverticulitis or one attack of complicated diverticulitis in which emergent surgery was not required (Margolin 2009; Parks and Connell 1970). In addition, surgery was routinely recommended for patients age 40 or younger after a first attack. However, these recommendations have evolved to consideration for elective resection on a case-by-case basis (Fozard et al. 2011). This revision is due to the realization that diverticulitis follows a relatively benign course and that the risk of complications necessitating emergency surgery does not significantly increase with repeated attacks (Margolin 2009). In addition, between 75 and 85 % of patients who present with complicated diverticulitis requiring surgery do so with no antecedent history of diverticulitis (Margolin 2009; Chapman et al. 2006; Somasekar et al. 2002). According to an analysis using Markov modeling, an elective colectomy for patients over 50 years of age, performed after the fourth attack of documented uncomplicated diverticulitis, resulted in a decrease in mortality, colostomies, and cost (Salem et al. 2004). After one attack, about one-third of patients will have a second attack of acute diverticulitis, and after a second episode, an additional third will have yet another attack (Ferzoco et al. 1998; Somasekar et al. 2002). Thus, individual considerations such as age, comorbidities, immunocompromised state, frequent travel to remote areas without immediate access to medical care, frequency and severity of attacks, presence of persistent symptoms after the acute episode, and the patient's desires should be factored into decision-making.

Key Aspects of the Surgical Procedure

Standard preoperative preparation is required. We recommend the use of prophylactic ureteral stents, especially for patients with a history of severe attacks or ongoing inflammation. To prevent recurrence, the distal resection margin should be at the level of the upper rectum, at the point where the tenia coli splays out onto the rectum (Thaler et al. 2003). The presence of sigmoid colon distal to the anastomosis is an independent predictor of recurrence (Fozard et al. 2011). The proximal resection margin should include the segment of bowel involved in previous attacks (sigmoid ± descending colon) and should extend to compliant healthy bowel without hypertrophy or inflammation. The anastomosis should be fashioned with proximal bowel free of diverticula, although not all diverticula-bearing colon must be removed. To perform an adequate resection and to ensure a well-vascularized, tension-free anastomosis, mobilize the splenic flexure (Thaler et al. 2003, 2004). Laparoscopy for elective resections for diverticulitis has been demonstrated to be safe, feasible, and associated with the expected short- and long-term benefits of a minimally invasive approach (Fozard et al. 2011).

Diverticular Fistulas

Colovesical fistulas are the most common diverticular fistulas. Other common fistulas associated with diverticular disease include colovaginal (in females who have had a previous hysterectomy), coloenteric, and colocutaneous fistulas. Diverticular fistulas are usually suspected based on clinical presentation and may be visualized by a CT scan with oral, rectal, or intravenous contrast. However, some fistulas will not be identified by imaging studies (Beck et al. 2011). The primary aim of the diagnostic evaluation is not to visualize the fistula but instead to determine the etiology (diverticular or malignant or Crohn's related) so that the appropriate operation can be performed. The key parts of the operation are takedown of the fistula, resection of the diseased bowel, and interposition of viable tissue between anastomosis and the fistula tract. It is usually possible to perform a one-stage, elective primary resection of the diseased colon, with primary anastomosis. The involved portion of the bladder is typically small, drained with a bladder catheter and intra-abdominal drain, and curetted and imbricated with absorbable sutures or left to heal on its own. The omentum is placed between the bowel anastomosis and bladder. Similarly, no special treatment is needed for the vagina, and an omental flap may be placed between the vagina and the colorectal anastomosis.

Diverticular Obstruction

Complete colonic obstruction due to diverticular disease accounts for approximately 10 % of large bowel obstructions and is due to recurrent progressive fibrosis and stricture (World Gastroenterology Organisation 2007). It is often difficult to distinguish between a diverticular stricture and cancer. Patients who present with complete obstruction can be managed with resection and Hartmann's procedure, resection and primary anastomosis with (or without) temporary diverting loop ileostomy, or with endoscopic stent placement as a bridge to elective resection and primary anastomosis. The caliber and quality of the proximal bowel must be normal and suitable for a primary anastomosis. Because a malignancy often cannot be completely excluded prior to resection, an oncologic resection is generally performed.

Diverticular bleeding is one of the most common causes of massive lower gastrointestinal hemorrhage, occurring in approximately 15 % of patients with diverticulosis (Beck et al. 2011). In more than 75 % of patients, the bleeding spontaneously resolves. If the patient is hemodynamically unstable during the first episode, or if the bleeding recurs, surgical intervention may be warranted. If the bleeding site can be localized (and ideally marked) by endoscopy or arteriography, a segmental resection can be performed. If the bleeding site cannot be localized, a total abdominal colectomy may be necessary after preoperative proctosigmoidoscopy and anoscopy have excluded the presence of a bleeding site in the anus and rectosigmoid. Most often, a colectomy with end stoma is performed in the emergency setting; however, this decision ultimately depends on the patient's hemodynamic status, coagulation profile, and comorbidities.

Volvulus

Volvulus of the colon results from twisting of a mobile portion of the colon around a narrow, fixed base of its mesentery, resulting in a closed-loop obstruction and potential strangulation of the inferior mesenteric vessels. The most common sites of colonic volvulus are the sigmoid colon and cecum. The resulting clinical presentation is one of bowel obstruction, which may rapidly progress to strangulation, gangrene, and perforation. The sigmoid is the site most frequently involved, and this clinical presentation often occurs in the elderly population with a male preponderance (Ballantyne et al. 1985). Plain radiographs of the abdomen may display the "bent inner-tube" or "omega-loop" appearance of a massively distended bowel loop, with both ends closely adjacent in the pelvis. If the diagnosis is equivocal, a water-soluble (gastrograffin) enema or CT scan with rectal water-soluble contrast may be performed and will demonstrate the "bird's beak" appearance of the barium terminating at the level of the torsion.

If no bowel ischemia is suspected (patient has normal vital signs and no peritoneal signs), the first maneuver is endoscopic detorsion with flexible sigmoidoscopy or colonoscopy. It is important that the mucosa be visualized during detorsion to ensure its viability. Endoscopic decompression is successful in up to 75 % of cases (Tan et al. 2010) and will result in a significant decrease in visible abdominal distention and a rapid evacuation of flatus and stool. A rectal tube should be placed to allow continued decompression and to prevent retorsion. A plain radiograph may be obtained to confirm relief of volvulus and absence of free intra-abdominal air. Because there is a high rate of retorsion (over 60 %) and a high mortality rate (up to 20 %) associated with emergency surgery (Tan et al. 2010; Larkin et al. 2009), it is recommended to proceed with mechanical bowel preparation and an elective one-stage sigmoid resection during the same admission. Sigmoid mobilization is seldom necessary as the volvulus by definition occurs in a redundant, loose, poorly fixed colon. The proximal resection margin requires a normal caliber, healthy sigmoid or descending colon, and the distal resection margin should be at the upper rectum to facilitate a stapled end-to-end circular anastomosis. The splenic flexure does not need to be mobilized as long as a tension-free, well-vascularized colorectal anastomosis can be fashioned.

Elective laparoscopic sigmoid colectomy for volvulus has been demonstrated to be safe and feasible in the elderly and associated with the expected short-term benefits of minimally invasive surgery (Cartwright-Terry et al. 2008; Liang et al. 2006). Some authors have found that a medial-to-lateral approach is particularly helpful to manage the redundant colon, as the longer the lateral abdominal wall attachments of the sigmoid colon are preserved, the better the exposure and the easier the dissection (Liang et al. 2006). A number of nonresectional techniques for management of sigmoid volvulus have been described; however, they are all associated with unacceptably high recurrence rates and morbidity (Beck et al. 2011).

If there is any evidence of peritonitis, impending gangrene (localized peritonitis, fever, hemodynamic changes, or an elevated white blood cell count), or if endoscopic decompression is unsuccessful, emergent surgery is indicated. If at the time of operation the involved segment of the sigmoid colon appears viable, the torsion can be reduced and resected; if obvious gangrene is found, detorsion is avoided and resection of the involved segment is performed. The decision to perform a Hartmann's procedure (end colostomy with closure of distal stump) or to perform a primary anastomosis is based on standard surgical criteria: the presence of fecal or purulent soilage, hemodynamic instability, or poor nutritional parameters precluding an anastomosis. As the colostomy may be permanent, it is important to keep the fascial opening to a minimal size and to have patients preoperatively marked by an enterostomal therapist at an appropriate site in the rectus abdominis muscles. This goal can sometimes be difficult to achieve with edematous dilated colon.

Cecal volvulus is the next most common colonic volvulus. It presents with small bowel obstruction. Plain radiographs of the abdomen may demonstrate features of a small bowel obstruction in association with the classic "coffee-bean" or "comma" sign (a distended cecum with a single fluid level and haustral creases pointing toward the left upper quadrant). It may also be visualized on CT scan or on a water-soluble contrast study which depicts a tapered lumen culminating in a pointed blockage within the right lower quadrant (Haskin et al. 1981).

The standard treatment for cecal volvulus is surgery. Detorsion alone is less successful than for sigmoid volvulus and recurrence rates are high (Beck et al. 2011, p. 403). Once the patient is adequately resuscitated and appropriate preoperative antibiotics are administered, a laparoscopic or open exploration is performed. At the time of operation, the diagnosis is confirmed, bowel viability is assessed, and the bowel is resected. Although ileostomy and mucous fistula creation together represent traditional management, primary anastomosis of the ileum to the transverse colon is equally safe in hemodynamically stable patients who do not have peritoneal contamination or a markedly dilated transverse colon. Suture cecopexy and tube cecopexy have been described; however, the recurrence rates following these procedures are high and the morbidity is equivalent to that observed for resection; thus, the standard treatment for cecal volvulus is a resection (Madiba and Thomson 2002).

Ischemic Colitis

Ischemic colitis is the most common form of gastrointestinal ischemia. It is heterogeneous in terms of etiology, anatomic site of involvement, presentation, and degree of severity (Bower 1993; Gandhi et al. 1996). The "watershed" areas, where the arterial arcades join, such as the splenic flexure and sigmoid colon, are the areas most prone to ischemic colitis. Presentation may include bloody diarrhea, abdominal pain, and fever; however, the signs and symptoms are often subtle and a high index of suspicion is required (Biaxauli et al. 2003). Findings on physical examination may range from mild tenderness over the involved colon in early or limited ischemia to peritonitis from severe ischemia with transmural necrosis of the bowel.

Colonoscopy is the gold standard test for diagnosing colonic ischemia, as significant mucosal changes can be visualized, and biopsies can be taken. However, there are no pathognomonic endoscopic findings for ischemic colitis, and therefore the complete clinical picture must be considered. A CT scan often demonstrates circumferential colonic wall thickening, and when intravenous contrast is administered, outer colonic wall enhancement with inner mucosal hypoperfusion ("halo sign") may be seen. Other CT findings suggestive of severe ischemia include pneumatosis coli and gas within the portal vein (Biaxauli et al. 2003; Sreenarasimhaiah 2005; Brandt and Boley 2000).

The initial treatment is supportive and consists of fluid resuscitation, bowel rest, and broad-spectrum antibiotics (Brandt and Boley 1992). Parenteral nutrition should be considered for patients who do not respond to conservative management within a few days. Although most episodes (80–90 %) are self-limiting and resolve with conservative management, all patients require a colonoscopy 6–8 weeks after the event.

Despite appropriate supportive therapy, a minority of patients will experience worsening abdominal pain or peritonitis, as well as increasing leukocytosis. These are indications for emergent surgical intervention. The goals of surgery are to assess the extent of ischemia and to resect all nonviable bowel. It is crucial that normal mucosa be present at the margins of the resection. Adjuncts such as intraoperative endoscopic evaluation, Doppler, and intravenous fluorescein dye administration combined with a Wood's lamp may be helpful in the assessment of mesenteric viability. Most commonly, following resection of the ischemic segment of colon, a Hartmann's procedure is performed (an end colostomy and a Hartmann's pouch or mucous fistula are created). In the rare instance that ischemia is limited to the right colon, a primary anastomosis may be created if the terminal ileum and transverse colon appear well vascularized and provided that the patient is hemodynamically stable and there has been no major contamination. Since many of the patients who undergo emergency colectomy for ischemic colitis are critically ill, the associated mortality is high (up to 60 %) (Longo et al. 1992).

A small percentage (2 %) of patients will develop strictures (Bower 1993; Gandhi et al. 1996) as a consequence of ischemic colitis. Surgical resection is required if obstructive symptoms develop or if cancer cannot be definitively excluded. After appropriate bowel preparation, an elective one-stage procedure is done, resecting the diseased segment of colon and performing the anastomosis in noninvolved, normal bowel.

Rectal Prolapse

Full-thickness, complete rectal prolapse (procidentia) presents with circumferential intussusception of all layers of the rectum through the sphincters and/or out of the anal canal (Kim et al. 1999). Thus, the presence of circumferential folds seen on examination distinguishes full-thickness rectal prolapse from prolapsed hemorrhoids or mucosal prolapse (radial rings). The rectum may spontaneously reduce or may require manual reduction, and on rare occasions it may incarcerate, requiring urgent surgical intervention. Although uncommon, a neoplasm may form the lead point for a rectal intussusception; thus, all patients should undergo a colonoscopy. If the prolapse cannot be produced during the physical examination, a defecography may be performed to confirm the diagnosis. As many patients will present with concomitant fecal incontinence or constipation, anorectal physiology testing may be performed to provide postoperative prognostic information for patient counseling. For patients with significant chronic constipation, a preoperative colon transit study should be performed to assess whether a concomitant total abdominal colectomy should be considered (Varma et al. 2011).

Surgery is the mainstay of treatment for rectal prolapse (Varma et al. 2011; Larulf et al. 2000). Although numerous operative approaches are described, many are of mere historical interest. Two general surgical approaches are considered: abdominal and perineal. The surgical approach is chosen based on the patients' comorbidities and bowel function as well as the surgeon's preference and experience. The abdominal approaches generally have the lowest recurrence rates and are the preferred treatment for healthier patients. However, although morbidity and mortality rates are low after an abdominal approach, they are slightly higher than rates associated with perineal repairs (Varma et al. 2011). The perineal approaches result in reduced morbidity, pain, and hospital stay; however, recurrence rates are higher than those for abdominal operations. Furthermore, as the rectum is removed, suboptimal functional outcomes can be expected.

Abdominal approaches include rectopexy, with or without a segmental resection. Fixation of the rectum in the pelvis with suture, first described by Cutait in 1959, aims to correct the telescoping of the redundant bowel and causes fixation of the rectum from the resultant scarring and fibrosis (Cutait 1959; Madoff and Mellgren 1999). The recurrence rates for suture rectopexy are generally reported to be from 3 to 9 % (Varma et al. 2011). Prosthetic materials can also be used to fix the rectum to the sacrum. The modified Ripstein procedure involves posterior fixation of mesh to the sacrum with attachment of the ends of the mesh to the lateral rectum. The ventral mesh rectopexy avoids posterolateral mobilization of the rectum. First described by D'Hoore et al., with a recurrence rate of 3.4 %, this technique involves mobilization of the anterior wall of the rectum with fixation of mesh to the anterior wall, which is in turn affixed to the sacrum (D'Hoore and Penninckx 2006). As any form of rectopexy can produce new-onset or worsened constipation, some surgeons advocate a concomitant sigmoid resection. Finally, the impact and importance of division of the lateral stalks during rectal dissection of these abdominal approaches remains controversial (Varma et al. 2011). Division of the stalks has been shown to reduce recurrence rates but to increase the risk of postoperative constipation. Associated complications of abdominal operations for rectal prolapse are few, consisting mainly of anastomotic dehiscence and, when a mesh is used, obstruction secondary to mesh wraps or sepsis related to the foreign body. All abdominal operations for rectal prolapse have been performed laparoscopically with equivalent recurrence rates (4–8 %) compared with open approaches; however, improvements in pain control, length of stay, and return of bowel function have been observed with laparoscopy (Varma et al. 2011; Byrne et al. 2008). An anterior resection alone to treat rectal prolapse has been described, although it is associated with higher recurrence rates and should not be considered as an optimal option.

Perineal approaches include both simple encirclement of the anus and excisional rectosigmoidectomy. Simple encirclement, the Thiersch procedure, has evolved over time but has been relegated to historical curiosity due to high rates of recurrence and septic complications. Perineal rectosigmoidectomy involves a full-thickness resection of the rectum and sigmoid colon through the anus with a coloanal hand-sewn or stapled anastomosis (Altemeier et al. 1971). Compared with an abdominal approach, this operation involves a shorter hospital stay and has lower complication rates (10 %), which include anastomotic bleeding, pelvic abscess, and, rarely, an anastomotic leak; however, recurrence rates have been reported to be as high as 16–30 %. The addition of a concomitant levatorplasty reduces recurrence rates. A Delorme procedure, circumferential mucosal sleeve resection and imbrication of the muscularis layer with serial vertical sutures, can be performed for short full-thickness rectal prolapse or mucosal prolapse. Recurrence rates are higher for this procedure than for perineal rectosigmoidectomy, and the recurrence rates for all perineal procedures are higher than for all abdominal procedures.

Inflammatory Bowel Disease

Mucosal Ulcerative Colitis

Mucosal ulcerative colitis (MUC) is an inflammatory bowel disease of unknown etiology. It is confined to the colonic mucosa and characteristically starts in the rectum and extends proximally without skip lesions. Bloody diarrhea, mucous discharge, and tenesmus are the hallmarks of ulcerative colitis; additionally, patients may report urgency and nocturnal incontinence. At presentation, approximately 50 % of cases have disease confined to the rectum, 30 % have disease extending to the left colon, and 20 % have disease extending beyond the splenic flexure. Backwash ileitis (inflammation of the most distal terminal ileum secondary to reflux of stool from the cecum (Gordon and Nivatvongs 2007)) may occur in up to 10 % of patients and resolves after surgery. The progression of the disease may be insidious, acute, or fulminant. Indications for surgery include chronic disease refractory to medical management, complications of medical management, dysplasia or cancer, fulminant colitis, growth retardation (in children), or patient choice. The goal of surgery is to cure the patient from disease and, whenever possible and desirable, to restore intestinal continuity. This procedure may be performed in one to three stages. The type of operation offered largely depends on the patient's current nutritional status, medical fitness, recent use of immunosuppressant medications, and sphincter function.

Severe acute colitis affects up to 15 % of patients with MUC. The diagnosis of severe colitis is based on the criteria of Truelove and Witts and is defined as colitis with more than six bloody stools per day, fever (temperature >37.5 °C), tachycardia (heart rate >90 beats per minute), anemia (hemoglobin <75 % of normal), and elevated erythrocyte sedimentation rate (ESR >30 mm/h) (Truelove and Witts 1955). A three-stage procedure is recommended for patients who are malnourished, receiving high-dose steroids (>40 mg/day) or tumor necrosis factor inhibitors, or who have indeterminate colitis (The Standards Practice Task Force of The American Society of Colon and Rectal Surgeons 2005). The first stage is a subtotal colectomy with end Brooke ileostomy, which allows the patient to recuperate from the acute illness, stop immunosuppressant medications, regain normal nutritional status, or confirm a pathologic diagnosis of ulcerative colitis. It is important at this first operation that the presacral space be preserved and the integrity of the stapled rectosigmoid stump be assured. If there is any question about this seal, the staple line may be oversewn, or a mucous fistula just above the fascia may be fashioned. This procedure is often well suited for a laparoscopic approach. In addition to minimizing scars, pain, and disability, the laparoscopic method results in significantly less adhesions than does laparotomy. Fewer adhesions after the first stage greatly facilitate the second reconstructive procedure. The second stage is generally a restorative completion proctocolectomy with ileal J-pouch-anal anastomosis and a diverting loop ileostomy. There are multiple possible pouch configurations; however, the "J"-pouch configuration is the most widely used because of its simplicity, suitability for fitting into the pelvis, and excellent functional results (Utsunomiya et al. 1980). The J-pouch is a 15–20-cm ileal reservoir, fashioned with two firings of a GIA or ILA—100 stapler—using the portion of the distal ileum that best reaches the anus. A stapled pouch-anal anastomosis is then performed 1–2 cm from the dentate line. This procedure results in the best functional outcomes. However, if the patient has a history of low rectal cancer or dysplasia, a mucosectomy and hand-sewn ileoanal anastomosis may be performed (Lovegrove et al. 2006). Prior to the third operation, closure of the diverting loop ileostomy, the integrity of the anastomosis is assessed with a pouchoscopy and gastrograffin pouchogram. Typically, patients have excellent outcomes following this procedure, averaging approximately six to ten bowel movements per day with good control and no urgency.

Patients with all other surgical indications may be candidates for a two-stage procedure: restorative proctocolectomy and ileoanal pouch anastomosis with diverting loop ileostomy followed by closure of loop ileostomy. Prior to offering a restorative proctocolectomy with ileoanal pouch anastomosis, the surgeon must have diligently excluded any possibility of Crohn's disease, as the pouch failure rate in patients with Crohn's disease is very high, up to 50 % (Mitchell et al. 2007). This confirmation can be achieved by a detailed history and examination to exclude any perianal or small bowel disease, in addition to obtaining small bowel imaging (such as a CT enterography) to exclude any small bowel involvement suspicious of Crohn's disease. The accurate histological differentiation between MUC and CD is challenging. In approximately 40 % of patients, there is a disparity in diagnosis between general and specialist pathologists; thus a preoperative review of previous colonoscopic biopsies by a gastrointestinal expert pathologist is important (Farmer et al. 2000).

For patients with compromised anal sphincter function, a restorative proctocolectomy and end ileostomy is the most suited procedure (The Standards Practice Task Force of The American Society of Colon and Rectal Surgeons 2005). An alternate procedure is a total proctocolectomy and continent ileostomy ("Kock pouch") which is constructed from 45 cm of distal terminal ileum with intussusception of the ileum back into the pouch to create a nipple valve. This procedure has not gained widespread acceptance because of its intricate construction and its high rate of complications, namely, valvular dysfunction requiring revisions. Pouchitis can occur after any type of pouch construction, whether the pouch is anastomosed to the anus or to the abdominal wall.

Special Considerations

The Elderly

Safety and feasibility of total proctocolectomy and ileoanal pouch anastomosis have been demonstrated in the elderly, with physiologic age, rather than chronological age being a determining factor (Takao et al. 1998; Delaney et al. 2003).

Obesity

Ileoanal pouch reconstruction is feasible in patients with a body mass index >30 kg/m^2; however, it is associated with increases in risk of septic complications (Efron et al. 2001), incidence of incisional hernia, and operative time (Canedo et al. 2010). Furthermore, it is the authors' experience that obesity decreases the ease and likelihood of pouch reach. Thus, an alternate approach for obese patients is to recommend a three-stage procedure with medical or surgical weight loss prior to pouch reconstruction (Boutros and Maron 2011).

Laparoscopy has been shown to be safe and effective, and in most cases superior for two- and three-stage restorative proctocolectomy-ileoanal pouch reservoir procedures (Pokala et al. 2005; Ahmed Ali et al. 2009), even in the setting of fulminant colitis (Chung et al. 2009).

Pouch That Does Not Reach

There are several maneuvers that can be performed if there is inadequate pouch length to perform a tension-free pouch-anal anastomosis. First, it is important to ensure complete mobilization of the small bowel mesentery up to and anterior to the duodenum. Second, a slightly more proximal portion of distal ileum can be used to fashion the ileal pouch if it allows for more adequate length. Third, superficial incisions on the anterior and posterior aspects of the small bowel mesentery along the course of the superior mesenteric artery can be performed. Fourth, selective division of mesenteric vessels to the apex of the proposed J-pouch can be performed. Last, division of the ileocolic vessels can be performed. Finally, when the ileum will not reach the pelvic floor despite these maneuvers, it may be necessary to staple the distal rectum and perform an abdominal colectomy and end ileostomy with Hartmann's pouch. With time, the mesentery of the ileum often elongates, thereby allowing adequate reach, and an ileoanal pouch anastomosis can be reattempted at a later date.

Indeterminate Colitis

In approximately 5–10 % of patients with inflammatory colitis, the diagnosis of Crohn's or ulcerative colitis is equivocal even after a thorough endoscopic and histopathologic evaluation. The preferred approach for these patients is a total abdominal colectomy with end ileostomy; which allows for the entire colon specimen to be examined and a diagnosis of Crohn's to be excluded. If a diagnosis of ulcerative colitis still cannot be definitively made following total abdominal colectomy, the patient is classified as having indeterminate colitis. In this setting, the authors recommend delay of the completion proctectomy and ileoanal pouch reconstruction to allow a period of observation for the clinical evolution of disease. If after 6–12 months, there is no evidence of Crohn's disease, an ileoanal pouch reconstruction can be offered to the patient after an informed discussion. Pouch failure rates for indeterminate colitis may be as low as those for ulcerative colitis or slightly higher (2–10 %) (Delaney et al. 2002; Brown et al. 2005).

Crohn's Colitis

Crohn's disease (CD) is a chronic inflammatory disorder that cannot be cured by medical therapy or operative intervention. Accordingly, treatment focuses on safely alleviating disease symptoms and restoring quality of life while attempting to maintain continuity of the intestinal tract. CD with only colonic involvement accounts for up to 40 % of patients with CD and may present with abdominal pain, diarrhea, or tenesmus (Beck et al. 2011, p. 500). Surgery is indicated for complications of disease (nondrainable abscesses, perforation, chronic bleeding and anemia, stricture formation, fulminant colitis, and the development of dysplasia or adenocarcinoma) and failure of medical management (including dependence on high doses of immunosuppressive agents and steroids) (Standards Practice Task Force of The American Society of Colon and Rectal Surgeons 2007).

Similar to patients with MUC, patients with fulminant colitis should undergo a total abdominal colectomy with end ileostomy (Standards Practice Task Force of The American Society of Colon and Rectal Surgeons 2007). Typically, anemia, malnutrition, and sepsis rapidly resolve following colectomy. A delayed ileorectal anastomosis can be recommended in select patients who demonstrate minimal mucosal inflammation, adequate rectal compliance, absence of anorectal disease, and good sphincter function. Otherwise, the diseased rectum may be removed or left in place with appropriate endoscopic surveillance.

In the elective setting, surgical treatment must be tailored to the anatomic extent of the disease. If the colitis is limited to the right colon, a right hemicolectomy can suffice; if disease extends past the splenic flexure and the rectosigmoid is devoid of disease, an abdominal colectomy with ileorectal anastomosis is necessary. Isolated sigmoid or left-sided colon disease can be treated with a segmental colectomy, whereas disease limited to the rectum can be treated with abdominoperineal proctectomy with end colostomy. Although segmental resection may avoid or delay a permanent stoma, patients should be informed of the higher recurrence rate compared to proctocolectomy with ileostomy.

In the presence of pancolitis, a proctocolectomy with end ileostomy is the procedure of choice. For patients undergoing a proctectomy and permanent stoma, an intersphincteric resection has been found to improve perineal wound healing, a difficult and morbid complication of this procedure (Lubbers 1982). A restorative proctocolectomy with ileoanal pouch anastomosis is not recommended in Crohn's disease because of the high risk of perineal and pelvic septic complications and the high Crohn's disease recurrence rate in the ileal pouch (Brown et al. 2005; Tekkis et al. 2005).

Premalignant and Malignant Conditions

Polyps

Adenomas are the most common colorectal polyps and are the precursor lesion to the majority of colorectal cancers. Most colorectal cancers arise within an adenomatous polyp, and there is a 15–50 % incidence of synchronous polyps in patients diagnosed with a colorectal cancer (Beck et al. 2011, p. 746). The risk of invasive cancer increases with polyp size and histology (degree of villous component) (Stein and Coller 1993). Most adenomatous polyps are endoscopically excised, and if histopathologic examination excludes the presence of carcinoma, endoscopic removal is all that is needed.

The Malignant Polyp

If invasive carcinoma is identified, endoscopic removal of the malignant polyp is sufficient when several criteria are met: (1) invasion is limited to the mucosa (no invasion into the submucosa), (2) all margins are negative (at least 2 mm from the tumor), (3) the lesion is well to moderately differentiated, (4) there is no lymphovascular invasion, and (5) there is no extensive tumor budding (Cooper et al. 1995; Haggitt et al. 1985). All patients treated in this fashion require follow-up colonoscopy in 3–6 months to assess for local recurrence. If these criteria are not met, there is a risk of either residual tumor or lymph node metastases that warrants segmental colectomy. Similarly, if a polyp cannot be removed endoscopically or is extremely large (and malignancy cannot be excluded), the patient should undergo segmental resection. In these cases, it is important that the site of the polyp be tattooed so that it can be intraoperatively identified. Local excision should be considered for large endoscopically unresectable or malignant polyps in the rectum (discussed in "Rectal Cancer" section).

Colorectal Cancer

Colon Cancer

Preoperative Evaluation and Staging

Patients with colon cancer are often asymptomatic; however, abdominal pain, change in bowel habits, and rectal bleeding are the most common presenting symptoms (Beck et al. 2011, p. 703). Thorough physical examination and standard preoperative laboratory tests should be performed. Because anemia is common in colon cancer patients, it is important to check hemoglobin level prior to surgery. Carcinoembryonic antigen (CEA) levels should be assessed before elective surgery for colon cancer for the establishment of baseline values, as CEA is a helpful tumor marker in postoperative surveillance (Engstrom et al. 2009).

Whenever possible, all patients should undergo a full colonic evaluation prior to surgery.

The majority of patients will have undergone a colonoscopy; however, confirmation of a complete examination is important as the risk of synchronous carcinomas or adenomas within the colon may be as high as 10 % in the general population (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012). In the absence of complete obstruction or perforation, a gastrograffin enema or CT colonography can be used to complete the evaluation. The surgeon must also ensure tattoo ink-marking of the lesion, especially in cases in which laparoscopic resection is planned and endoscopic localization is unreliable (all locations except for the cecum and distal rectum). In addition, whenever possible, a pathologic diagnosis of colon cancer should be preoperatively obtained.

Preoperative imaging to assess for local invasion or metastases should be performed. This assessment includes imaging of the abdomen and pelvis (CT or PET-CT) and the chest (CT or chest x-ray) (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012; Association of Coloproctology of Great Britain and Ireland 2007).

Surgical Management

Surgery is the mainstay of colon cancer treatment. The oncologic principles are colon resection with a wide mesenteric resection corresponding to the lymphovascular drainage of the cancer. The mesenteric resection should be complete and en bloc with the bowel segment. This objective is achieved by ligating the feeding artery at its origin (Nelson et al. 2001), ensuring optimal lymph node harvest, the most critical prognostic feature in colon cancer treatment. Obtaining 12 lymph nodes or more in the specimen is associated with improved prognostic accuracy and possibly survival (McDonald et al. 2012). A surgical approach aimed at these aforementioned goals should achieve at least a 5-cm negative margin on either side of the tumor. For locally advanced disease, an en bloc resection with negative radial margins should be performed.

Special Considerations

Synchronous colon cancers: The reported incidence of synchronous colon cancers ranges between 2 and 5 % (Bat et al. 1985). Synchronous colon cancers can be treated by total abdominal colectomy or two separate resections (Standards

Practice Task Force of the American Society of Colon and Rectal Surgeons 2012). This decision largely depends on patient factors, especially any association with a genetic syndrome (such as Lynch syndrome), underlying colonic disease (such MUC or CD), age, and sphincter function.

Prophylactic oophorectomy has not been associated with improved survival (Young-Fadok et al. 1998). Oophorectomy should be considered even in the presence of grossly abnormal ovaries (in postmenopausal women) or contiguous extension of the colon cancer (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012).

Laparoscopy for colon cancer resections has equivalent (Clinical Outcomes of Surgical Therapy Study Group 2004; Bonjer et al. 2007) or better (Lacy et al. 2008) oncologic results compared to open resections, with no significant risk of port-site metastases or inferior oncologic outcomes due to laparoscopic conversion (Agha et al. 2008). The laparoscopic procedure should achieve the same goals as the open approach; if any compromise in oncologic quality is encountered, a conversion to an open approach is advised (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012).

Obstructing colon cancers represent more advanced disease and are associated with a poor prognosis. Surgical resection can be performed at the time of presentation, with or without anastomosis (Hartmann's procedure), or at a later time following temporary relief of obstruction with endoscopic stent placement (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012; Finan et al. 2007). Excellent procedural as well as ultimate oncologic and postoperative outcomes have been demonstrated with the latter approach (Saida et al. 2003). If a resection and anastomosis are performed, the surgeon must ensure that the proximal bowel used for the anastomosis is healthy and not dilated. In some instances this approach necessitates a subtotal colectomy with ileosigmoid or ileorectal anastomosis. Alternatively, if a segmental resection is planned, the surgeon must palpate and examine the entire bowel to identify any synchronous lesions. A complete colonoscopy should also be performed after the postoperative period.

Rectal Cancer

Preoperative Evaluation and Staging

Patients with rectal cancer should undergo the same preoperative evaluation as for patients with colon cancer (previous section). In addition, precise preoperative assessment of the tumor by digital rectal examination (DRE) and rigid proctosigmoidoscopy is critical. On DRE, the distance between the lower border of the tumor and the dentate line ring is measured; fixation to the sphincters or adjacent structures (vagina, prostate, sacrum) is evaluated; the position of the tumor (anterior, posterior, or lateral) is noted; and the patient's sphincter function is assessed. Following this examination, the surgeon can often determine whether the patient is a candidate for sphincter-saving surgery (low anterior resection or intersphincteric resection with colorectal or coloanal anastomosis) or will need an abdominoperineal resection.

Preoperative staging of the extent of tumor invasion and mesorectal lymph node metastases is performed by endorectal ultrasound (ERUS) and/or magnetic resonance imaging (MRI) of the pelvis (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2005). Early-stage cancer can be treated by surgical resection alone; however, mid and low rectal cancers that are preoperatively staged to be T3 or N positive, or any rectal cancers that have threatened circumferential margins, are treated with neoadjuvant chemoradiation followed by surgery (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2005). This approach, when combined with the correct adequate surgical resection, is associated with the lowest recurrence rates (van Gijn et al. 2011).

Surgical Management

Resection: Total mesorectal excision (TME), first described by Professor R. Heald in 1982, is the gold standard for rectal cancer care (Heald et al. 1982). TME involves precise sharp dissection and removal of the entire visceral mesorectum, with an intact fascia, to the level of the levators (Lowry et al. 2001). For proximal rectal tumors, a tumor-specific mesorectal resection, defined as a precise perpendicular and circumferential excision of the intact mesorectum to the level of a negative distal resection margin, is appropriate (Lowry et al. 2001). It is now clear that the quality of TME as measured by negative (>1 mm) circumferential margins and intactness of the mesorectum is the most critical determining prognostic factor for rectal cancer surgery. Meticulous adherence to the principles of TME will result in an adequate lymphovascular resection. Distal margins should be microscopically negative; however, the actual required distance from the tumor is debated and continues to decrease (Bernstein et al. 2012).

In addition to TME, routine splenic flexure mobilization and proximal ligation of the inferior mesenteric vessels will facilitate sufficient colon length for an anastomosis and a tension-free anastomosis.

During pelvic surgery, careful identification and preservation of the ureters and nerves for sexual and urinary function is important. Preoperative radiation and bulky tumors make this task even more challenging. Risk of ureteral injury is greatest during ligation of the inferior mesenteric vessels and the lateral dissection of the sigmoid and proximal rectum. Windows are created on either side of the inferior mesenteric vessels, so that ureteral identification and protection are ensured prior to vessel ligation. The sympathetic hypogastric nerves can be injured during ligation of the inferior mesenteric vessels, the posterior mesorectal dissection at the level of the sacral promontory, and the lateral mesorectal dissection, resulting in retrograde ejaculation. The parasympathetic nervi erigentes can be injured during distal anterolateral mesorectal dissection, resulting in bladder dysfunction, impotence, or dyspareunia (Bernstein et al. 2012). When the nerves are involved by tumor, they must be resected en bloc. Patients should be preoperatively counseled regarding this risk.

Reconstruction: Several factors impact the feasibility and suitability of a sphincter-saving operation including the patient's preoperative continence, body habitus, sphincter involvement with tumor, and adequacy of a negative surgical margin (Beck et al. 2011, p. 754). Tumors in the proximal, mid, and upper distal rectum can be resected, and reconstruction can be performed with a stapled colorectal or coloanal anastomosis. Tumors in the most distal rectum, located just above the dentate line, typically require an abdominoperineal resection. However, an intersphincteric resection with a hand-sewn coloanal anastomosis may be appropriate for a patient with excellent preoperative continence who has a tumor limited to the mucosa, submucosa, or the superficial internal sphincter and wishes to avoid a colostomy. This operation should be performed only by surgeons who have extensive experience with rectal cancer and pelvic surgery.

Reservoirs: Colorectal and coloanal anastomoses may be performed as a straight end-to-end anastomosis or with a colonic reservoir such as a colonic J-pouch, side-to-end anastomosis, or transverse coloplasty. The colonic J-pouch, constructed by folding the distal colon on itself for approximately 6–8 cm with creation of a common channel using a linear cutting stapler, has been demonstrated to improve functional outcomes for at least 2 years following proctectomy (Heriot et al. 2006). The Baker side-to-end anastomosis is an alternate reservoir that is fashioned by creating the circular stapled colorectal anastomosis 3–5 cm from the stapled colonic end (Machado et al. 2003). A transverse coloplasty, as first described by Z'Graggen, is created by an 8–10-cm longitudinal incision that is closed transversely; however, this reservoir has been associated with an increased leak rate (Ho et al. 2002) and has been largely abandoned.

Temporary diversion: Colorectal and coloanal anastomoses are associated with a substantial leak rate (up to 17 %) (Karanjia et al. 1994; Ho and Ashour 2010) compared to colonic anastomoses (Beck et al. 2011, p. 748). Routine use of a diverting loop ileostomy decreases the rate of symptomatic anastomotic leakage and need for urgent reoperation (Matthiessen et al. 2007).

The surgeon is a critical variable in the overall morbidity, sphincter preservation rate, and local recurrence rate for rectal cancer surgery (Hermanek et al. 1995; Holm et al. 1997). Thus, meticulous surgical technique and experienced clinical judgment are critical in the care of these patients.

Special Considerations

Locally invasive disease: Neoadjuvant chemoradiation is indicated for locally advanced disease. An en bloc resection, often performed by a multidisciplinary team, needs careful preoperative planning. A negative circumferential margin is of paramount importance.

Obstructing rectal cancers: Proximal rectal cancers can be managed with temporary diversion, either by a loop ileostomy or end colostomy or by endoscopic stent placement. For distal rectal cancers, placement of an endoscopic stent is not ideal as it can protrude from the anus or cause significant pain. Once the obstruction has been addressed, the patient should undergo imaging for staging of locoregional and metastatic disease (as previously described in the preoperative staging and evaluation section). If the patient is a candidate for curative treatment, neoadjuvant chemoradiation followed by curative resection should be planned.

Laparoscopy has been increasingly used for rectal cancer resections, resulting in the expected short-term benefits of minimally invasive surgery and equivalent oncologic outcomes to laparotomy (Park et al. 2011; Breukink et al. 2006). However, these outcomes are yet to be confirmed by large multi-institutional randomized, controlled trials (Row and Weiser 2010).

Local excision (*LE*) is an alternate surgical option for the management of early rectal cancers. The two most commonly used approaches for LE are standard transanal excision (TAE) and transanal endoscopic surgery (TES). TAE employs standard anorectal retractors and instruments, generally allowing reach to 10 cm from the dentate line. TES is performed with a 4-cm operating proctoscope and CO_2 insufflation to create a working space within the rectum. Long instruments (such as laparoscopic instruments) and an operating scope allow access to the entire rectum and rectosigmoid junction with magnified visualization. TES is associated with improved surgical and oncologic outcomes compared to TAE but requires specialized instrumentation and has a steep learning curve.

TAE and TES are both minimally invasive procedures that do not pose the standard risks of abdominal surgery and allow for rectal preservation. The goal of LE by either technique is full-thickness removal of the tumor and closure of the defect unfortunately. LE, whether performed by TES or by TAE, does not address the mesorectum. The likelihood of positive lymph nodes increases with increased T stage, such that T1, T2, and T3 tumors are associated with <10 %, 25 %, and up to 45 % risk of lymph node involvement, respectively (Coco et al. 2007). Thus, careful patient selection is key when utilizing this approach for a curative intent. LE is appropriate for excision of T1 cancers (in which the tumor does not penetrate muscularis propria) without evidence of any associated lymph node spread on preoperative ERUS and/or MRI. Furthermore, the tumor should have favorable features such as well-differentiated histology, lack of lymphovascular invasion, and lack of mucin (Boutros and Sands 2012). The patient must be preoperatively informed that once the tumor is excised, the final pathology is reviewed for adequate margins and lack of poor prognostic features and that if these criteria are not met, a standard abdominal operation with removal of the lymphatic bed is recommended. When surgery is indicated, it should be performed 4–6 weeks after full-thickness excision to allow the bowel wall to heal. If preoperative staging suggests a stage 2 or 3 lesion, radical resection of the rectum should be performed unless there are mitigating circumstances that preclude an abdominal approach.

Hereditary Colon Cancer Syndromes

A complete history, including family and colon cancer-specific history, can guide the surgeon to suspect hereditary cancer syndromes, initiate mutational analysis of the tumor, and refer for genetic counseling (Standards Practice Task Force of the American Society of Colon and Rectal Surgeons 2012).

Familial Adenomatous Polyposis

Familial adenomatous polyposis (FAP) is a rare, autosomal dominant disease caused by a germline mutation of the adenomatous polyposis coli (*APC*) gene on chromosome 5q21 (Kinzler et al. 1991). FAP accounts for less than 2 % of all colorectal cancer. Patients with FAP develop hundreds to thousands of colorectal polyps and can present with rectal bleeding or a protein-losing enteropathy. In addition to colorectal neoplasms, patients with FAP may develop several extracolonic tumors including desmoids, small intestinal adenomas and cancers, osteomas, dermoid cysts, and medulloblastomas (Turcot's syndrome). Individuals at risk for FAP, as assessed by personal or family history, or those who are positive for an APC gene mutation are advised to begin clinical screening by annual colonoscopy starting at age 12–14 years (Gryfe 2009). When polyps are detected, prophylactic surgery should be undertaken.

Surgical Management

The timing and extent of surgery depend on the severity of polyposis and whether there is rectal sparing. Surgical options include total proctocolectomy with ileal pouch-anal anastomosis, abdominal colectomy with ileorectal anastomosis, or total proctocolectomy with end ileostomy. For most cases of classic FAP, an ileoanal pouch ("J") reconstruction is now the standard of care (Beck et al. 2011, p. 658; Gryfe 2009; Church et al. 2003). Following colectomy, annual endoscopic surveillance of any remaining rectal mucosa should be performed.

The clinical management of FAP is complex and involves counseling, genetic testing, surveillance, and treatment of multiple organ systems, not only for the affected individual, but also for their at-risk relatives (Gryfe 2009). Thus, it is recommended that individuals with FAP be referred to specialized centers with FAP registries, genetic counselors, and coordinated multidisciplinary management (Church et al. 2003).

Lynch Syndrome

Lynch syndrome (also known as hereditary nonpolyposis colon cancer) is an autosomal dominant disorder characterized by colorectal cancer at a young age in the absence of a multitude of polyps. Lynch syndrome accounts for up to 4 % of all colorectal cancer. Individuals affected with Lynch syndrome have a 50–60 % lifetime risk of developing a colorectal cancer, and they are at increased risk for endometrial (more than 50 %), gastric (13 %), ureter or renal pelvis (7 %), brain (4 %), small bowel (4 %), and hepatobiliary (2 %) cancers (Beck et al. 2011, p. 658).

Clinically, Lynch syndrome is defined by the Amsterdam II criteria: (1) 3 or more relatives with HNPCC-associated cancer, (2) 1 affected individual should be a first-degree relative of the other 2 relatives, (3) 2 or more successive generations should be affected, (4) 1 or more of these cancers should be diagnosed before the age 50, (5) FAP should be excluded, and (6) tumors should be verified by pathologic examination (Vasen et al. 1991; Umar et al. 2004).

To date, germline mutations in four mismatch repair genes—MLH1, MSH2, MSH6, and PMS2—have been implicated in Lynch syndrome. Mutations in mismatch repair genes allow for an increased mutation rate in short repetitive DNA repeats in noncoding regions of a gene known as microsatellites. Microsatellite instability (MSI) emerges when the copy number of a particular microsatellite DNA region is different in cancer cells compared to normal tissue from the same individual. MSI can be tested in the colon specimen of an affected individual. MSI-high is defined as instability in two or more of the five National Cancer Institute-recommended panels of microsatellite markers. Patients with MSI-high tumors and lack of expression of a specific mismatch repair protein (as indicated by immunohistochemistry) are candidates for Lynch syndrome genetic screening (Beck et al. 2011, p. 662; Gryfe 2009).

Surgical Management

The surgical options for colon cancer in Lynch syndrome are segmental resection or total abdominal colectomy. For rectal cancer, the options are proctectomy or total proctocolectomy with ileoanal pouch reconstruction or end ileostomy. If the patient is young and medically fit, the more extensive resections are preferred as they remove most at-risk mucosa and prevent metachronous cancer (Church et al. 2003). Women with Lynch syndrome and a colorectal cancer should be offered a prophylactic hysterectomy at the time of colectomy (Beck et al. 2011, p. 662). Annual surveillance of the remaining large bowel is indicated for all patients with Lynch syndrome.

Squamous Carcinoma of the Anus

Patients with squamous cell cancer (SCC) of the anal canal are often initially misdiagnosed and diagnosed at a later stage. SCC most commonly presents with bleeding or anal pain, but it may also present as a palpable mass, pruritis, change in bowel habits, or new-onset fecal incontinence (Beck et al. 2011).

Evaluation and Staging

A thorough history should be taken with assessment of predisposing factors (HIV, HPV, history of cervical cancer, sexually acquired diseases, cigarette smoking, anoreceptive intercourse, multiple sexual partners, and immunosuppression) (Fleshner et al. 2008). DRE should be performed to determine tumor size, location, and fixation to adjacent structures. A careful examination of the groins should be performed to identify any suspicious inguinal adenopathy, for which fine-needle aspiration or core biopsy should be performed.

CT or PET-CT of the chest, abdomen, and pelvis should be performed to detect occult inguinal adenopathy or distant metastases. ERUS and/or pelvic MRI should be performed to assess tumor involvement of the anal sphincter and perirectal lymph nodes (Fleshner et al. 2008).

Management

Combined modality chemoradiation (5-FU, mitomycin C, and radiation therapy) is the first-line therapy for primary SCC. The primary treatment for involved inguinal lymph nodes is a boost of radiation (Cummings et al. 1991).

The standard treatment for persistent disease or locoregional recurrence following chemoradiation is salvage abdominoperineal resection (APR). APR is also sometimes necessary for patients who respond to chemoradiation but suffer complications of treatment including incontinence, skin breakdown, or stenosis. The perineal wound complication rate following salvage APR for SCC is high; thus, prophylactic plastic surgery reconstruction using rectus or gluteal flaps to promote healing may be a good option (Sunesen et al. 2009).

General Technical Considerations in Colorectal Surgery

Preoperative Preparation and Planning

Bowel Preparation

Bowel preparation has been routinely used for colorectal surgery as it allows luminal visualization, decreases fecal flora, and facilitates manipulation of the large bowel. A recent Cochrane review demonstrated no difference in outcomes following colon and rectal resections with and without bowel preparation (Güenaga et al. 2011). Nonetheless, bowel preparation is still commonly used, as many surgeons find that it facilitates laparoscopic bowel manipulation and creation of low colorectal and coloanal anastomoses.

Antibiotic Prophylaxis

A dose of perioperative intravenous antibiotics with coverage of skin and gut flora is given, ideally 30 min before making the incision. For longer cases, antibiotics should be re-dosed according to the serum half-life of the antibiotic used. Perioperative systemic coverage is expanded in patients with prosthetic heart valves, a history of endocarditis, or a surgically constructed systemic shunt (Beck et al. 2011, p. 746).

Patient Positioning

For most colorectal abdominal and pelvic procedures, it is optimal for the patient to be placed in the modified lithotomy position with both arms tucked, allowing access to both sides of the abdomen and the perineum at all times. This positioning reduces operative time and allows the surgeon to stand between the legs when necessary. This approach can be particularly helpful when mobilizing a difficult splenic flexure. As many of these operations last more than several hours, it is crucial that meticulous attention be given to protecting potential pressure areas on the wrists, elbows, and calves.

Ureteral Stents

Knowledge of ureteral anatomy is key for intraoperative ureteral identification and protection from injury. Inflammation, large bulky tumors, previous surgery, or radiation cause marked deviation of the ureter from its normal anatomic position (Fazio et al. 2005). Although prophylactic ureteral stent placement has not been shown to reduce risks of injury, it has been demonstrated to significantly improve intraoperative identification of ureteral injury (Da Silva et al. 2012). This method allows for immediate repair, resulting in better outcomes compared to delayed identification and repair. Thus, the use of prophylactic ureteral stents is advisable for any high-risk pelvic colorectal resection.

Intraoperative Decisions and Technical Considerations

Safe Colorectal Anastomoses

Anastomotic leak remains one of the most feared complications of colorectal surgery. Careful patient selection and attention to technical detail are of prime importance.

Patient factors. Patients who are severely malnourished or immunosuppressed lack physiologic reserve and the appropriate immune response required for healing. Other patient-related risk factors for poor healing include uncontrolled diabetes, anemia, smoking, and radiation. Intraoperative hemodynamic instability, peritonitis, and massive hemorrhage also preclude creation of an anastomosis. Moreover, the patient's overall condition and reserve to tolerate the consequences of an anastomotic leak, should it occur, need to be considered when deciding whether to create a primary anastomosis.

Technical factors. When performing an anastomosis, the surgeon must ensure that both ends of the bowel are of similar caliber. At emergent surgery of a large bowel obstruction, the proximal bowel may be significantly dilated. In this case, a Hartmann's procedure can be performed or the resection must include the dilated bowel such that the proximal resection margin is in normal caliber bowel suitable for an anastomosis. Alternatively, when appropriate, a side-to-side functional end-to-end stapled anastomosis can be fashioned

The bowel wall should be pink, soft, and pliable; and the transected edge should demonstrate bleeding of bright red blood, confirming an intact blood supply. Intramural hematomas at the site of the anastomosis or a hematoma in the adjacent mesentery may impair blood flow and should be avoided by handling and manipulating the bowel and mesentery gently during mobilization, resection, and construction of the anastomosis.

A tension-free anastomosis is essential. For colorectal and coloanal anastomoses, this goal can be achieved by routine mobilization of the splenic flexure and ligation of the inferior mesenteric artery and vein.

Distal obstruction causes anastomotic failure. All efforts are made to ensure that there is no coexisting distal obstruction prior to construction of any bowel anastomosis. Preoperative radiographic contrast studies and endoscopy can be used to ascertain any possible distal obstruction.

Regardless of the level of anastomosis, the risk of leak following stapled versus hand-sewn colorectal anastomoses is similar, although a higher stricture rate has been noted for the former technique (Ho and Ashour 2010). When creating a hand-sewn anastomosis, accurate seromuscular apposition of both bowel ends is critical. This aim is achieved by including submucosa in each suture, as the submucosal layer has the greatest strength due to its rich connective tissue composition. The anastomosis may be created by stapling, suturing, or compression.

Pelvic Bleeding

Significant bleeding may occur in pelvic colorectal operations, particularly in reoperative cases. Bleeding should be anticipated, and patients should be appropriately cross-matched and counseled regarding the possible need for transfusion. The patient's platelet count and coagulation parameters should also be preoperatively evaluated.

Pelvic bleeding most frequently occurs by (1) inadvertent breaching of Waldeyer's (presacral) fascia, resulting in bleeding from the presacral and lateral sacral veins, (2) tearing or injuring the internal iliac vein, and (3) dissection on the vagina or prostate (Fazio et al. 2005).

As soon as bleeding is encountered, it should be initially controlled with finger or sponge tamponade, and anesthesia should be notified. The surgeon must ensure good assistance, lighting, exposure, and more than one suction. Specific measures for control of presacral bleeding include continuous direct pressure, high-current electrocoagulation or a suture ligature (if a bleeding vessel is visualized), presacral thumbtack placement, or application of high-current coagulation over of a 2 × 2-cm piece of rectus muscle (Fazio et al. 2005). If the bleeding cannot be controlled, or if the patient is coagulopathic, hypothermic, or hemodynamically unstable, the pelvis should be packed for 24–48 h. Following warming and resuscitation, the patient is brought back to the operating room, at which time the packs are removed, usually revealing a dry field (Fazio et al. 2005).

Intestinal Stomas

A properly placed and created stoma can greatly improve the patient's quality of life (Fazio et al. 2005). An essential procedure is preoperative stoma-site marking by an enterostomal therapist, with the patient dressed in usual clothing and placed in sitting, standing, and supine positions (Bass et al. 1997). Whenever possible, the stoma should be placed in the rectus abdominis muscle sheath. In general, the optimal location is approximately one-third the distance from the umbilicus to the anterior superior iliac spine. However, obese patients should be marked in all four abdominal quadrants as creation of a stoma in these patients may be very difficult and feasible in only one quadrant.

Types of Stomas

End ileostomies may be permanent or temporary when future restoration of bowel continuity is planned. When constructing an end ileostomy, the surgeon should exercise care to make a snug fascial opening and not to remove excess subcutaneous fat. Exteriorization of 5–6 cm of ileum should be accomplished such that the final Brooke ileostomy protrudes at least 2 cm beyond the abdominal wall (Gordon and Nivatvongs 2007). Protrusion prevents bowel contents from seeping between the appliance wafer and the peristomal skin, thus minimizing skin irritation and breakdown. Furthermore, it is important to create a snug fascial opening to reduce the risk of peristomal hernia.

The mucosal surface should be pink and it should bleed freely at the edges. The ileostomy maturation is best performed after the abdominal incisions are closed to prevent any spillage of ileostomy contents into the abdominal cavity and onto the wound.

Loop ileostomies are commonly used for protecting an anastomosis and are 99 % effective at diverting the fecal stream (Gordon and Nivatvongs 2007). When creating a loop ileostomy, a portion of ileum 30–40 cm proximal to the ileocecal junction or ileoanal pouch (depending on the indication), which easily reaches the pre-marked ileostomy site, is chosen. It is important that the chosen site for a loop ileostomy be proximal enough to facilitate the future ileostomy closure. On the other hand, if the ileostomy is too proximal, the risk of dehydration increases. Prior to exteriorization of the loop ileostomy, the proximal and distal limbs should mark (with suture, cautery, staples, or graspers) in order to ensure correct orientation before maturation. The proximal limb is matured in the same fashion as an end ileostomy, and the distal limb is sutured flush to the skin.

End-loop ileostomies may be created in any situation when an end ileostomy is indicated. They may be particularly helpful in individuals with thick abdominal walls or short ileal mesenteries. The end-loop ileostomy is constructed by dividing the ileum and elevating it above the abdominal wall at a point where the bowel is redundant enough. The ileostomy is matured in the same way as a conventional loop ileostomy.

An end colostomy has the advantage of the added absorptive capacity of the proximal colon, making it the easiest type of intestinal stoma for the patient to manage; end colostomies may be permanent or temporary. For temporary end colostomies, whenever possible it is advisable to leave the distal stapled limb just above the fascia. This approach facilitates closure of the colostomy at a later date. The same key principles used for construction of an end ileostomy apply to end colostomies. Peristomal herniation is a very common problem following end colostomy construction. Techniques for minimizing this morbidity include attention to creation within the rectus sheath, creating a snug fascial opening and prophylactic placement of bioprosthetic mesh at the stoma site. Once again, the colostomy is usually matured, in a Brooke fashion, following closure and protection of the abdominal incisions. However, if colostomy maturation is difficult, it may be necessary to mature the stoma prior to closure of the abdominal incision in order to ensure viability.

Loop colostomies were commonly used for fecal diversion, but due to an increased complication rate and incomplete diversion, their use has been almost entirely replaced with loop ileostomy and end colostomy creation.

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Right Colectomy for Cancer

49

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Malignancy of the ileocecal region, ascending colon, and transverse colon.

A less extensive modification of this procedure may be used for benign problems requiring regional resection.

Preoperative Preparation

Colonoscopy to confirm the diagnosis and exclude other pathology

Computed tomography (CT) of abdomen

Carcinoembryonic antigen (for carcinoma)

Mechanical and antibiotic bowel preparation

Perioperative antibiotics

Pitfalls and Danger Points

Injury or inadvertent ligature of superior mesenteric vessels

Laceration of retroperitoneal duodenum

Trauma to right ureter

Avulsion of branch between inferior pancreaticoduodenal and middle colic veins

Failure of anastomosis

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Operative Strategy

The extent of the resection depends on the location of the tumor. For tumors of the cecum, the main trunk of the middle colic artery may be preserved (Fig. 49.1). For tumors of the hepatic flexure or right transverse colon, it is necessary to ligate this vessel and resect additional colon (Figs. 49.2 and 49.3).

There are several anatomic advantages to the "no-touch technique" described here, although the oncologic advantages are still debated. First, a dissection initiated at the origins of the middle colic and ileocolic vessels makes it possible to perform a more complete lymph node dissection in these two critical areas. Second, by devoting full attention to the lymphovascular pedicles early during the operation, before the anatomy has been distorted by traction or bleeding, the surgeon gains thorough knowledge of the anatomic variations that may occur in the vasculature of the colon. Finally, the surgeon becomes adept at performing the most dangerous step of this procedure—high ligation of the ileocolic vessels—without traumatizing the superior mesenteric artery and vein.

In most cases when the vascular pedicles are ligated close to their points of origin, it can be seen that the right colon is supplied by two vessels: the ileocolic trunk and the middle colic artery. The middle colic artery generally divides early in its course into right and left branches. The left branch forms a well-developed marginal artery that connects with the left colic artery at the splenic flexure. When the proximal half of the transverse colon is removed, the left colic connection of this marginal artery supplies the remaining transverse colon. *Rarely*, a patient does not have good arterial flow from the divided marginal artery. In such a case the splenic flexure and sometimes the descending and sigmoid colon may have to be resected.

After the two major lymphovascular pedicles have been divided and ligated, the remainder of the mesentery to the

†Deceased

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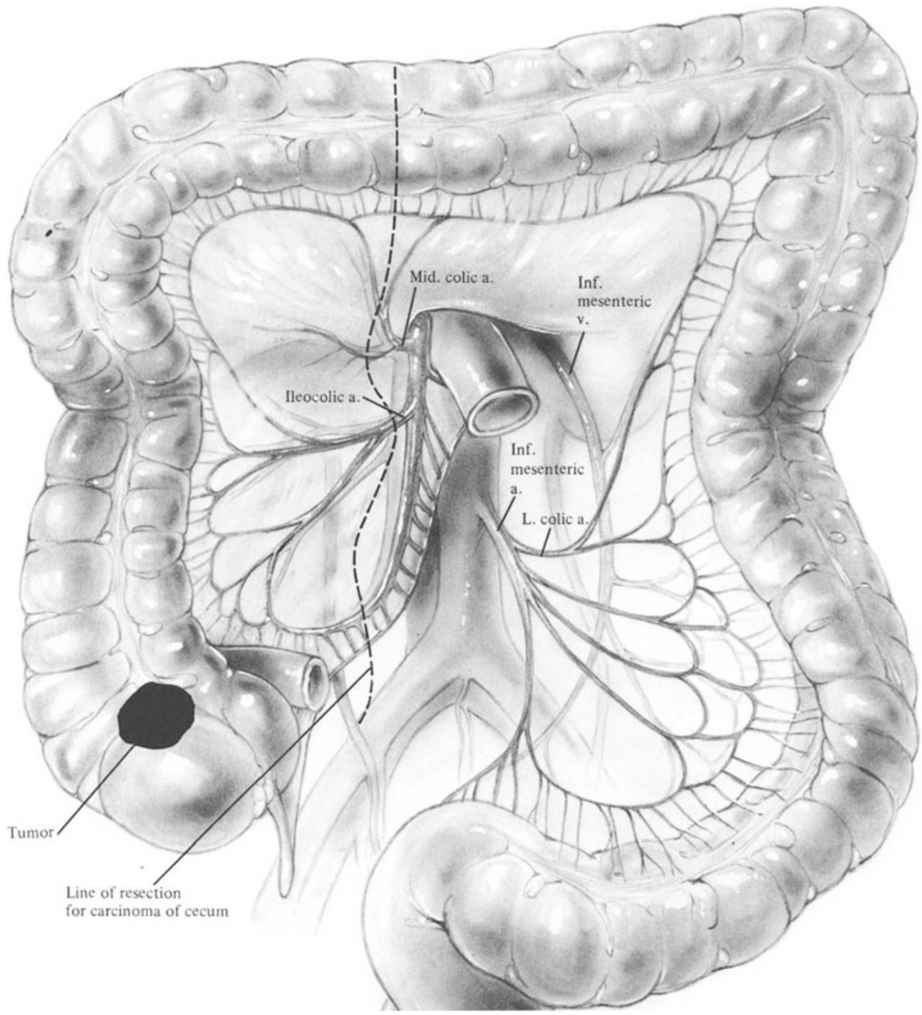

Fig. 49.1

right colon and the mesentery to the distal segment of the ileum should be divided. If occluding clamps are applied to the anticipated points of transection of the transverse colon and the ileum at this time, the entire specimen can be seen to be isolated from any vascular connection with the patient. This is all done before there is any manipulation of the tumor—hence the "no-touch" technique. The specimen may now be removed by the traditional method of incising the peritoneum in the right paracolic gutter and elevating the right colon.

When right colon resection is performed for benign disease, extensive mesenteric resection is not required and a lateral to medial approach may be utilized. In this approach, the peritoneal attachments of the colon are incised and the colon mobilized. Resection is then performed, with care to visualize and protect the ureter. Vessels are secured and divided at a convenient point, rather than at their origin.

Documentation Basics

- Findings

Operative Technique (Right and Transverse Colectomy)

Incision

Make a midline incision from the mid-epigastrium to a point about 8 cm below the umbilicus. A short transverse incision

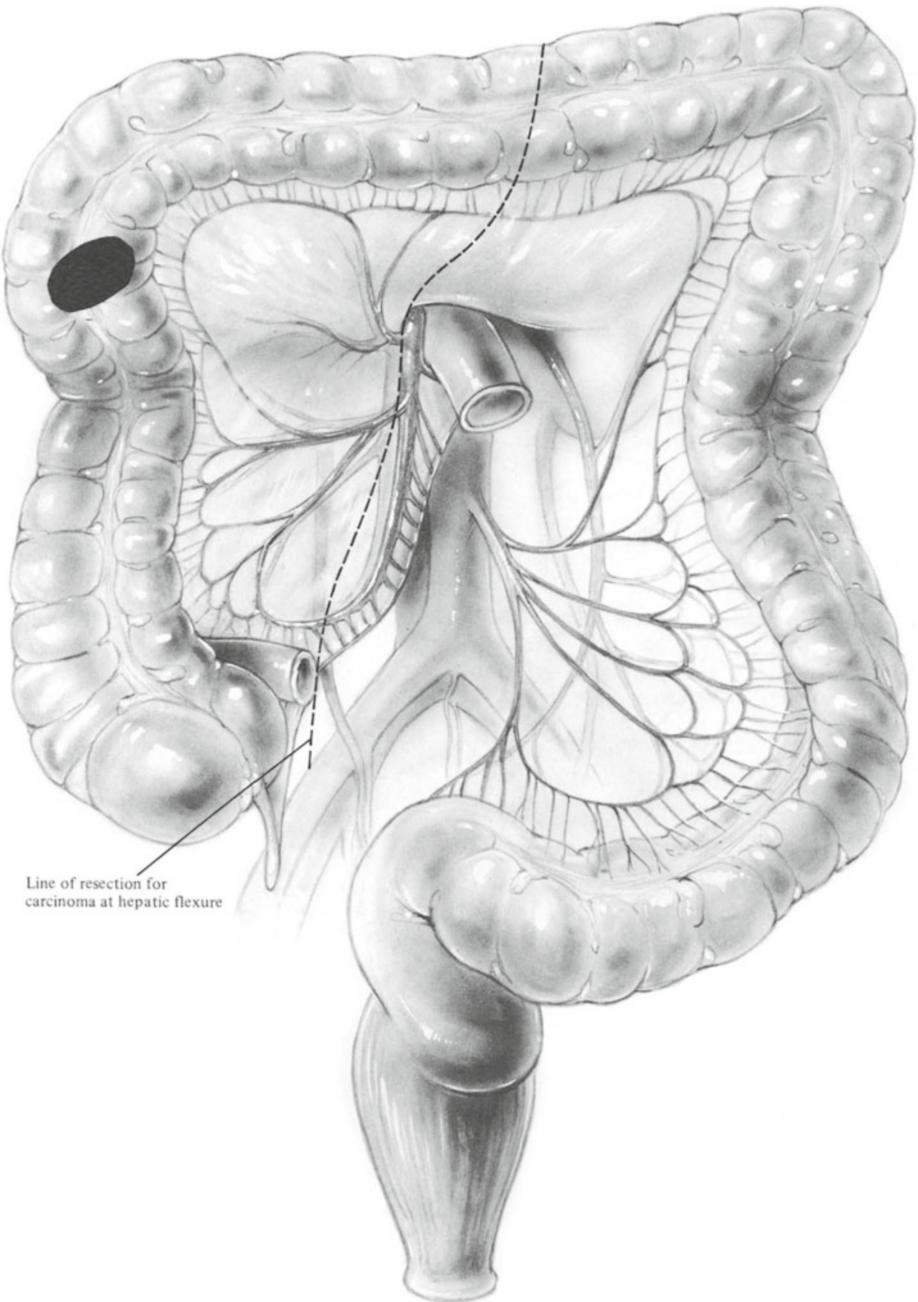

Fig. 49.2

centered extending from a point midway between the anterior superior iliac spine and the lower edge of the ribcage medially toward the midline is preferred by some surgeons. Explore the abdomen for hepatic, pelvic, peritoneal, and nodal metastases. A solitary hepatic metastasis may well be resected at the same time the colectomy is performed. A moderate degree of hepatic metastasis is not a contraindication to removing a locally resectable colon carcinoma. Inspect the primary tumor but avoid manipulating it at this stage.

Ligature of Colon Proximal and Distal to Tumor

Insert a blunt Mixter right-angle clamp through an avascular portion of the mesentery close to the colon, distal to the tumor, and draw a 3 mm umbilical tape through this puncture in the mesentery. Tie the umbilical tape firmly to occlude the lumen of the colon completely. Carry out an identical maneuver at a point on the terminal ileum, thereby completely occluding the lumen proximal and distal to the tumor.

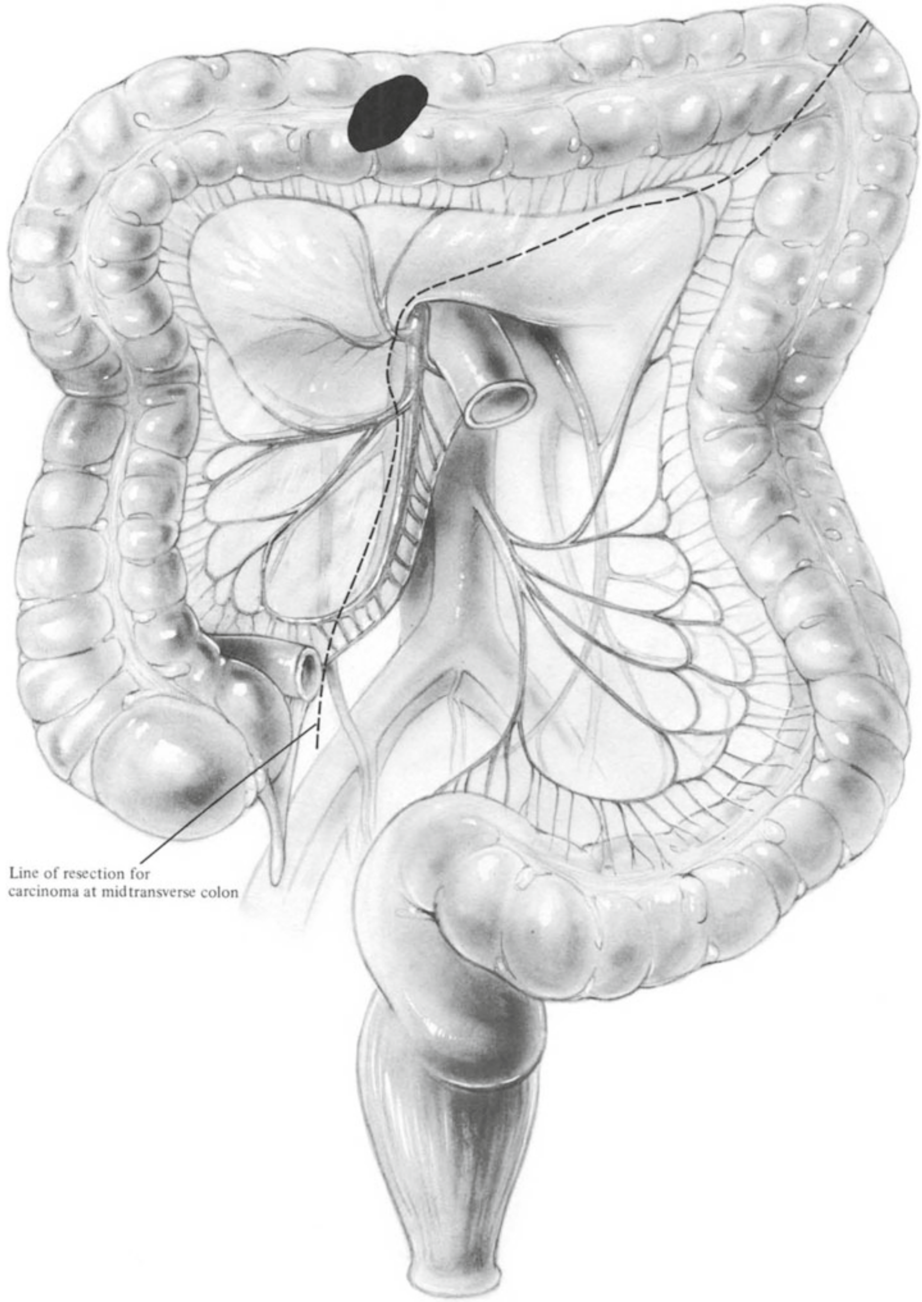

Fig. 49.3

Omental Dissection

For a carcinoma located in the hepatic flexure, divide the adjacent omentum between serially applied Kelly hemostats just distal to the gastroepiploic arcade of the stomach (Fig. 49.4). If the neoplasm is located in the cecum, there appears to be no merit in resecting the omentum. The omentum may be dissected (with scalpel and Metzenbaum scissors) off the right half of the transverse colon through the avascular plane, resecting only portions adhering to the cecal tumor. After this has been accomplished, with the transverse colon drawn in a caudal direction, the middle colic vessels can be seen as they emerge from the lower border of the pancreas to cross over the retroperitoneal duodenum.

Division of Middle Colic Vessels

During operations for carcinoma of the cecum and the proximal 5–7 cm of the ascending colon, it is not necessary to

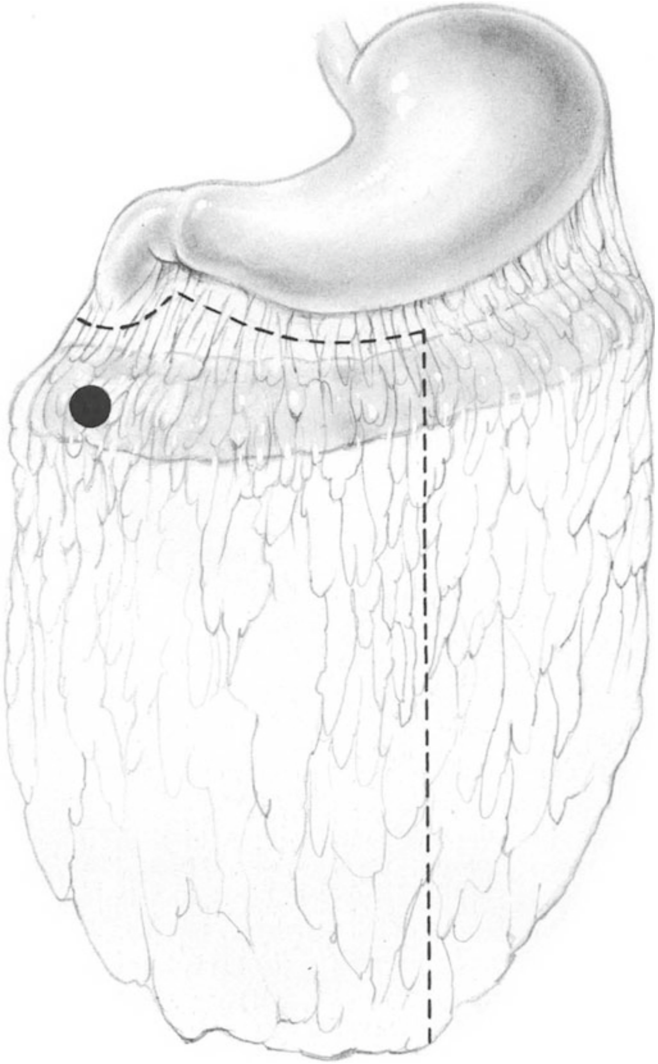

Fig. 49.4

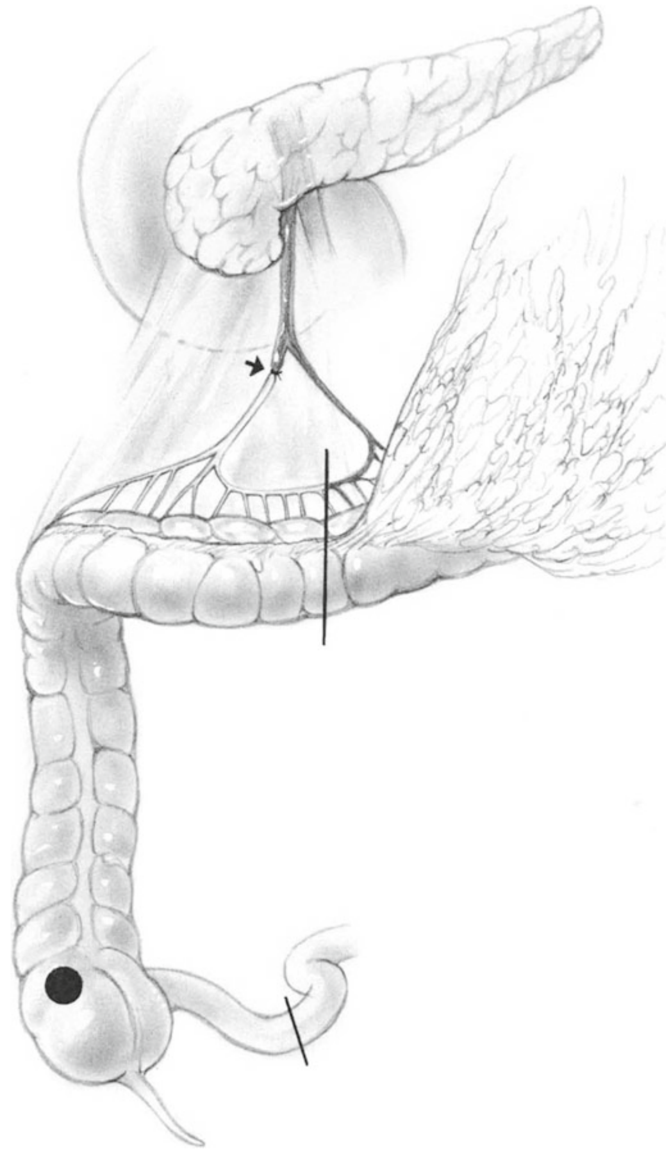

Fig. 49.5

divide the middle colic vessels before they branch (Fig. 49.1). The left branch of the middle colic vessel may be preserved and the right branch divided and ligated just beyond the bifurcation (Fig. 49.5).

During operations for tumors near the hepatic flexure of the transverse colon, dissect the middle colic vessels up to the lower border of the pancreas (Figs. 49.2, 49.3, and 49.6). Be careful not to avulse a fairly large collateral branch that connects the inferior pancreaticoduodenal vein with the middle colic vein (Fig. 49.7). If this is torn, considerable bleeding follows, as the proximal end of the pancreaticoduodenal vein retracts and is difficult to locate. Gentle dissection is necessary, as these structures are fragile. Place a Mixter clamp deep to the middle colic vessels at the appropriate point; then draw a 2-0 silk ligature around the vessels and ligate them. Sweep any surrounding lymph nodes down toward the specimen and place a second ligature 1.5 cm distal to the first. Divide the vessels 1 cm beyond the proximal ligature. Divide the mesocolon toward the point on the transverse colon already selected for division. Divide and ligate the marginal artery and clear the transverse colon of fat and areolar tissue in preparation for an anastomosis. Now apply an Allen clamp to the transverse colon, but to minimize bacterial contamination of the abdominal cavity, do not transect the colon at this time.

Division of Ileocolic Vessels

Retract the transverse colon in a cephalad direction. Pass the left index finger deep to the right mesocolon (Fig. 49.8), inserting the finger through the incision already made in the

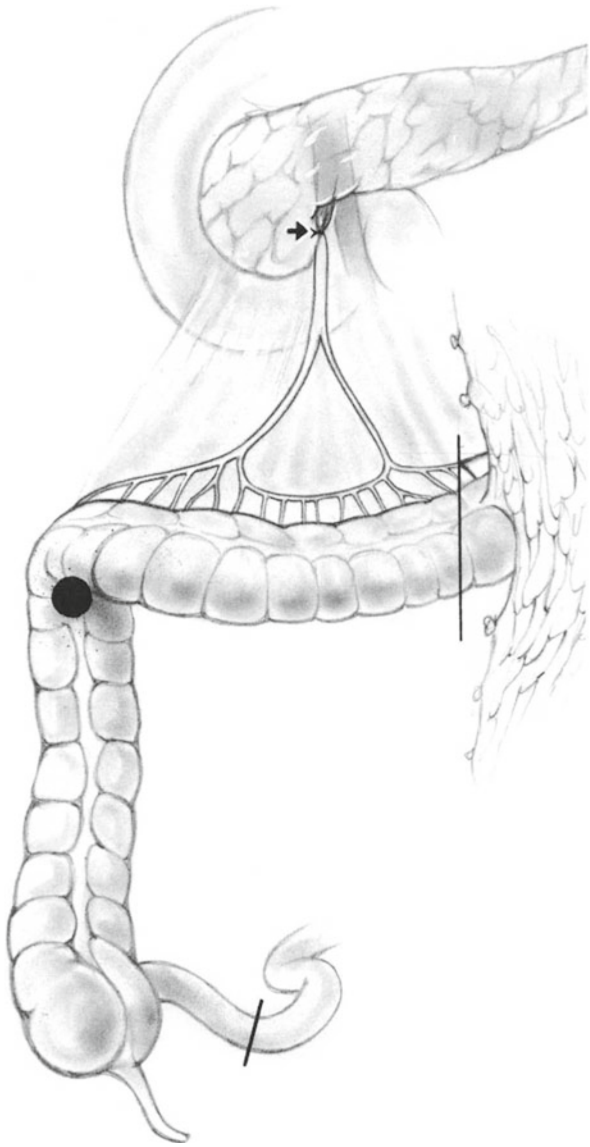

Fig. 49.6

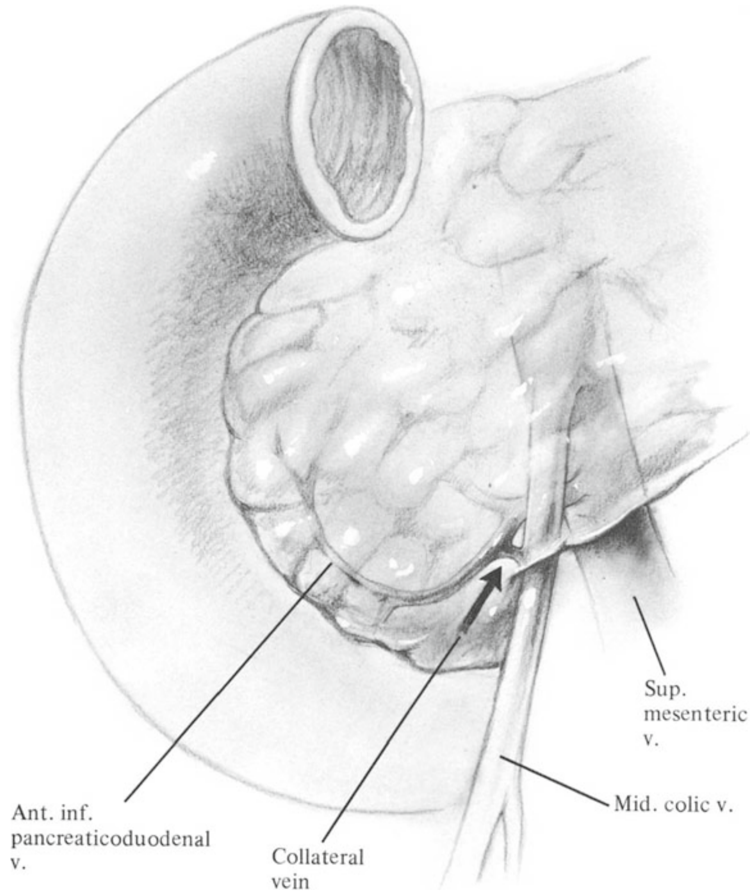

Fig. 49.7

transverse mesocolon. Gentle finger dissection should disclose, in front of the fingertip, a fairly large artery with vigorous pulsation; it is the ileocolic arterial trunk (Fig. 49.8). As the surgeon's index finger moves toward the patient's left, it palpates the adjacent superior mesenteric artery. After identifying these two major vessels, it is a simple matter to incise the peritoneum overlying the ileocolic artery with Metzenbaum scissors. By gentle dissection, remove areolar and lymphatic tissue from the circumference of the ileocolic artery and vein. After rechecking the location of the superior mesenteric vessels, pass a blunt Mixter right-angle clamp underneath the ileocolic artery and vein. Ligate the vessels individually with 2-0 silk ligatures and divide them at a point about 1.5 cm distal to their junctions with the superior mesenteric vessels.

Division of Ileal Mesentery

Pass the left index finger behind the remaining right mesocolon into an avascular area of 3–4 cm. This can be divided and leads to the mesentery of the terminal ileum. For neoplasms close to the ileocecal junction, include 10–15 cm of ileum in the specimen.

For tumors near the hepatic flexure, no more than 8–10 cm of ileum need be resected. In any case, divide the ileal mesentery between Crile hemostats applied serially until the wall of the ileum has been encountered. After ligating each of the hemostats with 3-0 or 2-0 PG, clear the areolar tissue from the circumference of the ileum in preparation for an anastomosis and apply an Allen clamp to this area. At this point the specimen has been isolated from any vascular connection with the host.

Division of Right Paracolic Peritoneum

Retract the right colon in a medical direction and make an incision in the peritoneum of the paracolic gutter (Fig. 49.8).

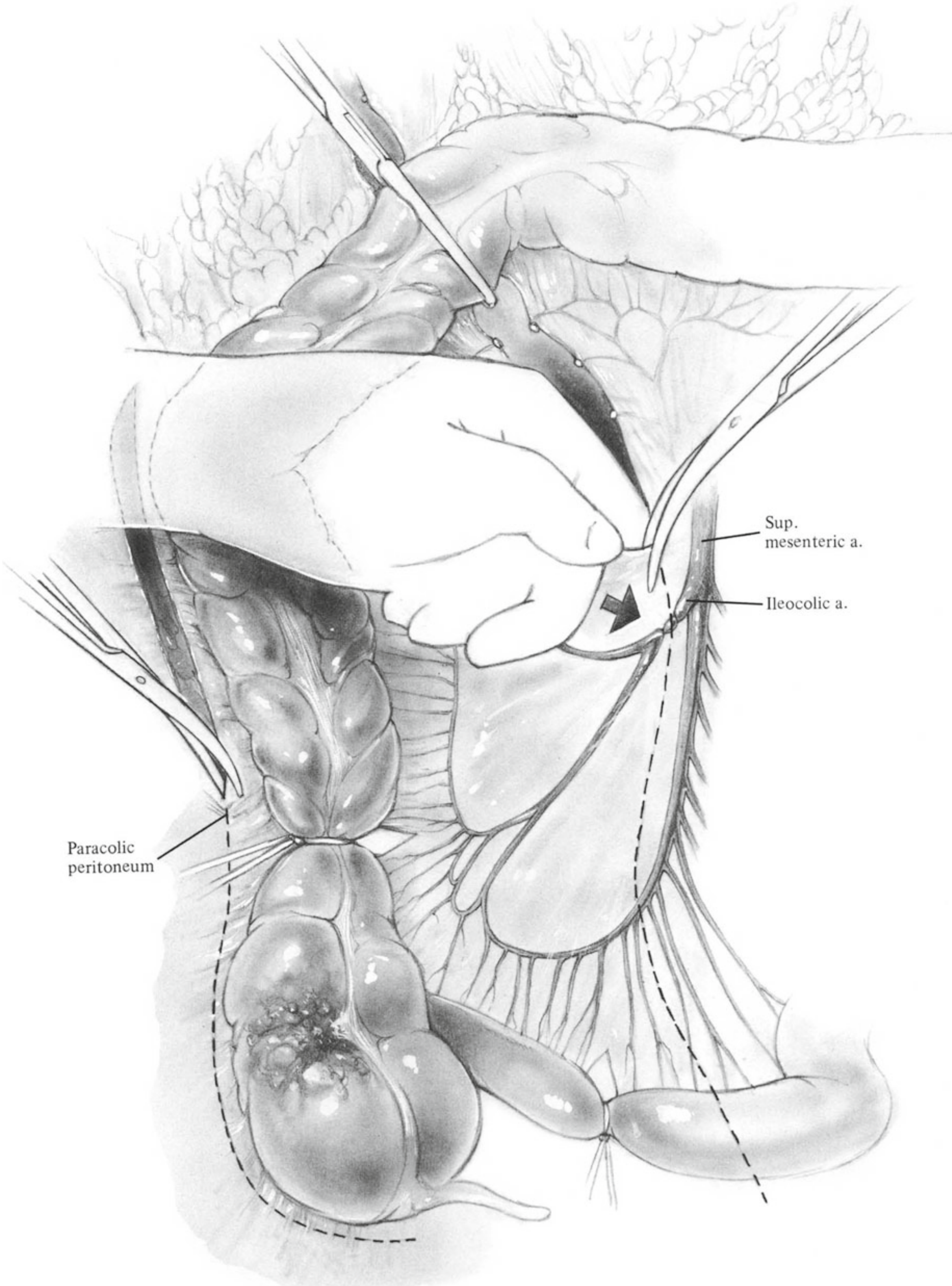

Fig. 49.8

The left index finger may be inserted deep to this layer of peritoneum, which should then be transected over the index finger with Metzenbaum scissors or electrocautery. Continue this dissection until the hepatic flexure is free of lateral attachments. Rough dissection around the retroperitoneal duodenum may lacerate it inadvertently, so be aware of its location. Next, identify the right renocolic ligament and divide it by Metzenbaum dissection. When this is accomplished, the fascia of Gerota and the perirenal fat may be gently swept from the posterior aspect of the right mesocolon. Continue this dissection caudally, eventually unroofing the ureter and gonadal vessel.

Identification of Ureter

If the location of the ureter is not immediately evident, identify the right common iliac artery. The undisturbed ureter generally crosses the common iliac artery where it bifurcates into its internal and external branches. If the ureter is not in this location, elevate the lateral leaflet of the peritoneum, as the ureter may be adhering to the undersurface of this peritoneal flap. The ureter is often displaced by retraction of the peritoneal flap to which it adheres. If the ureter is not present on the lateral leaflet of peritoneum, similarly elevate and seek it on the medial leaflet of the peritoneum. Typical ureteral peristalsis should occur when the ureter is compressed with forceps.

The right colon remains attached to the peritoneum now only at the inferior and medial aspects of the cecum and ileum. There should be no difficulty dividing it.

Division of Ileum and Colon

Protect the abdomen with large gauze pads and remove the specimen and the Allen clamps that had been applied to the ileum and transverse colon. If necessary, linen-shod Doyen noncrushing intestinal clamps may be applied to occlude the ileum and transverse colon at a point at least 10 cm from their cut edges in preparation for an open, two-layer end-to-end anastomosis (Fig. 49.9).

Before the anastomosis is begun, the blood supply must be carefully evaluated. Generally there is no problem with the terminal ileum if no hematoma has been induced. Test the adequacy of the blood supply to the cut end of the colon by palpating the pulse in the marginal artery. For additional data about the blood supply, divide a small arterial branch near the cut end of the colon and observe the pulsatile arterial flow. If there is any question about the vigor of the blood supply, resect additional transverse colon.

Ileocolic Two-Layer Sutured End-to-End Anastomosis

Align the cut ends of the ileum and transverse colon to face each other so their mesenteries are not twisted. Because the diameter of ileum is narrower than that of the colon, make a Cheatle slit with Metzenbaum scissors on the antimesenteric border of the ileum for a distance of 1–2 cm to help equalize these two diameters (Fig. 49.10). Do not round off the corners of the slit.

Insert the first seromuscular layer of interrupted sutures using 4-0 silk on atraumatic needles. Initiate this layer by inserting the first Lembert suture at the antimesenteric border and the second at the mesenteric border to serve as guy sutures. Attach hemostats to each of these sutures. Drawing the two hemostats apart makes insertion of additional sutures by successive bisection more efficient (Fig. 49.11). Now complete the anterior seromuscular layer of the anastomosis by inserting interrupted Lembert seromuscular sutures (Fig. 49.12). After the entire anterior layer has been inserted and tied, cut the tails of all the sutures except the two guy sutures.

To provide exposure for the mucosal layer, invert the anterior aspect of the anastomosis by passing the hemostat containing the antimesenteric guy suture (Fig. 49.13A) through the rent in the mesentery deep to the ileocolonic anastomosis. Then draw the mesenteric guy suture (Fig. 49.13B) in the opposite direction and expose the mucosa for application of the first layer of mucosal sutures (Fig. 49.14). Use 5-0 PG, double-armed, and begin the first suture at the midpoint (Fig. 49.15a). Then pass the suture in a continuous fashion toward the patient's right to lock each stitch. Take relatively small bites (4 mm). When the right margin of the suture line is reached, tag the needle with a hemostat; with the second needle, initiate the remainder of the mucosal approximation, going from the midpoint of the anastomosis toward the patient's left in a continuous locked fashion (Fig. 49.15b). When this layer has been completed (Fig. 49.15c), close the superficial mucosal layer of the anastomosis with continuous Connell or Cushing sutures beginning at each end of the anastomosis. Terminate the mucosal suture line in the midpoint of the superficial layer by tying the suture to its mate (Fig. 49.16).

Accomplish the final seromuscular layer by inserting interrupted 4-0 silk Lembert sutures (Fig. 49.17). Devote special attention to ensuring a secure closure at the mesenteric border. Then cut all the sutures and test the lumen with the thumb and forefinger to gauge the width of the anastomotic stoma. It should admit the tip of the thumb.

Close the defect in the mesentery by continuous 2-0 PG sutures. Take care to avoid occluding important vessels

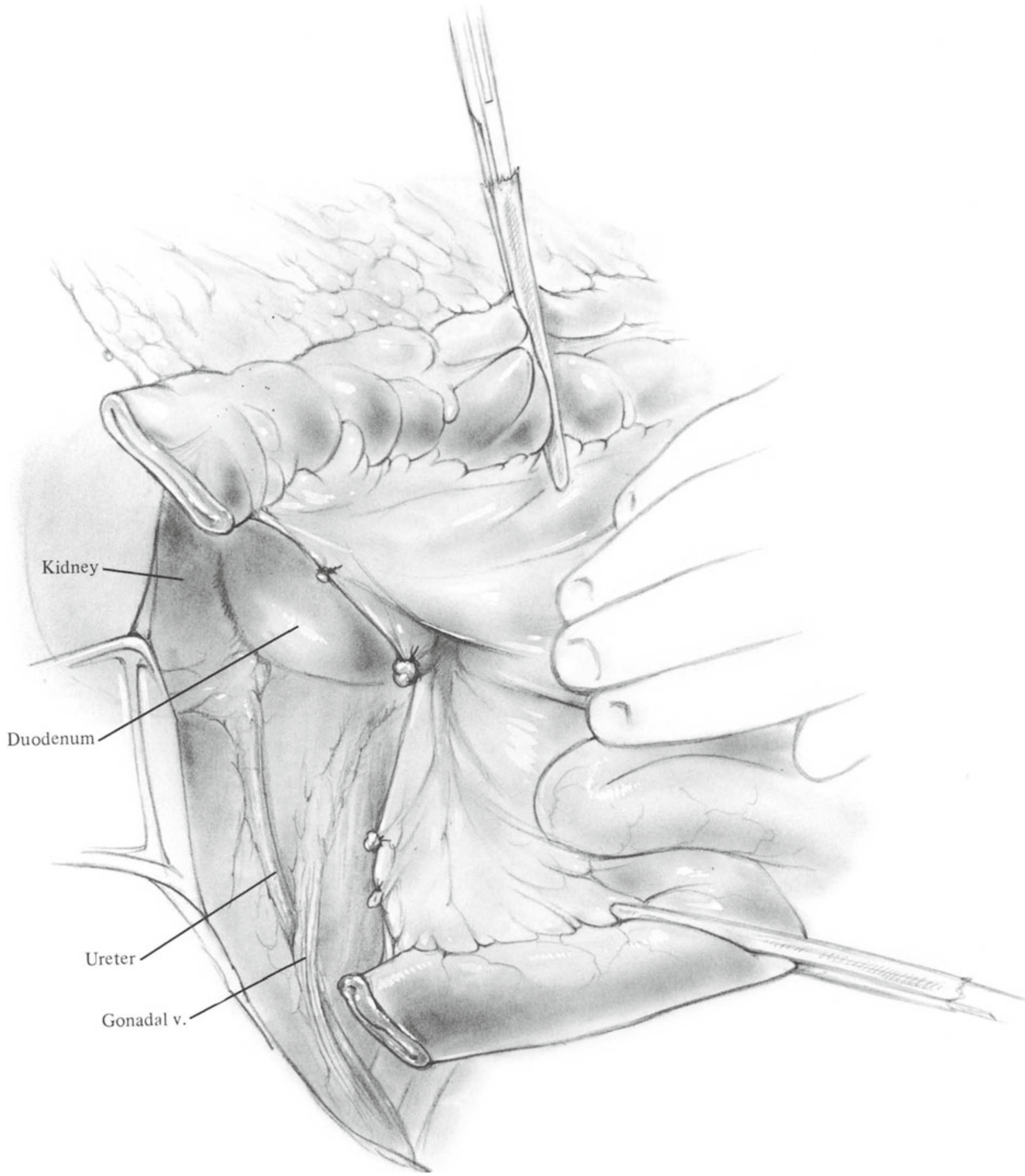

Fig. 49.9

running in the mesentery during the course of the continuous suture. If desired, a one-layer anastomosis can be constructed by the technique described above, simply by omitting the mucosal suture. If it is accomplished without error, the result is as successful as after the two-layer method.

Anastomosis by Stapling, Functional End-to-End

To perform a stapled anastomosis, clear an area of mesentery and apply the 55/3.5 mm linear stapler transversely across the colon. Transect the colon flush with the stapler using a

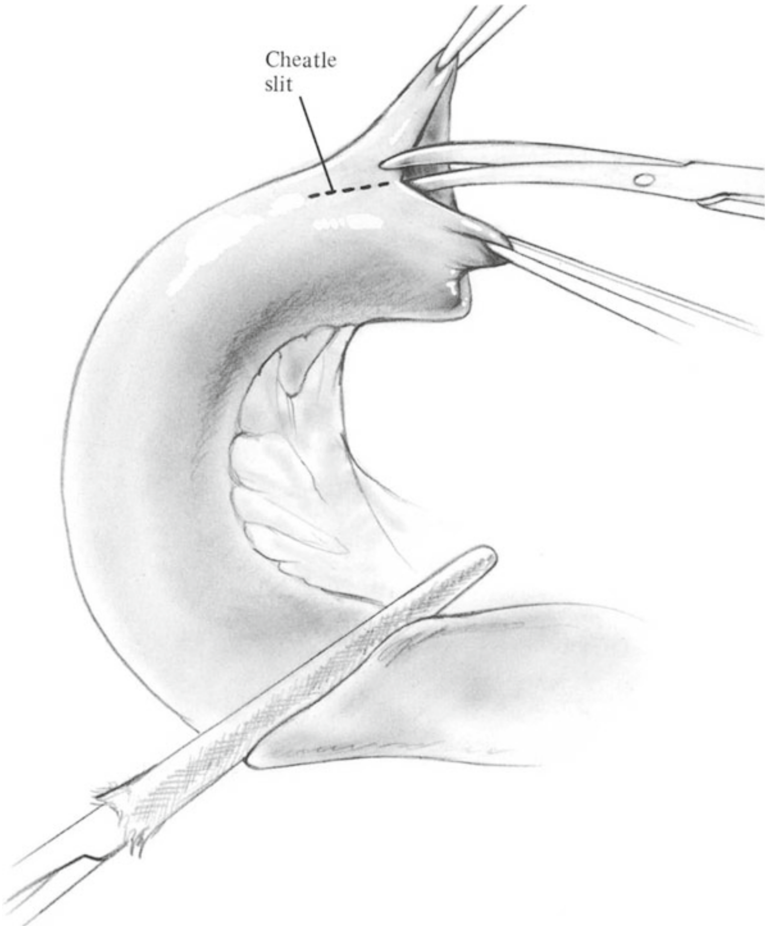

Fig. 49.10

scalpel. Carry out the identical procedure at the selected site on the ileum. Alternatively, the bowel may be stapled and divided with the linear cutting stapler. Some oozing of blood should be evident despite the double row of staples. Control excessive bleeding by carefully applying electrocoagulation or chromic sutures. Align the ileum and colon side by side, and with heavy scissors, excise a triangular 8 mm wedge from the antimesenteric margins of both ileum and colon (Fig. 49.18).

Insert one of the two forks of the cutting linear stapling instrument into the lumen of the ileum and the other into the colon, *hugging the antimesenteric border* of each (Fig. 49.19). Neither segment of intestine should be stretched, as it may result in excessive thinning of the bowel, leaving inadequate substance for the staples to grasp. After ascertaining that both segments of the bowel are near the hub of the stapler, fire the device; this should result in a side-to-side anastomosis 4–5 cm long. Unlock and remove the device and inspect the staple line for bleeding and possible technical failure when closing the staples.

Now apply Allis clamps to the remaining defect in the anastomosis and close it by a final application of the 55/3.5 mm linear stapling instrument (Fig. 49.20). Take care to include a portion of *each of the previously applied staples lines* in the final application of the stapler. However, when applying the Allis clamps, do not align points X and Y (Fig. 49.21) exactly opposite each other, as it would result in six staple lines meeting at one point. The alignment of these two points, as shown in Fig. 49.22, produces the best results. Check the patency of the anastomosis by invaginating the colon through

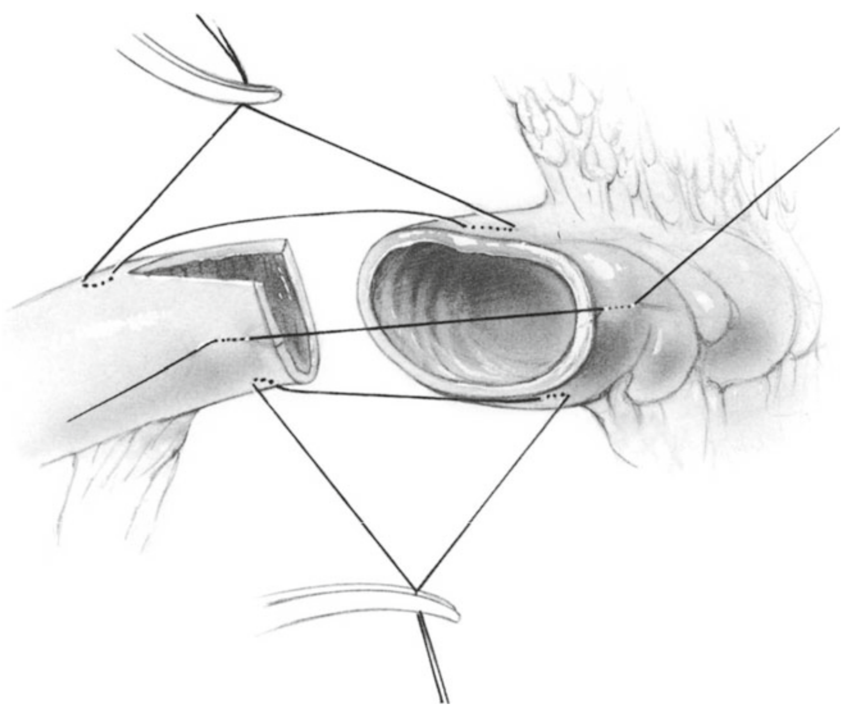

Fig. 49.11

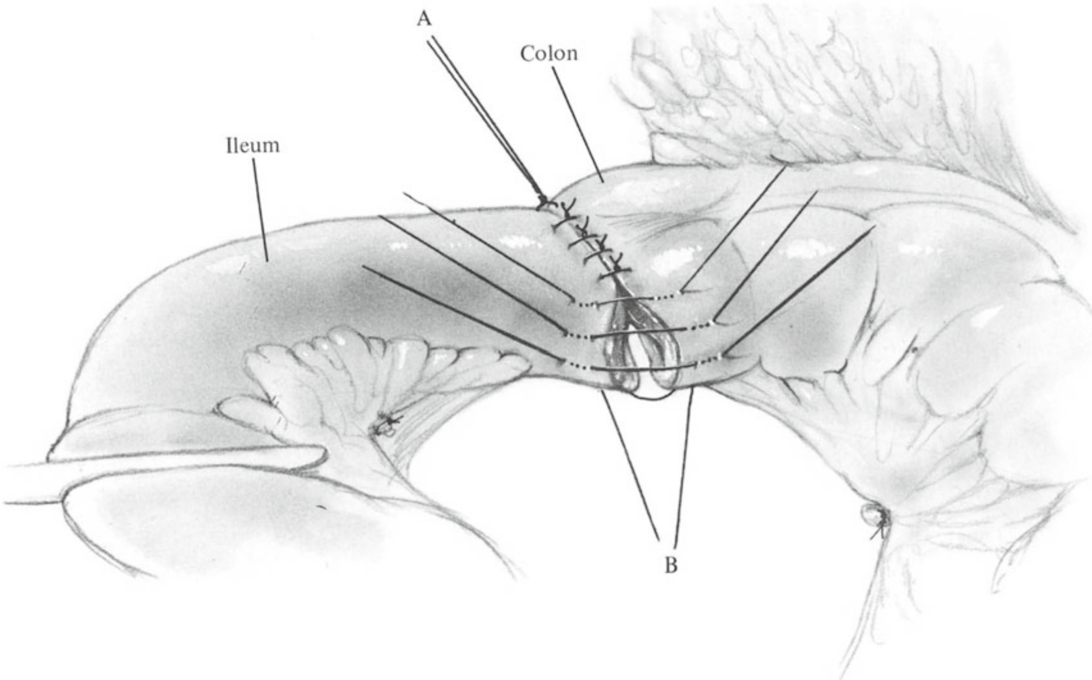

Fig. 49.12

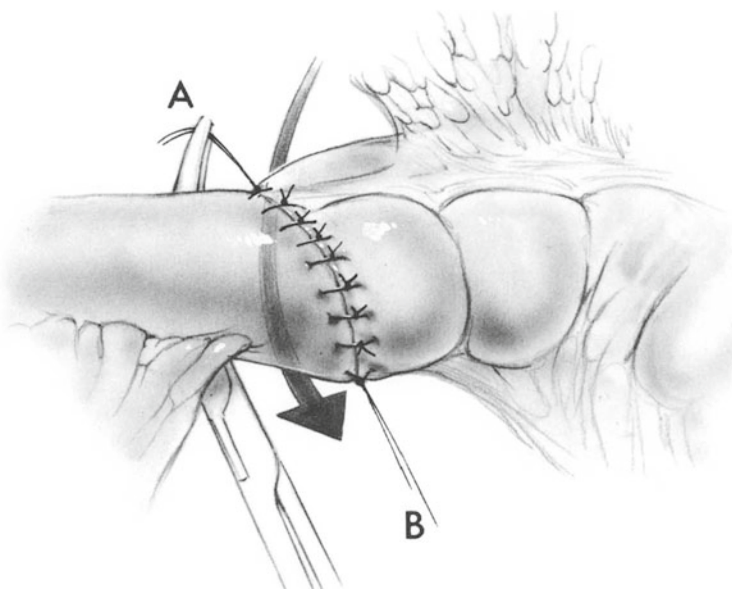

Fig. 49.13

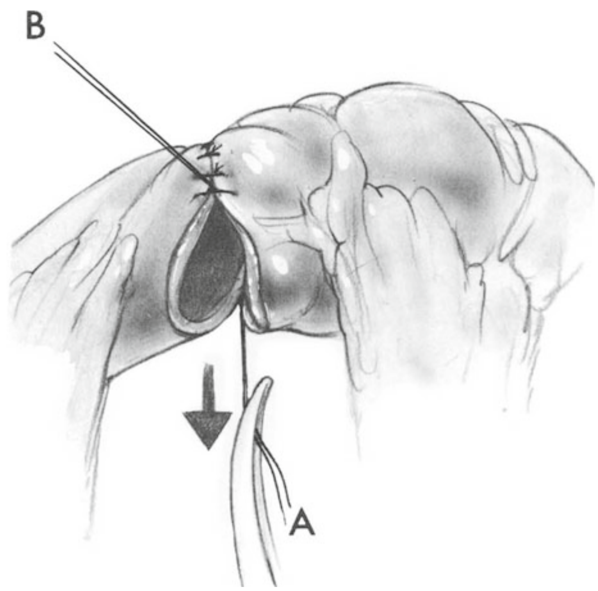

Fig. 49.14

the anastomosis, which should admit the tips of two fingers. Then lightly touch the everted mucosa with the electrocautery instrument. During closure of the mesentery, cover the everted staple lines with adjoining mesentery or omentum if convenient.

We have modified Steichen's method of anastomosing ileum to colon, making it simpler by eliminating two applications of the stapler. With our technique, the first step is to insert the cutting linear stapling device, one fork into the open end of ileum and the other fork into the open colon. Then fire the stapler, establishing a partial anastomosis between the antimesenteric borders of ileum and colon, as seen in Fig. 49.21. Apply four or five Allis clamps to approximate the lips of the ileum and colon (in eversion), taking care that points X and Y are not in apposition. Then apply a 90/3.5 mm linear stapler underneath the Allis clamps and fire the staples. The end result is illustrated in Fig. 49.23. In our experience this is the most

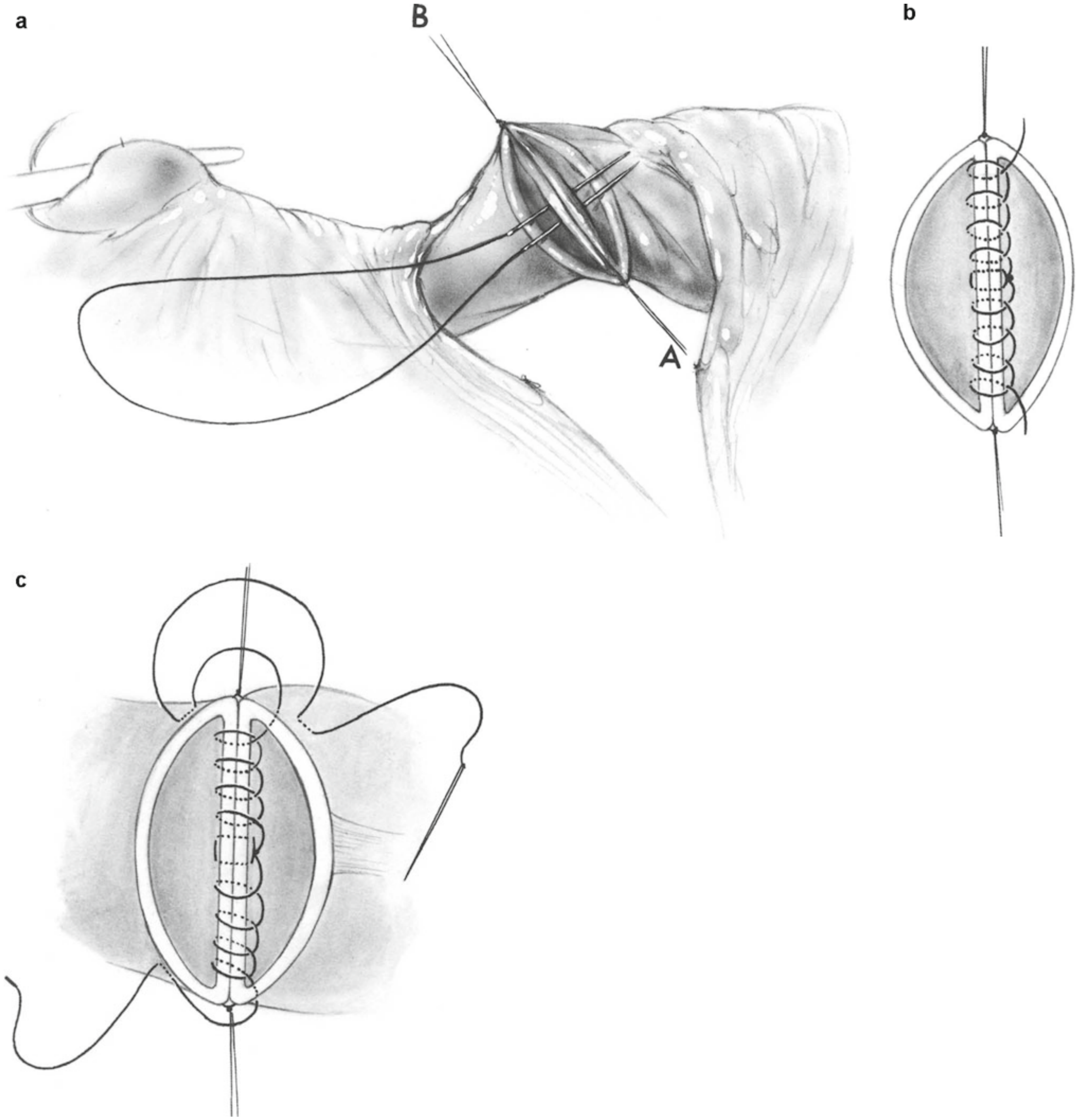

Fig. 49.15

efficient and reliable method for constructing an ileocolonic anastomosis.

Wound Closure

The surgical team now changes gloves and discards all instruments used up to this point. Irrigate the operative field with saline. Cover the anastomosis with omentum if possible. Close the abdomen in routine fashion without drainage.

Postoperative Care

Discontinue gastric suction in the operating room or as soon as possible thereafter.

Initiate early oral intake of liquids and food as tolerated.

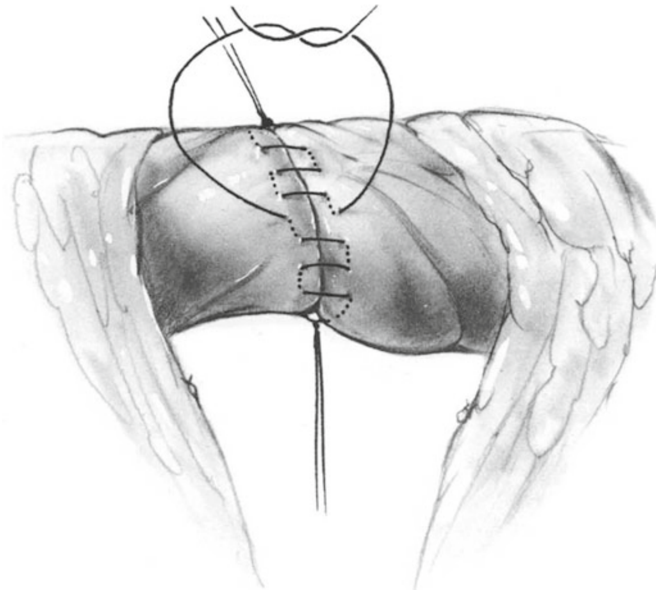

Fig. 49.16

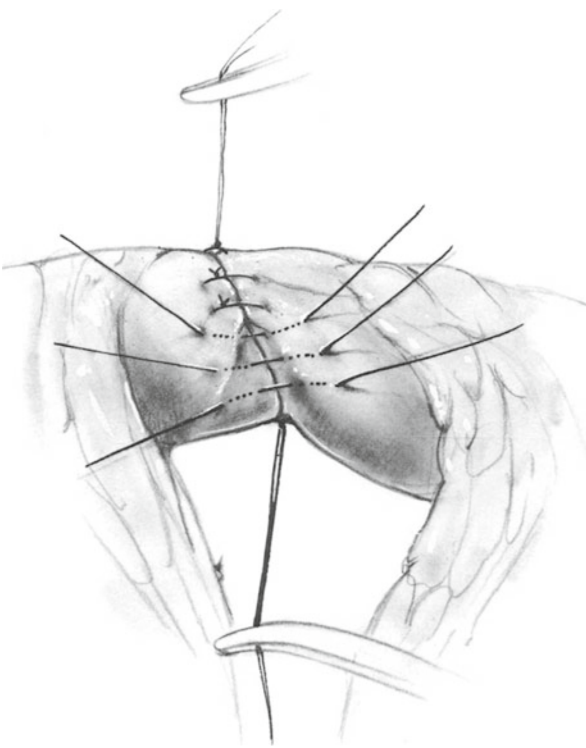

Fig. 49.17

If ileus occurs, discontinue oral intake and perform CT of the abdomen to exclude abscess, obstruction, or leak.

In the absence of preoperative intra-abdominal sepsis, discontinue antibiotics after the operation.

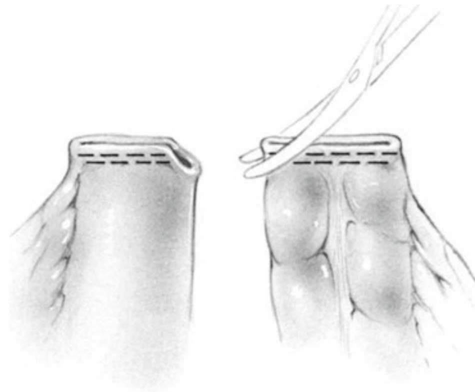

Fig. 49.18

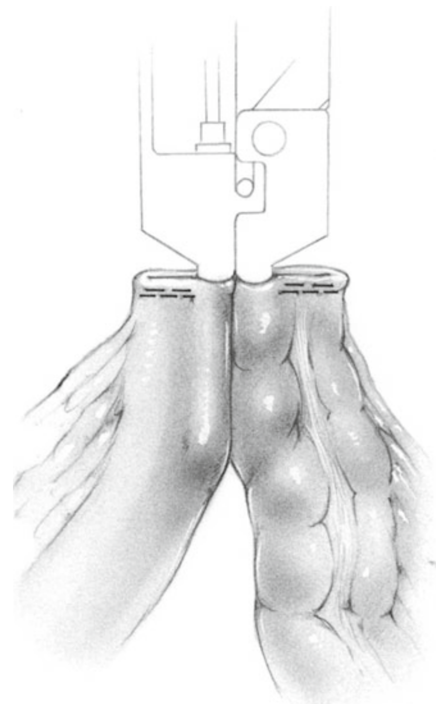

Fig. 49.19

Complications

Leakage from an ileocolonic or colocolonic anastomosis may manifest as peritonitis, colocutaneous fistula, or localized intraperitoneal abscess. Localized or spreading peritonitis should be managed by prompt relaparotomy and exteriorization of both ends of the anastomosis.

Sepsis in the subhepatic, subphrenic, or pelvic areas is an occasional complication of anastomoses of the colon, even in the absence of leakage. CT of the abdomen generally provides the diagnosis, and percutaneous drainage is usually successful.

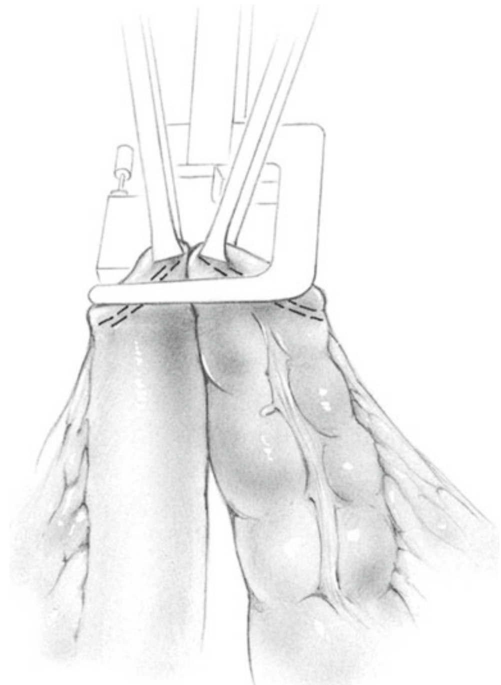

Fig. 49.20

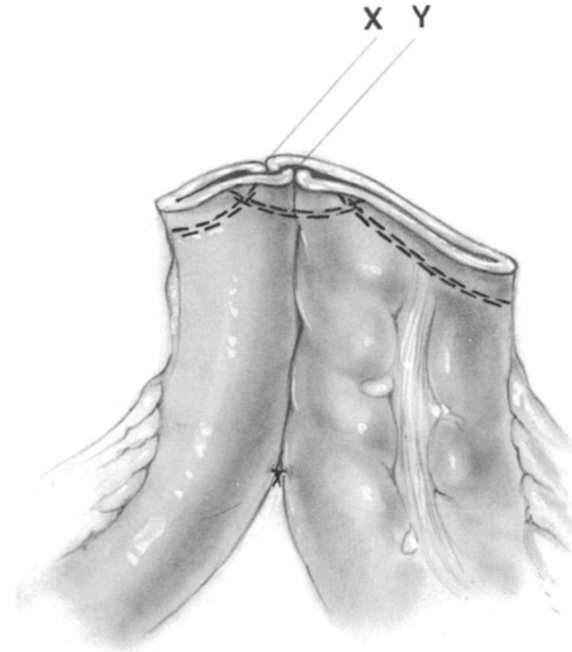

Fig. 49.22

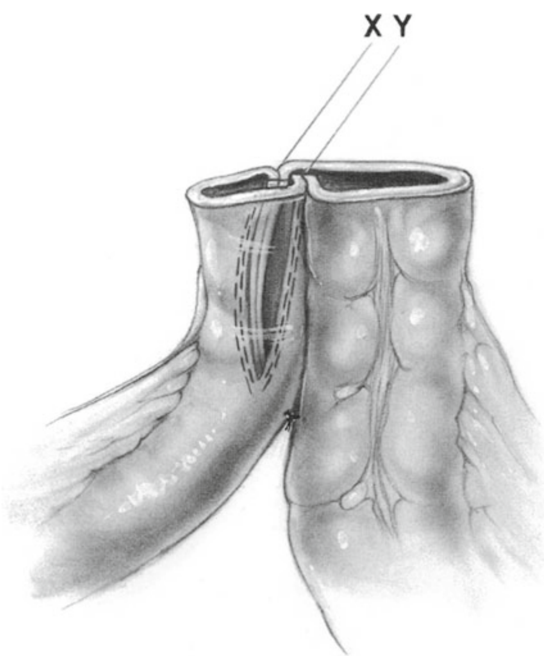

Fig. 49.21

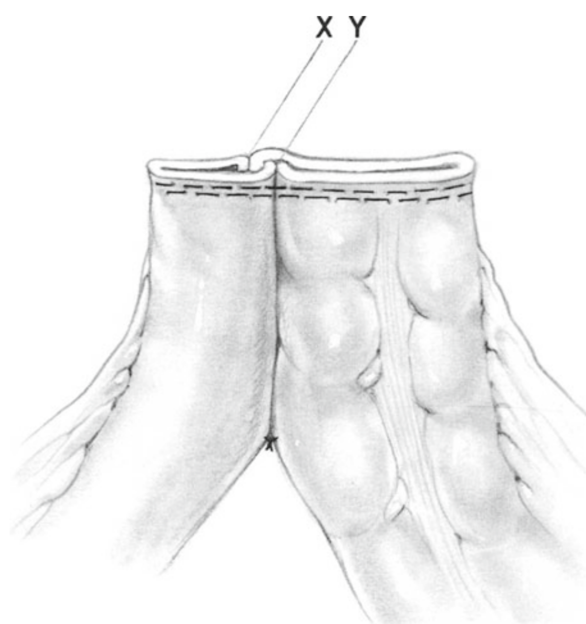

Fig. 49.23

Wound infection requires prompt removal of all overlying skin sutures to permit wide drainage of the entire infected area.

Further Reading

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Laparoscopic Right Hemicolectomy

50

Steven D. Wexner and Susan M. Cera

Indications

Ileocolic Crohn's disease
Endoscopically irretrievable adenomatous polyps
Arteriovenous malformations
Cecal volvulus
Ischemia
Carcinoma
Right-sided diverticulitis

Pitfalls and Danger Points

Injury to liver, duodenum, or contents of the hepatoduodenal ligament
Hemorrhage from epigastric, mesenteric, iliac, or gonadal vessels
Inadvertent enterotomy or colotomy
Inadvertent retrorenal dissection
Anastomotic insufficiency or twist

Preoperative Preparation

Preoperatively, patients undergo an appropriate medical evaluation. Imaging studies including CT scan, barium studies, and colonoscopy are undertaken for preoperative planning to assess the location of disease, review any associated complications, and identify any synchronous lesions. Preoperative marking of polyps by endoscopic tattooing using India ink is necessary to ensure intraoperative identification of the lesion and to avoid the need for intraoperative colonoscopy. In patients with recurrent Crohn's disease or history of multiple laparotomies, imaging studies are particularly important in providing "roadmaps" to define the extent of previous resections, length of remaining bowel, and degree of previous mobilization of flexures. Preoperative mechanical and antibiotic bowel preparation consists of 45 cc sodium phosphate solution (Fleets phosphosoda; C.B. Fleet Co., Inc., Lynchburg, VA) PO at 4 pm and at 9 pm, each followed by 3–8 oz glasses of water, and 1 g neomycin with 500 mg metronidazole at 7:00 and 11:00 pm. In addition, 2 g of cefotetan are administered intravenously and 5,000 units of heparin injected subcutaneously at the start of the operation.

Operative Strategy

Elective laparoscopic right hemicolectomy is performed in a laparoscopic-assisted fashion with intracorporeal mobilization of the ileum, cecum, and hepatic flexure medially to the level of the duodenum and middle colic vessels. The bowel is then exteriorized through a small midline port incision extended to approximately 4 cm. Extracorporeal division of the mesentery is followed by resection of bowel and creation of a side-to-side functional end-to-end ileocolic anastomosis. The bowel is returned to the abdomen, and re-insufflation allows final inspection of the intraperitoneal contents.

The resection may be performed in a lateral-to-medial fashion as described here. That dissection is most nearly analogous to the open hemicolectomy with which most surgeons are familiar. Alternatively, medial-to-lateral dissection is feasible (see references at the end). Dissection may begin at the cephalad aspect of the field and progress caudally or vice versa.

For patients with primary or recurrent Crohn's ileitis, significant inflammation and adhesions may be encountered. Dissection is initiated in areas free of inflammation to

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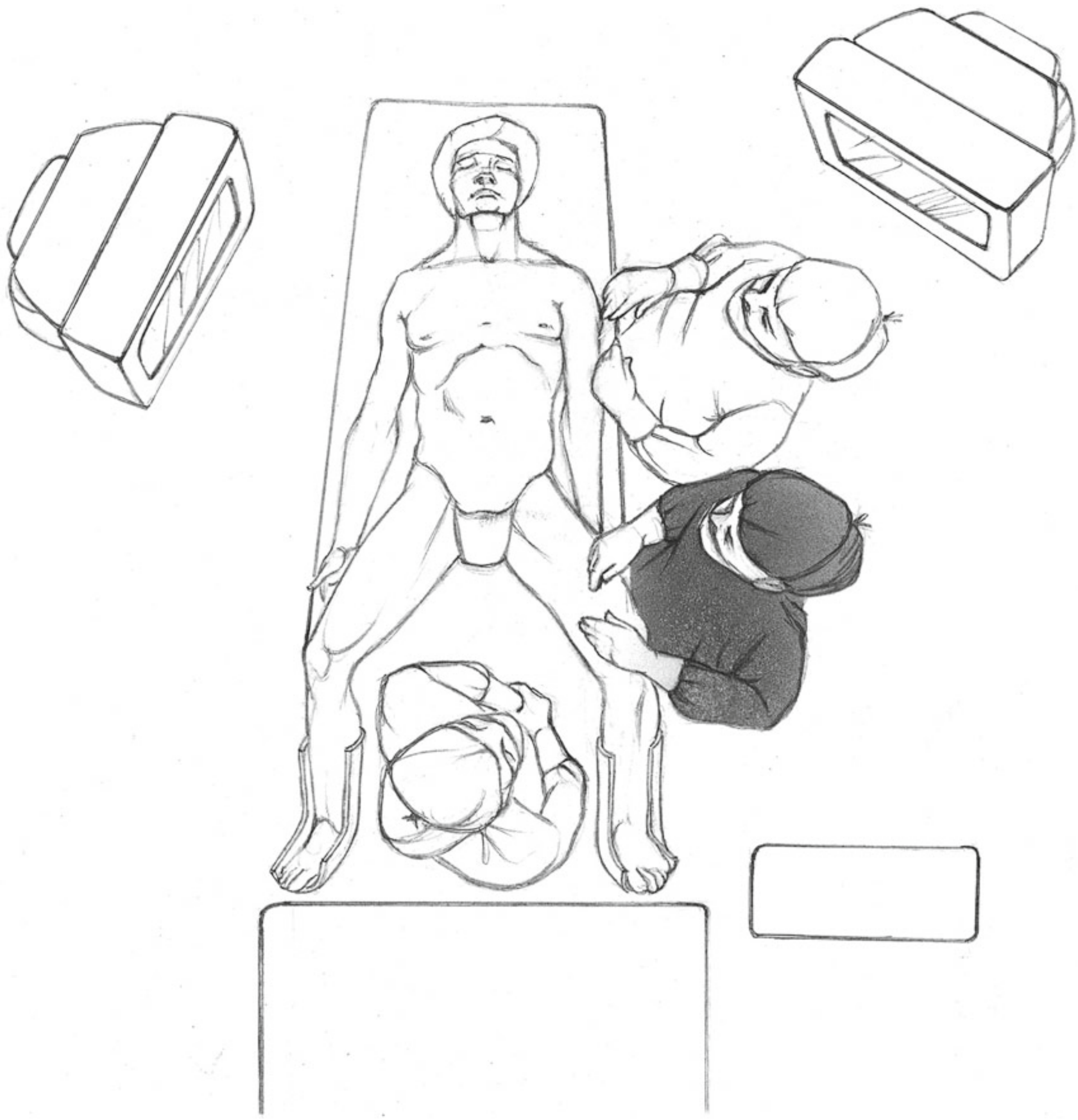

Fig. 50.1

identify appropriate planes. Thorough inspection of the small bowel from the ileocecal valve to the jejunoduodenal junction using a two-instrument technique is essential to assess synchronous locations of disease which are addressed after maximal mobilization is accomplished laparoscopically. Resections, anastomoses, enterotomy repairs, and stricturoplasties are most easily performed extracorporeally through a limited incision, preferably midline to preserve future potential ostomy sites.

Operative Technique

Room Setup and Trocar Placement

After the induction of general anesthesia, the patient is placed in the modified lithotomy position with the lower extremities in padded stirrups placed low for unimpeded movement of the instruments. Both arms are tucked at the patient's sides, and extra care is taken to secure the patient to the bed because of the rotation and tilt required during surgery. A minimum of two monitors is needed and are placed one on each side of the patient at the head of the bed (Fig. 50.1). Bilateral ureteral stents may be placed by a urologist, if desired, followed by insertion of a urinary catheter and an orogastric tube. The patient's abdomen is prepped and appropriately draped.

For port placement, the assistant stands to the right of the patient while the surgeon stays to the left. Three to four 10 mm trocars are employed for most procedures (Fig. 50.2a, b). Initially, a 10 mm trocar is placed by the open Hasson technique in the supraumbilical position through which the camera is inserted. In the reoperative abdomen, the initial trocar can be placed in the left upper quadrant in a site remote from scars. The abdomen is insufflated to an intra-abdominal pressure of 15 mmHg. Two additional

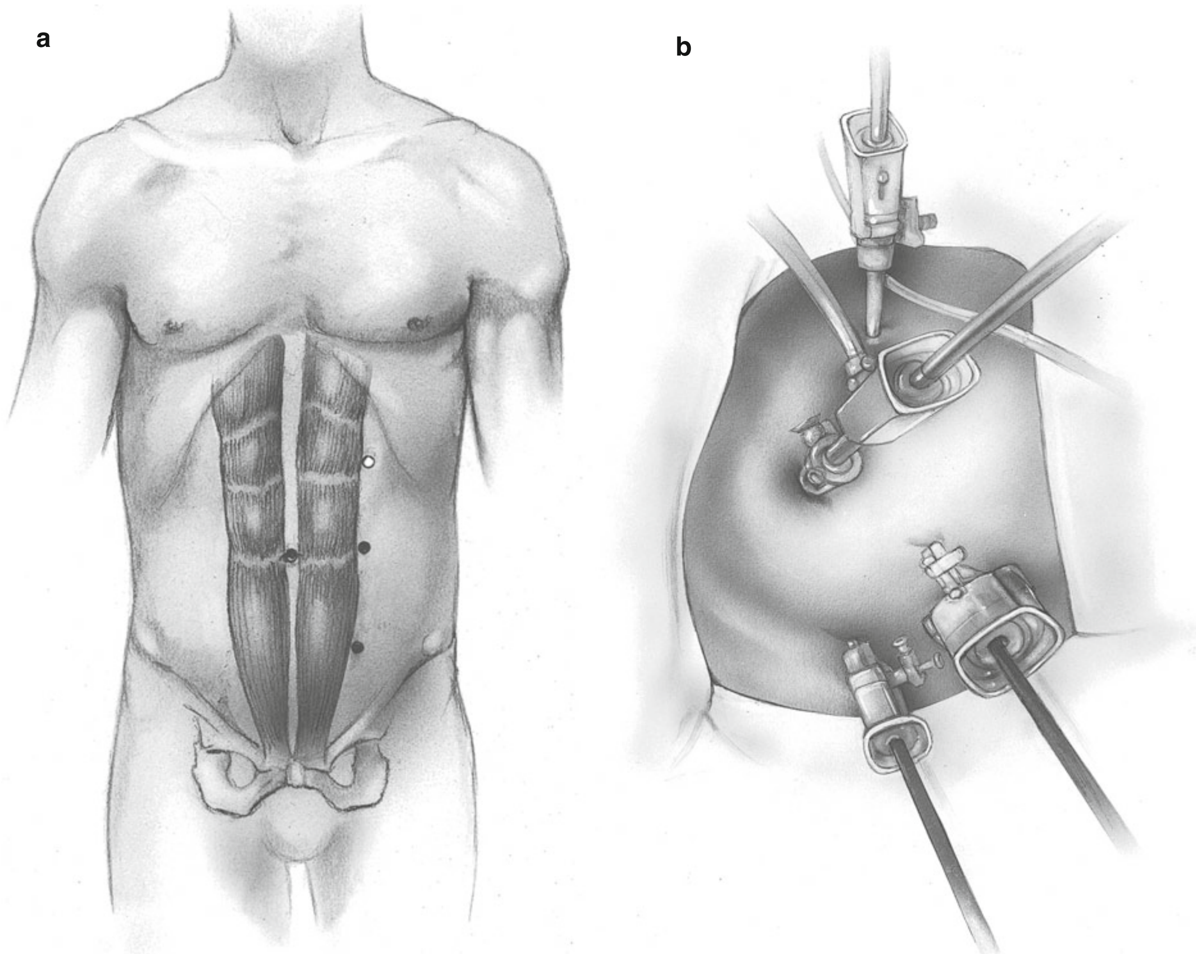

Fig. 50.2

trocars are placed along the lateral edge of the left rectus muscle, 8–10 cm apart, in the mid-abdomen and iliac fossa positions. This configuration allows adequate triangulation of the instruments to facilitate the dissection. All port placements should take into consideration the potential for future ostomy or drain sites. In obese patients or patients with extensive intra-abdominal adhesions, an optional port can be placed in the left upper quadrant to assist in retraction during dissection of the hepatic flexure. Once all ports are placed, the assistant moves to the patient's left to direct the camera.

Exploration

Exploration is undertaken to assess for adhesions and unexpected pathology and to define the extent of disease. In the cases of neoplasia, peritoneal surfaces and the liver are inspected for metastases. Extensive adhesions may require early conversion while large phlegmons or masses may require long incisions for removal obviating the need for a laparoscopic approach. Unexpected complications of inflammatory bowel disease mandates advanced laparoscopic skills and may necessitate conversion to laparotomy. Thorough inspection of the small bowel from the ileocecal valve to the jejunoduodenal junction using a two-instrument technique is essential to assess anatomy and identify pathology. Any synchronous "skip areas" of disease, such as inflammation or strictures, can be marked with sutures for subsequent resection or strictureplasty after the index resection has been accomplished through the midline incision.

Mobilization of the Cecum

The operating table is tilted toward the patient's left side, and Trendelenburg position is used to facilitate medial retraction of the right colon and prevent the small bowel from entering the field of dissection. The mesentery of the cecum is gently grasped and retracted medially using Babcock clamps placed through the left upper port. With the 10 mm ultrasonic shears placed through the left lower port, the peritoneum along the base of the terminal ileum mesentery and around the cecum is opened exposing the retroperitoneum (Fig. 50.3a). Dissection is begun in an area free of inflammation and adhesions and proceeds in the avascular plane medially under the cecum to the level of the duodenum and superiorly to the hepatic

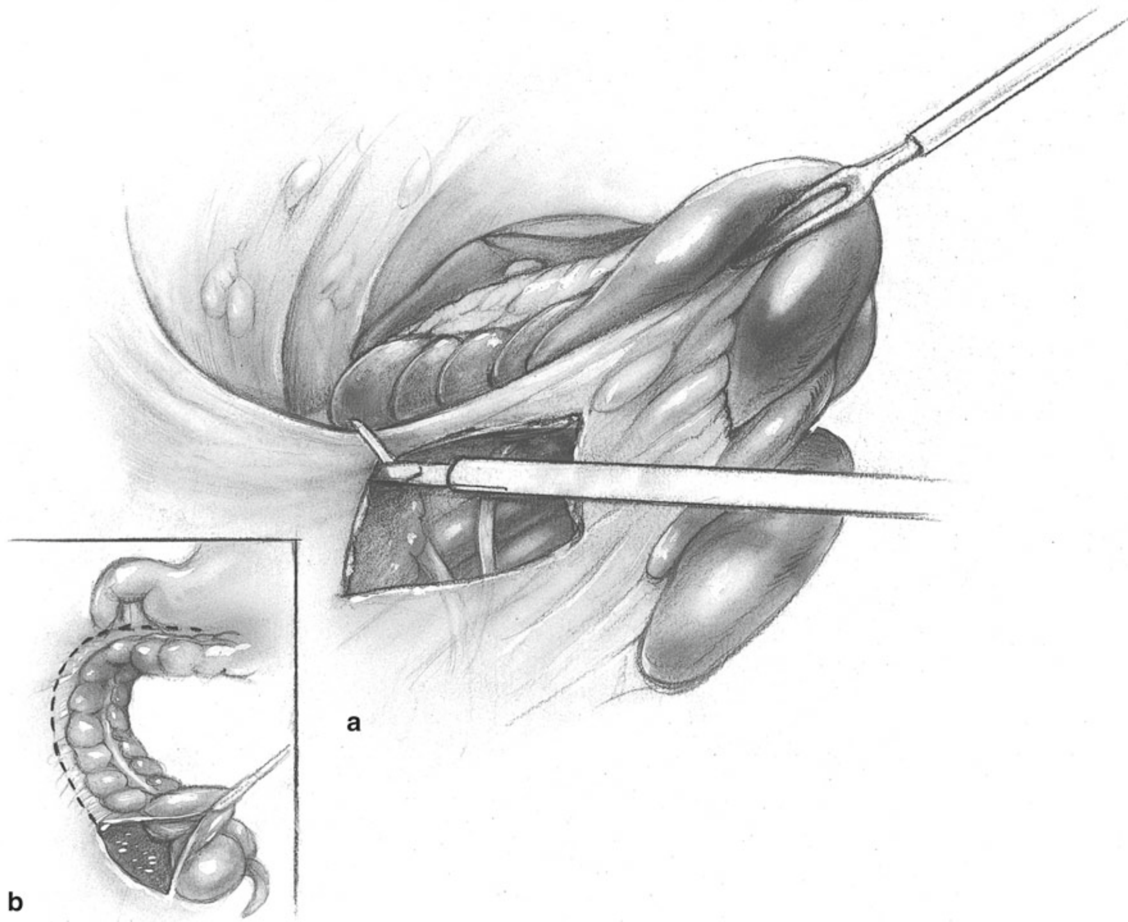

Fig. 50.3

flexure (Fig. 50.3b). The lateral peritoneal attachments of the cecum are incised (Fig. 50.4a). The ureter is identified in the retroperitoneum traversing the right iliac vessels in parallel with the gonadal vessels. Great care should be taken to identify the correct plane of dissection anterior to Gerota's fascia as more lateral dissection results in medial mobilization of the kidney with difficulty in subsequent mobilization of the hepatic flexure. Hemostasis of small vessels is important for visualization of the tissue planes during this portion of the procedure. Early identification of the duodenum is imperative in preventing injury and inadvertent electrocautery burns. For patients expected to have extensive intra-abdominal adhesions and/or intra-abdominal, pelvic, or retroperitoneal inflammation, ureteric catheters can be a valuable adjunct.

Mobilization of the Hepatic Flexure

The surgeon often moves to a position between the patient's legs while working on the hepatic flexure and transverse colon. With the patient in steep reverse Trendelenburg position, dissection of the lateral attachments is continued around the hepatic flexure dividing the hepatocolic ligament (Fig. 50.4b). With the transverse colon retracted caudad and the greater omentum retracted cephalad, the omentum is separated from the midtransverse colon to the hepatic flexure with the ultrasonic scalpel or scissors through the avascular omental-colic junction (Fig. 50.5a, b). An optional fourth upper left-sided port may be placed to provide upward traction on the omentum and is particularly in the presence of significant obesity, inflammation, or adhesions (Fig. 50.2a, b). It is generally best to mobilize the proximal transverse colon to the level of the middle colic vessels to ensure optimal length for mobilization into the midline. Upon completion of the mobilization, the right colon is suspended by its mesentery where the origins of the ileocolic, right colic, and middle colic arteries reside.

Extracorporeal Resection and Anastomosis

Once appropriate mobilization has been achieved, the supraumbilical port site is extended to an approximately 4 cm

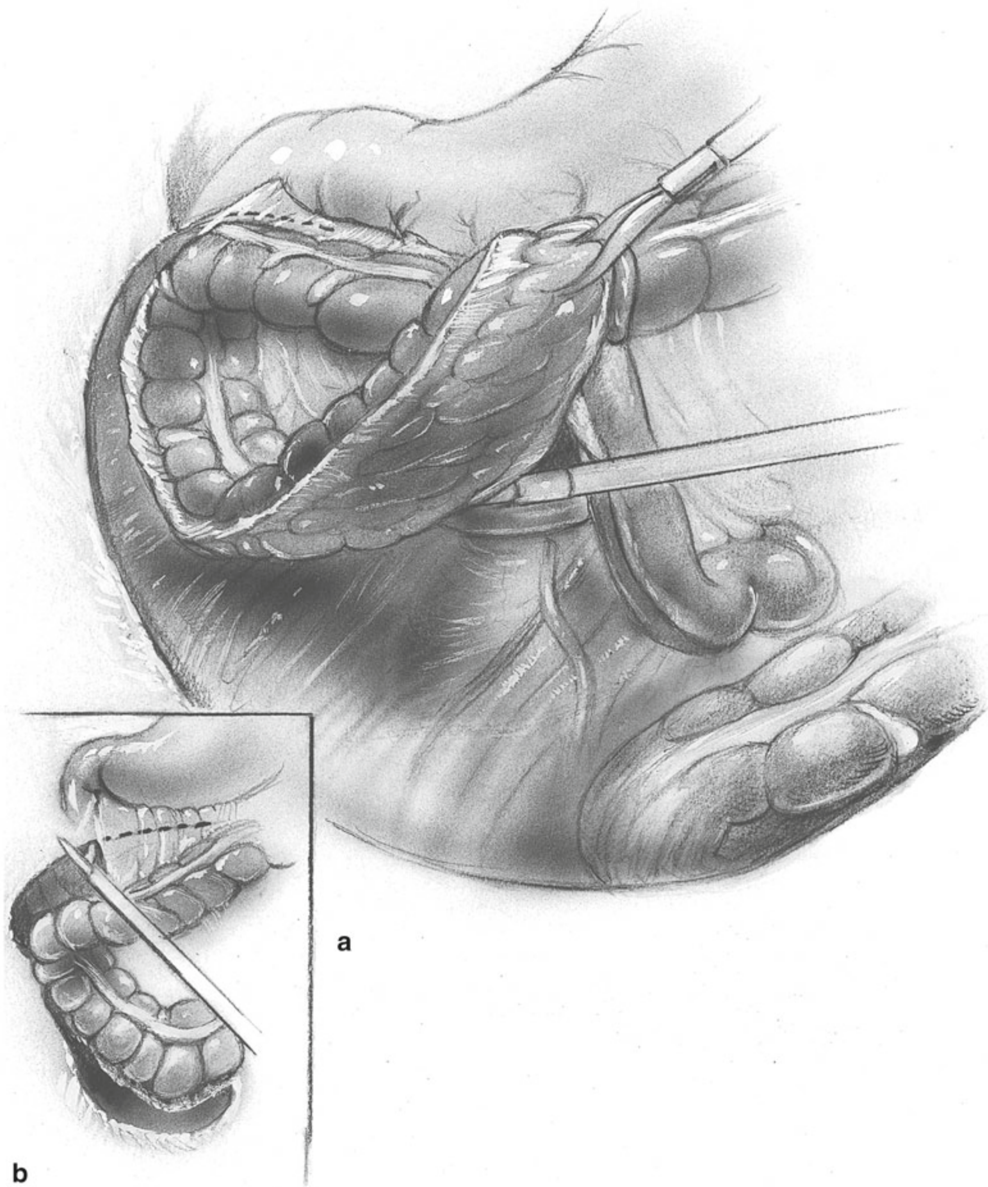

Fig. 50.4

midline incision. A plastic, impervious wound drape is placed, the cecum is gently grasped, and the right colon is easily delivered through the wound (Fig. 50.6). Points of transection on the ileum and colon are chosen and marked. The mesentery between these points is clamped, ligated, and divided prior to bowel resection to prevent twisting of the bowel and mesentery. Once the mesentery is divided, closure of the mesenteric defect with absorbable suture is begun but left untied. Linear cutting staplers are used to divide the ileum and transverse colon and, subsequently, to perform the side-to-side ileocolic anastomosis. The anastomosis should be tension-free, airtight, and well vascularized. Closure of the mesenteric defect is then completed. Any synchronous lesions, strictures or phlegmons, can be addressed at this time. In patients with inflammatory bowel disease, it may be useful to inspect the entire length of the small bowel through this incision.

Re-insufflation and Inspection

The fascia of the midline incision is closed with running absorbable sutures begun at each end but left open in the midportion. The 10 mm cannula is reinserted and the abdomen re-insufflated. Inspection of the intra-abdominal contents is undertaken to ensure no twisting of the mesentery and absence of hemorrhage in areas of pervious dissection. The ports are removed under direct vision and the midline

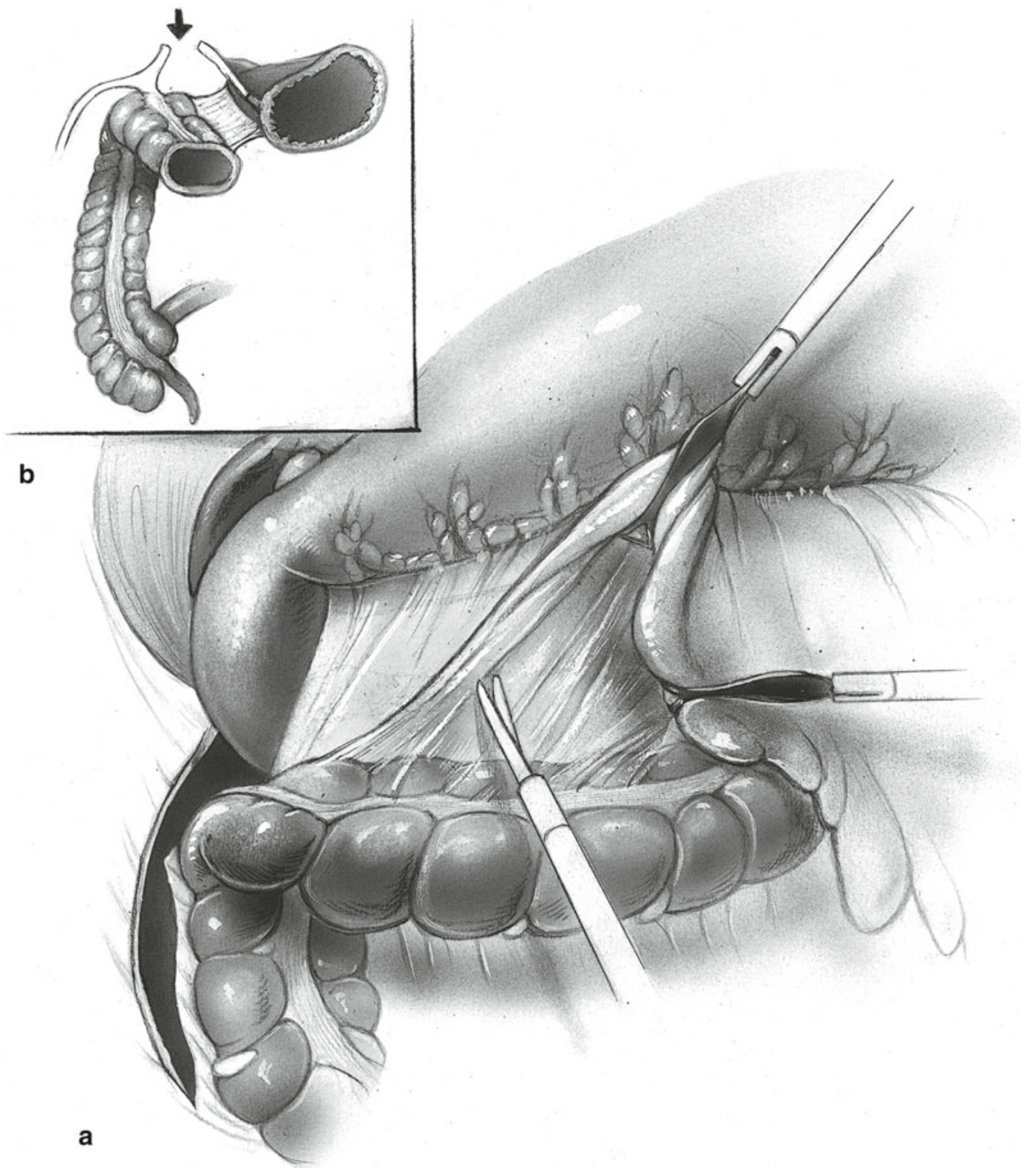

Fig. 50.5

fascia closed. The skin of the midline and port-site wounds are reapproximated with absorbable sutures and covered with adhesive strips and gauze dressings (Fig. 50.7).

Postoperative Care

Postoperatively, the patient is begun on clear liquids and a self-administered analgesic pump. On the first postoperative day, the bladder catheter is removed and pain is controlled with oral medication. The diet advanced with onset of bowel function and the patient discharged shortly thereafter.

Complications

Anastomotic leak
Small bowel obstruction
Wound infection
Port-site hernia

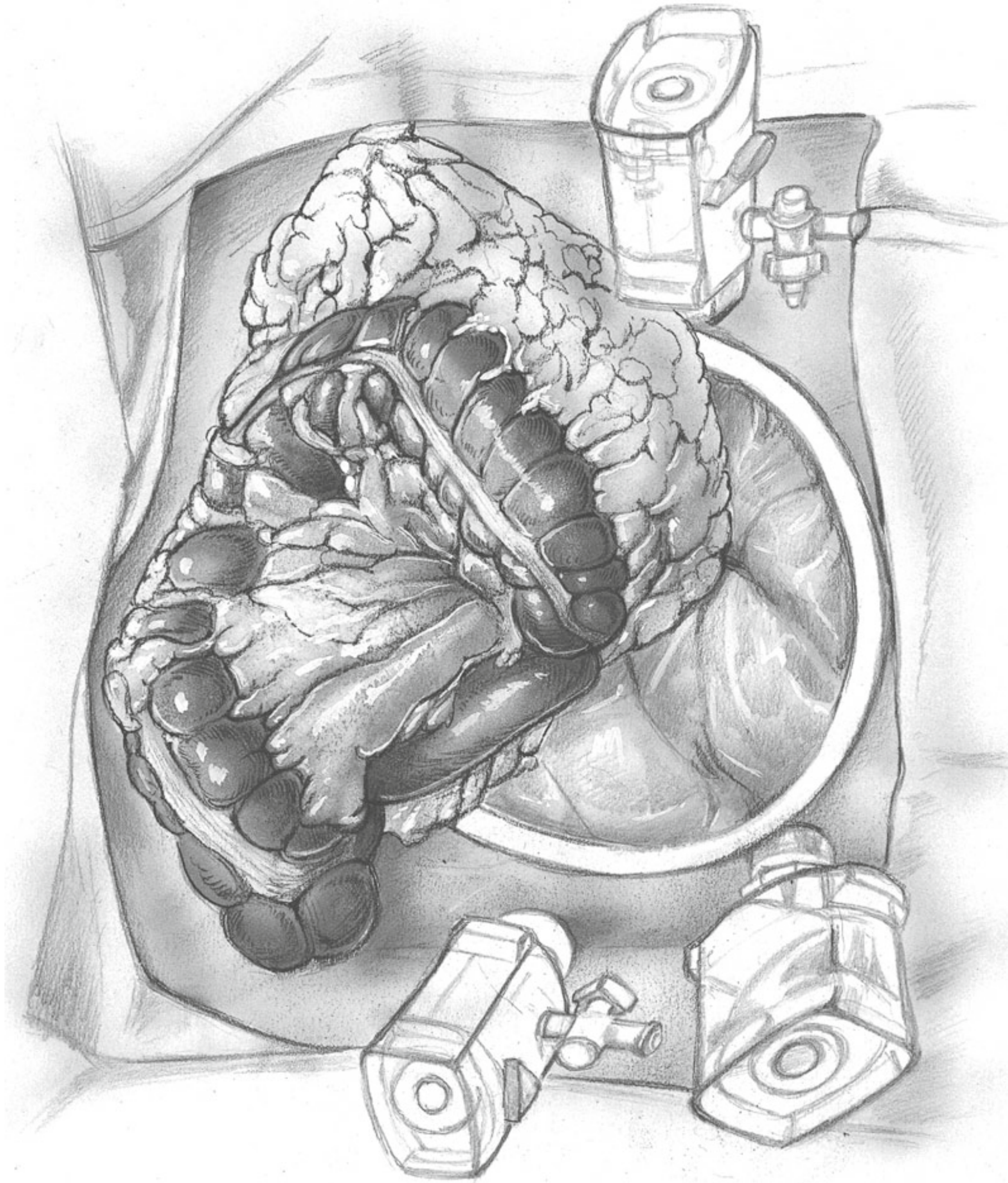

Fig. 50.6

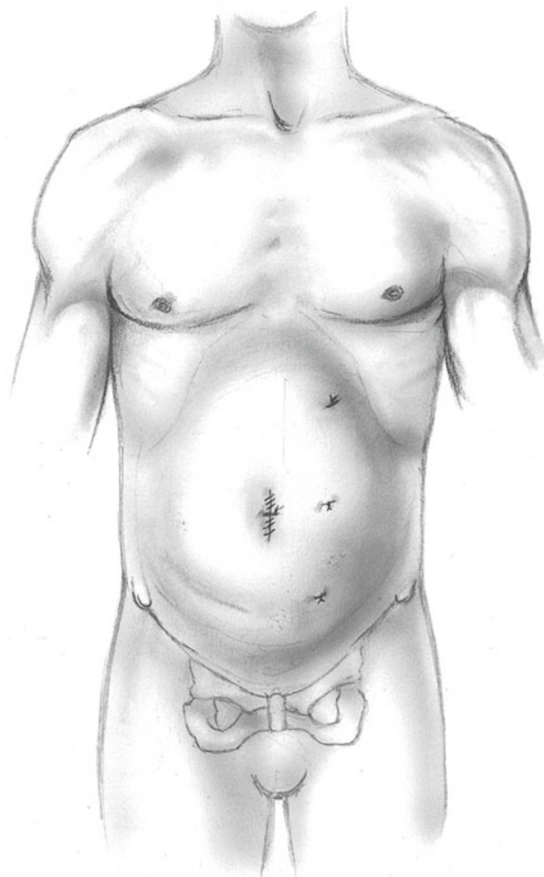

Fig. 50.7

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51 Left Colectomy for Cancer

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Whereas malignancies of the proximal three-fourths of the transverse colon require excision of the right and transverse colon, cancers of the distal transverse colon, splenic flexure, descending colon, and sigmoid are treated by left hemicolectomy (Figs. 51.1 and 51.2).

Preoperative Preparation

See Chap. 49.

Pitfalls and Danger Points

Injury to spleen
Injury to ureter
Failure of anastomosis

Operative Strategy

Extent of Dissection

Lymph draining from malignancies of the left colon flows along the left colic or sigmoidal veins to the inferior mesenteric vessels. In the usual case, the inferior mesenteric artery should be divided at the aorta and the inferior mesenteric vein at the lower border of the pancreas.

Except for treating lesions situated in the distal sigmoid, the lower point of division of the colon is through the upper rectum, 2–3 cm above the promontory of the sacrum (Figs. 51.1 and 51.2). Presacral elevation of the rectal stump need not be carried out, and the anastomosis should be intraperitoneal (please see Chap. 53 for low anterior resection, the operation typically required for lower lesions). The blood supply of a rectal stump of this length, arising from the inferior and middle hemorrhoidal arteries, is almost invariably of excellent quality. The blood supply of the proximal colonic segment, arising from the middle colic artery, generally is also excellent, provided care is exercised not to damage the marginal vessel at any point in its course.

Liberation of Splenic Flexure

The splenic flexure of the colon may be completely liberated without dividing a single blood vessel if the surgeon can recognize anatomic planes accurately. The only blood vessels going to the colon are those arising from its mesentery. Bleeding during the course of this dissection arises from three sources.

1. Frequently, *downward traction on the colon and its attached omentum* avulses a patch of splenic capsule to which the omentum adheres. It is worthwhile to inspect the lower pole of the spleen at the *onset* of this dissection and to divide such areas of adhesion with Metzenbaum scissors under direct vision before applying traction.
2. Bleeding arises when the *surgeon does not recognize the plane* between the omentum and appendices epiploica attached to the distal transverse colon. The appendices may extend 1–3 cm cephalad to the transverse colon. When they are divided inadvertently, bleeding follows. Note that the character of the fat in the omentum is considerably different from that of the appendices. The former has the appearance of multiple small lobulations, each 4–6 mm in diameter, whereas the appendices epiploica contain fat that

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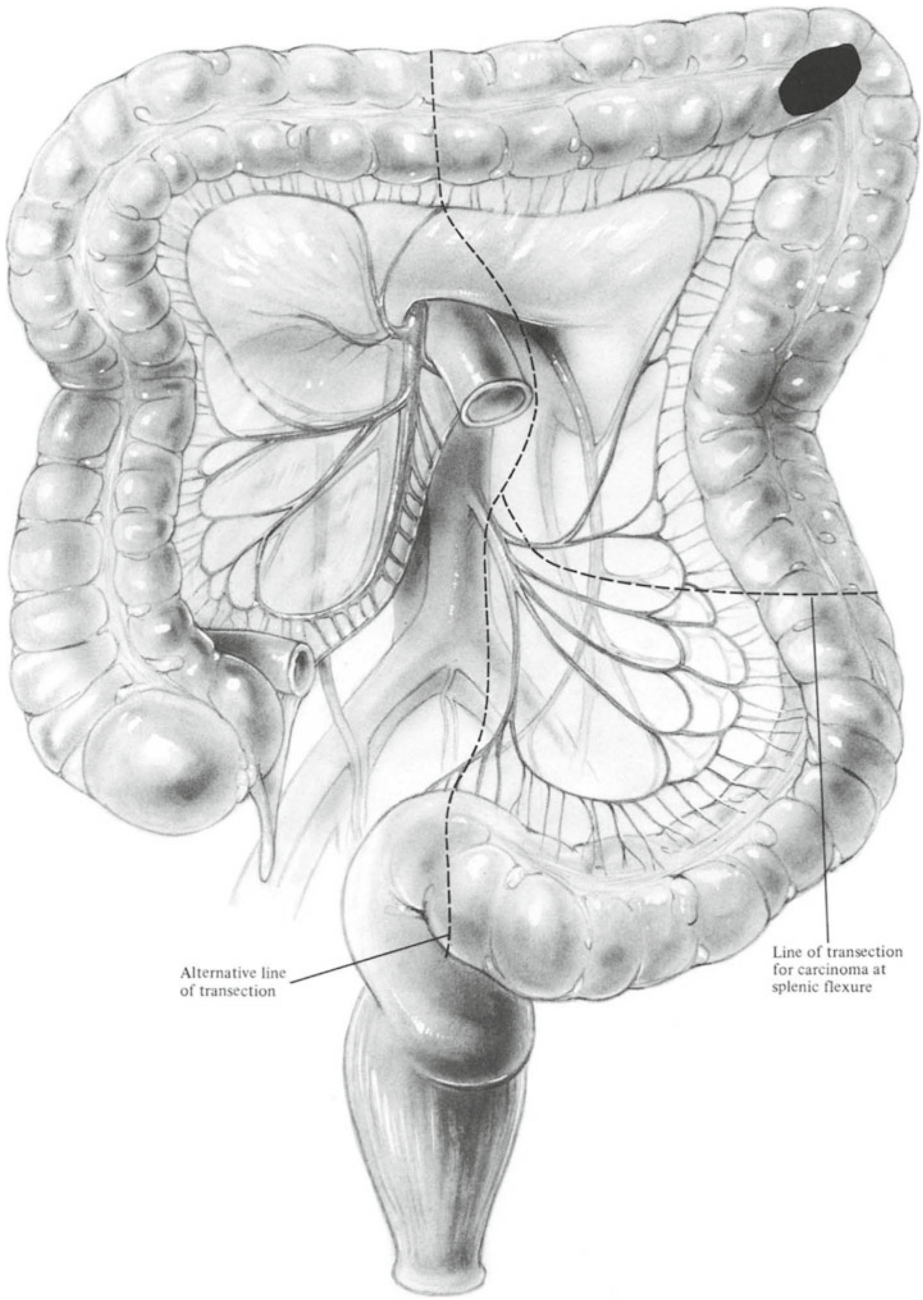

Fig. 51.1

appears to have a completely smooth surface. If the proper plane between the omentum and appendices can be identified, the dissection is bloodless.

3. Bleeding can arise from the *use of blunt dissection* to divide the renocolic ligament. This ruptures a number of veins along the surface of Gerota's capsule, which overlies the kidney. Bleeding can be prevented by accurately identifying the renocolic ligament, delineating it carefully, and then dividing it with Metzenbaum scissors along the medial margin of the renal capsule.

   Although the classic anatomy books do not generally describe a "renocolic ligament," it can be identified as a thin structure (Figs. 51.3 and 51.4) extending from the anterior surface of the renal capsule to the posterior surface of the mesocolon.

There are three essential steps to safe liberation of the splenic flexure. First, the obvious one is to incise the parietal peritoneum in the left paracolic gutter going cephalad to the splenic flexure. Second, dissect the left margin of the omentum from the distal transverse colon as well as from the left parietal peritoneum near the lower pole of the spleen (in patients who have this attachment). The third, least well-understood step is to identify and divide the renocolic ligament between the renal capsule and the posterior mesocolon.

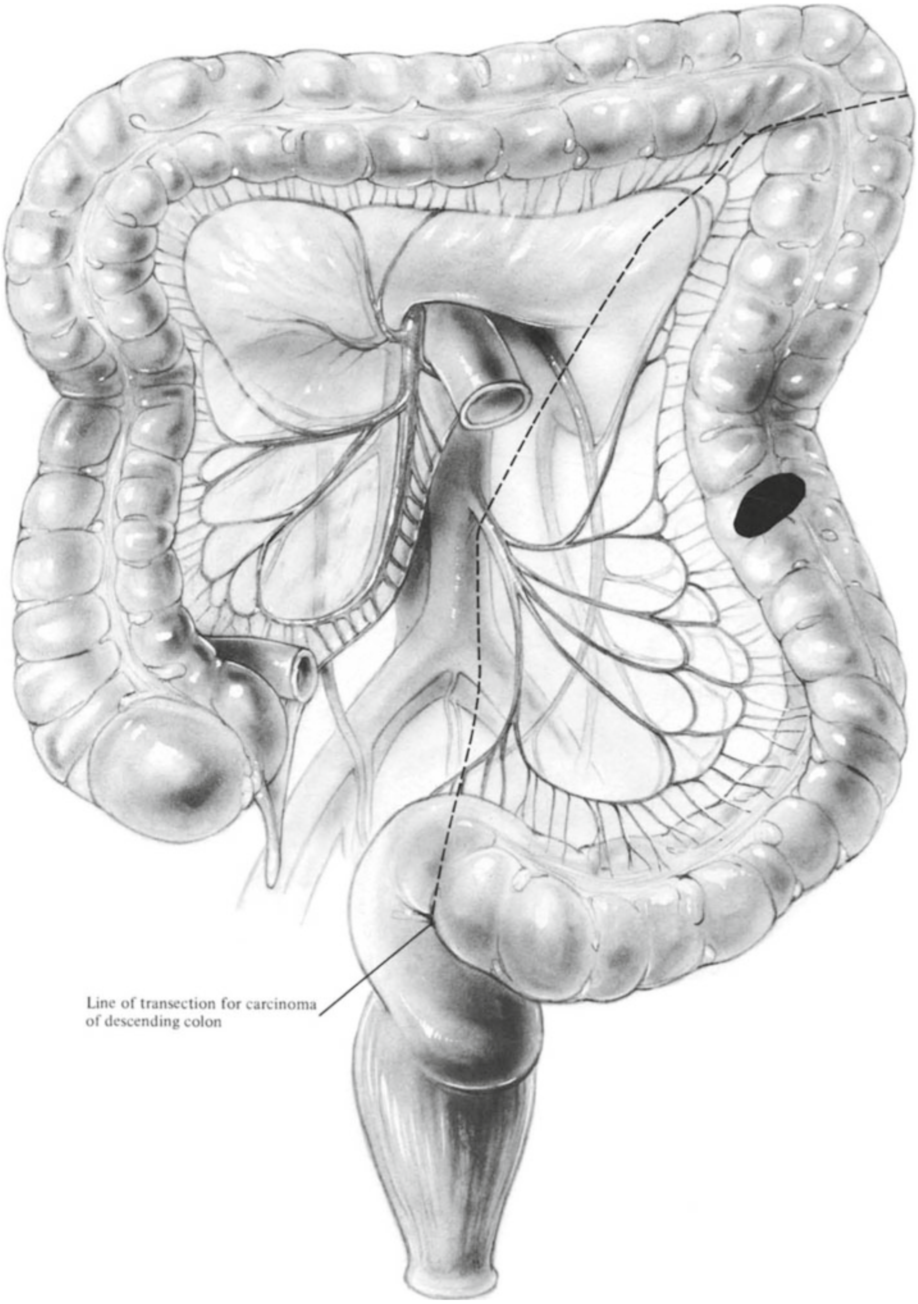

Fig. 51.2

Then pass the index finger deep to this ligament in the region of the splenic flexure (see Fig. 51.4); this plane leads to the lienocolic ligament, which is also avascular and may be divided by Metzenbaum scissors provided this ligament is separated from underlying fatty tissue by finger dissection. The fatty tissue may contain an epiploic appendix with a blood vessel. After the lienocolic ligament has been divided, the index finger should lead to the next avascular "ligament," which extends from the pancreas to the transverse colon. This pancreaticocolic "ligament" comprises the upper portion of the transverse mesocolon. Dividing it frees the distal transverse colon and splenic flexure, except for the mesentery. For all practical purposes the renocolic, lienocolic, and pancreaticocolic "ligaments" comprise one continuous avascular membrane with multiple areas of attachment.

No-Touch Technique

The no-touch technique is more difficult to apply to lesions of the left colon than to those on the right. In many cases it can be accomplished by liberating the sigmoid colon early in the procedure, identifying and ligating the inferior mesenteric

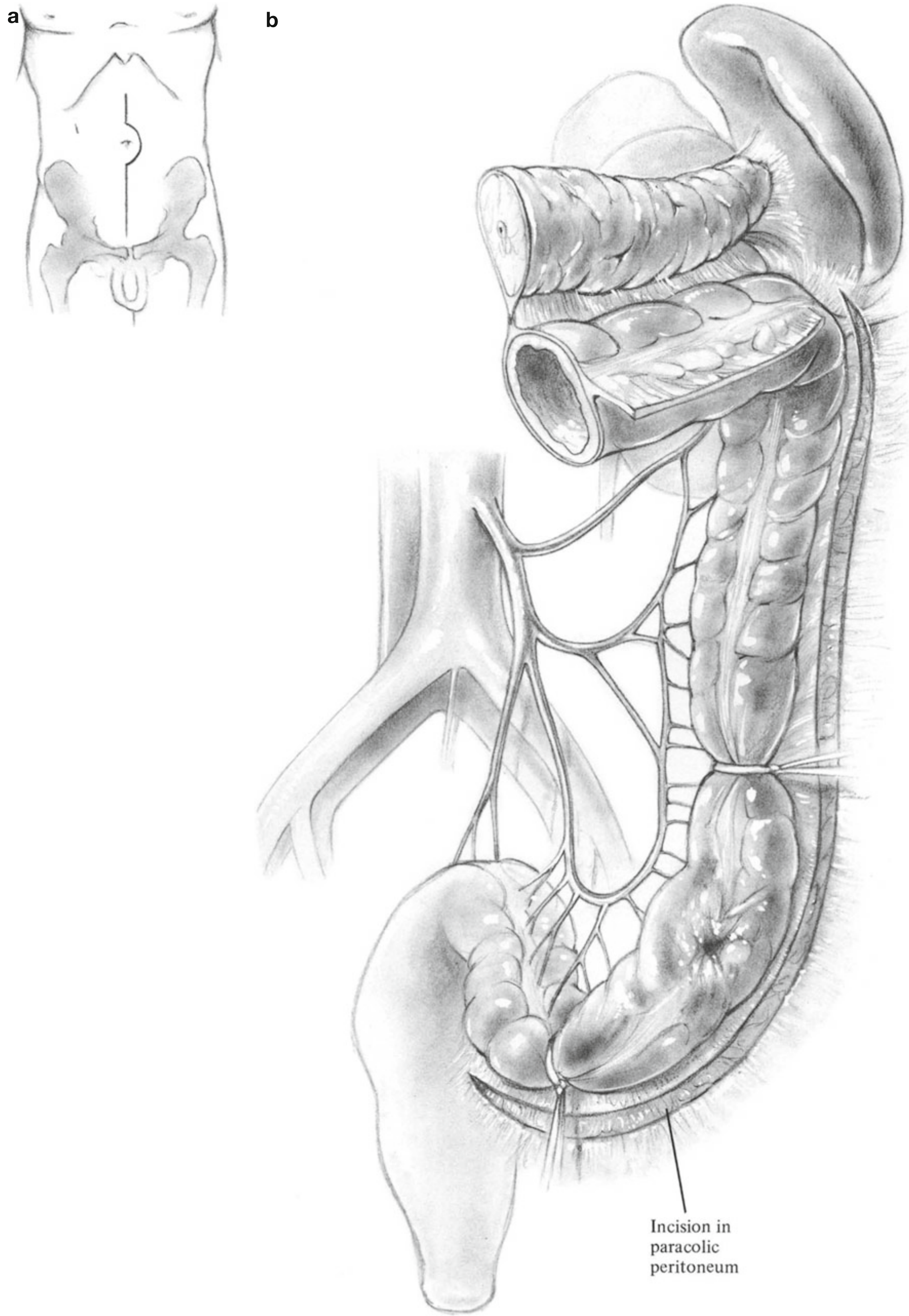

Fig. 51.3

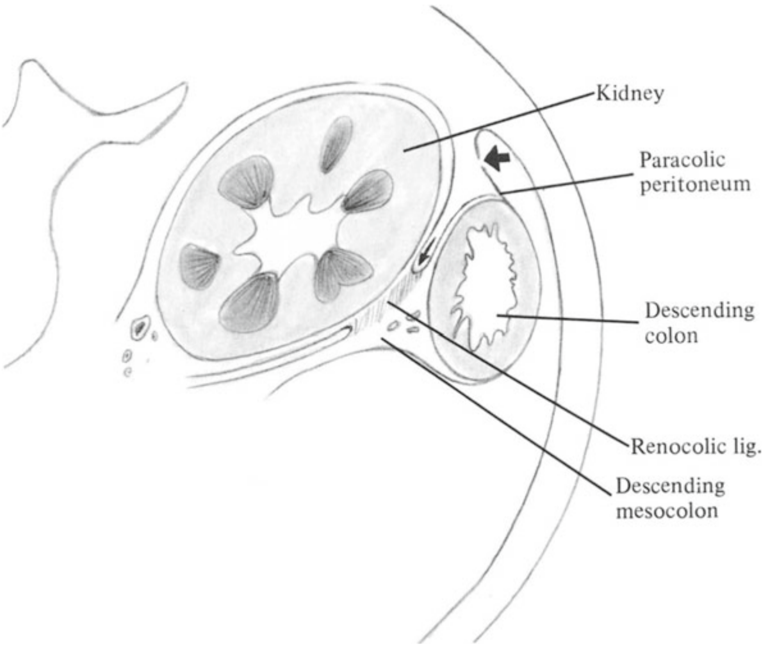

Fig. 51.4

vessels, and dividing the mesocolon—all before manipulating the tumor. Care must be taken to identify and protect the ureter.

In some cases, the tumor's location or the obesity of the mesocolon makes this approach more cumbersome for the surgeon, unlike the situation on the right side where the anatomy lends itself to adoption of the no-touch method as a routine procedure. Most surgeons content themselves with minimal manipulation of the tumor while they use the operative sequence of first liberating the left colon and then ligating the lymphovascular attachments. No specific oncologic benefit has been associated with the use of no-touch technique.

Technique of Anastomosis

Because the anastomosis is generally intraperitoneal and the rectal stump is largely covered by peritoneum, the leak rate in elective cases is less than 2 %. Anastomosis may be done by the end-to-end technique or the Baker side-to-end method based on the preference of the surgeon.

If a stapling technique is desired, we prefer the functional end-to-end anastomosis (please refer to the section below on Stapled Colocolonic Functional End-to-End Anastomosis). A circular stapling device (see Figs. 53.25, 53.26, 53.27, 53.28, 53.29, 53.30 and 53.31) may also be used, but the internal diameter of the anastomosis resulting from this technique may be slightly narrow.

Documentation Basics

- Findings
- Extent of resection
- Type of anastomosis

Operative Technique

Incision and Exposure

Make a midline incision from a point about 4 cm below the xiphoid to the pubis (Fig. 51.5a) and open and explore the abdomen. Insert a Thompson retractor to elevate the left costal margin; it improves the exposure for the splenic flexure dissection. Exteriorize the small intestine and retract it to the patient's right. Apply umbilical tape ligatures to occlude the colon proximal and distal to the tumor.

Liberation of Descending Colon and Sigmoid

Standing at the patient's left, make a long incision in the peritoneum of the left paracolic gutter between the descending colon and the white line of Toldt (Fig. 51.5b). Use the left index finger to elevate this peritoneal layer and continue the incision upward with Metzenbaum scissors until the right-angle curve of the splenic flexure is reached. At this point the peritoneal incision must be moved close to the colon; otherwise the incision in the parietal peritoneum tends to continue upward and laterally toward the spleen. Similarly, with the index finger leading the way, use Metzenbaum scissors to complete the incision in a caudal direction, liberating the sigmoid colon from its lateral attachments down to the rectosigmoid region.

Division of Renocolic Ligament

With the descending colon retracted toward the patient's right, a filmy attachment can be visualized covering the renal capsule and extending medially to attach to the posterior surface of the mesocolon (see Fig. 51.3). Most surgeons bluntly disrupt this renocolic attachment, which resembles a ligament, using a gauze pad in a sponge holder, but this maneuver often tears small veins on the surface of the renal capsule and causes unnecessary bleeding. Instead, divide this structure with Metzenbaum scissors near the junction of the medial margin of the renal capsule and the adjacent mesocolon. Once the incision is initiated, delineate this fibrous structure by elevating it over an index finger (see Fig. 51.4). After the renocolic ligament has been divided, the upper ureter and gonadal vein lie exposed. Trace the ureter down to its

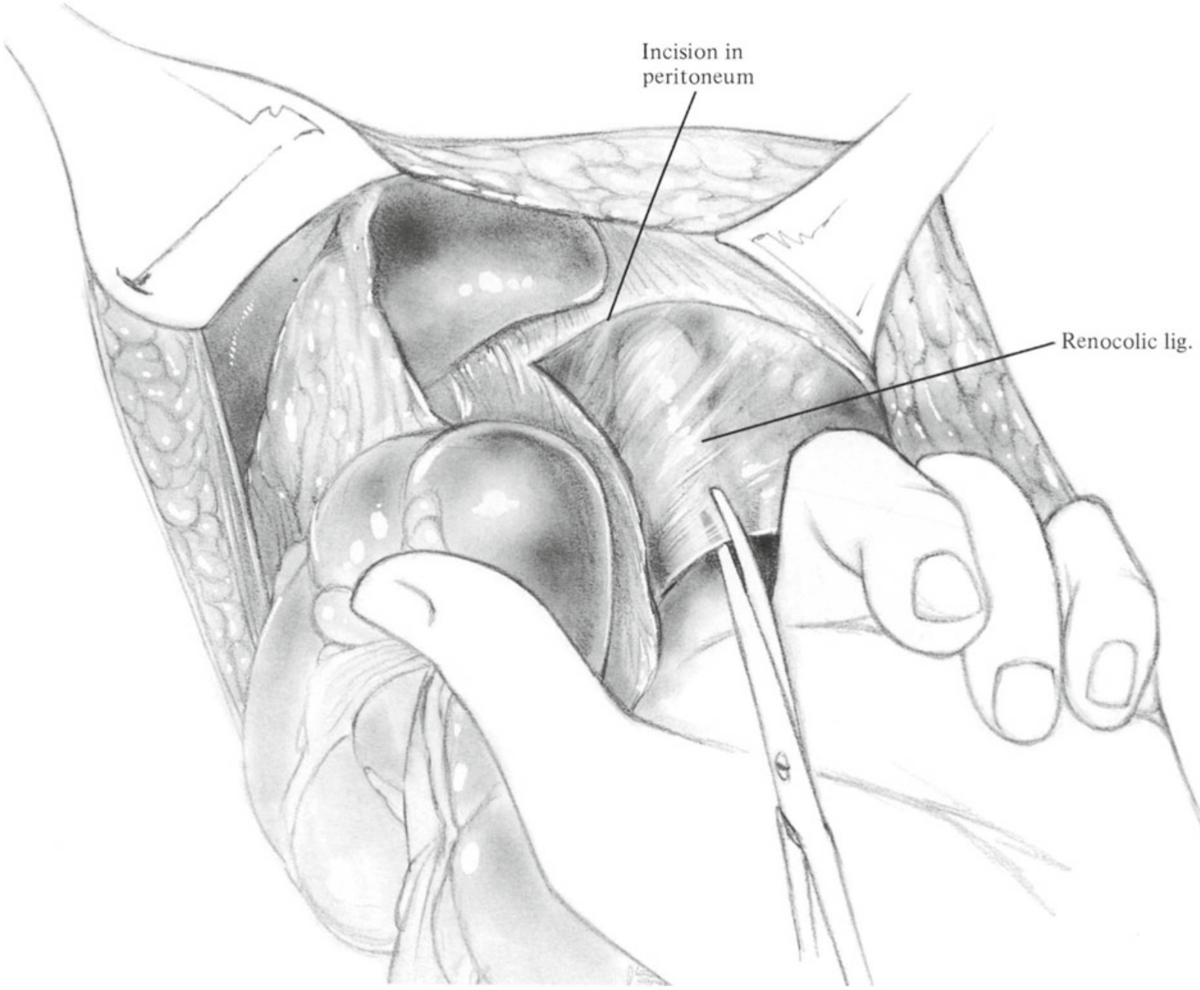

Fig. 51.5

entrance into the pelvis and encircle it with a Silastic loop tag for future identification.

Splenic Flexure Dissection

The lower pole of the spleen can now be seen. Sharply divide any adhesions between the omentum and the capsule of the spleen to avoid inadvertent avulsion of the splenic capsule (due to traction on the omentum). If bleeding occurs because the splenic capsule has been torn, it can usually be controlled by applying a piece of topical hemostatic agent. Occasionally sutures on a fine atraumatic needle are helpful.

At this stage identify and divide the attachments between the omentum and the lateral aspect of the transverse colon. Remember to differentiate carefully between the fat of the appendices epiploica and the more lobulated fat of the omentum (see Operative Strategy, above). Free the omentum from the distal 10–12 cm of transverse colon (Fig. 51.6). If the tumor is located in the distal transverse colon, leave the omentum attached to the tumor and divide the omentum just outside the gastroepiploic arcade.

Return now to the upper portion of the divided renocolic ligament. Insert the right index finger underneath the upper portion of this ligament and pinch it between the index finger and thumb; this maneuver localizes the lienocolic ligament (Fig. 51.7). The ligament should be divided by the first assistant guided by the surgeon's right index finger. By inserting the index finger 5–6 cm farther medially, an avascular pancreaticocolic "ligament" (Figs. 51.7 and 51.8) can be identified. It is an upper extension of the transverse mesocolon. After this structure has been divided, the distal transverse colon and splenic flexure become free of all posterior attachments. Control any bleeding in the area by suture ligature or electrocautery.

Ligation and Division of Inferior Mesenteric Artery

Make an incision on the medial aspect of the mesocolon from the level of the duodenum down to the promontory of the sacrum. The inferior mesenteric artery is easily

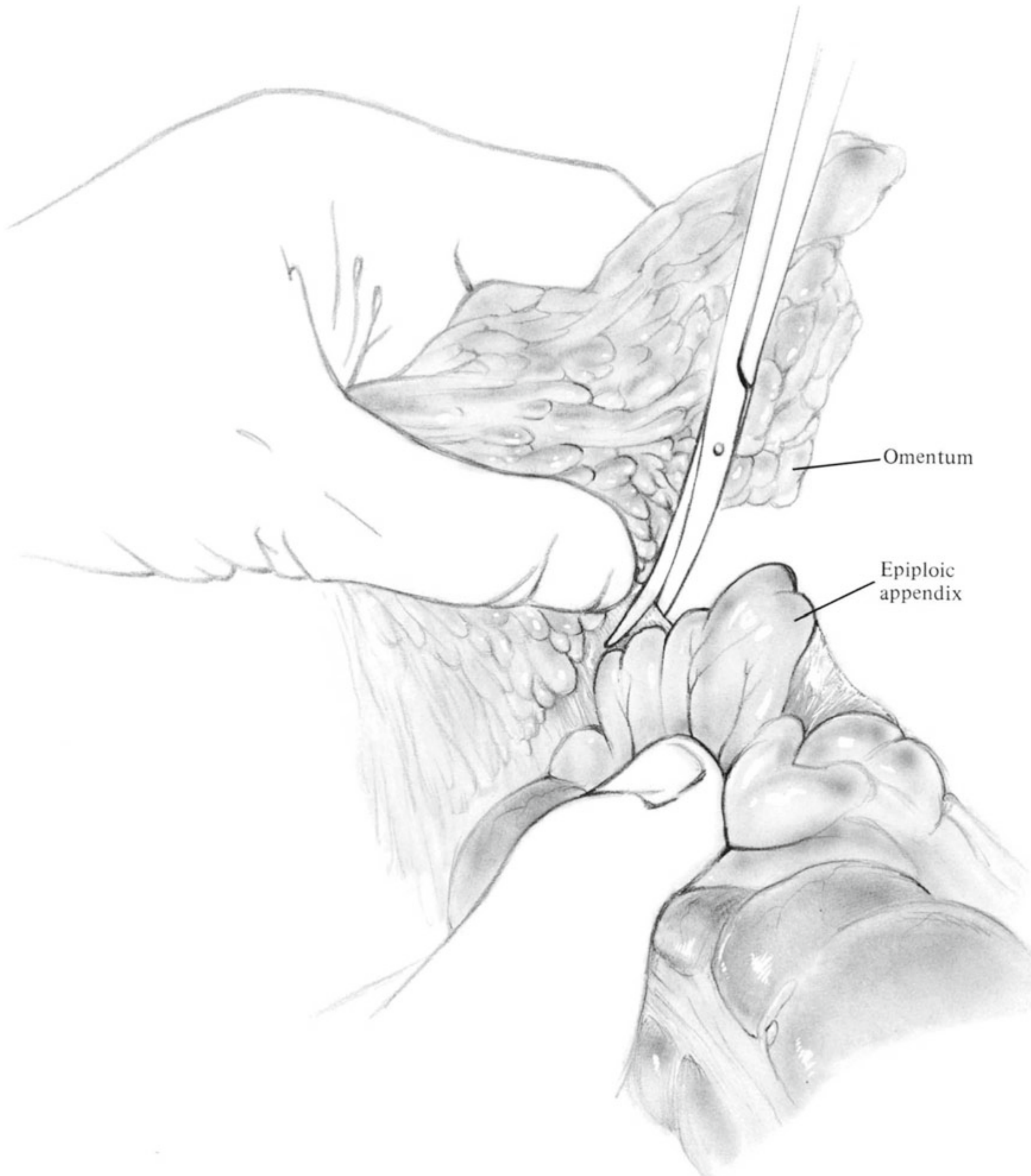

Fig. 51.6

identified by palpation at its origin from the aorta. Sweep the lymphatic tissue in this vicinity downward, skeletonizing the artery, which should be double ligated with 2-0 silk at a point about 1.5 cm from the aorta (Fig. 51.9) and then divided. Sweep the preaortic areolar tissue and lymph nodes toward the specimen. It is not necessary to skeletonize the anterior wall of the aorta, as it could divide the preaortic sympathetic nerves, which would result in sexual dysfunction in male patients. If the preaortic dissection is carried out by gently sweeping the nodes laterally, the nerves are not divided inadvertently. Now divide the inferior mesenteric vein as it passes behind the duodenojejunal junction and pancreas.

Division of Mesocolon

Depending on the location of the tumor, divide the mesocolon between clamps up to and including the marginal artery (Fig. 51.10).

Ligation and Division of Mesorectum

Separate the distally ligated pedicle of the inferior mesenteric artery and the divided mesocolon from the aorta and iliac vessels down to the promontory of the sacrum. Divide the vascular tissue around the rectum between pairs of hemostats sequentially

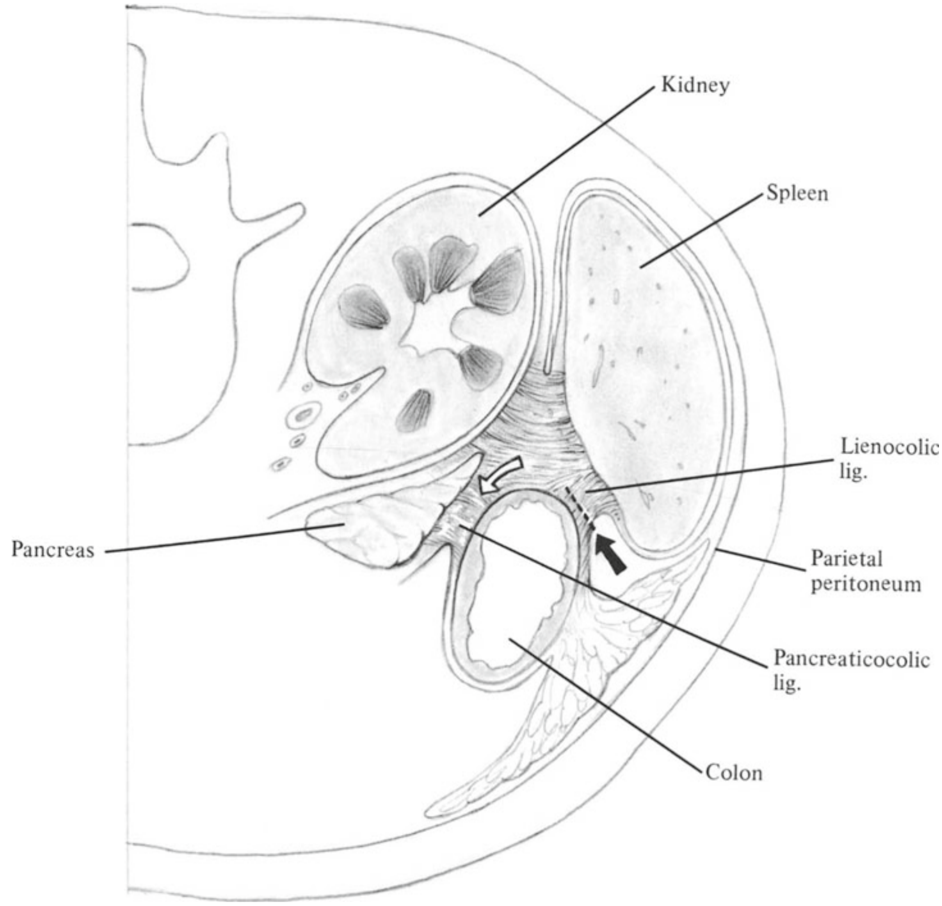

Fig. 51.7

until the wall of the upper rectum is visible. Then free the rectal stump of surrounding fat and areolar tissue at the point selected for the anastomosis. This point should be 2–3 cm above the promontory of the sacrum, where three-fourths of the rectum is covered anteriorly and laterally by peritoneum.

Insertion of Wound Protector

Insert a Wound Protector ring drape or moist laparotomy pads into the abdominal cavity to protect the subcutaneous panniculus from contamination when the colon is opened.

Division of Colon and Rectum

Expose the point on the proximal colon selected for division. Apply an Allen clamp to the specimen side. Divide the colon after applying a Doyen or other type of nontraumatic clamp to avoid contamination. Completely clear the areolar tissue and fat from the distal centimeter of the proximal colon so the serosa is exposed throughout its circumference. Handle the distal end of the specimen in the same manner by applying an Allen clamp to the specimen side. Now divide the upper rectum and remove the specimen. Suction the rectum free of any contents. Apply no clamp. Use fine PG or PDS sutures to control any bleeding from the rectal wall. Completely clear surrounding fat and areolar tissue from a cuff of rectum 1 cm in width so seromuscular sutures may be inserted accurately.

End-to-End Two-Layer Anastomosis, Rotation Method

There are eight steps to the end-to-end two-layer anastomosis, rotation method.

1. Check the *adequacy of the blood supply* of both ends of the bowel. Confirm that a *cuff of at least 1 cm of serosa* has been cleared to the areolar tissue and blood vessels at both ends of the bowel.
2. *Rotate the proximal colonic segment* so the mesentery enters from the right lateral margin of the anastomosis. Leave the rectal segment undisturbed (Fig. 51.11).
3. If the diameter of the lumen of one of the segments of bowel is significantly narrower than the other, *make a*

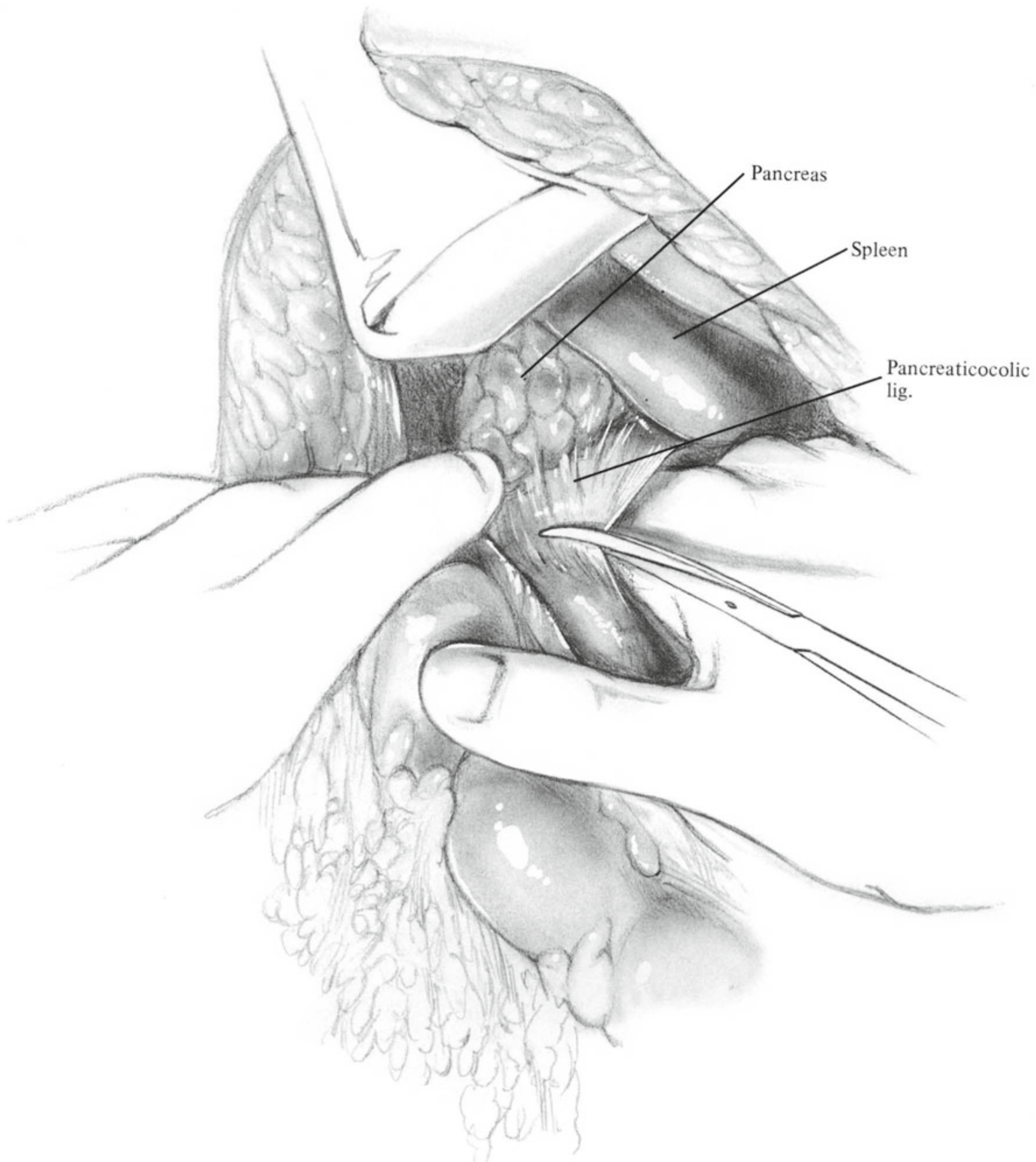

Fig. 51.8

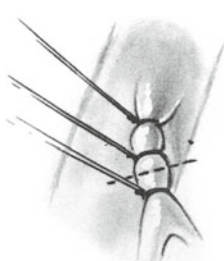

Fig. 51.9

Cheatle slit, 1–2 cm long, on the antimesenteric border of the narrower segment of bowel (see Figs. 49.10 and 49.11).

4. *Insert the first layer of seromuscular sutures*. If the rectal stump is not bound to the sacrum and if it can be rotated easily for 180°, it is more efficient to insert the anterior seromuscular layer as the first step of the anastomosis.
5. Insert interrupted 4-0 silk atraumatic Lembert seromuscular guy sutures, first to the lateral border of the anastomosis and then to the medial border. Using the technique of successive bisection, place the third Lembert

Fig. 51.10

suture on the anterior wall halfway between the first two (Fig. 51.11). Each stitch takes about 5 mm of tissue (including the submucosa) from the rectum and then from the descending colon.

6. After all the anterior sutures have been inserted, tie them and cut all the suture tails except for those of the two end guy sutures, which should be grasped in hemostats (Fig. 51.12). Pass a hemostat underneath the suture line, grasp the right lateral stitch (Fig. 51.13A), and rotate the anastomosis 180° (Fig. 51.14).
7. Place a double-armed 5-0 Vicryl or PG suture in the middle of the deep mucosal layer (Fig. 51.15a). Complete this layer with a continuous locked suture through the full thickness of the bowel (Fig. 51.15b). Then, with the same two needles and using a continuous Connell or Cushing suture, complete the remainder of the mucosal approximation (Fig. 51.16).
8. Approximate the *final seromuscular layer* with interrupted 4-0 atraumatic Lembert silk sutures (Fig. 51.17). After all the suture tails are cut, permit the anastomosis to rotate back 180° to its normal position.

End-to-End Anastomosis, Alternative Technique

When the rectum and colon cannot be rotated 180° as required for the method described above, an alternative technique must be used in which the posterior seromuscular layer is inserted first. To do this, insert a seromuscular

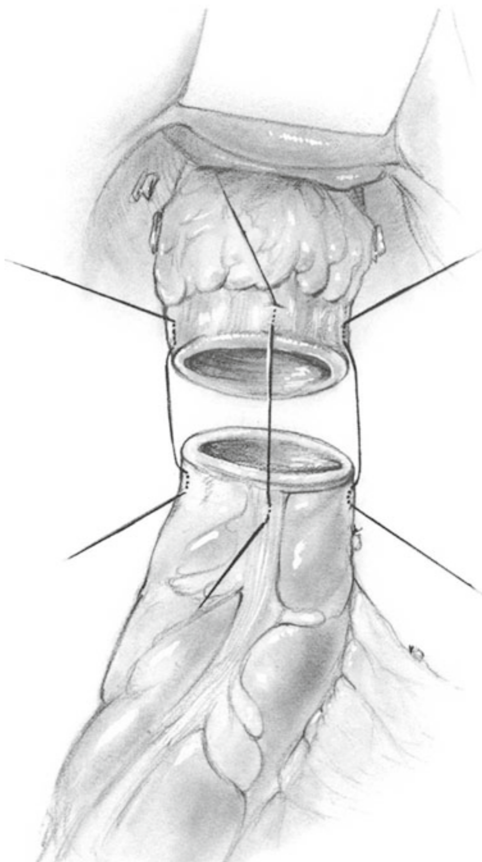

Fig. 51.11

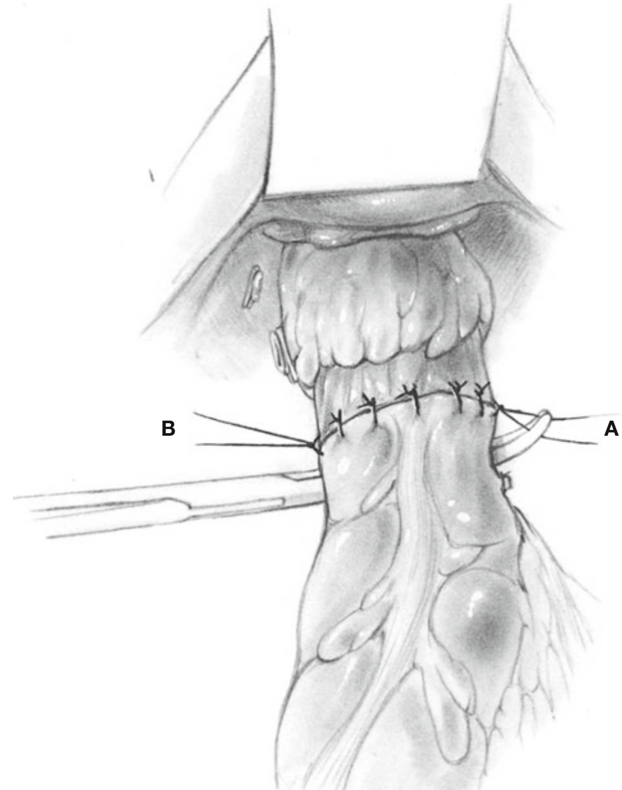

Fig. 51.13

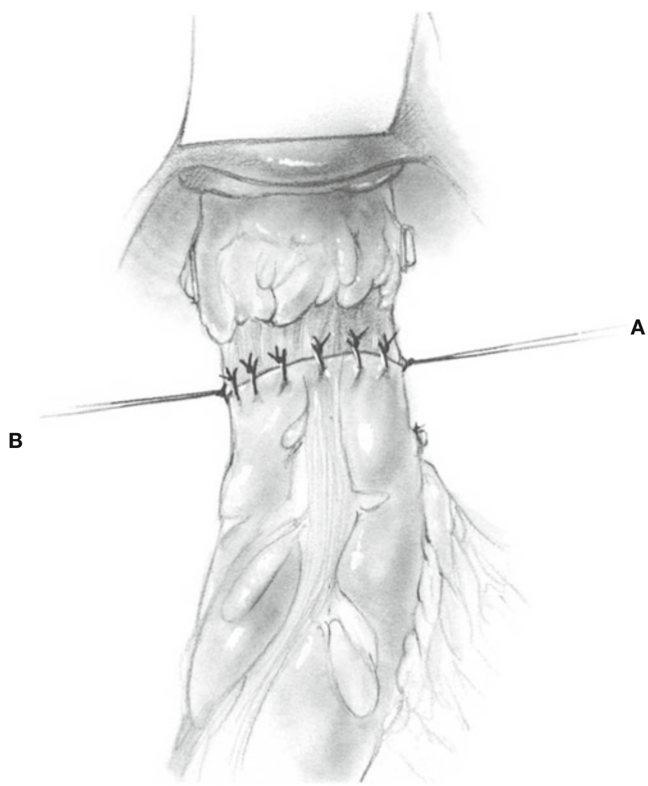

Fig. 51.12

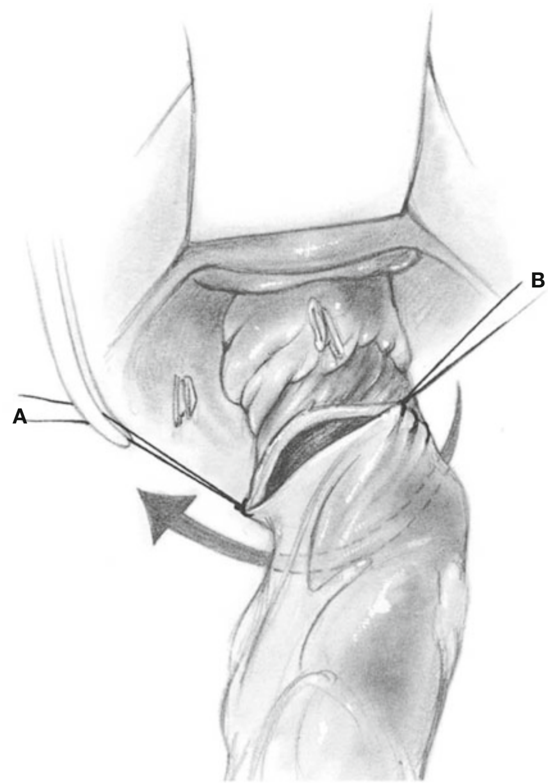

Fig. 51.14

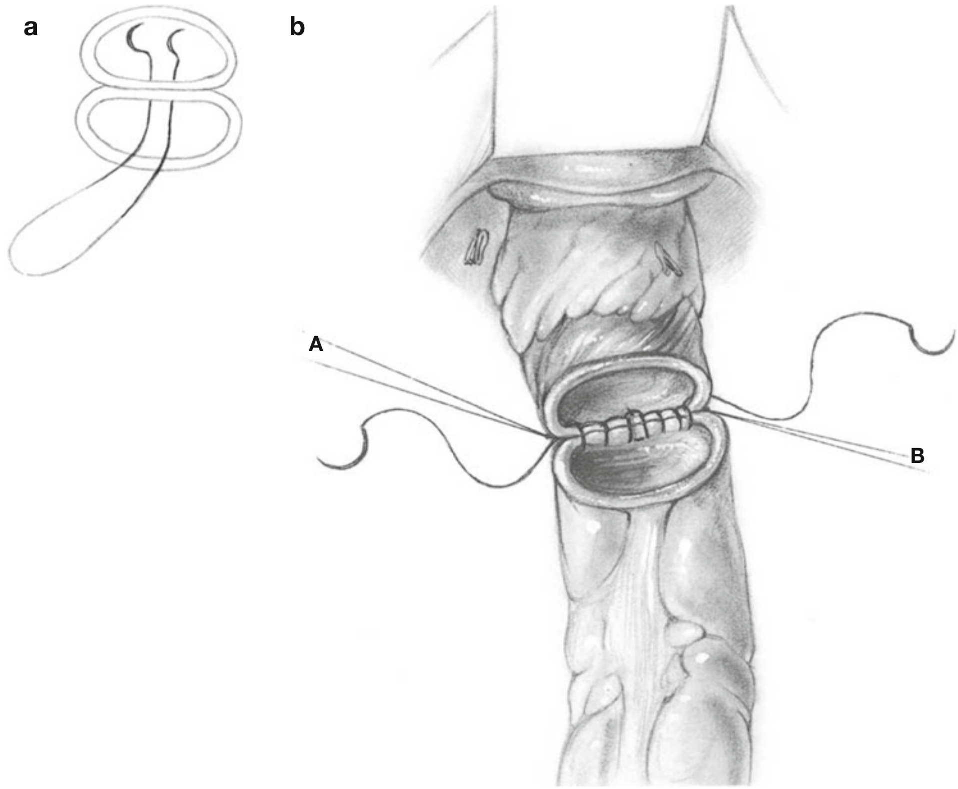

Fig. 51.15

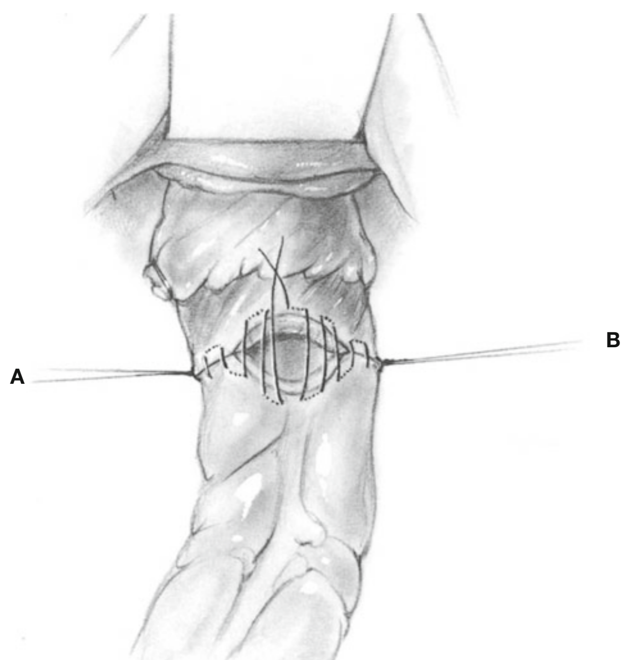

Fig. 51.16

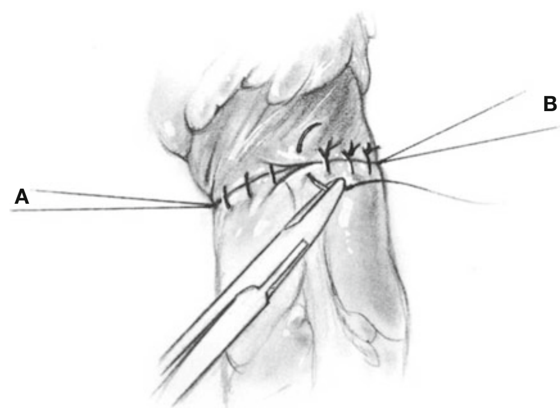

Fig. 51.17

suture of 4-0 silk into the left side of the rectum and the proximal colon. Do not tie this suture; grasp it in a hemostat and use it as the left guy suture. Place a second, identical suture on the right lateral aspects of the rectum and proximal colon and similarly hold it in a hemostat (Fig. 51.18).

Insert interrupted 4-0 silk seromuscular Lembert sutures (Fig. 51.19) to complete the posterior layer by successive bisection. As each suture is inserted, attach it to a hemostat until the layer is completed. At the conclusion of the layer, tie all the sutures and cut all the tails except for those of the two lateral guy sutures. Begin the posterior mucosal layer with a double-armed atraumatic suture of 5-0 Vicryl. Insert the suture in mattress fashion in the midpoint of the posterior layer of mucosa and tie it (Fig. 51.20). Use one needle to

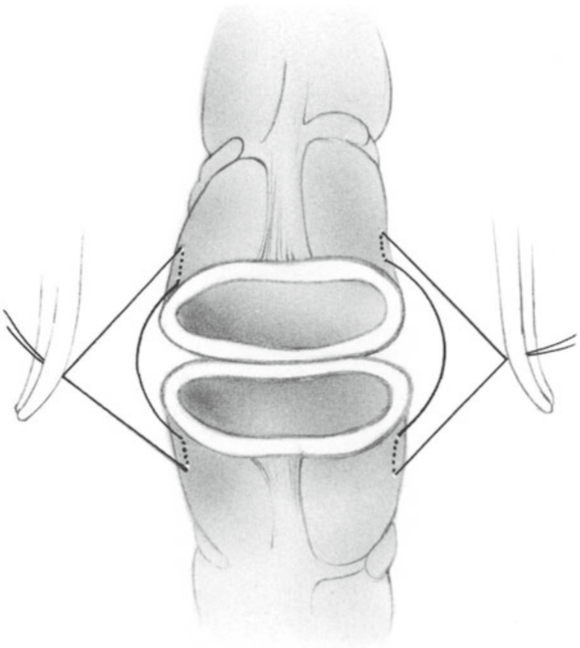

Fig. 51.18

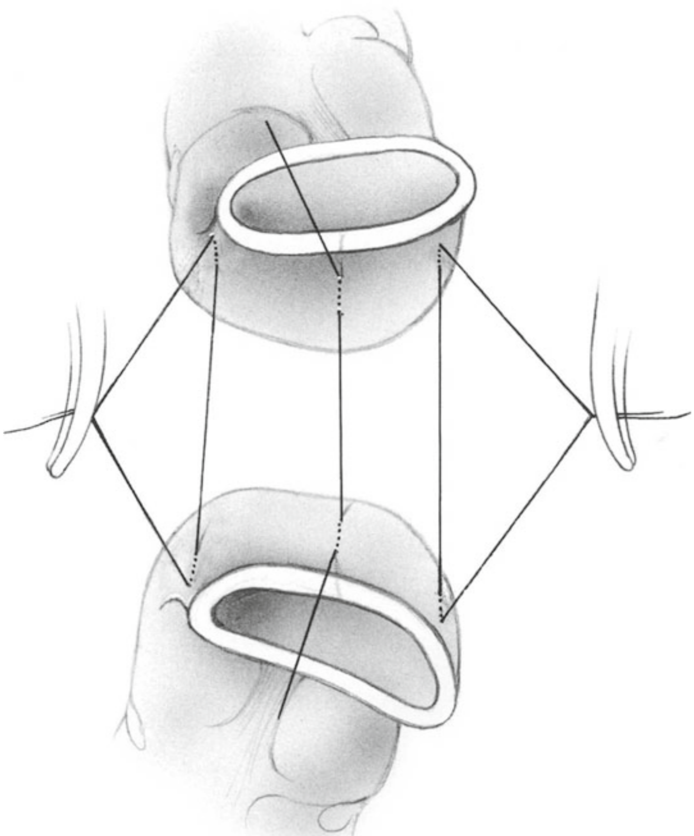

Fig. 51.19

initiate a continuous locked suture, taking bites averaging 5 mm in diameter and going through all coats of bowel (Fig. 51.21). Continue this in a locked fashion until the left

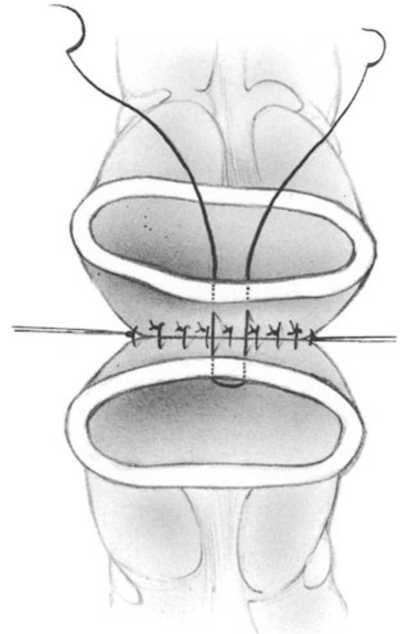

Fig. 51.20

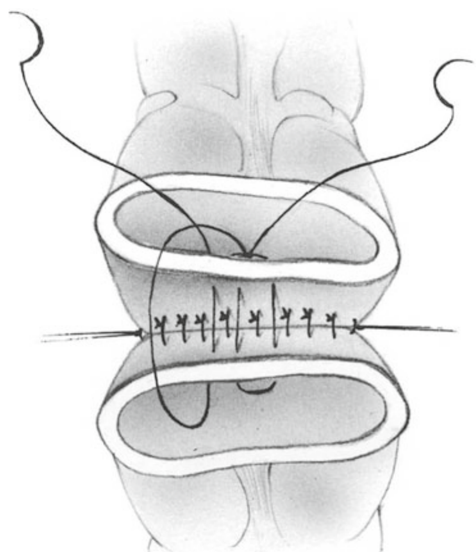

Fig. 51.21

lateral margin of the anastomosis is reached (Fig. 51.22). At this point pass the needle from the inside to the outside of the rectum and hold it temporarily in a hemostat.

Grasp the remaining needle and insert a continuous locked suture of the same type, beginning at the midpoint and continuing to the right lateral margin of the bowel. Here, pass the needle through the rectum from inside out (Fig. 51.23).

Standing on the left side of the patient, use the needle on the right lateral aspect of the anastomosis to initiate the anterior mucosal layer. Insert continuous sutures of either the

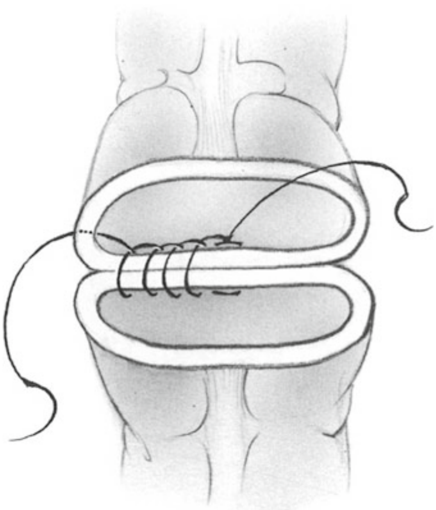

Fig. 51.22

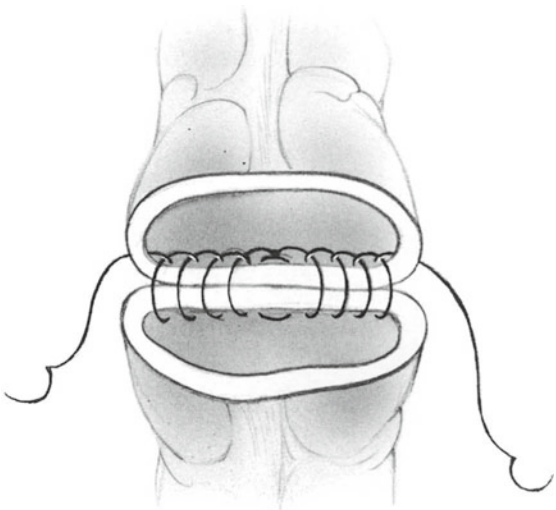

Fig. 51.23

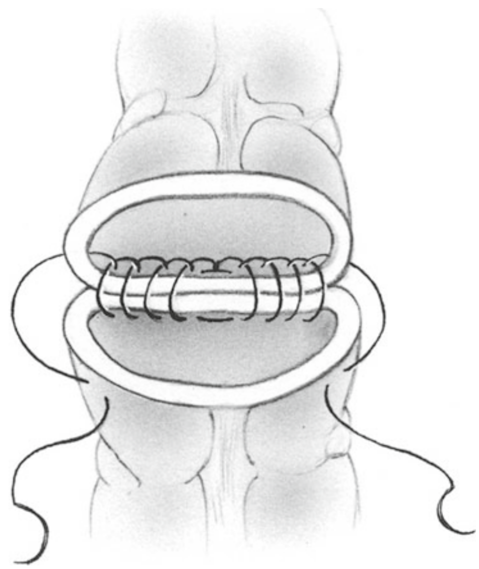

Fig. 51.24

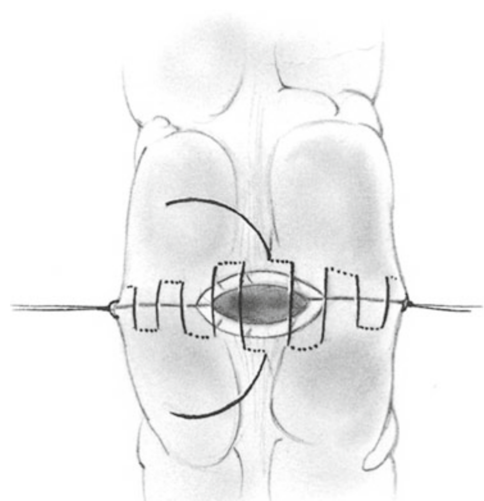

Fig. 51.25

Cushing or Connell type to a point just beyond the middle of the anterior layer. Then grasp the needle emerging from the left lateral margin of the incision and insert a similar continuous Connell or Cushing stitch. Complete the anterior mucosal layer by tying the suture to its mate and cutting the tails of these sutures (Figs. 51.24 and 51.25).

Complete the anterior seromuscular layer by inserting interrupted 4-0 silk atraumatic Lembert sutures (Fig. 51.26). Now carefully rotate the anastomosis to inspect the integrity of the posterior layer. Test the diameter of the lumen before closing the mesentery by invaginating the colon through the lumen gently with the thumb and forefinger. Then close the mesentery with continuous 2-0 PG sutures (Fig. 51.27). Leave the peritoneal defect in the left paracolic gutter unsutured.

Stapled Colorectal Anastomosis

To construct a stapled colorectal anastomosis, first close the proximal descending colon with a 55/3.5 mm linear stapling device (Fig. 51.28). Apply an Allen clamp to the specimen side and divide the colon flush with the stapler. Remove the stapler (Fig. 51.29) and replace the Allen clamp with an umbilical tape ligature covered with a sterile rubber glove (Figs. 51.30 and 51.31). Alternatively, divide the colon with a cutting linear stapler. Then direct attention to the rectum, a segment of which was previously cleared of surrounding fat and vascular tissue. Use the 55/3.5 mm linear stapling device (Fig. 51.28) to apply a layer of staples to this segment of rectum. Do not remove the specimen; retain it so mild

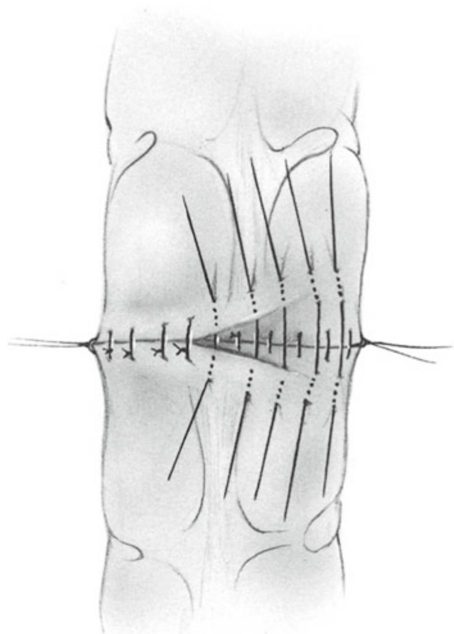

Fig. 51.26

upward traction on it can stabilize the rectum during application of the stapling device (Fig. 51.29).

Make a stab wound on the antimesenteric border of the proximal colon at a point 5–6 cm proximal to the staple line. A scalpel blade or electrocautery may be used to make this incision. Make a second stab wound in the anterior wall of the rectal stump at a point 1 cm distal to the staple line already in place (Fig. 51.32). Approximate the two stab wounds opposite each other, placing the proximal colonic segment anterior to the rectal stump. Insert the linear cutting stapling device, with one fork in the rectal stump and the other in the proximal colonic segment (Fig. 51.33). Allis clamps or guy sutures may be used to approximate the rectum and colon in the crotch of the stapler. Fire and remove the stapler; then carefully inspect the staple line for any defects or bleeding. Close the remaining defect with a continuous inverting 4-0 PG atraumatic suture to the mucosa. Reinforce this closure with a layer of interrupted 4-0 silk atraumatic seromuscular Lembert sutures (Fig. 51.34). Carefully inspect all the staple lines to ascertain that the staples have closed properly into the shape of a B. Bleeding points may require careful electrocoagulation or fine suture ligatures. Transect the rectosigmoid just above the rectal staple line (Fig. 51.34) and remove the specimen.

Stapled Colocolonic Functional End-to-End Anastomosis: Chassin's Method

When the lumen of one segment of bowel to be anastomosed is *much* smaller than the other, as in many ileocolonic anastomoses, the stapling technique illustrated in Figs. 49.21 and 49.23 is the simplest method. When a stapled anastomosis is constructed distal to the sacral promontory, the circular stapling technique (see Chap. 53) is preferred. However, for all other intraperitoneal anastomoses of small and large bowel, we have developed a modification of the end-to-end anastomosis. This modification, described in the following steps, avoids the possibility that six rows of staples are superimposed, one on the other, as may happen with the Steichen method.

1. Align the two open ends of bowel to be anastomosed side by side with the antimesenteric borders of each in contact.
2. Insert the linear cutting stapling instrument, placing one fork in each lumen (Fig. 51.35). Draw the mesenteric borders of the bowel in the direction opposite to the location of the stapler. Avoid bunching too much tissue in the crotch of the stapling device. Lock and fire the instrument.
3. After unlocking the stapling instrument, withdraw it from the bowel. Apply Allis clamps to the extremities of the GIA staple line (Fig. 51.36, point A, shows the first extremity).
4. Place the 90 mm linear stapler in the proper position and fire it (Fig. 51.37). Excise the redundant bowel with Mayo scissors and lightly electrocoagulate the everted mucosa.
5. Remove the linear stapler (Fig. 51.38), and carefully inspect the entire anastomosis for the proper B formation of staples.
6. Finally, insert a single 4-0 atraumatic silk seromuscular Lembert suture at the base of the anastomotic staple line (Fig. 51.38). This prevents any undue distracting force from being exerted on the stapled anastomosis.

Closure

Discard all contaminated surgical gloves and instruments. Irrigate the abdomen. Most surgeons prefer to close the defect in the mesocolon (Fig. 51.27). A continuous suture of 2-0 PG is suitable for this purpose, although the defect is usually so large that omitting this step does not seem to lead to internal bowel herniation. Close the abdominal incision in routine fashion without placing any drains in the peritoneal cavity.

Postoperative Care

See Chap. 49.

Complications

See Chap. 49.

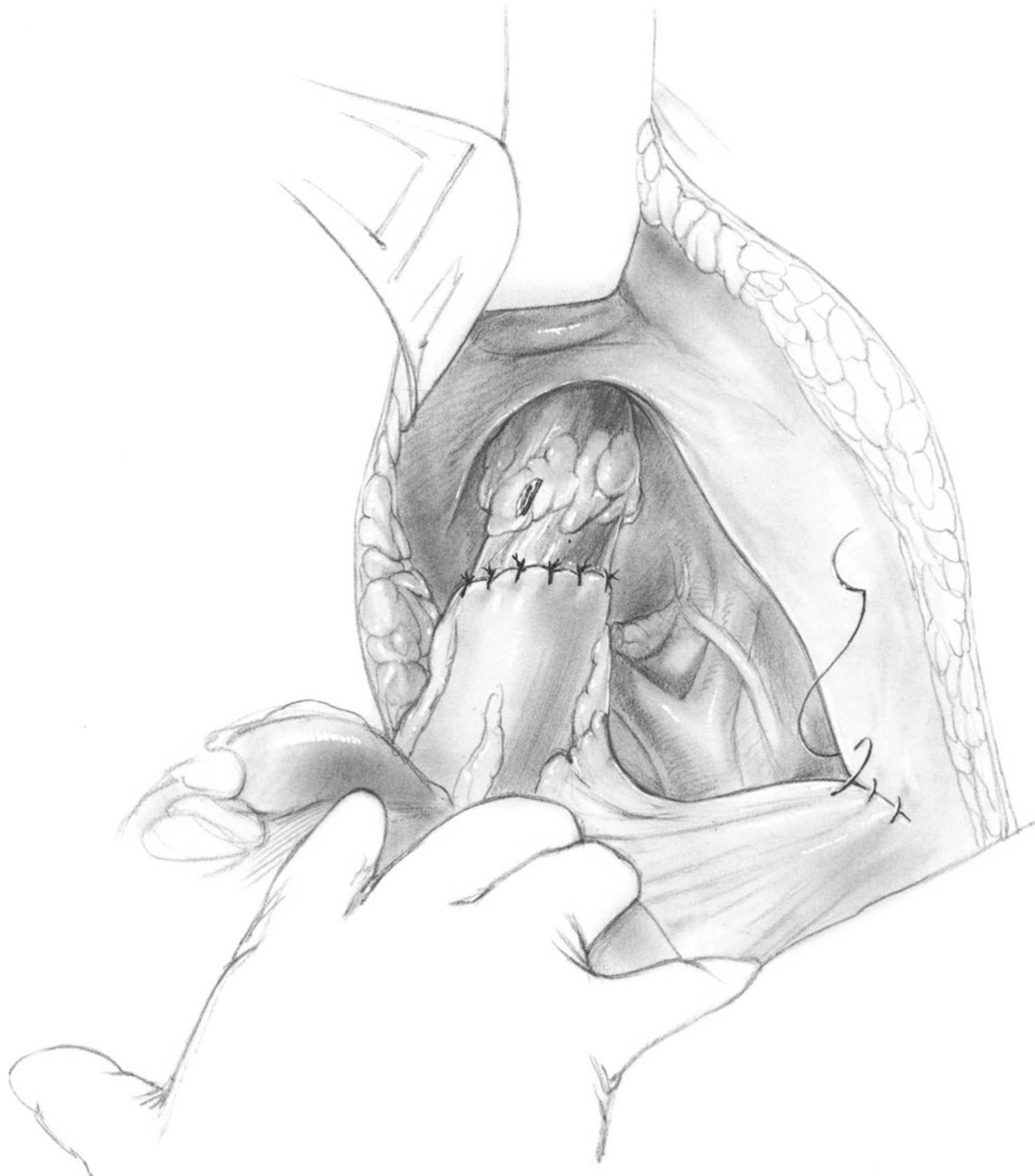

Fig. 51.27

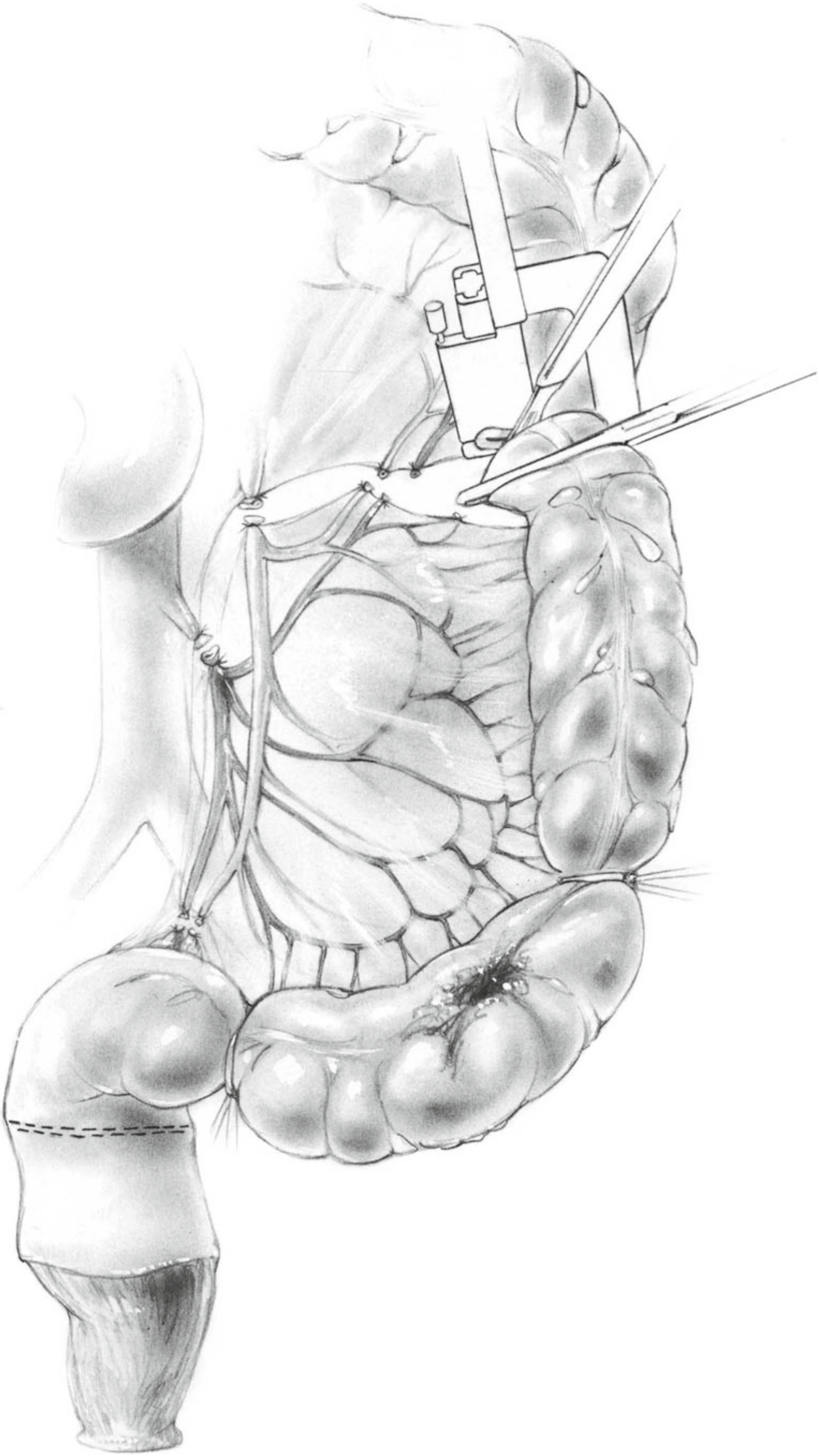

Fig. 51.28

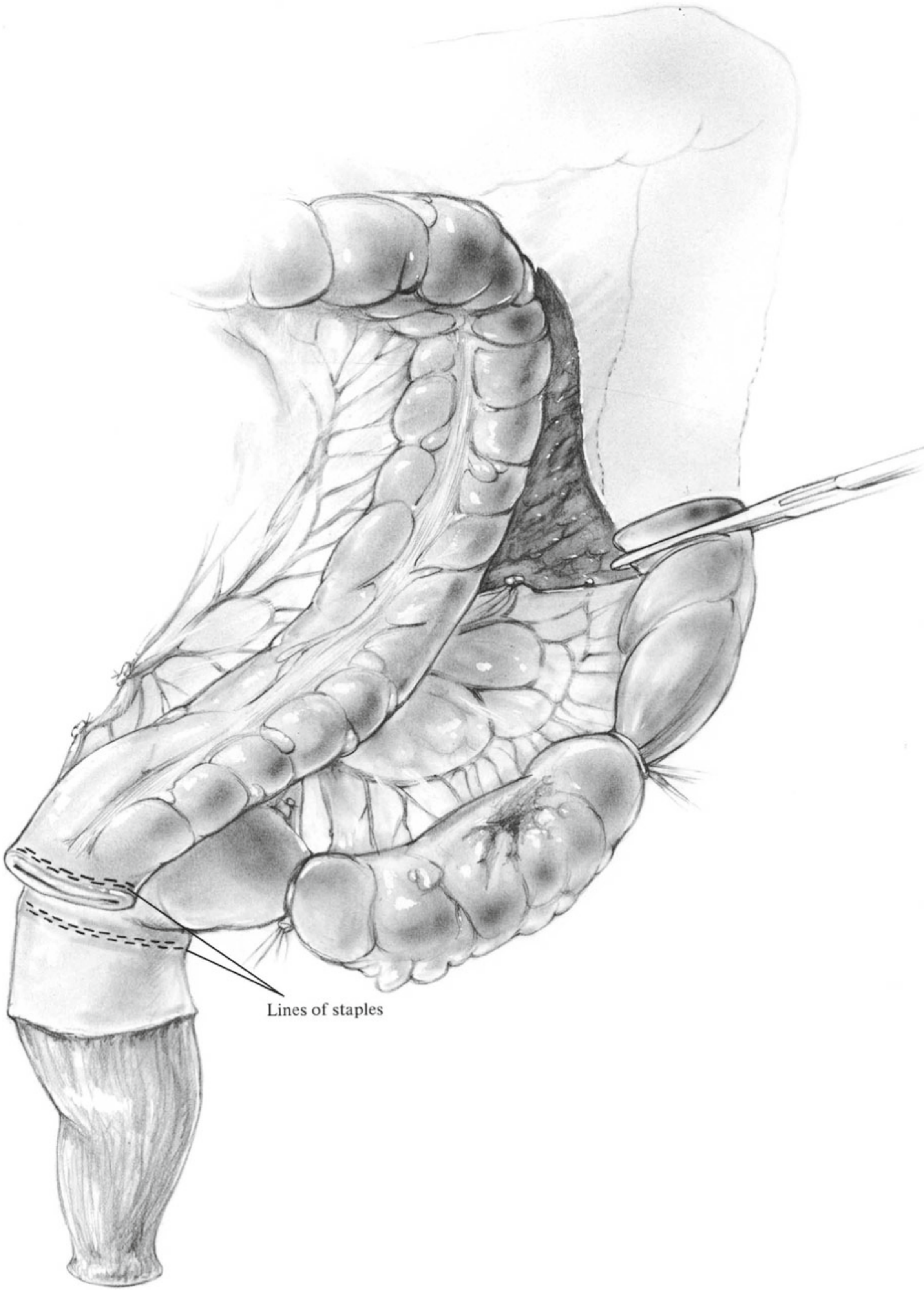

Fig. 51.29

Fig. 51.30

Fig. 51.31

Fig. 51.32

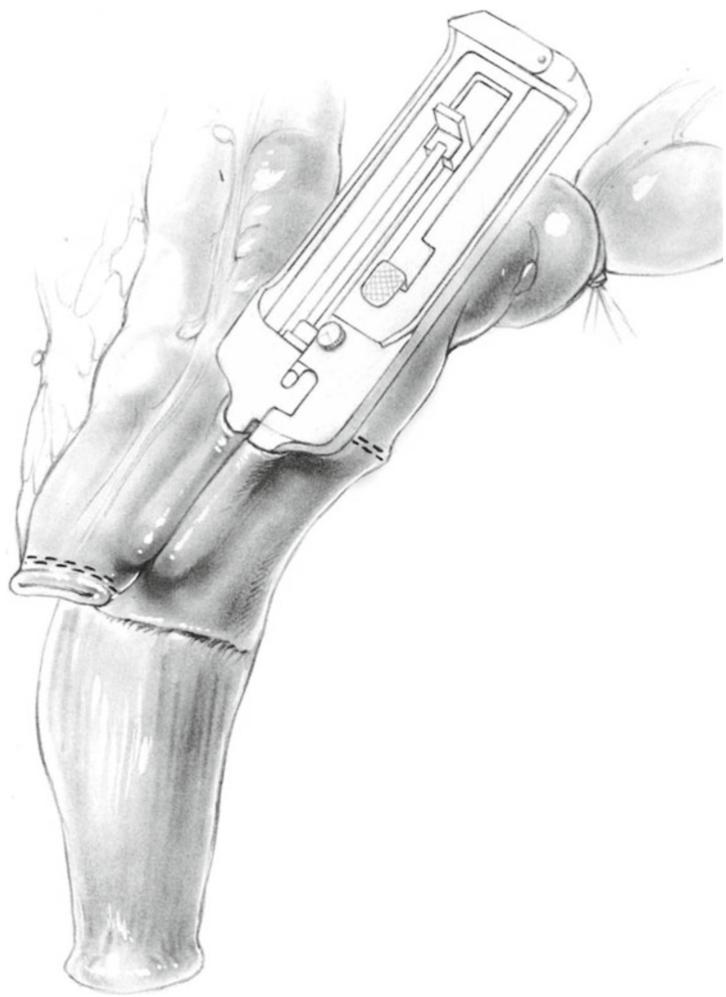

Fig. 51.33

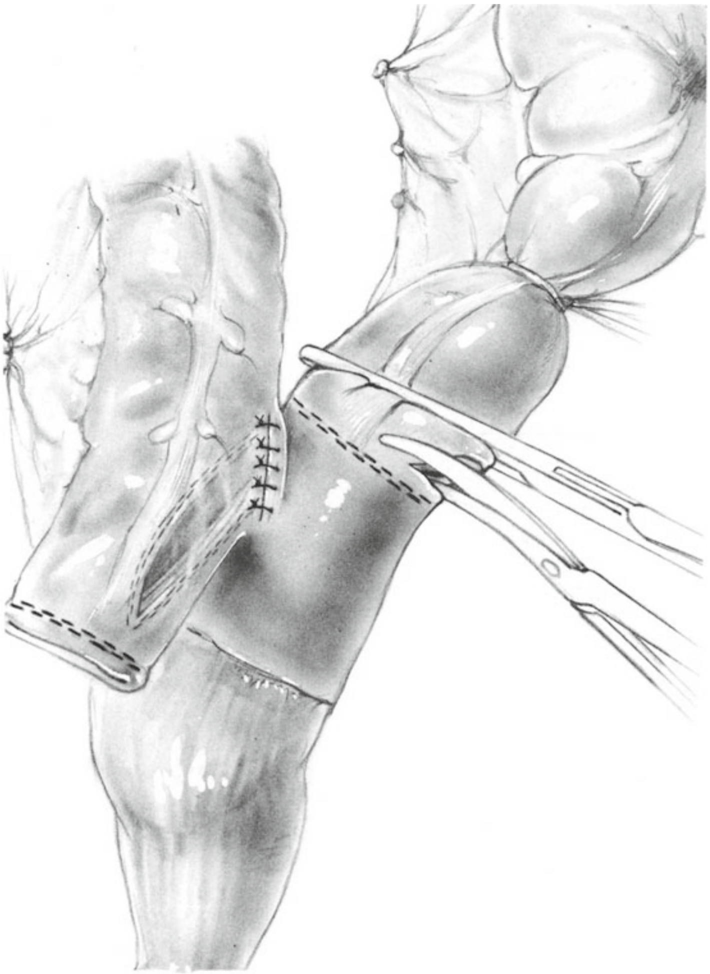

Fig. 51.34

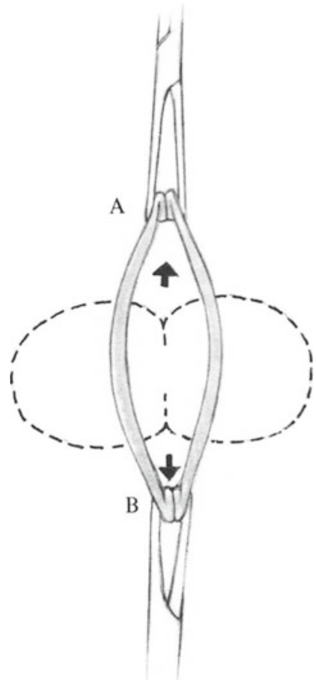

Fig. 51.36

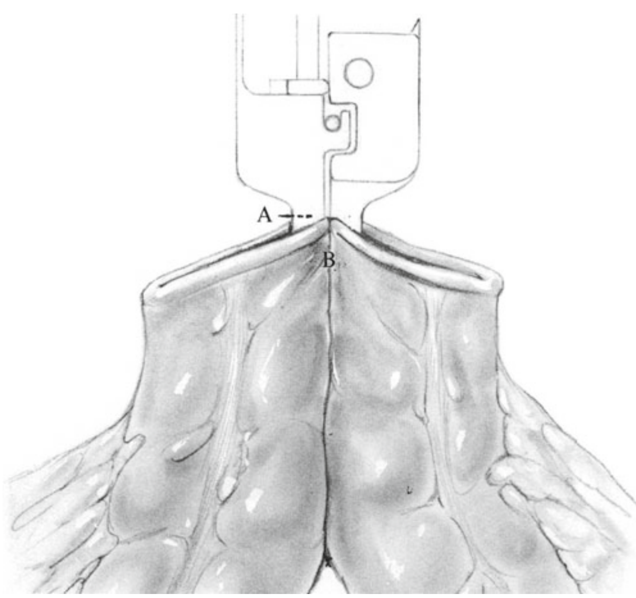

Fig. 51.35

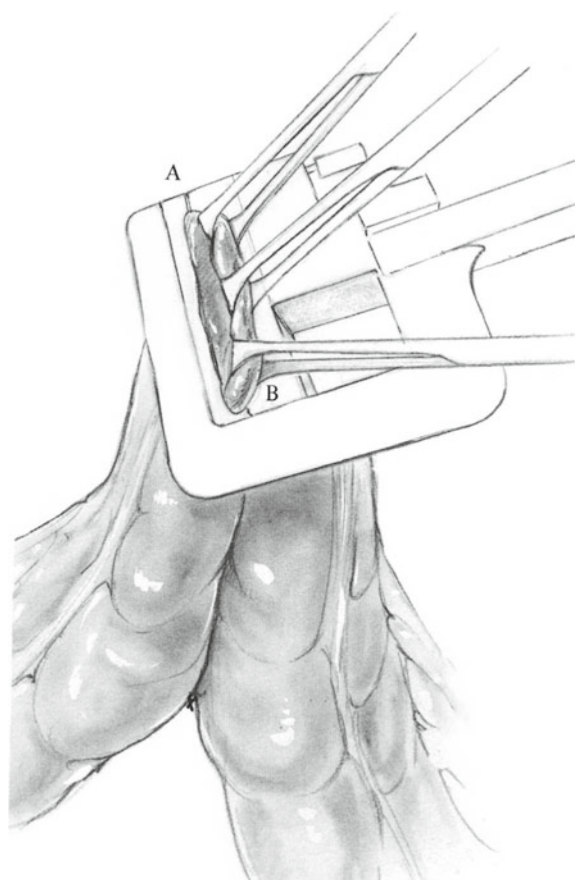

Fig. 51.37

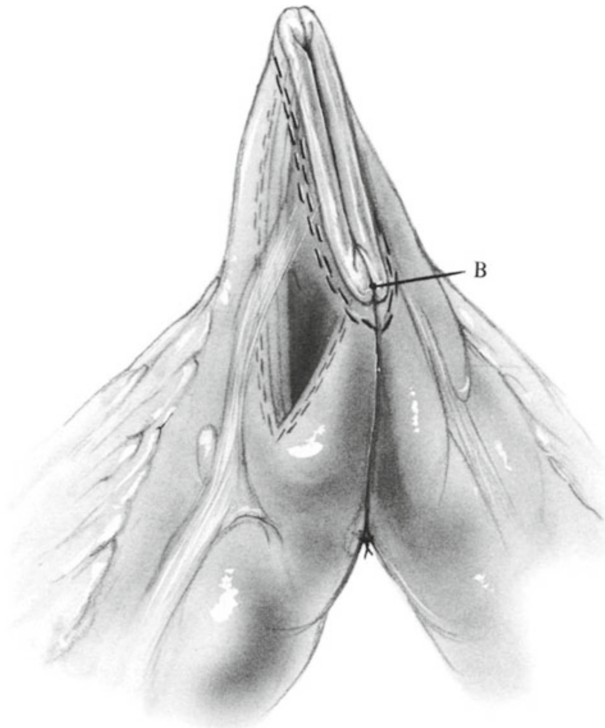

Fig. 51.38

Further Reading

Bergamaschi R, Arnaud JP. Intracorporeal colorectal anastomosis following laparoscopic left colon resection. Surg Endosc. 1997;11:800.

Laparoscopic Left Hemicolectomy and Low Anterior Resection

52

Kleber Ricciardi and Steven D. Wexner

Indications

Endoscopically unresectable colonic polyp
Crohn's colitis (limited segmental in selected cases)
Diverticulitis
Volvulus
Colonic carcinoma
Rectal carcinoma
Endometriosis
Solitary rectal ulcer

Preoperative Preparation

Mechanical Bowel Preparation

Sodium phosphate 90 ml on the day before the surgery

Administration of Prophylactic Antibiotics

Oral antibiotics (neomycin and metronidazole) on the day before the surgery and intravenous antibiotics at induction of anesthesia

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Other Perioperative Steps

Sequential compression stockings and subcutaneous heparin or low molecular weight heparin for venous thrombosis prophylaxis

Pitfalls and Danger Points

Injury to inferior epigastric vessels, spleen, ureters, bladder, and sacral vessels
Inadequate mobilization of colon and resection margin
Tenuous blood supply to the distal or proximal margins
Tension on the anastomosis

Operative Strategy

Laparoscopic left hemicolectomy and low anterior resection are technically demanding that necessitate successful completion of a challenging learning curve. The requisite learning is limited not only to the techniques and methods but also as importantly to appropriated patient selection. Moreover, appropriate preoperative evaluation(s) may be valuable to facilitate the procedure. Specifically, computed tomography (CT) scan can be useful to assess the extent of the disease; water-soluble contrast enema and/or small bowel series may be helpful to anatomically localize any stenosis or fistula tract in patients with inflammatory processes. Colonoscopy with biopsy is usually performed to determine the pathology; however, it may not always accurately detect the anatomical site. Intraoperative localization can be both difficult and time consuming, particularly when the surgical indication is an endoscopically unresectable adenoma or a small carcinoma. Therefore, it is advisable to preoperatively perform endoscopic tattoo marking to help ensure extraluminal recognition of the tumor site in these patients. Thus, preoperative endoscopic marking can facilitate lesion location and thus direct port placement and operative strategy. However,

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on some occasions, such as with diverticulitis or segmental Crohn's colitis, a water-soluble contrast enema may provide more useful data. In patients with low rectal cancer, endorectal ultrasonography can be performed for staging. Preoperative MRI can be useful in patients with endometriosis, solitary rectal ulcer, or presacral tumors.

Preoperative placement of ureteric stents may be useful when severe pelvic and/or retroperitoneal inflammatory processes are anticipated.

Operative Technique

Room Setup and Patient Positioning

The video monitors should be placed near the patient's left shoulder and the patient's right knee because a right-hand dominant surgeon typically stands on the patient's right side, with the assistant on the contralateral side and the camera operator on the ipsilateral side cephalad to the surgeon at the commencement of the surgery. The light sources, electrosurgical units, camera system, insufflator, and pressure monitor are on the patient's right side. The patient should be secured to the operating table allowing various positioning including steep Trendelenburg and lateral rotation during the procedure.

The patient is placed in the modified lithotomy position allowing the access to the perineum without interfering with the mobility of the surgical instruments. Both arms are tucked to the sides (adducted) enabling flexibility in the surgeon's position around the operating table. The arms and legs are well positioned and carefully padded with Allen stirrups (Allen Medical, Bedford Heights, OH) to help prevent peroneal nerve injuries and carefully padded to help prevent any brachial or other upper extremity plexopathy, neuropathy, or pressure injury.

If cystoscopy and bilateral ureteric catheters are not being utilized, then a sterile bladder catheter is placed after which rectal irrigation is undertaken. Irrigation is accomplished through a mushroom-tipped catheter initially with normal saline and then with povidone iodine.

Trocar Placement

The Hasson (open) technique is used to place a 12 mm port through a supraumbilical incision. After achieving a 15 mmHg pneumoperitoneum, a 30° angled 10 mm diameter laparoscope is introduced through this port. The port is secured to the fascia by suture materials on both sides of the port. Following camera insertion into the abdominal cavity, an exploration commences with a view at the entire abdomen. Anatomy, resectability, adhesions, and concomitant conditions are assessed.

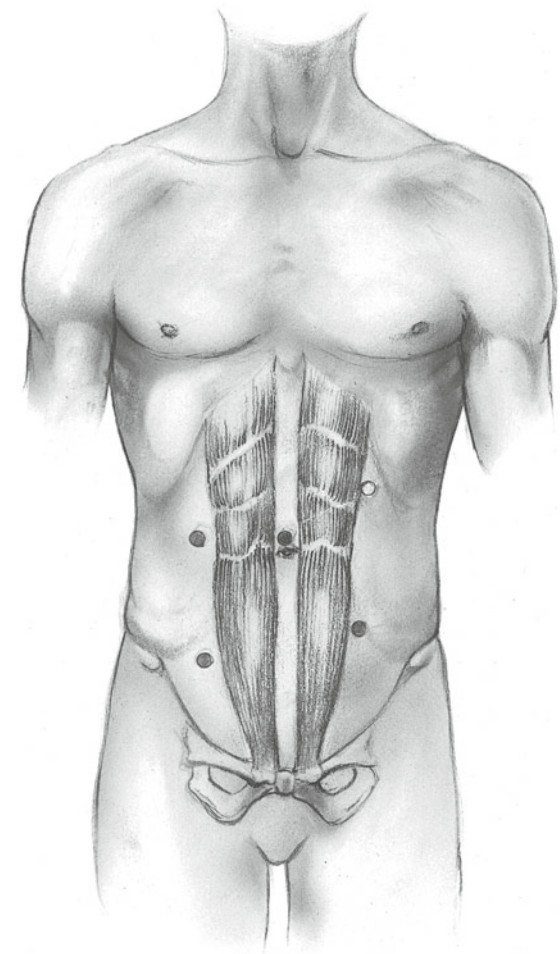

Fig. 52.1

Two trocars are placed in the right side lateral to the rectus muscle. Each trocar should be placed under direct vision lateral to the rectus muscle in order to give a mechanical advantage during dissection and avoid inadvertent injury to the epigastric vessels. It is essential that these accessory trocars should be placed at least a hand width from each other to avoid instrument crowding. One or two additional trocars may be placed in the left paraumbilical or suprapubic positions, if necessary to facilitate adequate mobilization of the splenic flexure or for pelvic access in low anterior resection. Proposed sites of port placement are shown in Fig. 52.1.

Intraoperative colonoscopy can be performed to localize the diseased segment after the establishment of the pneumoperitoneum and trocar placement.

Mobilizing the Left Colon and Identification of the Left Ureter

We typically perform the "lateral-to-medial" technique. Following positioning of the patient to right side tilted down,

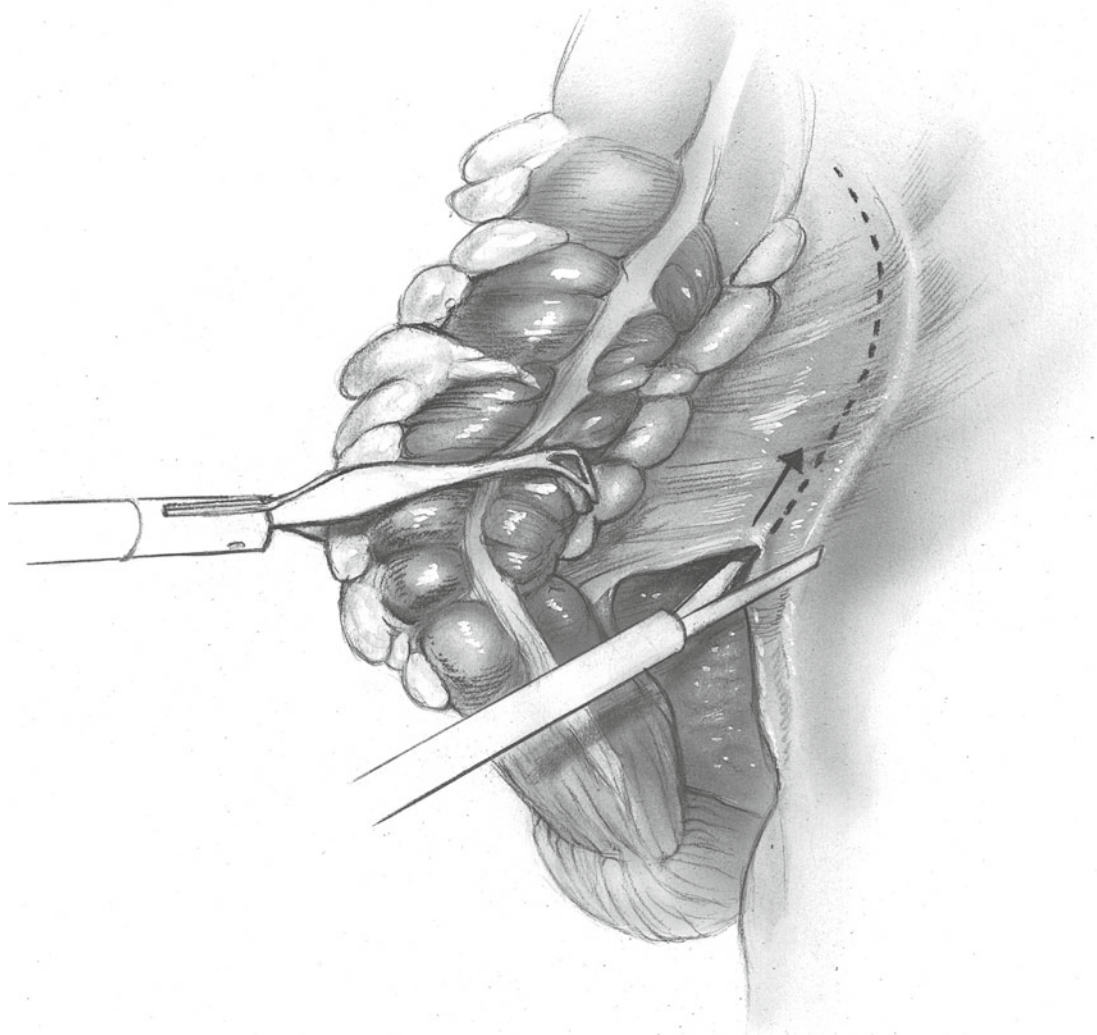

Fig. 52.2

start with the mobilization of the left colon from the left lateral sidewall, along with the white line of Toldt (Fig. 52.2). The surgeon uses the two right-side ports for instrumentation. The surgeon gently grasps the bowel with an atraumatic forceps and medially retracts it. This maneuver typically starts at the level of the sigmoid colon using either an electrocautery or the ultrasonic scalpel. The ultrasonic scalpel has among its several advantages in improved visualization as vessels and tissue are dissected without production of smoke. The dissection should be undertaken in the plane between the posterior aspect of the colonic mesentery and Gerota's fascia.

As the sigmoid colon and the distal descending colon are medially mobilized, it is crucial to identify the left ureter prior to any vascular division. The left ureter is usually identified in the left iliac fossa overlying the iliac vessels. Again, ureteric stents can be useful to assist with this step especially in patients with inflammatory processes. If the surgeon fails to identify the left ureter at this point in the laparoscopic procedure, conversion to an alternative approach may be indicated.

Dissecting the Splenic Flexure and the Transverse Mesentery

The operating table is placed in the reverse Trendelenburg position and tilted down towards the right side. Dissection then proceeds to the proximal colon to the splenic flexure and distal to middle portion of the transverse colon. The surgeon must ensure a sufficient resection margin and adequate mobilization to enable a tension-free anastomosis. This maneuver requires great attention not to traumatize the spleen (Fig. 52.3). The surgeon can move to the

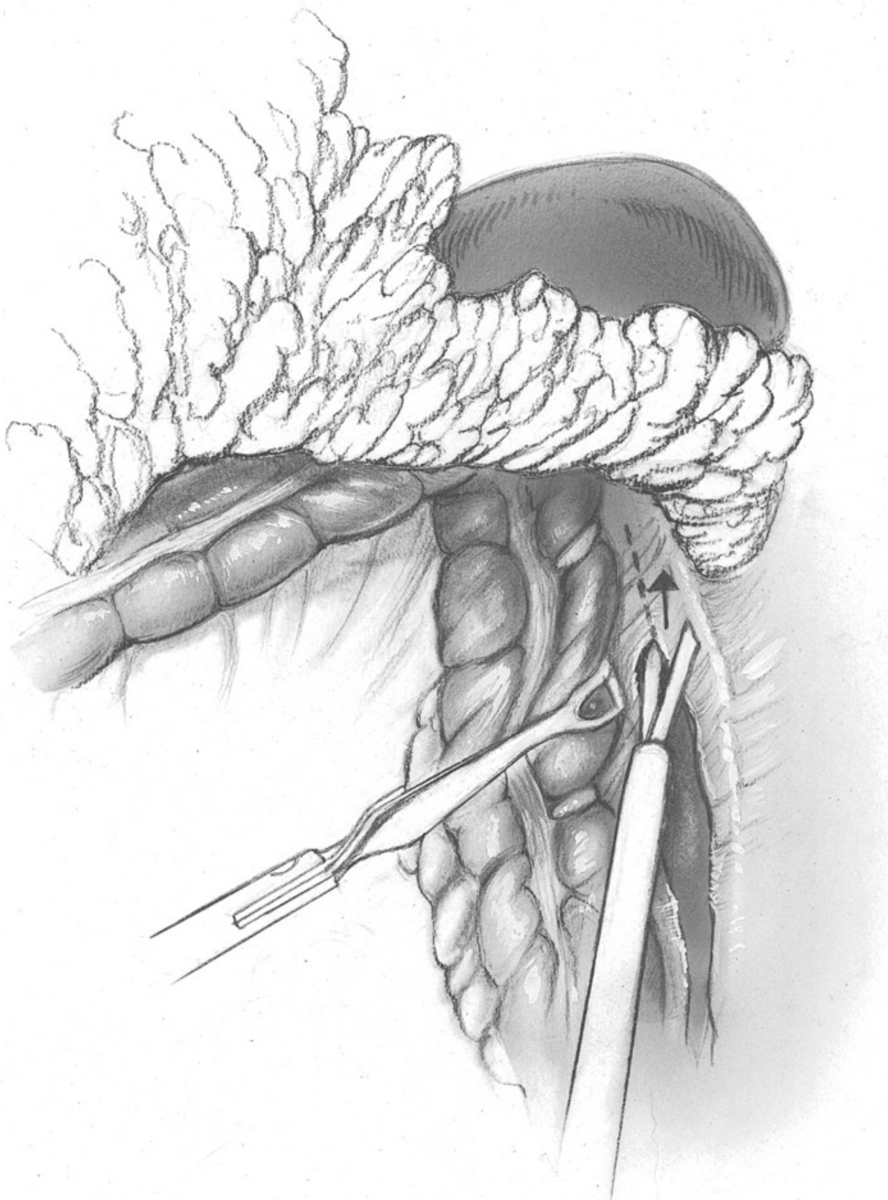

Fig. 52.3

position between the patient's legs, a position from which it may sometimes be technically superior to dissect the splenic flexure. The surgeon may place the additional trocars as previously described, in the suprapubic midline or left paraumbilical so that he or she can face both the splenic flexure and the monitor on the patient's shoulder in a straight line. The dissection should be continued as close to the bowel as possible, staying laterally and on the plane between Gerota's fascia and the mesentery.

Once the most cephalad portion of attachments at the splenic flexure are mobilized, then the greater omentum is separated from the transverse colon (Fig. 52.4). The division of the gastrocolic ligament can be performed with cautery, clips, ultrasonic scalpel, or a bipolar energy device (Fig. 52.5). Caudal and medial retraction of the transverse colon facilitates the isolation of the transverse mesentery; injuries to the pancreas body or tail must be carefully avoided.

Identification and Transection of the Mesenteric Vessels

Once the left colon has been completely mobilized, the next phase is to identify and transect the inferior mesenteric vessels. The surgeon moves back to the patient's right side

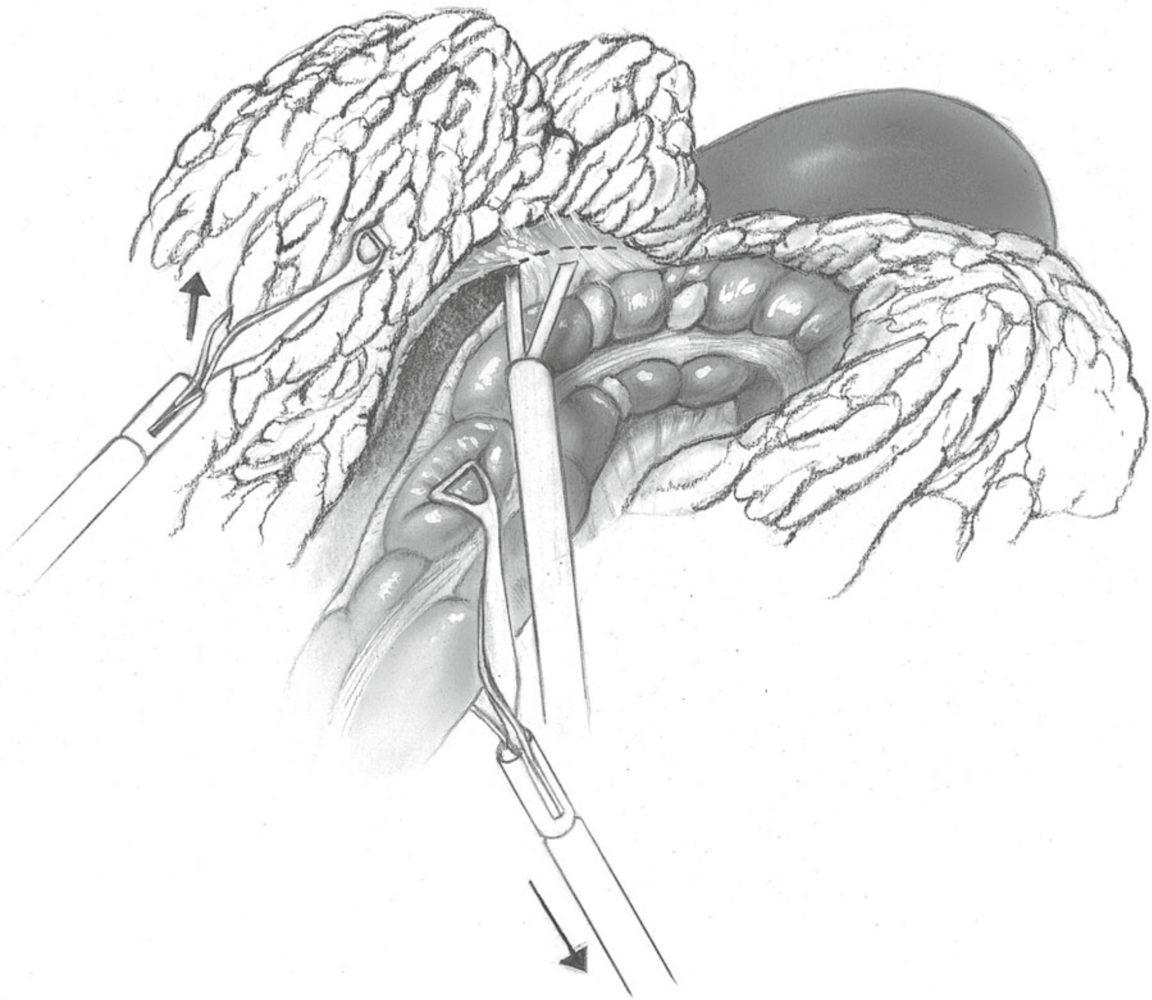

Fig. 52.4

and uses the right-side ports. Providing gentle countertraction with the Babcock clamp, the inferior mesenteric vascular arcade is exposed and identified within the sigmoid mesentery as a "bow stringing" (Fig. 52.6). Windows are created within the mesentery skeletonizing the vessels, after which a vascular stapler, clips, or an energy source is applied. The respective instrument must be accurately applied to avoid any injury to the left ureter, which lies just behind the sigmoid mesentery. The left ureter and the gonadal vessels may have to be gently reflected laterally to avoid being transected with the inferior mesenteric pedicle. After verification that the left ureter is not incorporated, whatever instrument is used, the vessels are divided close to their origins. It is crucial to visualize the distal tips of stapler application to insure that no extraneous tissue is incorporated. The inferior mesenteric vein can also be transected allowing the proximal colon to further reach towards to the pelvis. Vascular division may be extended to the left branch of the middle colic vessels depending upon the pathology and the location of diseased segment. Similar countertraction is performed, giving an adequate tension to the transverse mesentery.

The dissection of the remaining mesentery is then initiated from the transected vascular pedicle, using clips, a cautery, ultrasonic scalpel, or an alternate energy source. This dissection can be close to the bowel or along the root of the mesentery based on the indication for surgery.

After the vascular transection has been accomplished, the planned proximal margin of the colon is gently deliver to the pelvis in order to assure that adequate length of the colon has been mobilized for a tension-free anastomosis. The anatomical blood supply to the proximal margin of the colon needs to be evaluated as well.

Dissecting the Rectum and Total Mesorectum Excision (TME) in Low Anterior Resection

The total mesorectal excision and the mobilization of the rectum are performed in order to resect the pelvic visceral

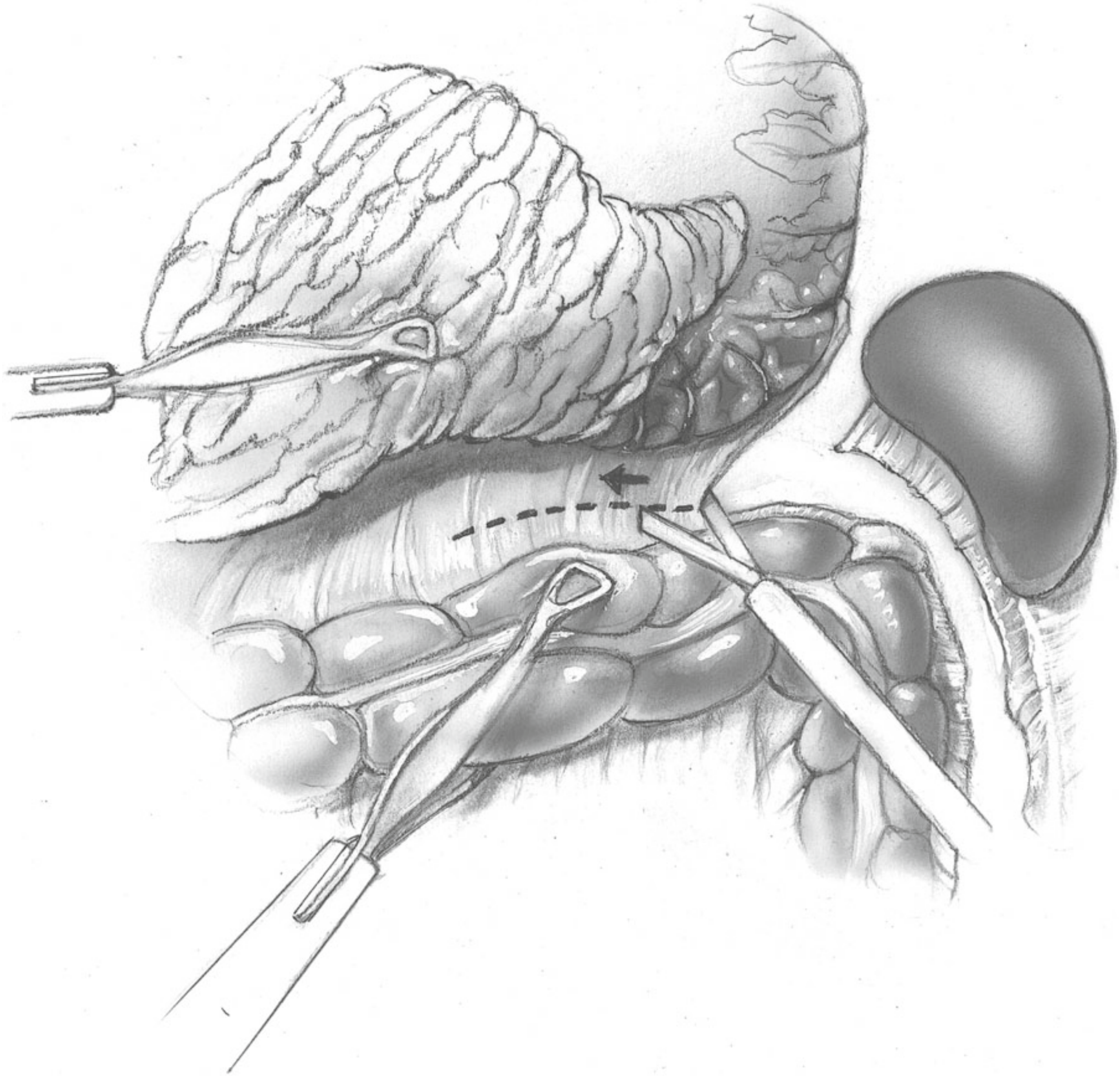

Fig. 52.5

structures (rectum and mesorectum), involved within visceral fascia and to preserve sympathetic autonomic nerves and plexuses parasympathetic, coated by the pelvic fascia. The surgeon dissects the posterior wall of the rectum with electrocautery or an ultrasonic scalpel through the avascular presacral space between visceral and the presacral fascia. Providing gentle anterior and superior traction with an atraumatic clamp through left paraumbilical port makes exposure easier. The upper rectal dissection is continued with the same exposure as the lateral peritoneum is divided.

Proceeding anteriorly, the anatomical reference will be the seminal vesicles in males or the superior vaginal wall (Douglas' cul-de-sac) in females. An atraumatic clamp placed in the left paraumbilical or suprapubic port is used to gently retract the rectum or sigmoid upwards, and the right or left second clamp can be used to gently retract the bladder or the uterus anteriorly and inferiorly, allowing dissection of the pelvic peritoneum. The dissection is usually accomplished with an ultrasonic scissors.

Anterior rectal traction is achieved by a clamp placed in left paraumbilical port and as the surgeon's left hand clamp exposes the distal rectum, allowing division of the posterior attachment, releasing the rectum from the levator ani muscles and until the dissection reaches the anal canal.

Transection of the Distal Colon or Rectosigmoid Junction in Left Hemicolectomy or the Rectum in Low Anterior Resection

To obtain an adequate distal margin, the dissection of the bowel may be extended over the sacral promontory and

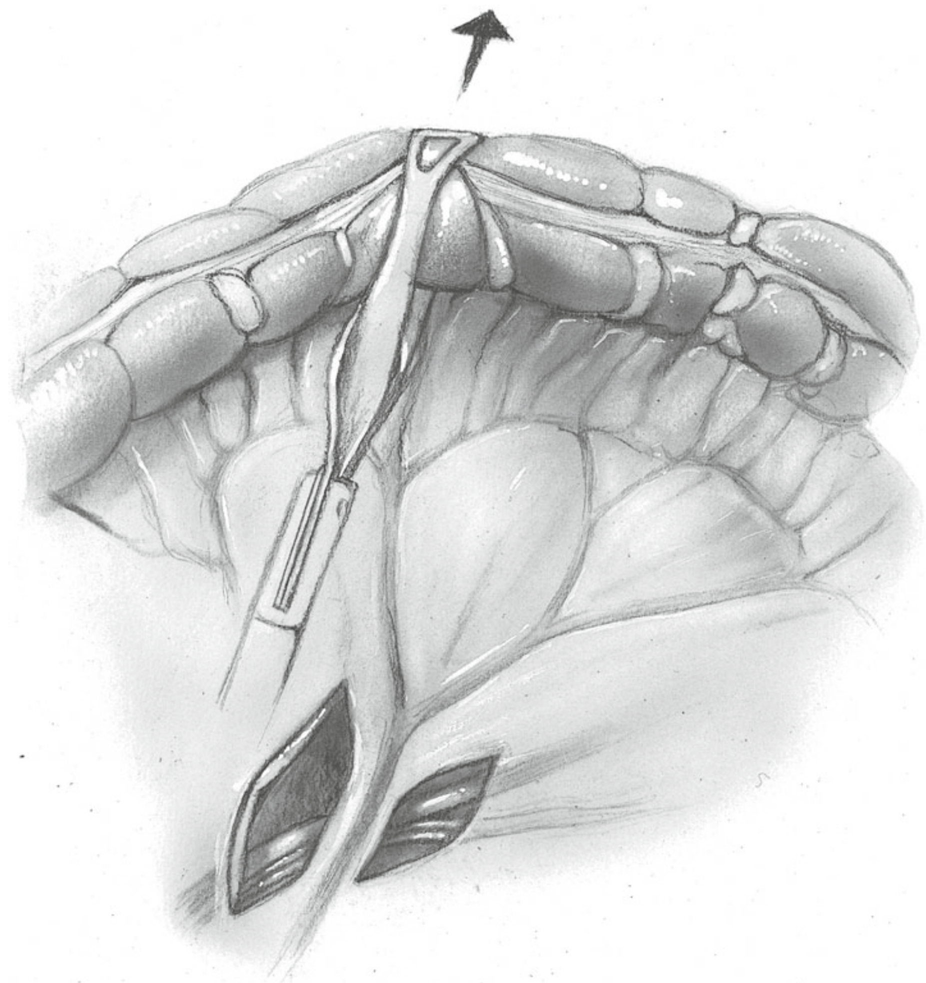

Fig. 52.6

into the presacral space as necessary. Termination of the colonic teniae and the appendices epiplocae at the sacral promontory is the landmark of the rectosigmoid junction. Verification of the distal level of the bowel transection must be done prior to the application of the linear stapler by the flexible endoscopy.

A 45 or 60 mm endoscopic linear cutting stapler is then introduced through the 12 mm right lower port, and the bowel is transected at the endoscopically and laparoscopically selected resection margin, insuring that no extraneous tissue is incorporated (Fig. 52.7). More than one application of the stapler may be necessary to accomplish the bowel transection. Assess the length of mesentery to insure a tension-free anastomosis in the following phase. If more length is necessary, further scoring of the peritoneum overlying the mesentery or transection of the inferior mesenteric vein may be necessary. If it is divided, proximal ligation at the duodenum with either clips or a stapler are preferred.

Exteriorization of the Left Colon or the Rectum

Once the left colon or the rectum has been completely mobilized, a trial reach to the intended level of anastomosis is undertaken. The preoperative proximal margin can be marked with clips to facilitate the extracorporeal component of the operation. The bowel is then exteriorized through either the left lateral or the suprapubic midline incision, and a 10–12 mm port is placed in the left lower quadrant position (if this port has not been placed prior to this point). A Babcock clamp is then used to gently hold the proximal colon in order to deliver it from the abdominal cavity. The incision is enlarged along the trocar length; typically 5 cm incision is adequate for this maneuver. A wound protector may assist in minimizing potential contamination.

Once the diseased segment has been completely exteriorized (Fig. 52.8), the proximal colonic resection proceeds with conventional surgical techniques. After an adequate resection margin has been obtained, a purse string clamp is applied on

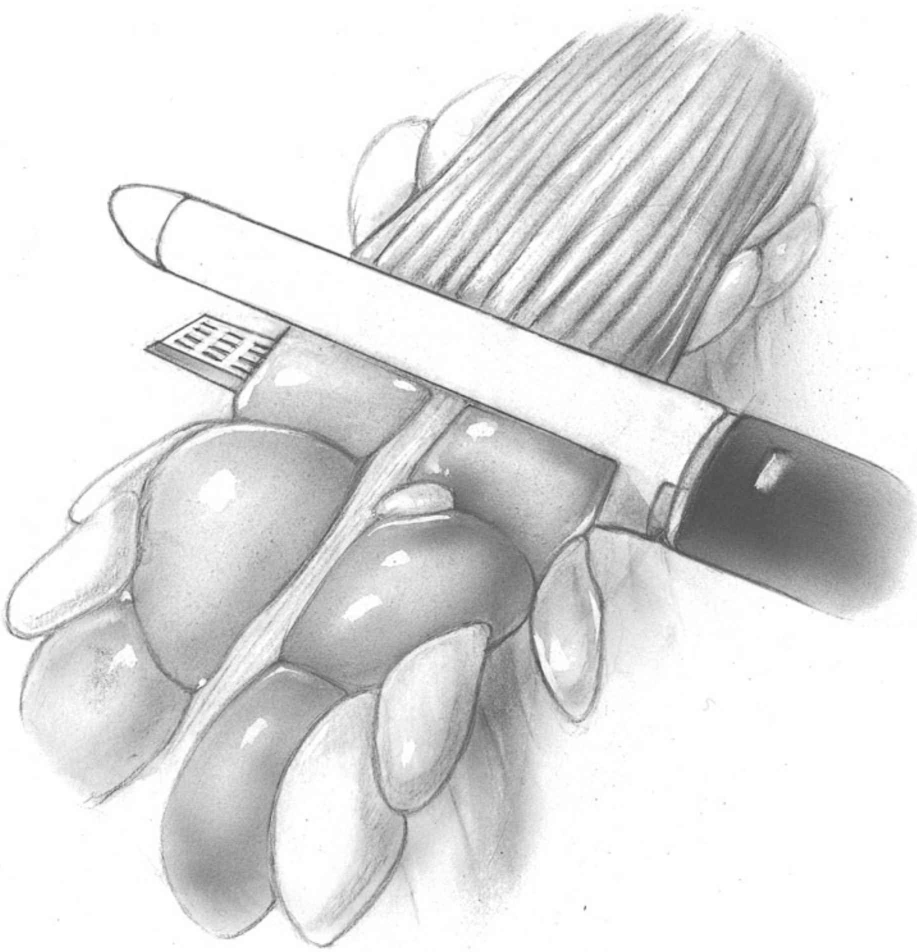

Fig. 52.7

the normal proximal bowel and the diseased segment is then transected (Fig. 52.9). After the purse string clamp is removed, the vascularity of the resection margin is verified.

Performing the Anastomosis

The distal margin will almost be at or distal to the rectosigmoid junction or necessitating an intracorporeal anastomosis. The anvil of the 29 or 33 mm circular stapler is placed into the proximal margin of the bowel, and the purse string suture is then secured (Fig. 52.10). The edge of the proximal bowel with anvil is appropriately trimmed by removing the attached appendices. The proximal bowel with the anvil is then returned into the abdominal cavity, and the incision is closed after which a pneumoperitoneum is reestablished.

The laparoscopic phase is resumed as the surgeon moves between the legs to introduce the 29 or 33 mm circular stapling device into the rectum. A Babcock clamp through the right lower quadrant port can help stabilize the distal stump of the bowel adjacent to the staple line. With slight pressure against the top of the stump, the spike is made to protrude (Fig. 52.11). The anvil holder is used in order to deliver the anvil into pelvis and then to approximate it to the circular stapler (Fig. 52.12). The camera can be repositioned as needed so that the entire team can circumferentially visualize both the distal and proximal portion of the anastomosis. While closing the stapler, any extraneous tissue must be reflected away, and the surgeon must verify that there is no tension and proper alignment prior to the firing. The stapler is then fired after verifying that both mesentery and bowel are oriented in their appropriate anatomical position. To check the integrity of the anastomosis, a noncrushing clamp is once again gently placed on the proximal bowel, in conjunction with transanal endoscopy with air insufflation into the water-filled pelvis ideally as part of flexible endoscopy with anastomotic visualization. The abdominal team then verifies that no air leaks are present.

Closure of the Wound

After irrigation of the wounds, each wound is closed by reapproximating the fascia. The skin may be then closed by either staples or subcuticular sutures.

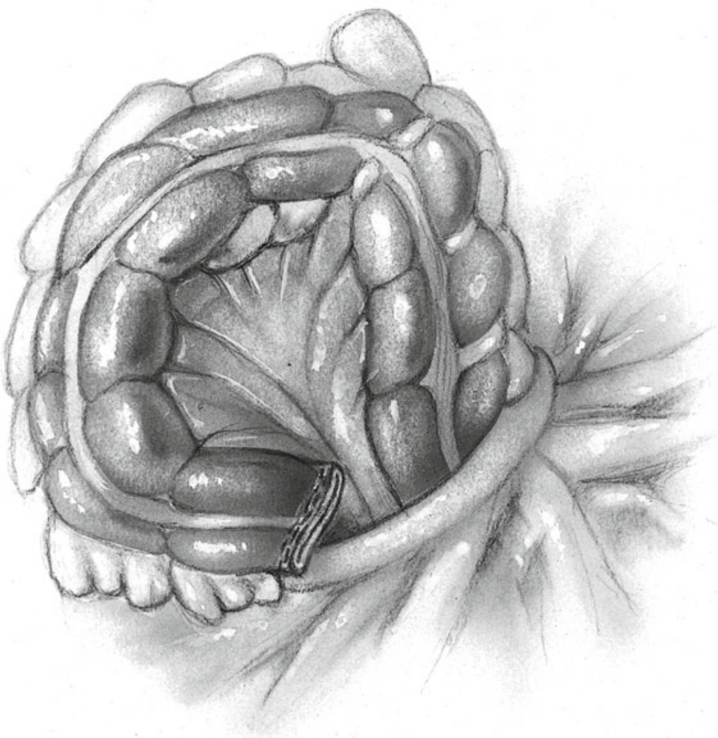

Fig. 52.8

Postoperative Care

Intravenous antibiotics are postoperatively continued for three doses unless significant fecal contamination or an abscess is encountered during the surgery.

Oral intake can be initiated on the day of surgery and then advanced to a regular diet as the patient tolerates feeding. In general the regimen begins in the clear liquid and then advanced to solid food.

Complications

Postoperative ileus or small bowel obstruction
Wound infection
Anastomotic leak
Anastomotic stenosis
Anastomotic bleeding
Port site herniation

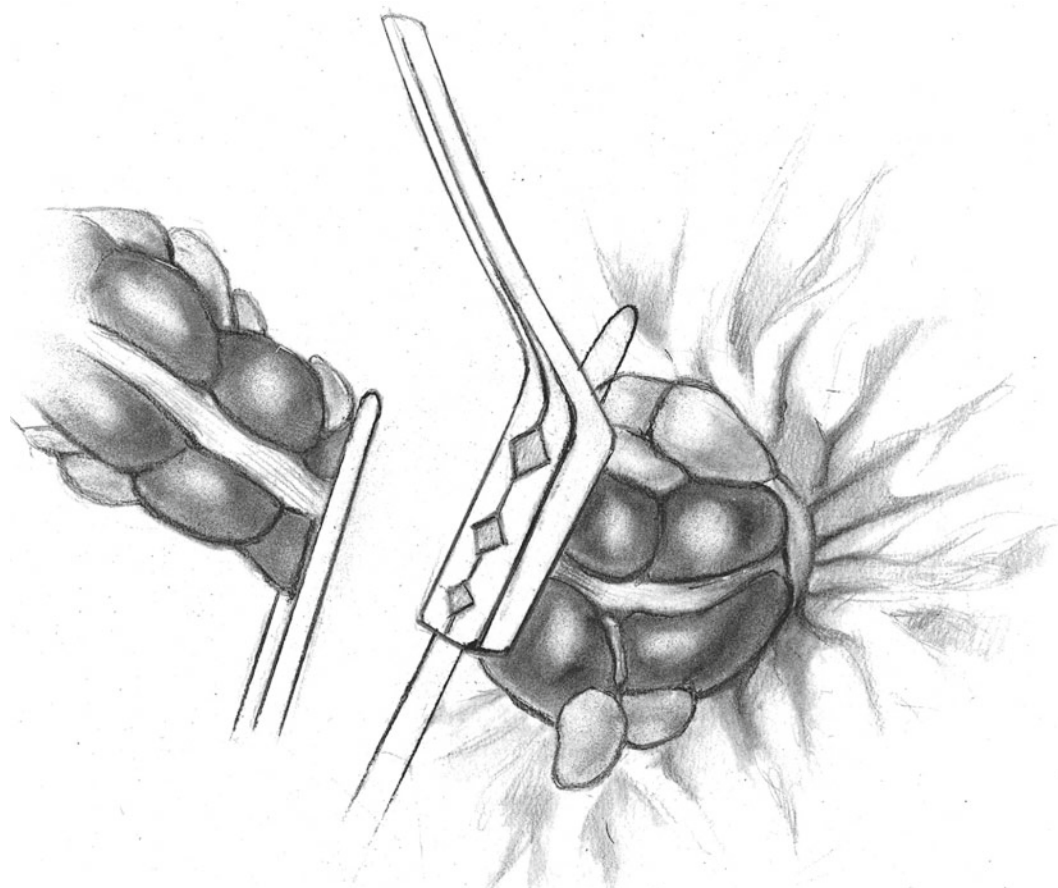

Fig. 52.9

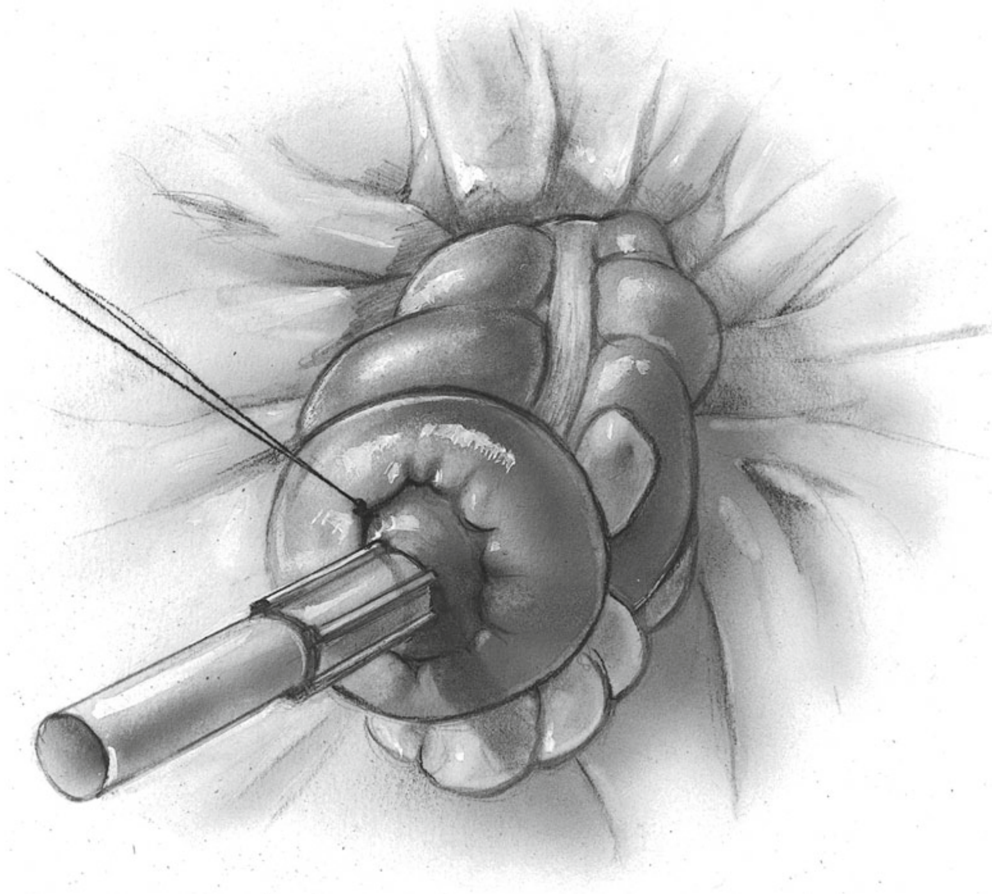

Fig. 52.10

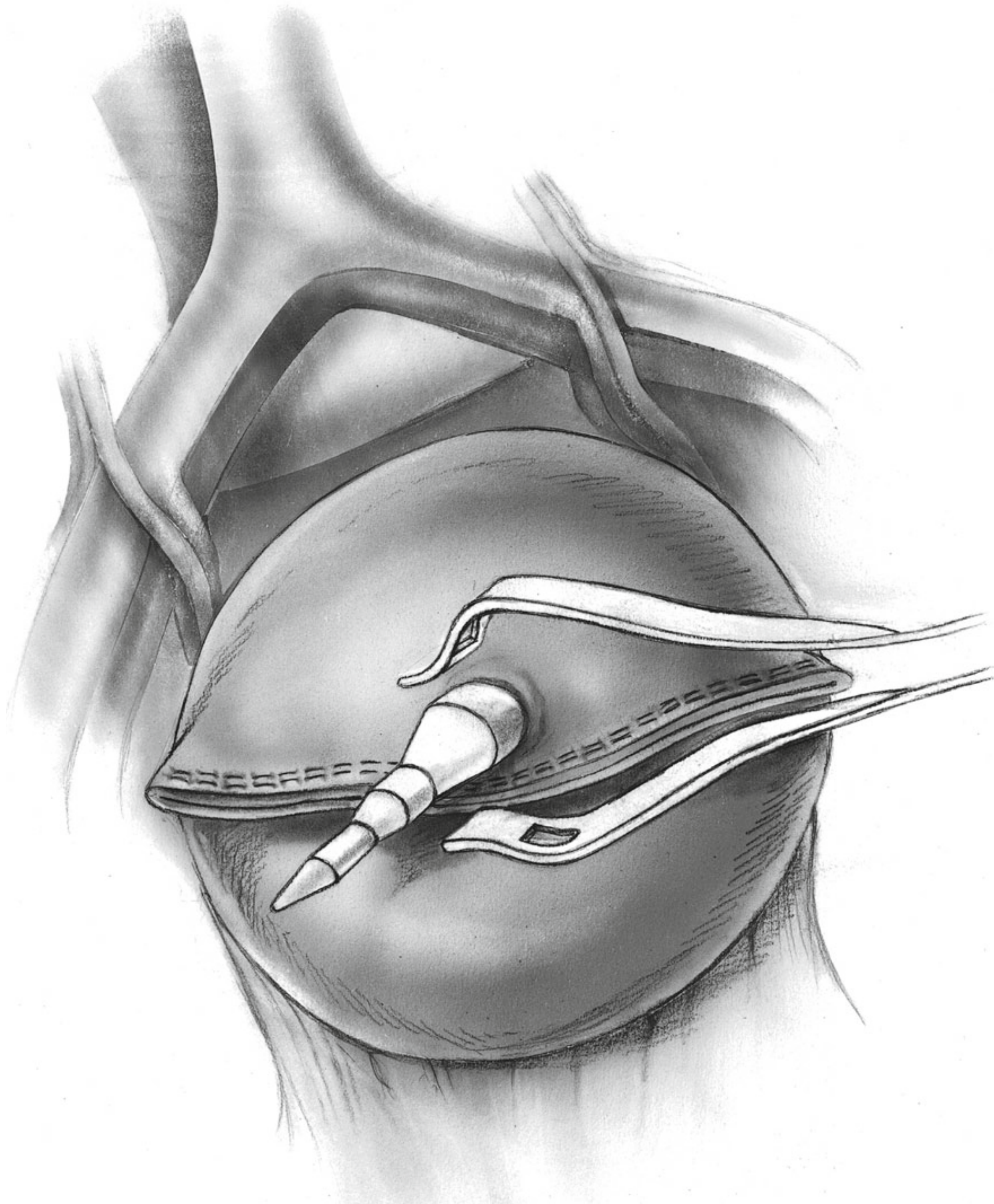

Fig. 52.11

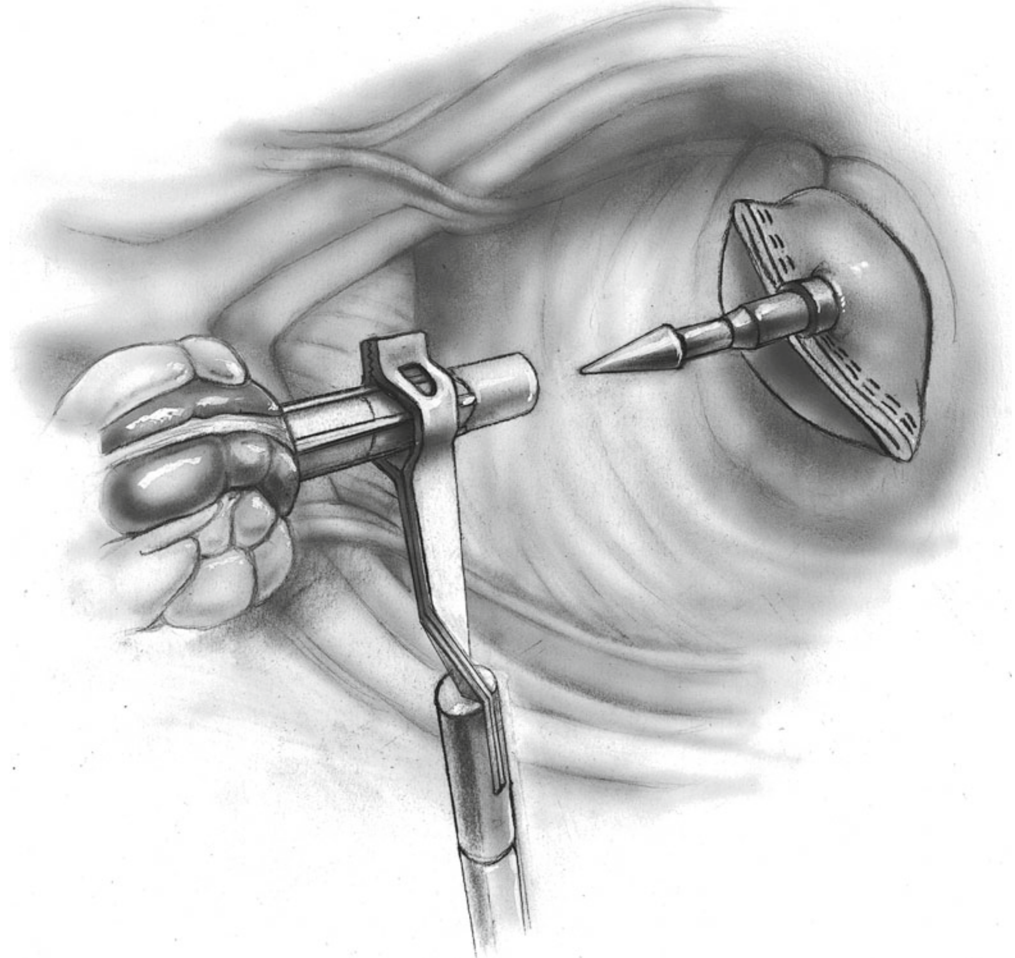

Fig. 52.12

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53 Low Anterior Resection for Rectal Cancer

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Low anterior resections are performed to treat malignant tumors of the middle and upper thirds of the rectum, 6–14 cm (and sometimes lower) from the anal verge.

Preoperative Preparation

Mechanical and antibiotic bowel preparation
Accurate staging including, as appropriate:

- Computed tomography (CT) of abdomen and pelvis
- MRI scan
- Endorectal ultrasonography

Other staging studies as indicated
Carcinoembryonic antigen
Preoperative radiation and chemotherapy, if appropriate, to increase resectability

Pitfalls and Danger Points

Anastomotic failure
Presacral hemorrhage
Trauma to rectal stump during presacral dissection
Ureteral damage

Operative Strategy

Oncologic Extent of Resection

Accurate preoperative staging and appropriate use of preoperative chemotherapy and radiation therapy should avoid situations where the surgeon must cut through tumor to effect resection. Three critical margins determine the success of surgery for rectal cancer: these are the proximal, the distal, and the circumferential. The proximal margin is generally not problematic as generally as large amount of proximal rectum and sigmoid are routinely removed. Current practice guidelines recommend a distal margin of 2 cm, although in some cases (particularly with early-stage disease) excellent results may be obtained with shorter margins. An adequate circumferential margin (defined as a minimum of 2 mm from the tumor) is best achieved by the technique of total mesorectal excision (TME). When properly performed, TME results in excision of a rectal specimen surrounded by an intact envelope of fascia propria, in which lymphatics and associated lymph nodes are fully encased. The specimen will be seen to be encased in a smooth, intact fatty envelope. TME is rendered more difficult by obesity, inadequate preoperative staging and use of preoperative chemotherapy and radiation, and failure of the tumor to respond to preoperative therapy. TME is facilitated by early entry into the proper plane posteriorly and laterally and the use of sharp dissection.

Extent of Lymphovascular Dissection

Older techniques required routine ligation of the inferior mesenteric artery at the aorta not only for lesions of the descending colon but also for rectal cancer. There is no oncologic advantage to this, and it is associated with an increased risk because the entire blood supply of the proximal colon must come through the marginal artery all the way from the middle colic artery

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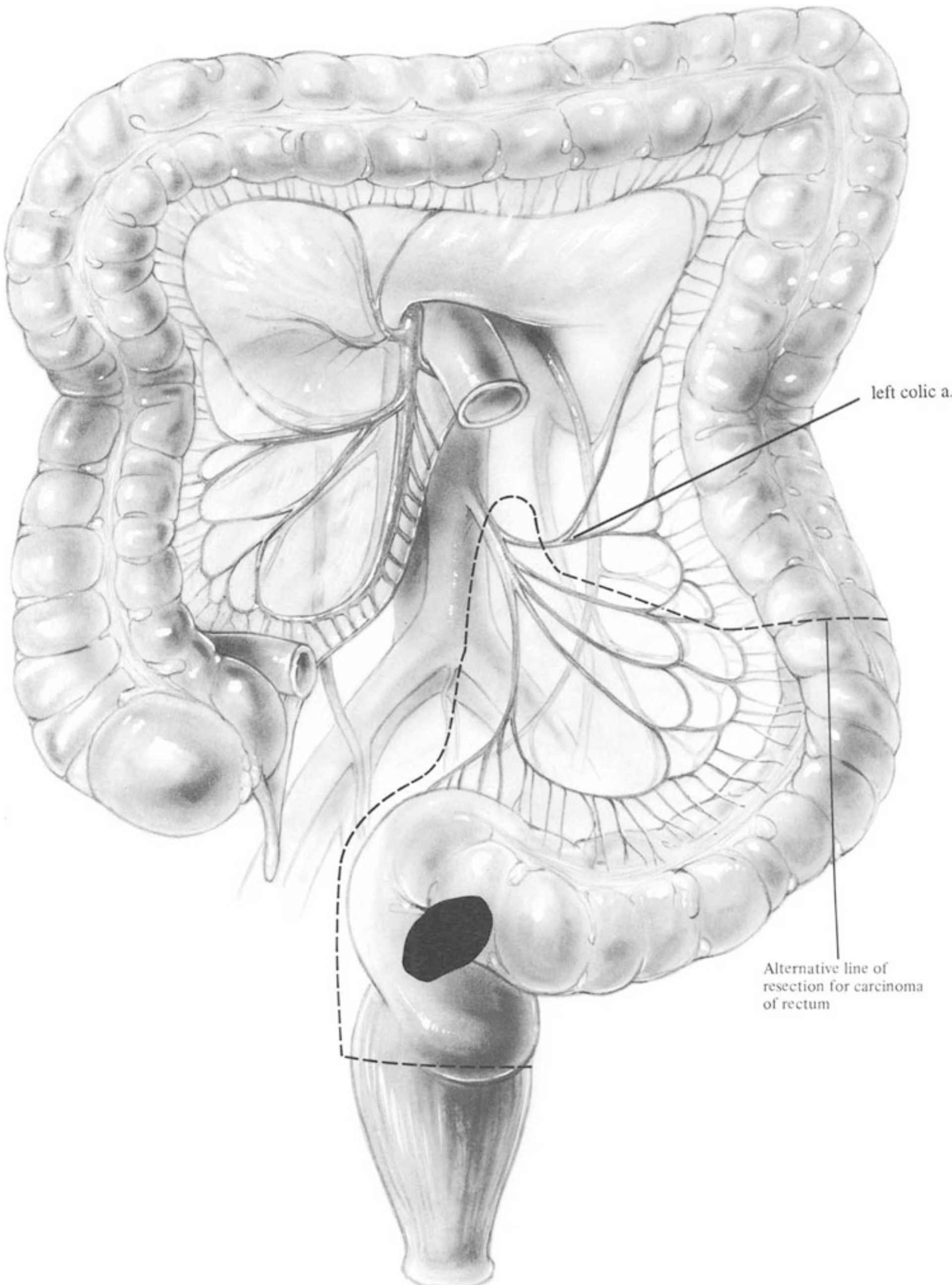

Fig. 53.1

(Fig. 53.1). Although this proves adequate in most patients, there is a danger that the surgeon may not recognize those patients whose blood supply is not sufficient. It is important that the blood supply to the proximal colon undergoing anastomosis not only be adequate but be optimal before this segment is used in a low colorectal anastomosis. Consequently, in the usual case of rectal cancer, we transect the inferior mesenteric artery just distal to the origin of the left colic vessel, thus sacrificing the superior rectal artery and a variable number of sigmoidal branches (Fig. 53.2). Even if only the ascending branch of the left colic artery is preserved, there usually is vigorous arterial pulsation in the mesentery of the descending colon. For obese patients, transillumination of the mesentery may assist in identification of branch vessels and appropriate site of division.

If the inferior mesenteric artery is ligated proximal to the takeoff of the left colic artery, be sure always to liberate the splenic flexure and resect most of the descending colon unless it can be proven that the circulation through the marginal artery at a lower level is vigorous. This can be accomplished only by demonstrating pulsatile flow from a cut arterial branch at the proposed site of the transection of the colon. *Poor blood flow leads to poor healing*.

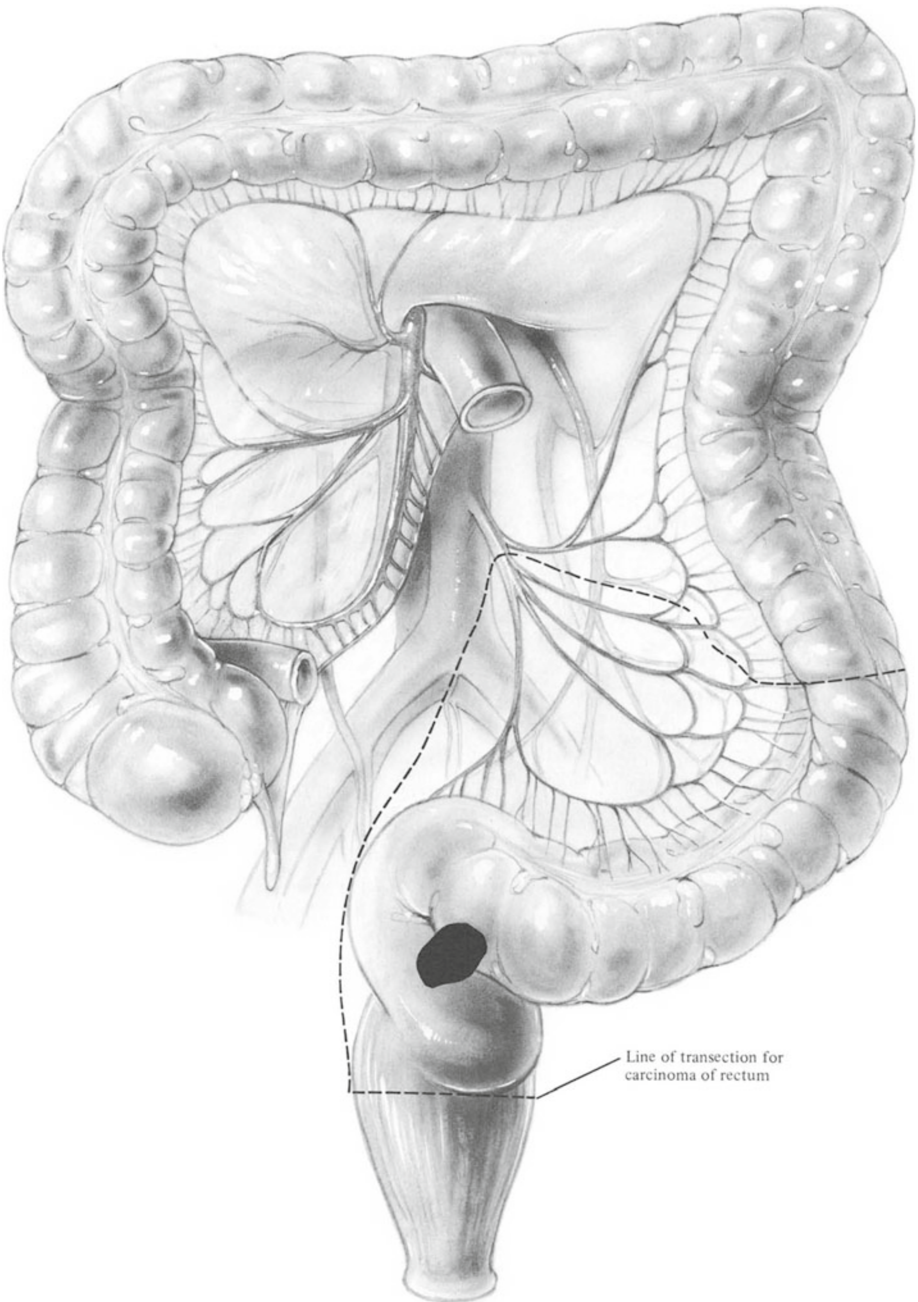

Fig. 53.2

In the usual rectal cancer case, the sigmoid colon is removed and the descending colon is used for anastomosis. This generally requires liberation of the splenic flexure, which can be accomplished in a few minutes once the surgeon has mastered the technique.

Prevention of Anastomotic Complications

Anastomotic complications are rare when the resection is high and the anastomosis is intraperitoneal (see Chap. 51). Conversely, a low anterior resection with a colorectal anastomosis below the peritoneal reflection is clinically and radiographically much more prone to leak. The low colorectal anastomosis offers additional difficulty for several reasons:

1. *Anatomic exposure is often difficult*. This is especially true in men, whose pelvis is narrow, and obese patients. Difficulty with exposure often requires the surgeon's hand to be held at an awkward angle, so it is easy to make small tears in the rectum when inserting sutures.
2. *It is easy to mistake mucosa for the muscular layer* owing to the lack of serosal cover over the retroperitoneal rectum. If

sutures or staples are erroneously inserted into the mucosal instead of the submucosal and muscular layers, the anastomosis will leak because the mucosa itself has little tensile strength. Identify the longitudinal muscle covering the rectum and be sure to incorporate this layer in the suture line.

3. *The diameter of the rectal ampulla frequently measures in excess of 5–6 cm*, and the lumen of the proximal colon, after proper bowel preparation, is often half this size. The anastomotic technique used must be capable of correcting this disparity.
4. When the surgeon has not achieved perfect hemostasis in the pelvis, *a hematoma forms in the presacral space*. It frequently becomes infected and develops into an abscess, which may erode through the colorectal suture line.
5. If the pelvic peritoneal floor is closed above the colorectal anastomosis, dead space may surround the anastomosis, which is especially conducive to leakage in the anastomosis. The peritoneal pelvic floor is not resutured after the colorectal anastomosis is completed.
6. Do not leave any empty space in the hollow of the sacrum behind a low anastomosis. For most low anterior resections, we free the attachments of the splenic flexure (see Figs. 51.4, 51.5, 51.6, 51.7, and 51.8) so the descending colon has sufficient redundancy that relaxed colon fills the sacral space behind the anastomosis. If this step cannot be accomplished, fill the empty space in the pelvis by lengthening the omentum sufficiently that it can be delivered to the presacral space.
7. Most anastomoses are done with circular staplers. If a handsewn technique is chosen, we advocate use of the side-to-end (Baker) colorectal anastomosis. This permits the diameter of the anastomosis to be exactly equal to that of the lumen of the commodious rectal ampulla. Healthy-sized bites of tissue may be enclosed in the sutures with no danger of postoperative stenosis. In effect, at the conclusion of the anastomosis, *the rectal ampulla has been invaginated into the side of the proximal colon* (see Fig. 53.23). Placing the anastomosis within 1 cm of the closed end of the proximal colon eliminates the danger of developing a blind loop syndrome.
8. Following a low anastomosis we routinely insert a closed-suction drain into the presacral space, bringing it out through a puncture wound in the left lower quadrant.
9. Although the use of staples for low colorectal anastomoses has been demonstrated to be safe by numerous studies and has, in fact, become the commonest technique, it is important to observe all the precautions described below to ensure uneventful healing.

Which Colorectal Anastomosis: Sutured, Circular Stapled, or Double Stapled?

Sutured colorectal anastomoses, described below, have been demonstrated to be safe when performed with delicacy of technique by a skilled surgeon on well-dissected healthy tissues. Lesions 9–10 cm from the anal verge can generally be removed and a sutured colorectal anastomosis performed. However, when the surgeon resects lesions lower than 10 cm from the anal verge, suturing the colorectal anastomosis can be difficult. Insertion of the circular stapler into the rectum allows construction of a safe colorectal stapled anastomosis with greater ease for the surgeon than is true for the sutured anastomosis.

If the cancer resection has left a rectal stump situated so low in the pelvis that even insertion of the purse-string suture becomes difficult (lesions at 6–8 cm), use the Roticulator 55 mm linear stapler (US Surgical Corp.) to close the proximal edge of the rectal stump rather than a purse-string suture. Passing the circular stapler into the rectum then permits construction of a circular colorectal anastomosis through the linear staple line closing the proximal edge of the rectal stump. This method is especially suitable for the lowest colorectal anastomoses.

Indications for Complementary Colostomy or Loop Ileostomy

When there is difficulty constructing a low colorectal anastomosis and it is likely the surgeon has created a less-than-perfect anastomosis, a complementary diverting right transverse loop colostomy or loop ileostomy should be constructed. It may be closed as early as 2 weeks after the low anterior resection if a barium enema shows a normal anastomosis.

Presacral Dissection: Prevention of Hemorrhage

Adequate TME requires that the surgeon strip lymphovascular tissues off the presacral space. However, it does not require stripping the tissues from the sacrum down to the periosteum as there is generally an areolar plane just anterior to the periosteum that can be entered and safely dissected. Dissection of the perirectal tissues proximal to the carcinoma is necessary for removal of *tumor emboli* in the lymph nodes and lymphatic channels. Enter this region by sharp dissection to ensure dissection in the proper plane. Once the plane has been identified, it is generally easy to extend the dissection down to the pelvic floor by sharp and blunt dissection. This should allow the rectum to be lifted up and the tumor will generally be palpable, encased in the fascia propria of the rectum. If tumor has widely invaded the mesorectum and presacral tissues, it is generally beyond cure by radical surgery.

The hazard associated with this dissection is massive hemorrhage from a network of veins lying on the presacral periosteum that drain into the sacral foramina (see Fig. 53.8b).

When these veins are torn by blunt dissection, clamping or ligation to control the hemorrhage that results often is impossible, as the torn vessel retracts into the foramen. The massive venous hemorrhage that follows may not be stemmed by ligating the hypogastric arteries. Most intraoperative fatalities during total proctectomy are caused by this type of presacral venous hemorrhage.

Nivatvongs and Fang (1986) described a method for controlling massive hemorrhage from a torn presacral branch of the basivertebral vein. Because the blood pours out of one of the sacral foramina, they proposed occluding the foramen with a titanium thumbtack (Hemorrhage Occluder Pin; Sugrin, Placentia, CA, USA) that is left permanently in place. To accomplish this step effectively, first demonstrate that the blood is emerging from a single foramen. If the bleeding is controlled by applying the fingertip to one foramen, applying the thumbtack will be effective. In some cases stuffing some cottonoid Oxycel (oxidized cellulose) into the foramen before inserting the thumbtack may be helpful.

If the surgeon cannot *quickly* control lacerated presacral veins with a stitch, a thumbtack, or bone wax, the bleeding area should be covered with a sheet of Surgicel over which a large gauze pack is placed, filling the sacral hollow. This practice almost always controls the hemorrhage.

Unless the presacral vessels are directly invaded by a bulky tumor of the mid-rectum, massive presacral venous hemorrhage is entirely preventable. Blunt hand dissection of the presacral space is not a desirable technique. The surgeon's hand does not belong in this area until scissors or electrocautery dissection under direct vision has freed all the perirectal tissues from any posterior attachments to the sacrum. This should be done with long Metzenbaum scissors combined with gentle upward traction on the rectum. As the scissors are inserted on each side of the midline, the perirectal tissues can easily be lifted in an anterior direction with the rectal mesentery and associated lymphatics intact but *without removing the periosteum and thin areolar tissue covers the presacral veins*. When the presacral dissection stays in the proper plane, the presacral veins are hidden from view by this layer of fascia (see Fig. 53.8a). Occasionally, branches of the middle sacral vessels enter the perirectal tissues from behind and can be divided by electrocautery.

This dissection is easily continued down to the area of the coccyx, where the fascia of Waldeyer becomes somewhat dense as it goes from the anterior surfaces of the coccyx and sacrum to attach to the lower rectum (see Fig. 53.10). Attempts to penetrate this fascia by blunt finger dissection may rupture the rectum rather than the fascia, which is strong. This layer must be incised sharply with scissors or a scalpel, after which one can see the levator diaphragm. When the posterior dissection has for the most part been completed, only *then* should the surgeon's hand enter the presacral space to sweep the dissection toward the lateral pelvic walls. This maneuver helps define the lateral ligaments. The dissection should be bloodless.

Other points of hemorrhage in the pelvic dissection may occur on the lateral walls. They can usually be readily identified and occluded by ligature. Pay close attention also to the left iliac vein, which may be injured during the course of the dissection. As most serious bleeding during pelvic dissections is of venous origin, ligation of the hypogastric arteries is rarely indicated.

Presacral Dissection: Preservation of Hypogastric Nerves

As the rectum is elevated from the presacral space and the anterior surface of the aorta cleared of areolar and lymphovascular tissue, a varying number of preaortic sympathetic nerves of the superior hypogastric plexus can be identified. They are the contribution of the sympathetic nervous system to the bilateral inferior hypogastric (pelvic) plexuses. In male patients their preservation is necessary for normal ejaculation. After they cross the region of the aortic bifurcation and sacral promontory, they coalesce into two major nerve bundles, called the hypogastric nerves. Each nerve, which may have one to three strands, runs toward the posterolateral wall of the pelvis in the vicinity of the hypogastric artery (see Figs. 53.4 and 53.6). With most malignancies of the distal rectum, these nerves can be preserved without compromising the patient's chances of cure.

After the inferior mesenteric artery and vein are divided and the lymphovascular tissues are elevated from the bifurcation of the aorta by blunt dissection, the sympathetic nerves remain closely attached to the aorta and need not be damaged if the dissection is performed gently. At the promontory of the sacrum, if the rectum is dissected as described above, the right and left hypogastric nerves can be seen posterior to the plane of dissection and can be preserved provided there is sufficient distance separating them from the tumor. There also seems to be diminution in the incidence of bladder dysfunction after nerve preservation.

Ureteral Dissection

To prevent damage to the ureters, these delicate structures must be identified and traced well down into the pelvis. The normal ureter crosses the common iliac artery, at which point this structure bifurcates into its external and internal branches. Because the ureter and a leaf of incised peritoneum are often displaced during the course of dissection, if the ureter is not located in its usual position, the undersurfaces of both the lateral and medial leaves of peritoneum should be inspected. The identity of the ureter can be confirmed if pinching or touching the structure with forceps results in typical peristaltic waves. If doubt exists, the anesthesiologist may be instructed to inject indigo carmine dye intravenously, which strains the ureter blue unless the patient is oliguric at the time of injection. The ureter should be traced into the pelvis beyond the point at which the lateral ligaments of the rectum are divided.

Operative Technique

Incision and Position

Patients who have lesions within 14 cm of the anal verge should be placed in the same modified lithotomy position utilizing Lloyd-Davies or Allen leg rests, as described in Chap. 46 for abdominoperineal proctectomy (Fig. 53.3a, b). The second assistant stands between the patient's abducted thighs for the pelvic portion of the operation, and the surgeon works from the patient's left. In this position the surgeon may judge, after the tumor is mobilized, whether an anterior anastomosis, abdominoperineal proctectomy, or end-to-end anastomosis with the EEA stapling device is suitable. These techniques are best done with the patient in this position. A midline incision, extending from a point about 6 cm below the xiphoid process down to the pubis, is used.

Exploration and Evisceration of Small Bowel

Palpate and inspect the liver. A moderate amount of metastasis is not a contraindication to a conservative version of the anterior resection. Explore the remainder of the abdomen and then eviscerate the small bowel into a plastic intestinal bag or moist gauze pads.

Mobilization of Sigmoid

Expose the left lateral peritoneal gutter. Occlude the lumen of the colon by ligating the distal sigmoid with umbilical tape. Draw the sigmoid colon medially to expose and divide several congenital attachments between the mesocolon and the posterolateral parietal peritoneum with scissors (Fig. 53.4). Extend the incision in the peritoneum cephalad as far as the splenic flexure.

Identify the left ureter and tag it with a Silastic loop for later identification. Use scissors to continue the peritoneal incision along the left side of the rectum down to the rectovesical pouch. Identify the course of the ureter well down into the pelvis. Now retract the sigmoid to the patient's left, and make an incision on the right side of the sigmoid mesocolon. The incision should begin at a point overlying the bifurcation of the aorta and should continue in a caudal direction along the line where the mesosigmoid meets the right lateral leaf of peritoneum in the presacral space. After the right ureter has been identified, carry the incision down toward the rectovesical pouch (Figs. 53.5 and 53.6).

If the exposure is convenient, incise the peritoneum of the rectovesical pouch, or the rectouterine pouch in female patients (Fig. 53.5). If the exposure is not convenient, delay this step until the presacral dissection has elevated the rectum sufficiently to bring the rectovesical pouch easily to the field of vision.

Lymphovascular Dissection

Apply skyward traction to the colon and gently separate the gonadal vein from the lateral leaf of the mesocolon, allowing it to fall posteriorly. Insert an index finger between the deep margin of the mesosigmoid and the bifurcation of the aorta to feel the pulsation of the inferior mesenteric artery lying superficial to the finger. In markedly obese patients

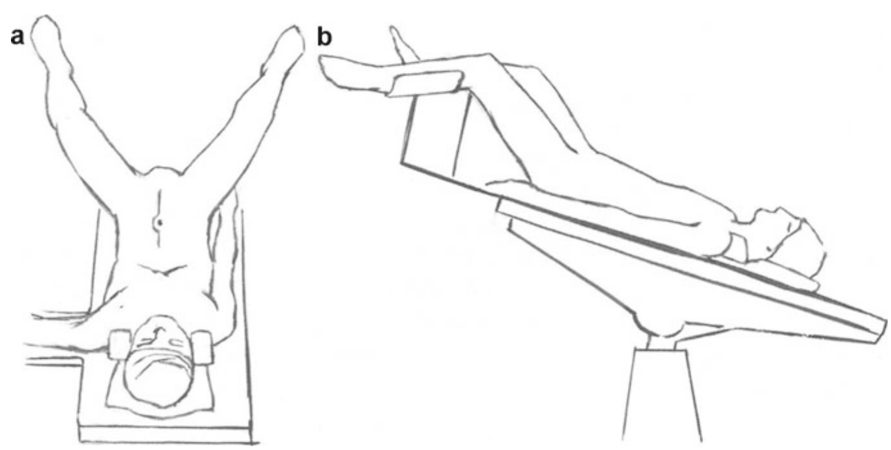

Fig. 53.3

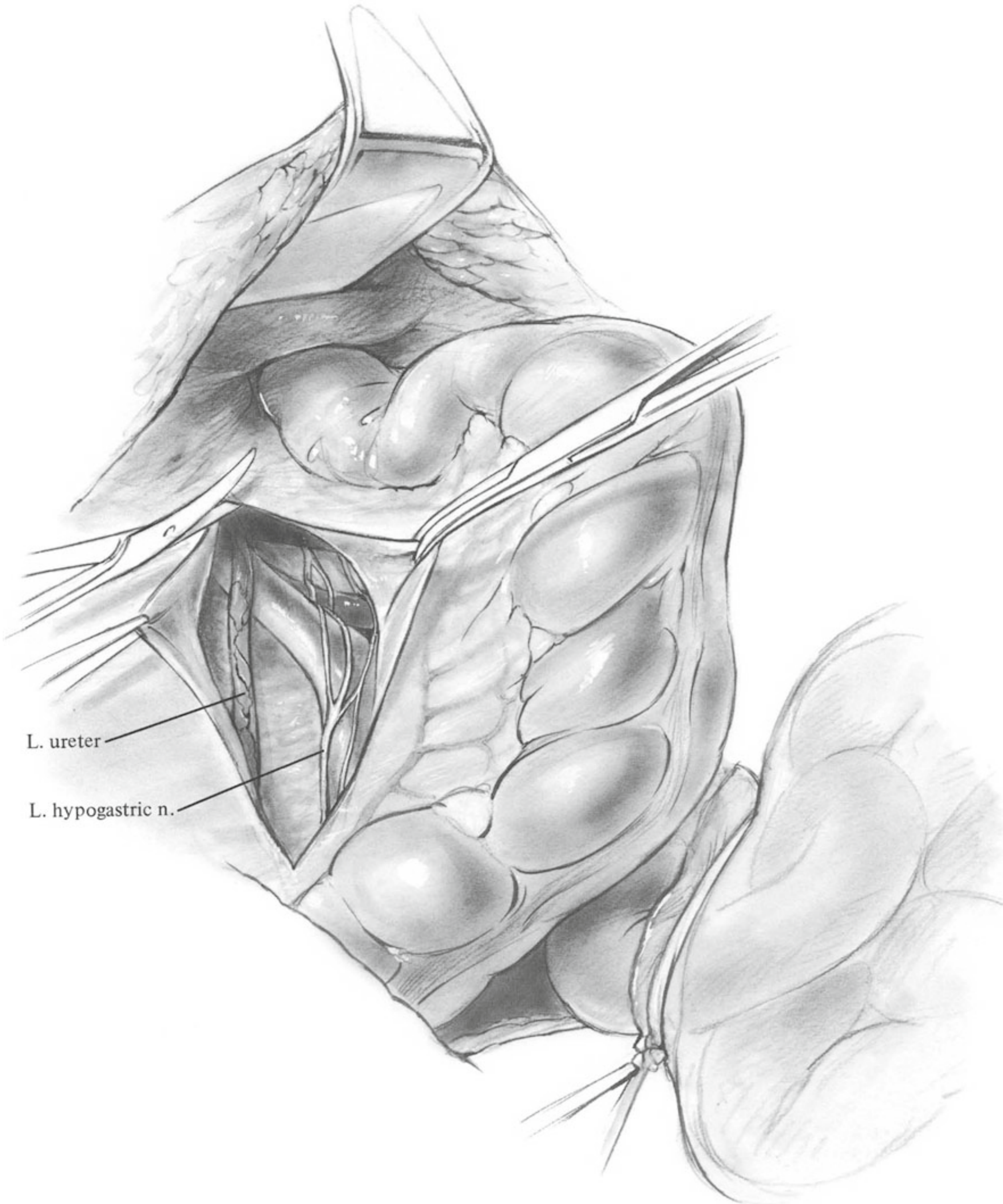

Fig. 53.4

this vessel may be divided and ligated at the level of the aortic bifurcation without further dissection. In most patients, however, it is simple to incise the peritoneum overlying the origin of the inferior mesenteric artery and to sweep the areolar and lymphatic tissue downward until one sees the point at which the inferior mesenteric artery gives off the left colic branch (Fig. 53.7). In routine cases divide the inferior mesenteric vessels between 2 and 0 ligatures just distal to this junction. Then make a superficial scalpel incision along the surface of the mesocolon: Begin at the point where the inferior mesenteric vessels were divided and continue to the descending colon or upper sigmoid. Complete the division of the mesentery along this line by dividing it between serially applied Kelly hemostats and then ligating with 2-0 silk or PG (Fig. 53.7). In nonobese patients it is feasible to incise the peritoneum up to the point where a vessel is visualized and then apply hemostats directly to each vessel as it is encountered. With this

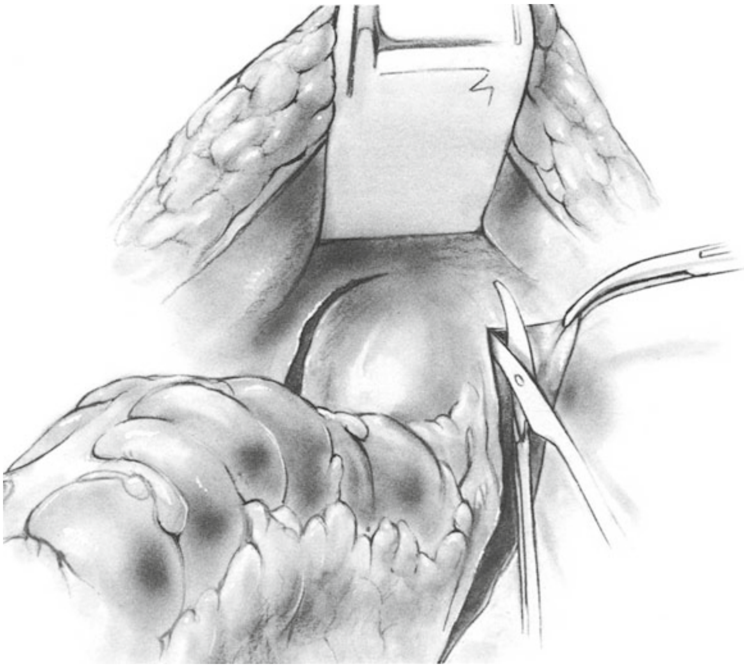

Fig. 53.5

technique, the surgeon encounters only one or two vessels on the way to the marginal artery of the colon.

Sweep the mesosigmoid and the lymphovascular bundle distal to the ligated inferior mesenteric vessels off the anterior surfaces of the aorta and common iliac vessels by blunt dissection. Leave the preaortic sympathetic nerves intact. To minimize the time during which the patient's abdomen is exposed to possible fecal contamination, do not divide the descending colon at this stage.

Presacral Dissection

With the lower sigmoid on steady upward retraction, it becomes evident that there is a band of tissue extending from the midsacral region to the posterior rectum and mesorectum. On either side of this dense band, there is only areolar tissue. Stoutly resist any tendency to insert a hand into the presacral space. Instead, use long, closed Metzenbaum scissors for sharp and judicious blunt dissection (Fig. 53.8a). Insert it first to the right of the midline behind the rectum; by gently

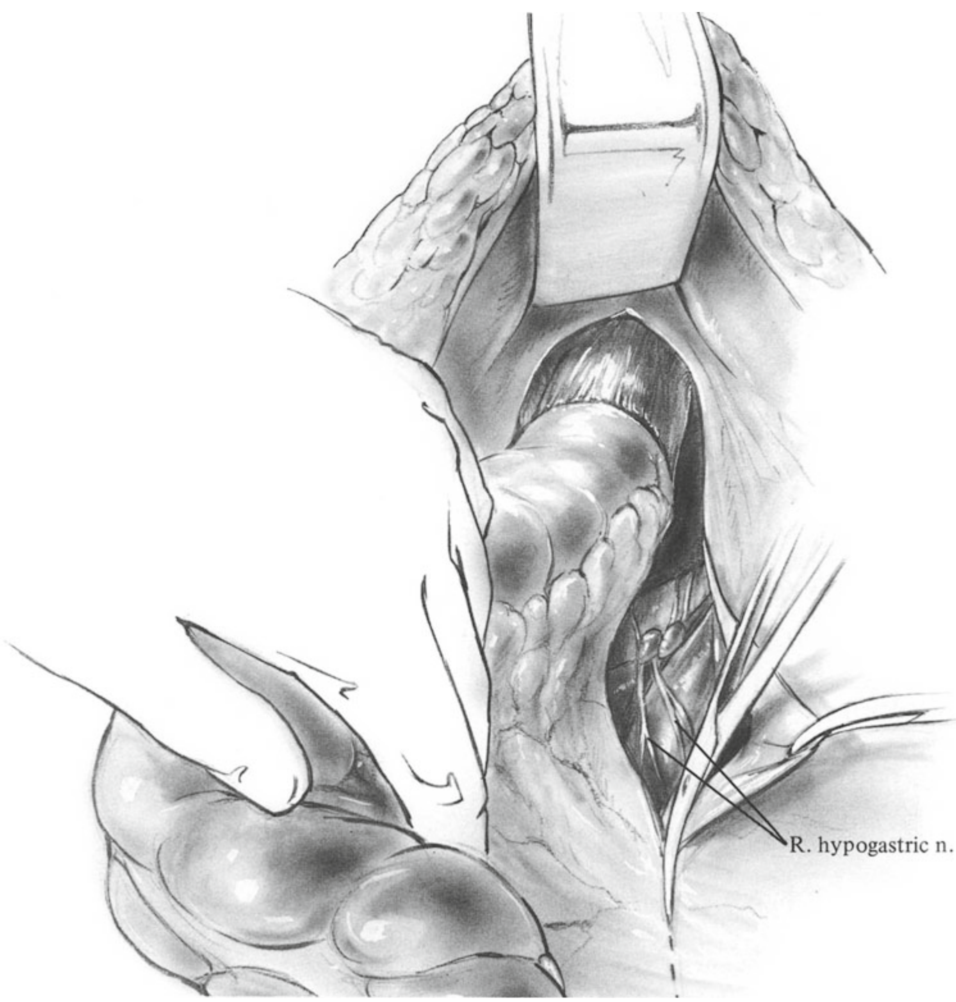

Fig. 53.6

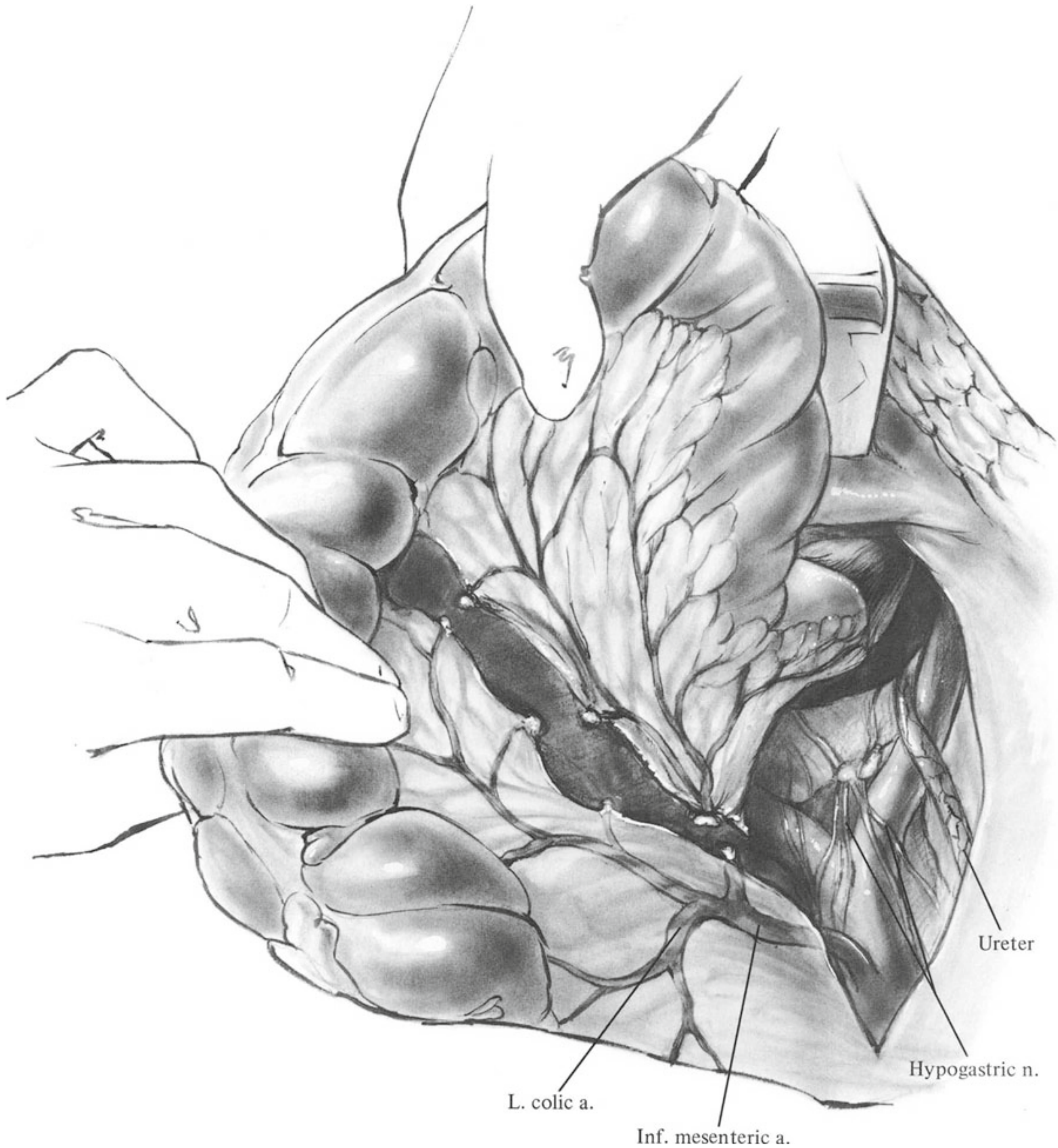

Fig. 53.7

elevating the mesorectum, the proper presacral plane is then entered. Repeat this maneuver identically on the left side of the midsacral line. Then direct attention to the remaining band of tissue, which contains branches of the middle sacral artery, and divide it with the electrocautery (Fig. 53.8a).

At this time the surgeon sees a thin layer of fibroareolar tissue covering the sacrum. If a shiny layer of sacral periosteum, ligaments, or the naked presacral veins can be seen (Fig. 53.8b), the plane of dissection is *too deep*, presenting a danger of major venous hemorrhage. Elevate the *distal* rectum from the lower sacrum with gauze in a sponge holder. If the dissection has been completed properly, as described, note that the preaortic sympathetic nerves divide into two major trunks in the upper sacral area and then continue laterally to the right and left walls of the pelvis (see Figs. 53.4 and 53.6). Gently dissect these nerves from the posterior wall of the specimen unless the nerves have been invaded by tumor.

Now insert a hand into the presacral space, with the objective not of penetrating more deeply toward the coccyx but, rather, of extending the presacral dissection laterally to the right and to the left, so the posterior aspect of the specimen is elevated from the sacrum as far as the lateral ligaments on each side. Place the lateral ligament on the left side on stretch by applying traction to the rectum toward the right. This ligament must be taken laterally, with the rectum and

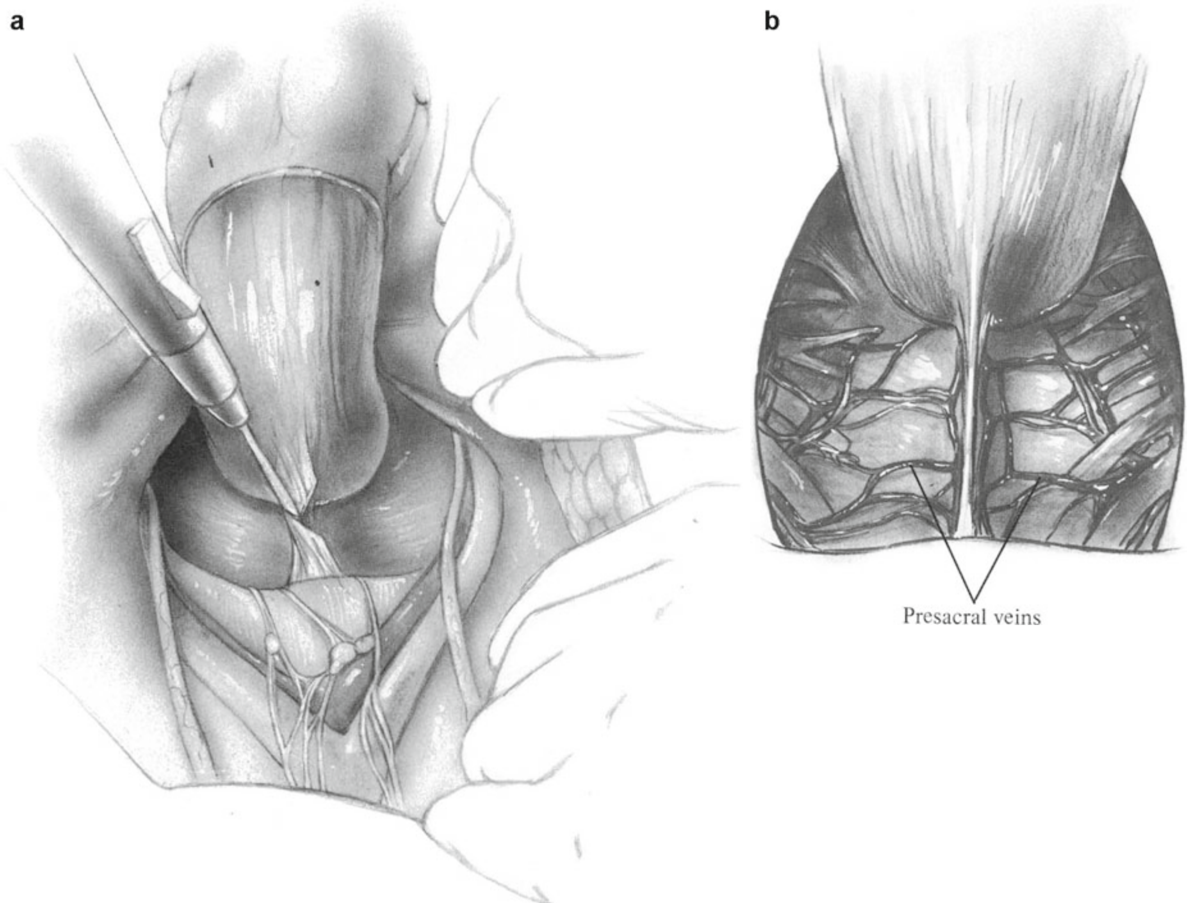

Fig. 53.8

associated fatty mesentery retracted by the surgeon's hand so that it can be removed intact. Place a right-angle Mixter clamp underneath the lateral ligament, and divide the tissue with electrocautery (Fig. 53.9).

Carry out a similar maneuver to divide the right lateral ligament. Before dividing each lateral ligament, recheck the position of the respective ureter and hypogastric nerve to be certain they lie away from the point of division. Then divide the fascia of Waldeyer, which extends from the coccyx to the posterior rectal wall (Fig. 53.10).

Now direct attention to the anterior dissection. Use a Lloyd-Davies bladder retractor to pull the bladder (in women, the uterus) in an anterior and caudal direction. If the peritoneum of the rectovesical pouch has not already been incised, perform this maneuver now, thereby connecting the incisions in the pelvic peritoneum previously made on the right and left sides of the rectum (Fig. 53.11a). Apply one or more long hemostats or forceps to the posterior lip of the incised peritoneum of the rectovesical pouch. Place traction on these hemostats to draw the peritoneum and Denonvilliers' fascia in a cephalad and posterior direction, and use Metzenbaum scissors dissection to separate the rectum from the seminal vesicles and prostate (Fig. 53.11b). Use blunt finger dissection to further separate the rectum from the posterior wall of the prostate. Finally, secure hemostasis in this region by cauterizing multiple bleeding points.

In female patients the anterior dissection is somewhat simpler. With a Harrington retractor elevating the uterus, use scalpel dissection to initiate the plane of dissection separating the peritoneum and fascia of Denonvilliers from the posterior lip of the cervix until the proximal vagina has been exposed. Some surgeons routinely perform bilateral salpingo-oophorectomy in women who have rectal and sigmoid cancer because the ovaries are sometimes a site of metastatic deposit. Whether this step is of value has not been ascertained. Generally this is not performed in the absence of visible metastasis to the ovaries.

Pelvic Hemostasis

The entire pelvic dissection, if properly performed in the TME plane, entails minimal blood loss. Although hemostatic clips may control clearly identified vessels along

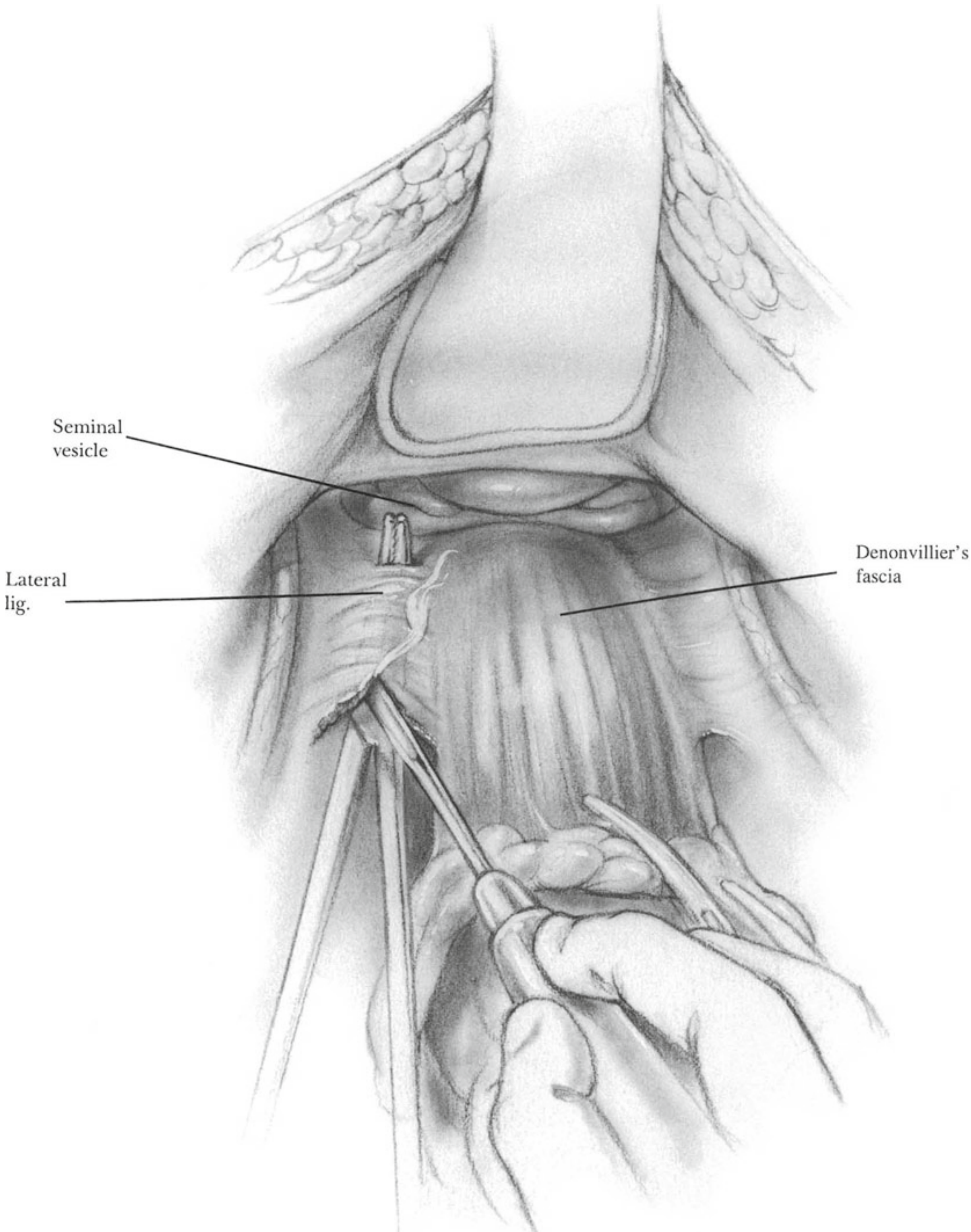

Fig. 53.9

the lateral wall of the pelvis, they are not useful in the presacral area. Here the vessels consist of thin-walled veins, which are easily torn by metallic clips at the time of application or during the act of sponging the area later.

Except in the case of a small, clearly defined bleeding point that can be held in a forceps, electrocautery may also be hazardous, as the coagulating tip may act as a scalpel and convert the bleeding point to a major venous laceration. Here a ball-tipped electrode is safer than one with a blade or pointed tip.

See the discussion above, under section "Operative strategy", concerning the use of a thumbtack to control massive presacral bleeding localized to a single foramen. Almost invariably, presacral bleeding results from a tear in one or more of the veins that drain into a sacral foramen. When

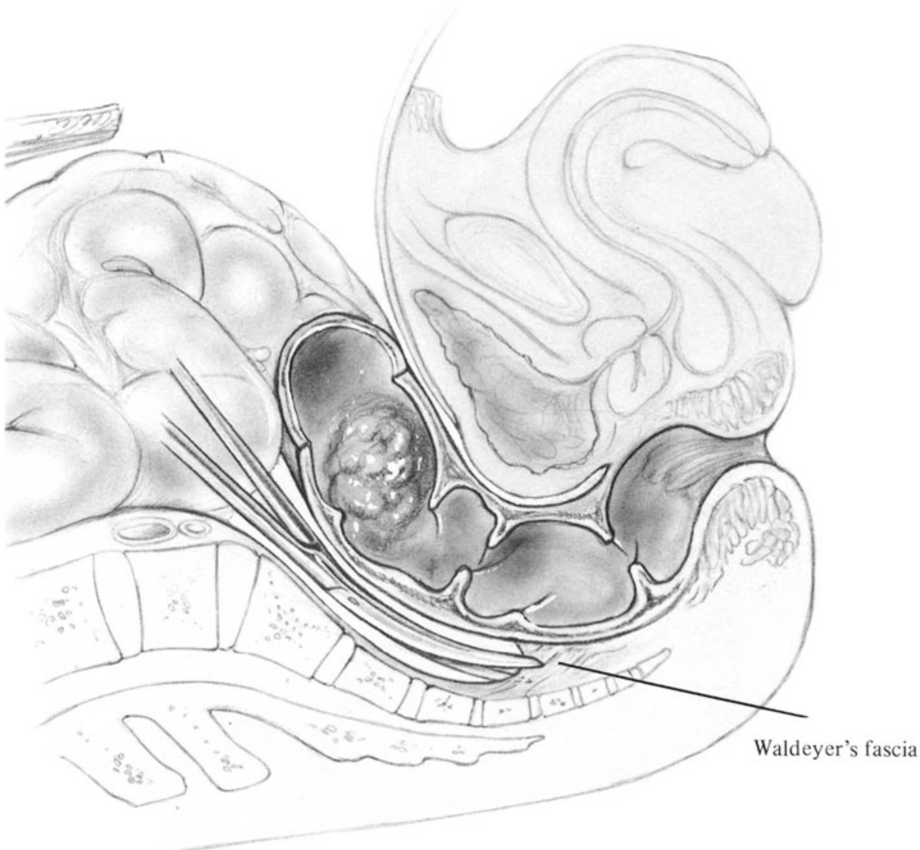

Fig. 53.10

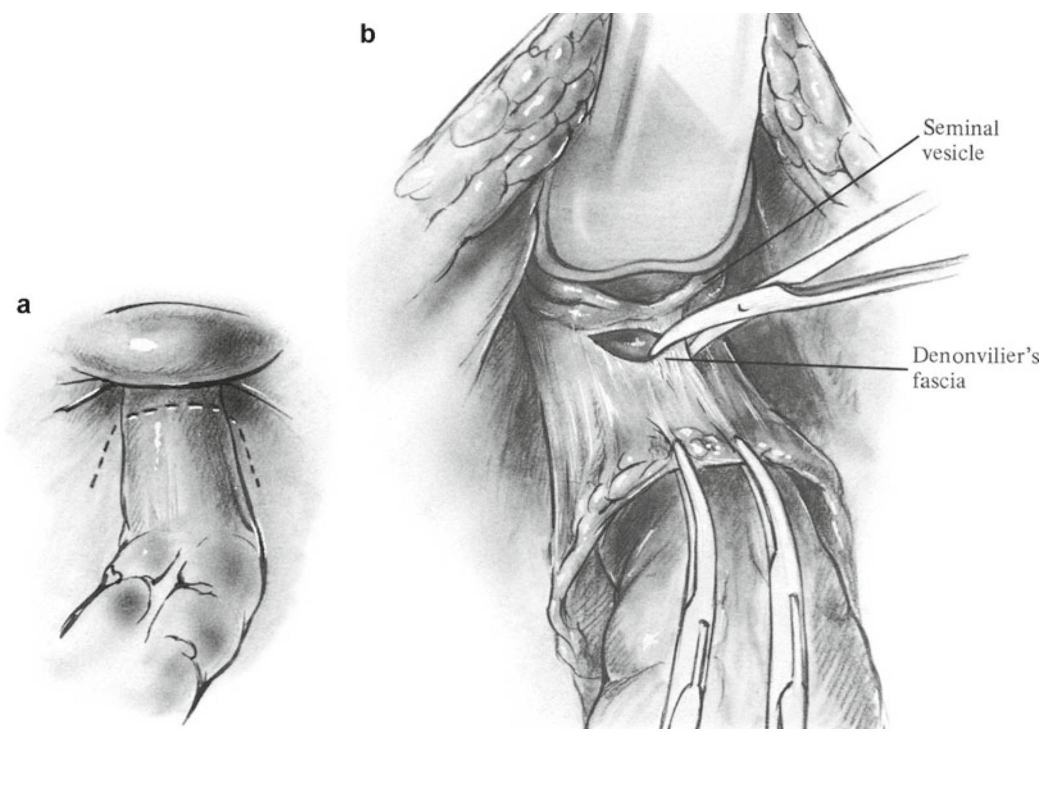

Fig. 53.11

hemorrhage occurs, the area of bleeding should be covered by a sheet of topical hemostatic agent over which pressure is applied with a large gauze pack. Place omentum between the pack and the anastomosis. If the area of bleeding is only 1–2 cm in diameter, removing the gauze pack may be attempted at a later stage in the operation, leaving a small patch of hemostatic agent. Unless this maneuver produces complete hemostasis, replace the gauze pack in the presacral space and leave it there for 24–48 h. Then remove it by relaparotomy under general anesthesia.

Mobilization of Proximal Colon

If the previously selected point on the descending colon does not easily reach down into the pelvis, mobilize the remainder of the descending colon by incising first the peritoneum in the paracolic gutter and then the "renocolic" ligament. Liberate the entire splenic flexure according to the steps described in Chap. 51. Considerable additional length may be obtained by dividing the transverse branch of the left colic artery (Fig. 53.1). Completely clear the fat and mesentery from a 1 cm width of serosa at the point selected for dividing the descending colon.

Preparation of Rectal Stump

When the rectum is divided at a low level, the mesorectum is no longer a single pedicle traveling along the posterior surface of the rectum. Rather, it fans out into multiple branches. Select a point 4–5 cm distal to the lower border of the tumor, and seek the plane between the muscularis of the rectum and the surrounding blood vessels. This plane can sometimes be palpated with the finger; and at other times a large blunt-nosed hemostat can be insinuated into it. In most patients this vascular layer can be divided by electrocoagulation after passing a right-angle clamp between the vasculature and the rectal wall.

Well-delineated longitudinal muscle fibers should now be visible all around the lower rectum at the site selected for the anastomosis. At this time place a large right-angle clamp across the entire lumen of the rectum below the tumor.

Irrigation of Rectal Stump

If there is any question as to the adequacy of the bowel preparation, insert a Foley catheter with a 5 ml bag into the rectum. Attach the catheter to plastic tubing to permit the intermittent inflow and drainage of 500 ml of sterile water. This not only removes retained fecal matter but lyses any shed tumor cells. After the irrigation is completed and the rectum is emptied, remove the catheter and apply a large right-angle clamp distal to the tumor to occlude the rectal lumen.

Selection of Anastomotic Technique

Use the side-to-end suture technique for a low colorectal anastomosis at or just below the peritoneal reflection. Alternatively, a circular stapling device may be used. At higher levels, the techniques described in Chap. 51 are also suitable. See also the discussion under section "Operative strategy", above.

Side-to-End Low Sutured Colorectal Anastomosis (Baker)

Turn to the previously cleared area on the descending colon that is to be used for the anastomosis. Apply a 55/3.5 mm linear stapler across this cleared area and fire the staples (Fig. 53.12). Place an Allen clamp 1 cm distal to the stapler to occlude the specimen side. Divide the colon flush with the stapling device using a scalpel, and lightly cauterize the everted mucosa (Fig. 53.13). Ligate the specimen side with umbilical tape. After the Allen clamp is removed, apply a sterile rubber glove over the ligated end, and tie the glove in place with another umbilical tape ligature (Fig. 53.14a, b). Alternatively, divide the colon with a linear cutting stapler. Retain this segment of colon containing the specimen temporarily to provide traction on the rectal stump.

Bring the stapled end of the proximal colon down into the pelvis, and line it up tentatively with the rectal stump 4–5 cm beyond the tumor. Place a scratch mark along the antimesenteric border of the descending colon beginning at a point 1 cm proximal to the stapled end and continuing cephalad for a distance equal to the diameter of the rectal stump.

Now insert a lateral guy suture into the left lateral margin of the rectal stump and the proximal colon, and hold this suture in a hemostat. Place a second guy suture in a similar fashion between the right lateral margin of the rectum and the colon and hold it in a hemostat (Fig. 53.15). Approximate the posterior muscular layer with interrupted 4-0 silk Cushing sutures, taking bites of colon and rectum 5 mm wide. Use a Stratte or a Finochietto angled needle holder (see Glossary) when sewing deep in the pelvis; this facilitates smooth insertion of the curved needle. Insert these sutures 6–7 mm behind the anticipated lines of transection of the colon and rectum. The preferred technique is successive bisection (Figs. 53.16 and 53.17). Tie none of these sutures until all have been placed. When the anastomosis is at a very low level, it is convenient to keep the proximal colonic segment well above the promontory of the sacrum until all the posterior seromuscular sutures have been inserted. Be sure these stitches catch the longitudinal muscle of the rectum. If only the mucosa is used for anastomosis, failure is likely.

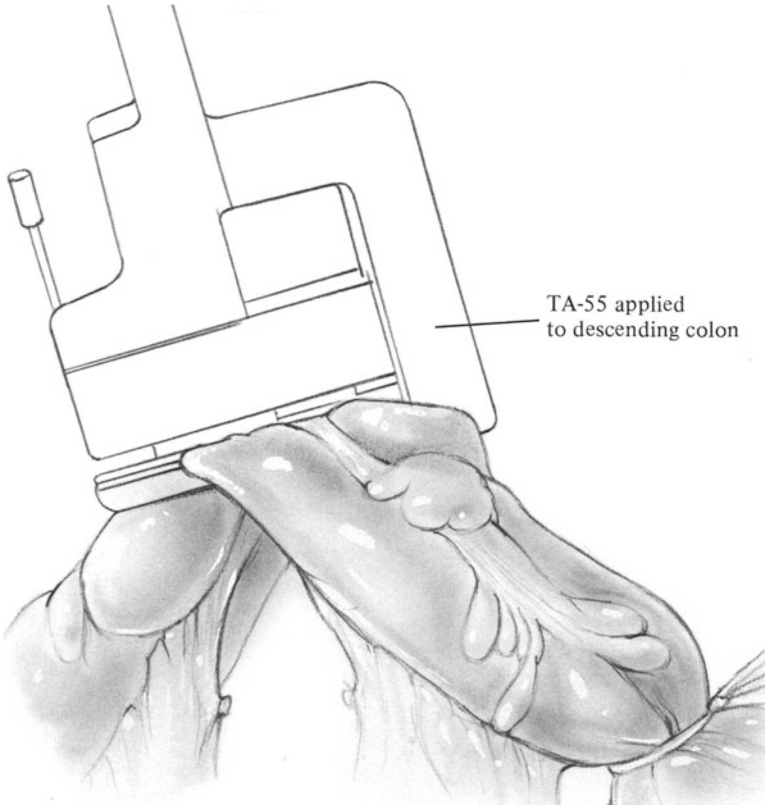

Fig. 53.12

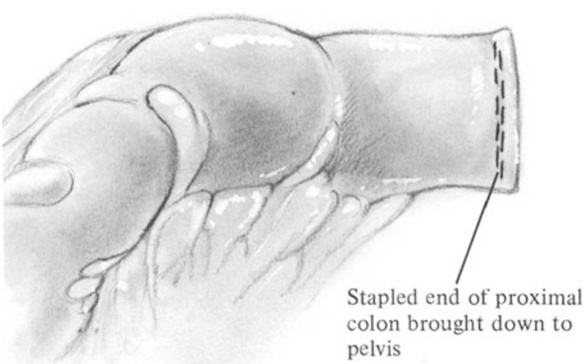

Fig. 53.13

Incise the previous scratch mark in the proximal colonic segment with a scalpel and Metzenbaum scissors (Fig. 53.18). Make a similar incision along a line 6–7 mm proximal to the sutures already placed in the rectum.

If exposure is difficult, it is sometimes helpful to maintain gentle traction on the tails of the Cushing sutures to improve exposure while suturing the mucosa. Then cut the tails of the Cushing sutures successively as the mucosal sutures are inserted. Otherwise, cut all the Cushing sutures at one time, except for the two lateral guy sutures, which should be retained for the moment.

Begin the posterior mucosal closure at the midpoint of the posterior layer using an atraumatic suture of 3-0 PG. Start a continuous locked suture at the midpoint, and continue it to the right lateral margin. The second suture of the same material should progress from the midpoint toward the left lateral margin of the suture line (Fig. 53.19).

Divide the anterior wall of the rectum below the large right-angle clamp and remove the specimen. Request an immediate frozen section histologic examination of the distal margin of the specimen to rule out the presence of cancer. If tumor cells are found at the margin, resection of additional rectum is indicated.

Now approximate the anterior mucosal layer by a continuous suture of the Connell or Cushing type (Fig. 53.20). Accomplish this by grasping the needle, which has completed the posterior mucosal layer and is now in the lumen at the right margin of the anastomosis, and passing it from inside out through the rectum. The suture line should progress from the right lateral margin toward the midpoint of the anterior layer. When this has been reached, grasp the second needle, located at the left lateral margin of the posterior mucosal layer. Use this needle to complete the anterior mucosal layer from the left lateral margin to the midpoint where the anterior mucosal layer is terminated with the mucosa completely inverted (Fig. 53.20).

Close the anterior muscular layer with interrupted 4-0 atraumatic silk Lembert or Cushing sutures (Figs. 53.21 and 53.22). Insert this row of sutures about 6 mm away from the mucosal suture line to accomplish a certain amount of invagination of the rectum into the colon. Because the dimension of the side-to-end lumen is large, narrowing does not result. A sagittal section of the anastomosis in Fig. 53.23 illustrates this point. After the anastomosis is completed, carefully inspect the posterior suture line for possible defects, which if present can be corrected by additional sutures.

At this point cut the sutures and thoroughly irrigate the pelvis with a dilute solution of antibiotics. The large defect in the peritoneum need not be closed. This omission has brought no noticeable ill effect, probably because the defect is so large as not to entrap any small intestine permanently.

Make a final check to ensure there is no tension on the colorectal suture line. If there is, additional proximal colon must be liberated. There must be sufficient slack that the colon *fills up the hollow of the sacrum* on its way to the anastomosis, thereby eliminating any dead space.

Alternative to Colorectal Side-to-End Anastomosis

When the surgeon does not find it practicable to leave the specimen attached to the rectal stump for purposes of traction (the preferred technique described above), an alternative method may be used for the anastomosis. After the first step in the Baker method (Fig. 53.12) has been completed, remove

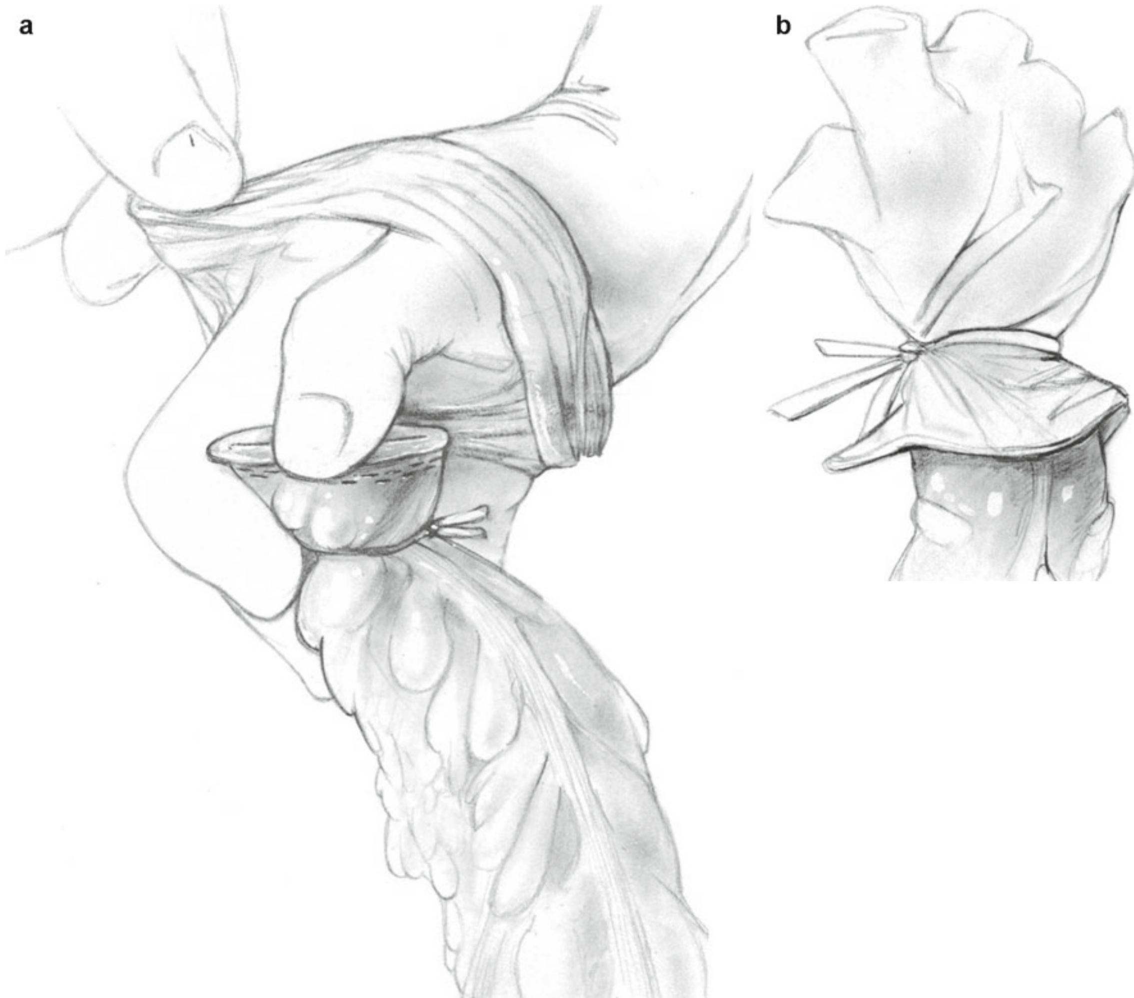

Fig. 53.14

the specimen by a scalpel incision across the rectum distal to the right-angle clamp. This leaves the rectal stump wide open. To prevent the short rectal stump from retracting beyond the prostate, apply long (30 cm) Allis clamps to the right and left corners of the rectal stump. Then insert a Lloyd-Davies bladder retractor deep to the prostate for exposure.

Bring the previously prepared segment of descending colon down to the sacral promontory. The end of this segment of colon should have already been occluded by application of the linear stapling device. Make an incision on the antimesenteric border of the colon beginning 1 cm from the stapled end and continuing proximally for 4–5 cm, which is the approximate diameter of the rectal ampulla.

Insert a guy suture of atraumatic 4-0 silk from the left lateral wall of the rectal stump to the termination of the incision in the colon. Grasp this suture in a hemostat without tying it. Place a similar suture in the right lateral walls of the rectal stump and colon.

Close the remainder of the posterior wall with interrupted horizontal mattress sutures of atraumatic 4-0 silk. Place the first suture at the midpoint of the posterior layer. Using a curved needle, begin the stitch on the mucosal side of the proximal colon, and go from inside out through all layers of colon. Then pass the needle from outside in into the rectal stump. It is vitally important that the muscularis of the rectum be included in this bite. Often the muscularis retracts 1 cm or more beyond the protruding rectal mucosa.

Bring the same needle back from inside out on the rectal stump and then from outside in on the proximal colon. Leave this suture untied but grasp it in a hemostat. When it is tied at a later stage in the procedure, the knot lies on the mucosa of the colon.

Place the second horizontal mattress suture halfway between the first suture and the *left* lateral guy suture by the same technique. Place the third suture so it bisects the distance between the midpoint of the posterior layer and the *right* lateral guy suture. Place the remaining stitches by the technique of successive bisection until this layer is complete (Fig. 53.24).

The colon should slide down against the rectal stump while the assistant holds the ends of all the sutures taut. Tie

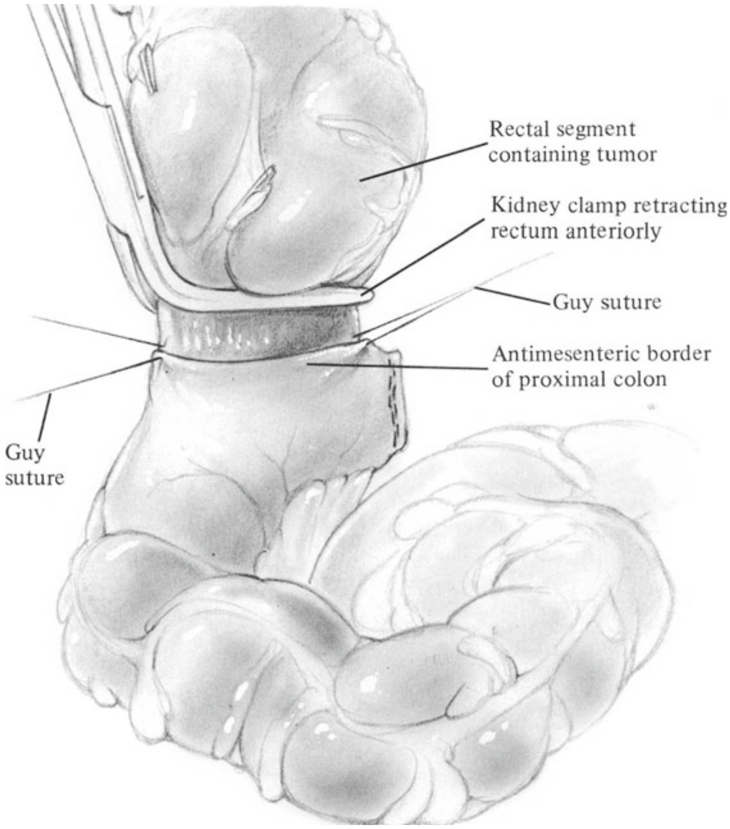

Fig. 53.15

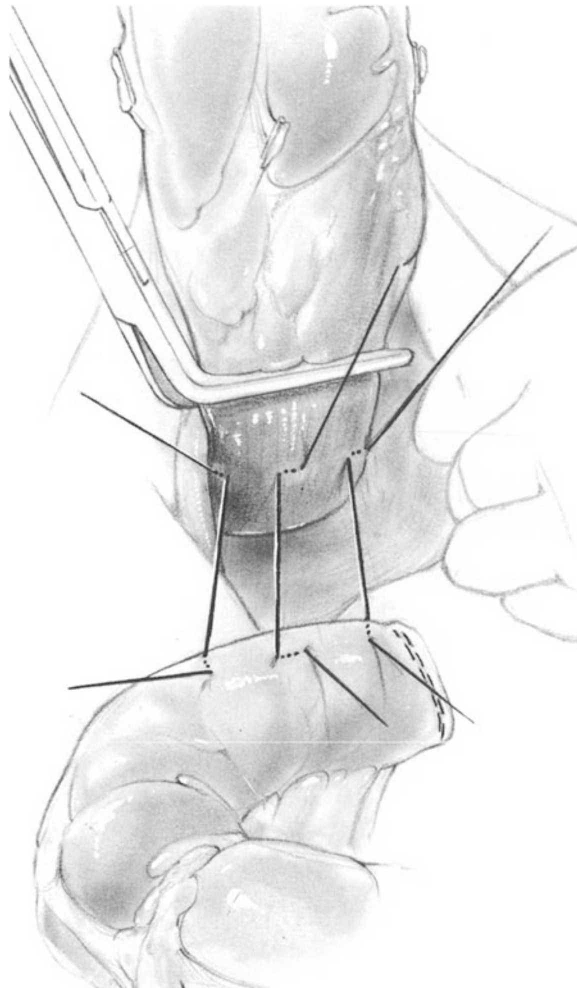

Fig. 53.16

the sutures and leave the tails long, grasping each again in a hemostat. Retaining the long tails of these stitches and applying mild upward traction improve the exposure for insertion of the mucosal sutures. The remainder of the anastomosis is similar to that described above for the Baker technique.

Circular Stapled Low Colorectal Anastomosis

To use the circular stapling technique for low colorectal anastomosis, place the patient in the Lloyd-Davies position, with thighs abducted, anus exposed, and sacrum elevated on a small sandbag. For tumors situated 6–9 cm above the anal verge, it is necessary to dissect the rectum down to the levator diaphragm, which requires complete division of Waldeyer's fascia posteriorly, dissection of the anterior rectum away from the prostate to the level of the urethra, and division of the lateral ligaments down to the levators.

Unless the patient has a narrow pelvis, the entire levator diaphragm then comes into view (Fig. 53.25). All of the perirectal lymphatics readily peel off the levator musculature. Then follow the posterior wall of the rectum down to the puborectalis muscle, which marks the cephalad margin of the anal canal. Take care not to continue dissecting beyond the puborectalis, as it is easy to enter the intersphincteric plane and liberate the rectum down to the anal verge. An anastomosis to the skin of the anal canal is technically feasible but would result in excision of the internal sphincter together with the specimen because the intersphincteric space is the natural plane of dissection one enters from above.

Place a large right-angle renal pedicle clamp across the rectum about 1 cm beyond the lower edge of the tumor. Then divide the upper colon between Allen clamps at the site previously selected for this purpose. Ligate the cut distal end of the descending colon with umbilical tape, and cover it with a sterile rubber glove (Fig. 53.14a, b). Bring the proximal colon down into the pelvis. There should be sufficient slack in the colon to fill the hollow of the sacrum on its way to the site of the anastomosis. If not, liberate the transverse colon to achieve sufficient slack.

Next, remove the Allen clamp and gently dilate the colon with appropriate sizers or a Foley catheter balloon. Dilating the colon may prove the most frustrating step of the entire operation. Be careful *not to produce any serosal tears* during this maneuver. It is advisable to use the largest cartridge possible to ensure an ample lumen.

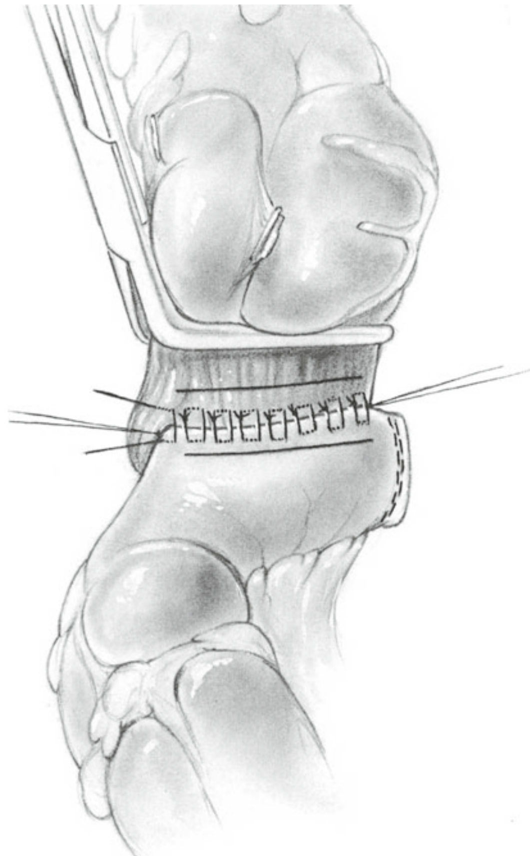

Fig. 53.17

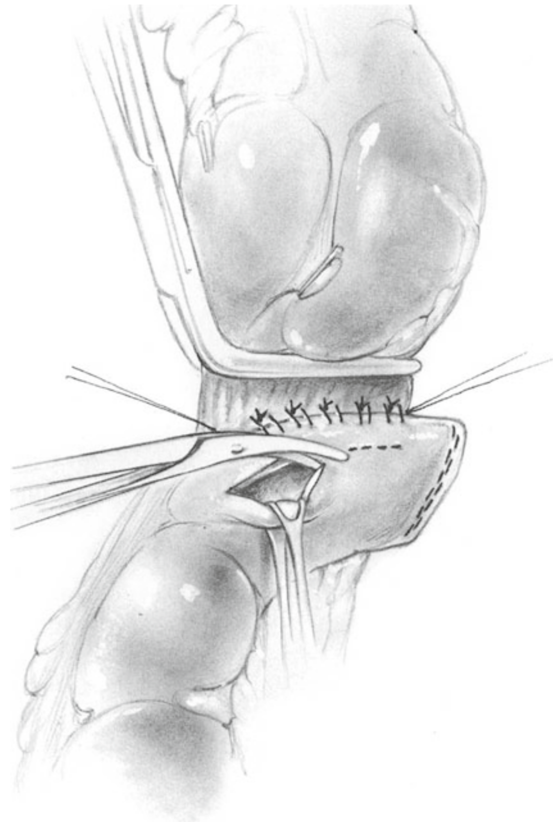

Fig. 53.18

Then insert a 2-0 Prolene continuous over-and-over whipstitch starting at the left margin of the proximal cut end of the colon (Fig. 53.26a). Ascertain that all fat and mesentery have been dissected off the distal 1.5 cm of colon so no fat or blood vessels are interposed between the layers of bowel included in the staple line. If blood vessels are trapped in the staple line, firing the stapler may produce significant bleeding in the rectal lumen, which is difficult to control. Alternatively a purse-string instrument may be used instead of a whipstitch.

Insert a sterile short proctoscope into the anal canal and aspirate the rectum of its contents. Thoroughly irrigate the rectum with sterile water to wash out any desquamated tumor cells, and remove the proctoscope.

Next, insert an over-and-over whipstitch into the rectal stump. To accomplish this, make an incision through the full thickness of the rectal wall on its left anterolateral aspect, leaving a 4 cm margin beyond the tumor. Place traction on the right-angle clamp to maintain exposure of the lower rectum. Initiate a 2-0 atraumatic Prolene over-and-over whipstitch at the left lateral corner of the rectal stump (Fig. 53.26b). As this stitch progresses along the anterior wall of the rectum toward the patient's right, divide more and more rectal wall (Fig. 53.26c). Continue the same suture circumferentially along the posterior wall of the rectum until the point of origin at the left lateral wall is reached and the specimen is completely detached (Fig. 53.26d, e). Do not attempt to insert the whipstitch *after* the specimen has been detached because the rectal stump would retract beyond the prostate and suturing from above would be impossible in the case of tumors of the mid-rectum (6–10 cm above the anal verge). Each bite should contain 4 mm of full-thickness rectal wall, and the stitches should be no more than 6 mm apart to prevent gaps when the suture is tied. A 1.5–2.0 cm width of muscular wall of rectum behind the whipstitch should be cleared of fat, blood vessels, and areolar tissue. When the staples are fired, there should be no fat or mesentery between the muscular wall of the rectum and the seromuscular wall of the proximal colon. Grasp both ends of the Prolene purse-string suture in a hemostat. Irrigate the pelvis.

Now move to the perineal portion of the operative field. Check that the stapler is correctly assembled. Because devices from different manufacturers vary, it is crucial to be familiar with the circular stapling device in use. Lubricate the tip of the stapling device with sterile surgical jelly. Insert the device into the anal canal and the rectum with the trigger handles pointing anteriorly (Fig. 53.27). Slowly push the anvil of the stapler through the lower rectal purse-string suture, then rotate the wing nut at the end counterclockwise

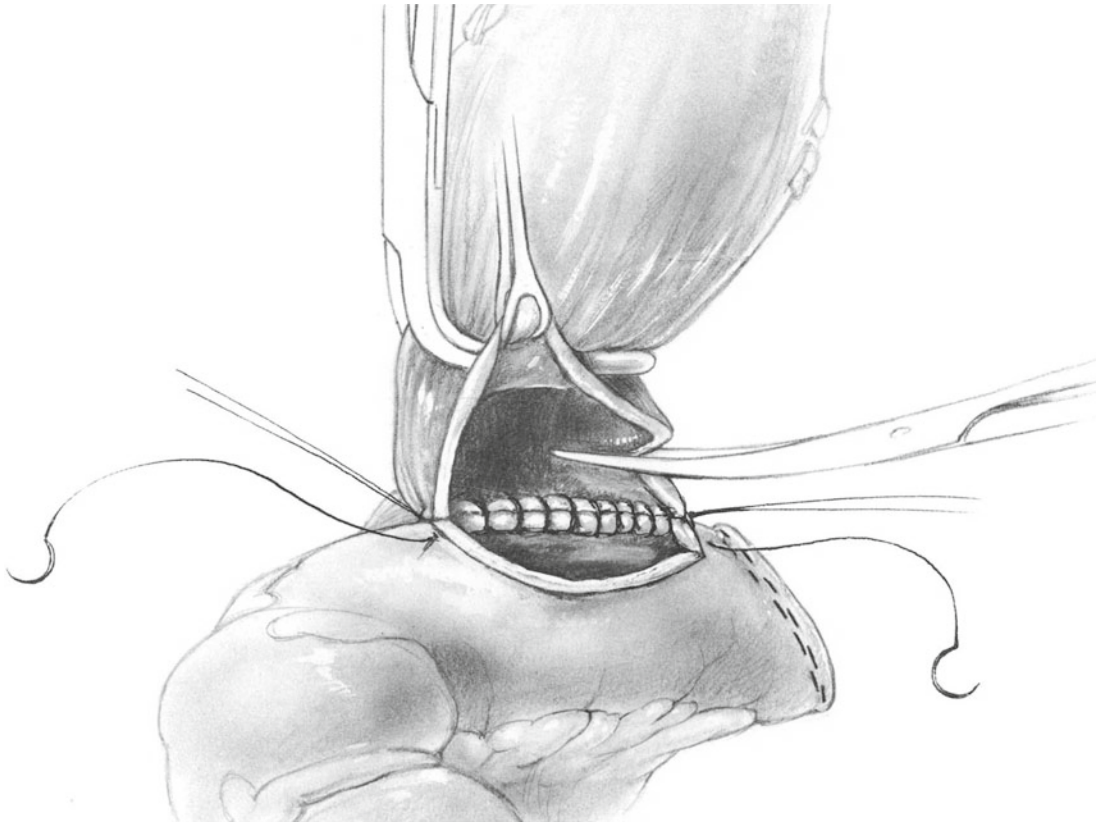

Fig. 53.19

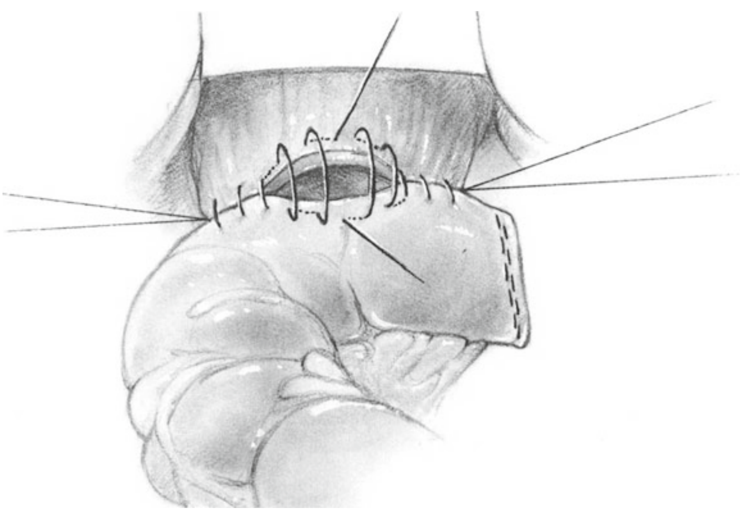

Fig. 53.20

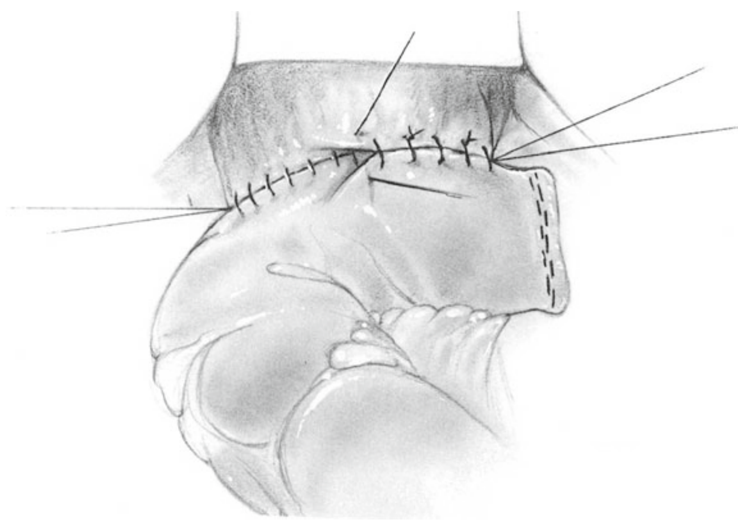

Fig. 53.21

until the device is wide open. Tie the rectal purse-string suture firmly around the shaft of the stapler (Fig. 53.28), and cut the tails 5 mm from the knot.

Apply three Allis clamps in triangular fashion to the cut end of the proximal colon, the lumen of which has been dilated so the colon may be brought over the cap of the circular stapler. When this has been accomplished, tie the colonic purse-string suture and cut its tails 5 mm from the knot (Fig. 53.29). It is vital to observe the integrity of the two purse-string sutures, as any gap in the purse-string closures can cause a defect in the anastomosis.

Now *completely* close the circular stapler by rotating the wing nut in a clockwise fashion (Fig. 53.30). Check the

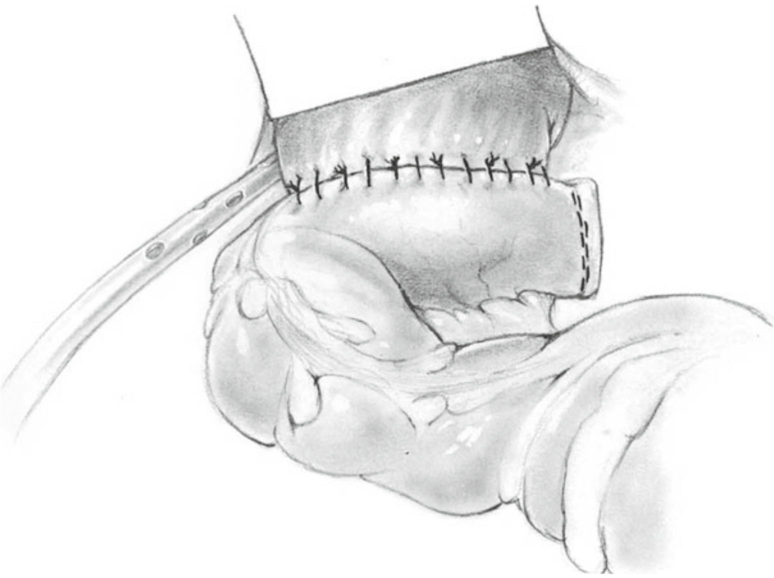

Fig. 53.22

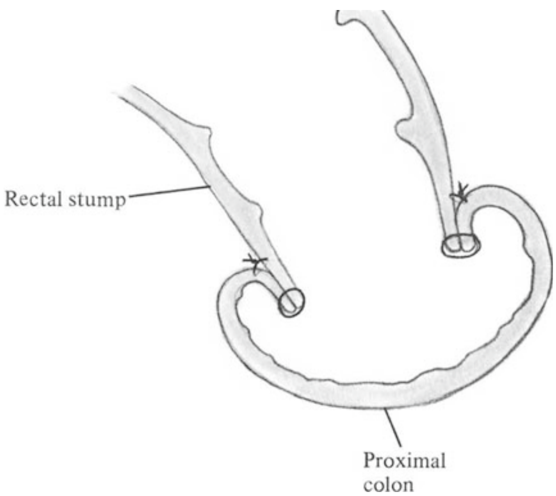

Fig. 53.23

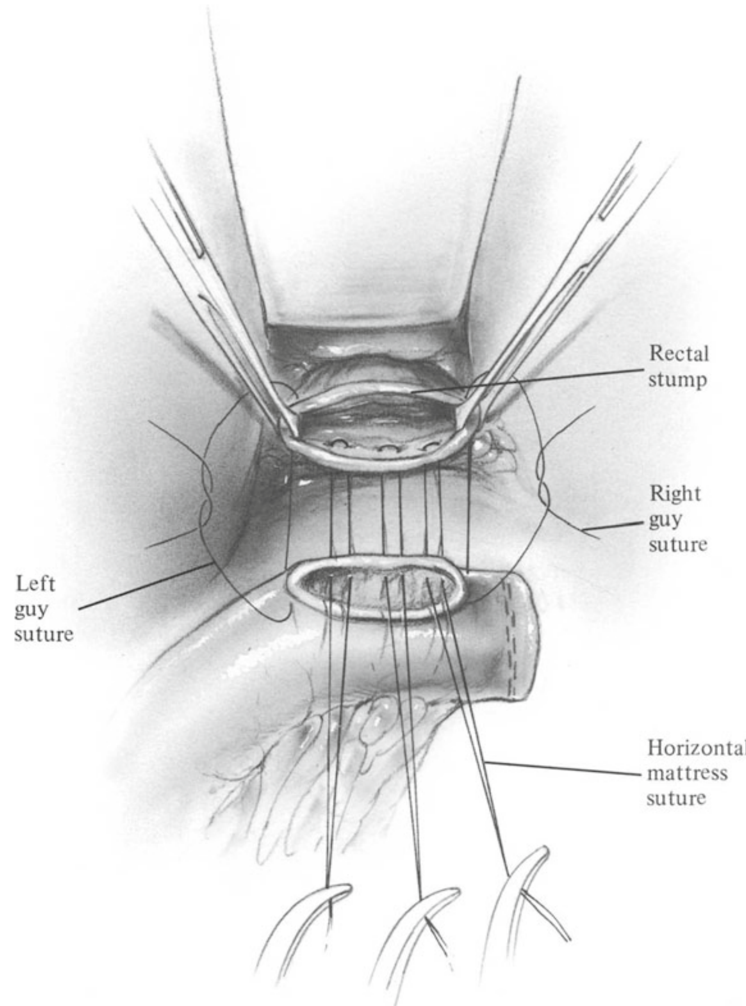

Fig. 53.24

vernier marks to confirm complete closure. This approximates the anvil to the staple cartridge. If closure is not complete, the staples are too far from the anvil and do not close to form the B shape. Be sure the vagina, bladder, and ureters are not grasped between the anvil and the cartridge during this step.

Unlock the trigger handles and then strongly compress them by applying a firm grip (Fig. 53.31). Check the strength of the compression by observing if the black mark on the shaft of the instrument is in the proper location. If this step is done properly, two circular, concentric rows of staples are fired against an anvil, and a circular scalpel blade excises the tissues compressed by the two purse-string sutures in the rectum and colon, resulting in a circular stapled anastomosis.

Now rotate the wing nut counterclockwise the recommended number of turns to open the device and separate the anvil from the cartridge. Rotate the stapler at least 180° to the right and then to the left to free any adherent tissue. Remember that the anvil cap is larger than the inner diameter of the anastomosis. Extract the anvil by depressing the stapling device handle toward the floor, thereby elevating the anterior lip of the anvil. Extract this lip first; then deliver the posterior lip by elevating the handle. It is sometimes helpful if the assistant grasps the anterior rectal stump with a gauze pad or inserts a Lembert suture to stabilize the staple line while the anvil is being extracted (Figs. 53.32 and 53.33).

After the instrument has been removed, turn the thumbscrew on the cap of the staple cartridge counterclockwise, and remove the cap containing the anvil to reveal the segments of rectum and colon that have been amputated. The cartridge should contain two complete circles, each resembling a small doughnut. One represents the proximal margin of the rectum and the other the distal margin of the proximal colon. Any gap in either of the two circles of bowel indicates a defect in the stapled anastomosis caused by the bowel

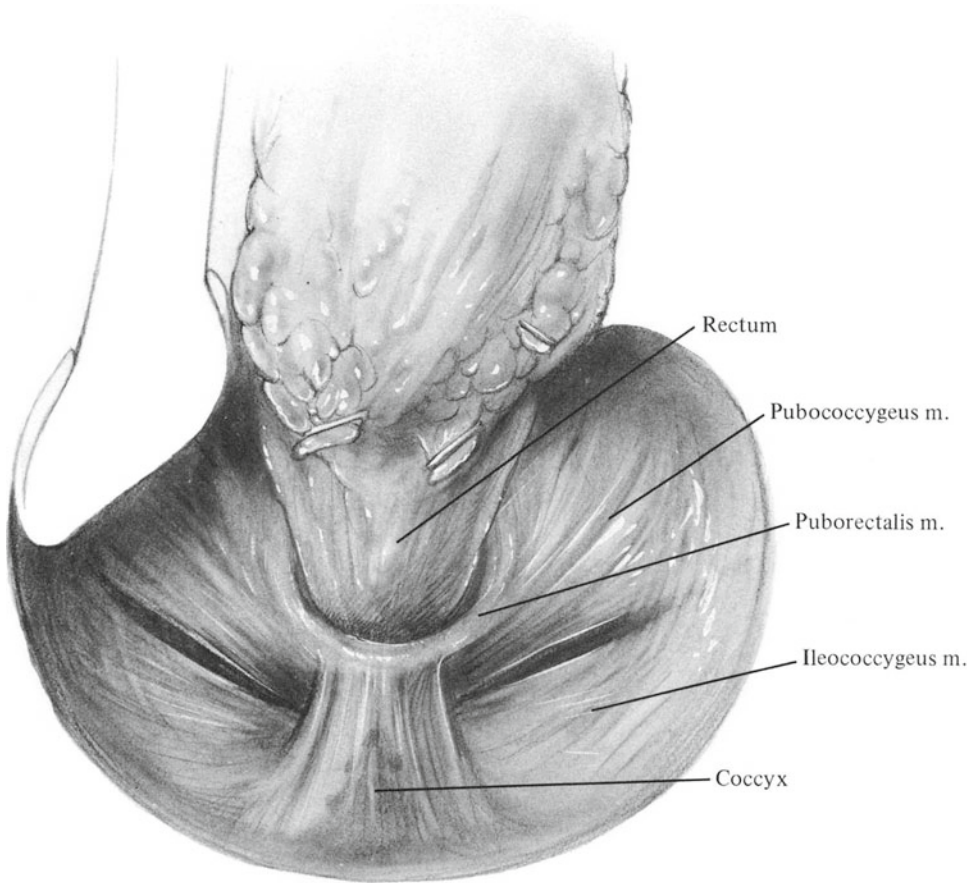

Fig. 53.25

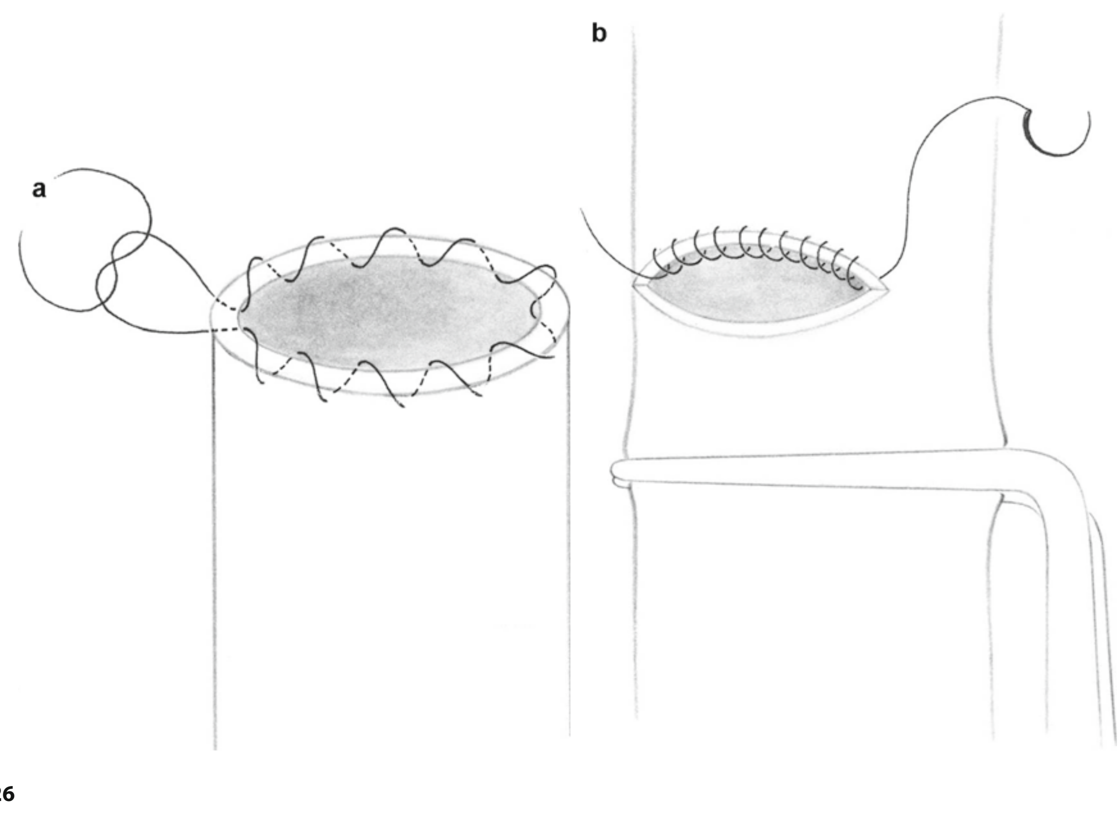

Fig. 53.26

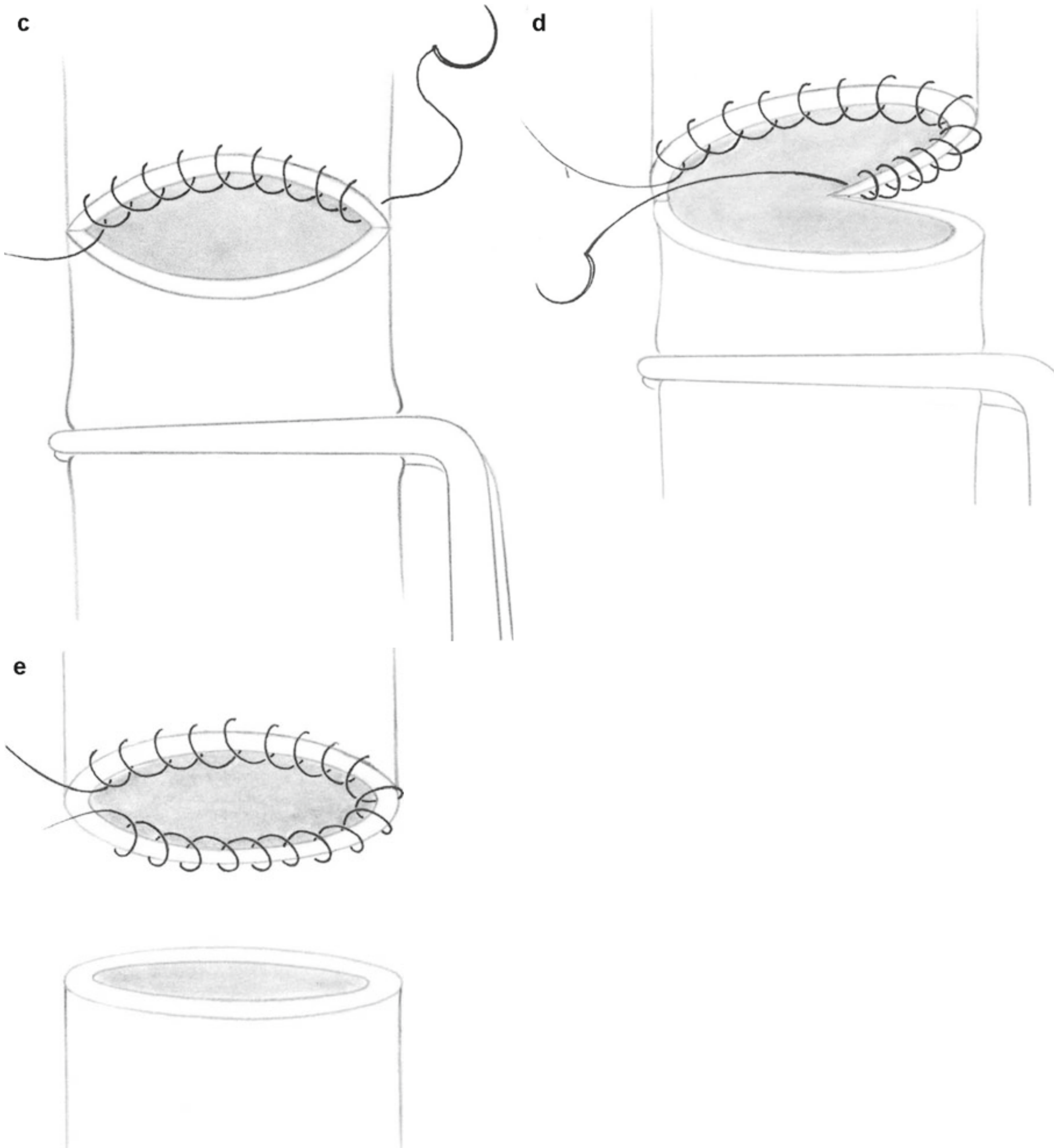

Fig. 53.26 (continued)

pulling out of the purse-string suture before being stapled. Locate and repair any such defects. Consider a complementary colostomy or loop ileostomy.

Now check the integrity of the stapled anastomosis by digital examination. An additional test of integrity is to flood the pelvis with sterile saline. Wait until all air bubbles have disappeared and then apply an atraumatic Doyen clamp to the colon above the anastomosis. The assistant then inserts an Asepto-type syringe or a Foley catheter into the anus and pumps air into the rectum while the surgeon palpates the colon. When the colon is inflated with air under only a moderate degree of pressure, observe the pool of saline for air bubbles. The absence of air bubbles is fairly reliable evidence of an intact anastomosis. If air bubbles are detected, attempt to find the source of the leak and repair it with sutures. Create a transverse colostomy if the leak cannot be located or if the suture repair seems unreliable. Another method is to insert a Foley catheter into the rectum and, through it, instill a sterile solution of methylene blue dye. Inspect the anastomosis for leakage of the dye. Use a sterile angled dentist's mirror to help observe the posterior aspect of the anastomosis.

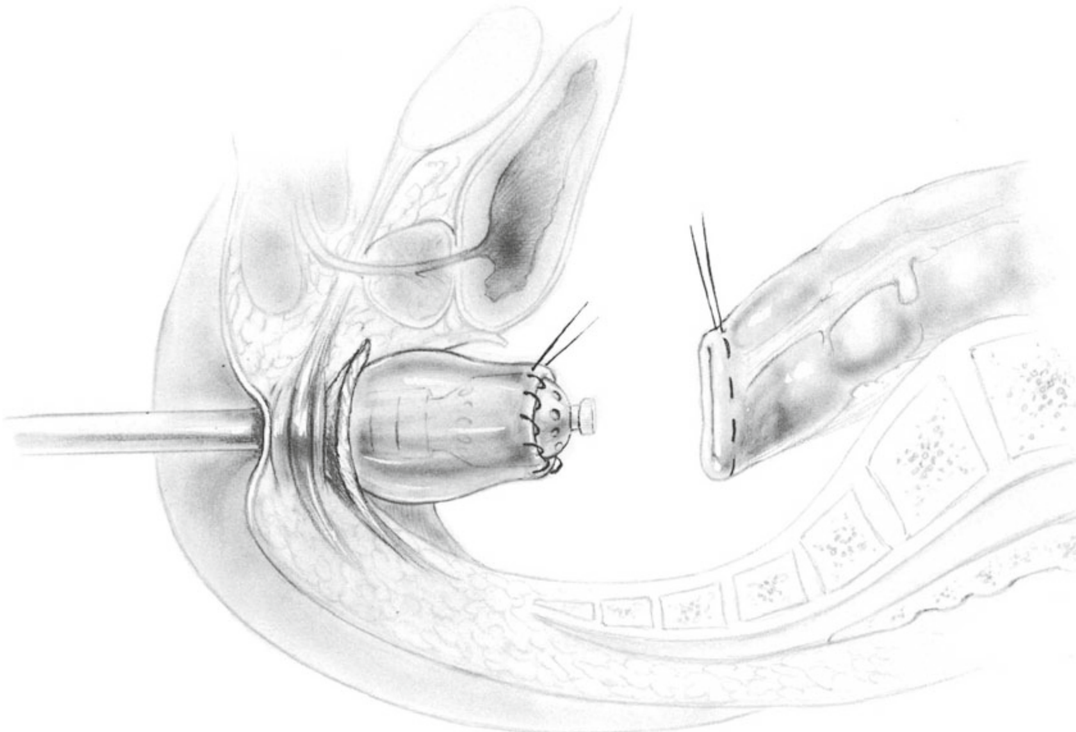

Fig. 53.27

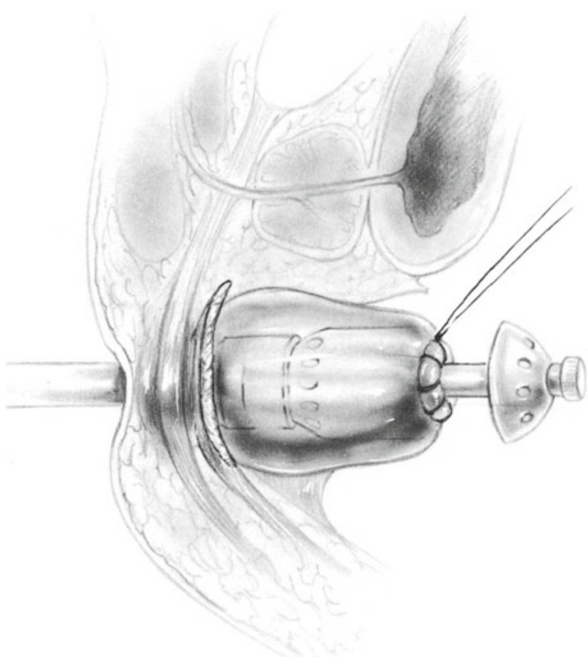

Fig. 53.28

Double-Stapled Technique for Very Low Colorectal Stapled Anastomosis

There are several situations in which the double-stapled method is advantageous. First, when the rectum is unusually thick or large, even the largest circular stapler cartridge is too small to accommodate the large bulk of tissue. Forcing this large bulk of tissue into the cartridge results in extruding some of the tissue between the colon and rectum being anastomosed (Fig. 53.34). Because the tissue is devitalized, it may interfere with healing and cause leakage. When the rectum is bulky, instead of a purse-string suture, apply the Roticulator 55 stapler and close the rectum with a line of staples. Then amputate the specimen. If a circular stapling device is inserted into the rectum, the circular stapled colorectal anastomosis does not encompass a large bulk of rectum, only a relatively thin circle of rectum (Fig. 53.38). Second, it is possible to close the rectal stump at a significantly lower level, as it is much simpler to apply the stapler in this location than to insert a purse-string suture. Third, in patients who have undergone a Hartmann operation, when performing the colorectal anastomosis to the stump of rectum left behind after the Hartmann operation, inserting the circular stapling device into the rectal stump makes reversal of the Hartmann operation much simpler than would construction of a sutured colorectal anastomosis.

Anterior resection of the rectum proceeds in the same manner as described above, except that the dissection generally continues farther into the pelvis than the average case, as the Roticulator 55 can be inserted closer to the anal canal than other methods of excising the rectum. After dissection is completed, using the usual retractors on the bladder or uterus, apply the Roticulator 55 to encompass the

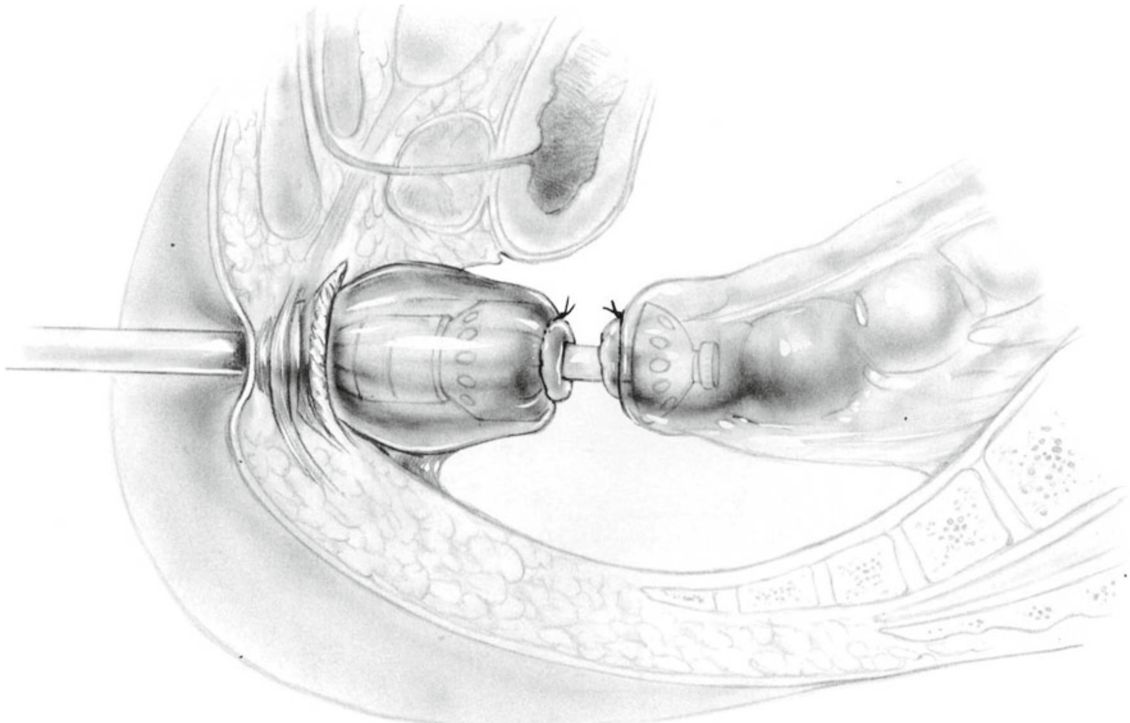

Fig. 53.29

entire lower rectum and no adjacent pelvic tissues (Fig. 53.35). Dissect the rectum down to the longitudinal muscle on all sides. After firing the stapler, apply a long-angled clamp to occlude the proximal rectum and then use the scalpel to divide the rectum flush with the proximal margin of the Roticulator device (Fig. 53.36). Locate the upper end of the specimen. Divide the colon and remove the specimen. Insert a 2-0 Prolene purse-string suture close to the cut margin of the colon; then insert the detached anvil into the colon and tie the purse-string suture (Fig. 53.37).

Insert the circular stapler cartridge, with the shaft containing the trocar recessed, through the anus into the rectum. Advance the instrument cautiously to the staple line of the closed rectal stump. Rotate the wing nut at the base of the stapler to advance the trocar through the rectal stump. Aim at a spot just anterior to the midpoint of the staple line. When the trocar has emerged through the rectal stump, remove the trocar (Fig. 53.37). Now engage the anvil shaft into the cartridge shaft. Under direct vision, slowly close the wing nut in such fashion that the anvil and the cartridge are properly approximated (Fig. 53.38). Then fire the stapler (Fig. 53.39). Now open the stapler and remove it as previously described. Carefully check the anastomosis and both "doughnuts" as previously described.

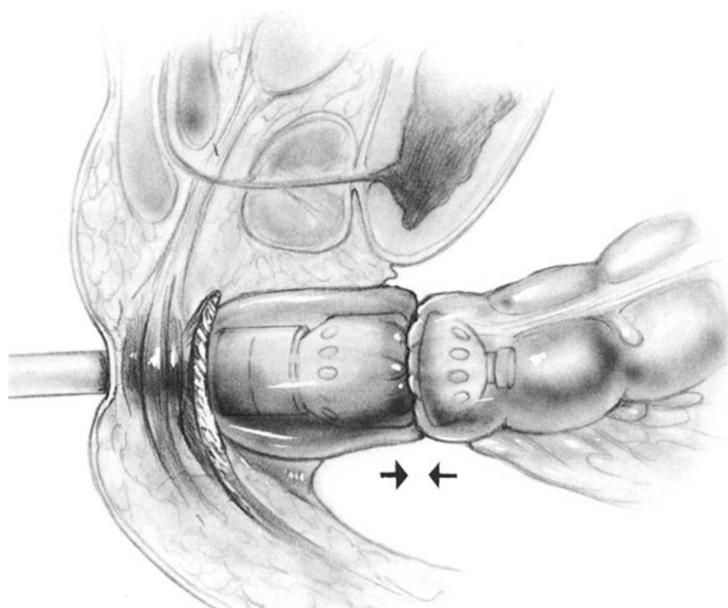

Fig. 53.30

Pitfalls and Danger Points of Circular Stapled Colorectal Anastomosis

Most defects in the staple line are the result of an imperfect purse-string suture. If this suture does not hold the entire cut end of the bowel close to the shaft of the stapling instrument, the staples cannot catch the complete circumference of the colon or rectum, resulting in a defect and postoperative leakage. If complete doughnutlike circles of full-thickness rectum and colon can be identified after the device has been fired, it indicates that the staples

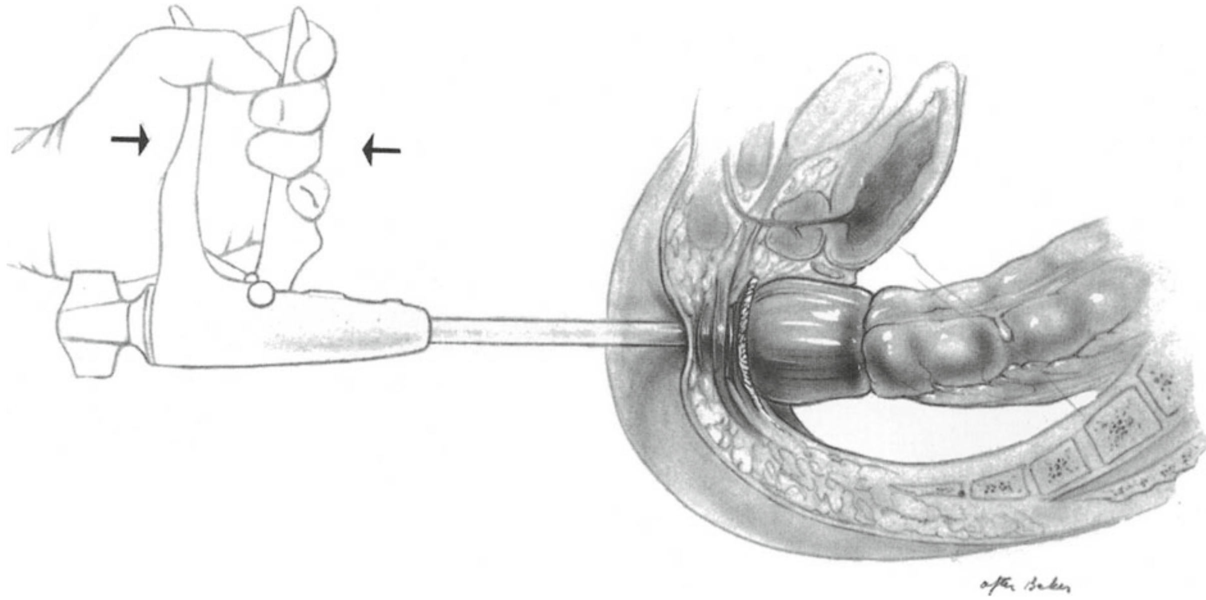

Fig. 53.31

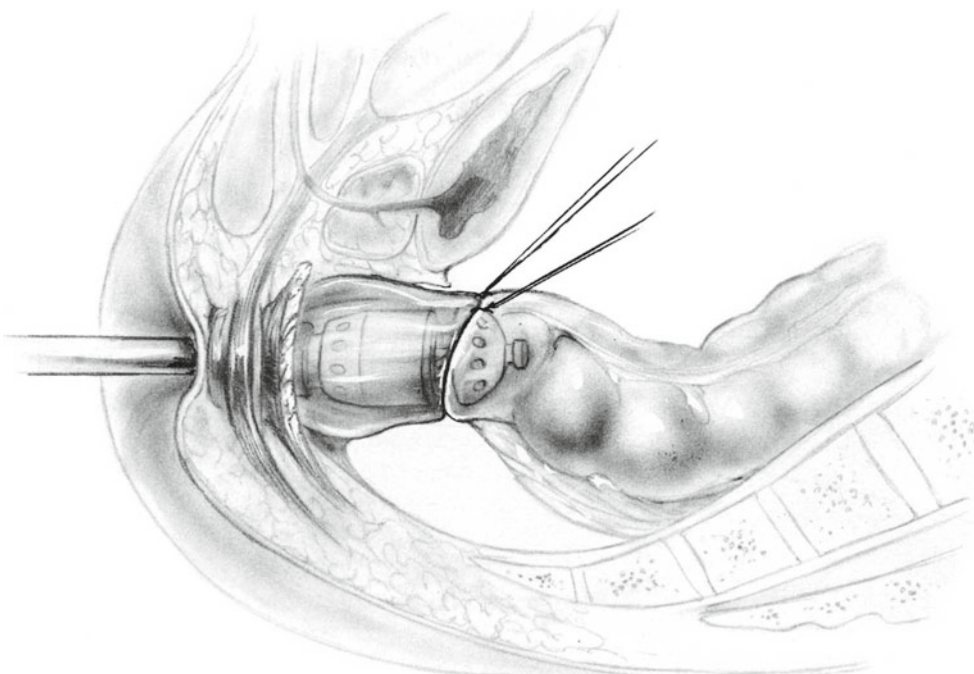

Fig. 53.32

have passed through complete circles of bowel and there should be no defect.

Low colorectal circular stapled anastomoses fail also when too much bowel is left beyond the purse-string sutures. When an excessive volume of tissue is admitted into the cartridge, the capacity of the cartridge is exceeded. This results in extrusion of tissue when the cartridge is compressed against the anvil. The devitalized extruded tissue may emerge between the two walls of stapled bowel and interfere with healing. It is also essential to remove fat from the two bowel walls in the area where the staples are to be inserted.

One important exception to use the whipstitch is where the rectal diameter is large. When a whipstitch is used to compress a large rectum, it is sometimes impossible to snug the entire diameter up close to the shaft of the stapling device. In this case close the rectum with a linear stapler and use the double-stapled method.

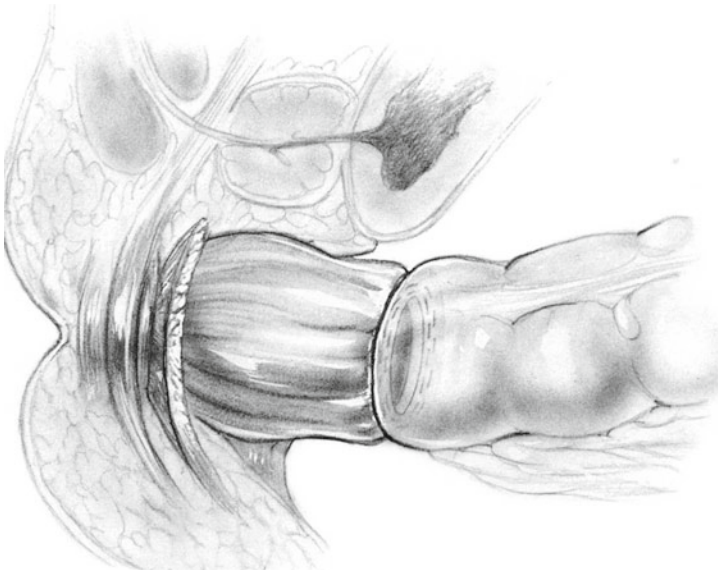

Fig. 53.33

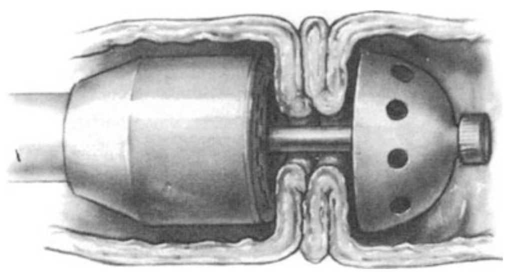

Fig. 53.34

An additional pitfall should be noted. If the trigger handles of the instrument are not compressed fully, the circular scalpel blade fires incompletely. The staples may be driven home, but the redundant colon and rectum within the anvil *are not cut*. Forceful removal of the stapling device under these conditions disrupts the entire anastomosis.

When the anvil cannot be disengaged easily, do not use force. Rather, make a colotomy incision on the antimesenteric border of the upper colon 3–4 cm above the staple line. Then unscrew and remove the anvil through the colotomy. Extracting the stapler from the anus is now a simple matter. Inspect the interior of the anastomosis through the colotomy opening. If a septum of inverted bowel remains in the lumen inside the circle of staples, excise the septum using a Potts angled scissors. Close the colotomy with a 55 mm linear stapler.

An obvious cause of failure is the erroneous use of a cartridge or stapler that has been fired already. In this case the circular blade may function, but there are no staples; the surgeon is left with two cut ends of bowel, but no anastomosis. To avoid this error, before attaching the anvil look closely into the cartridge to be certain it is properly loaded with staples and a circular blade.

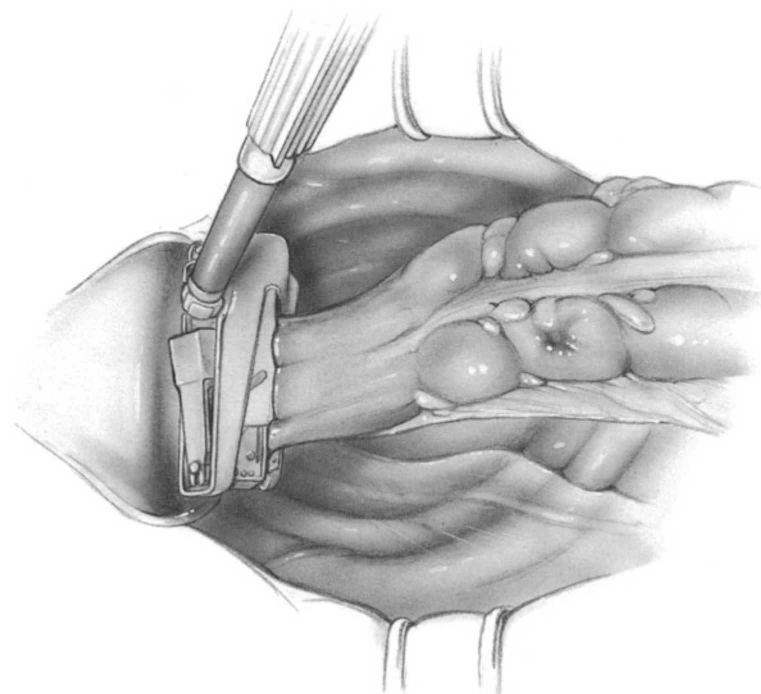

Fig. 53.35

Unless the stapler is fully opened, it cannot be removed from the rectum after firing the staples. This mishap occurs because the anastomosed bowel is still being grasped between the staple cartridge and the anvil, and forceful attempts to dislodge the stapler disrupt the anastomosis.

As mentioned above, if the screw that caps the anvil is not screwed on tightly or if the wing nut near the handle is not completely closed before the staples are fired, the space between the staple cartridge and the anvil is excessive. It prevents proper closure of the legs of the staples, in which case the anastomosis may pull apart at the slightest stress. Never use hemostatic clips on any part of the colon or rectum that may be included in the stapled anastomosis because these metal clips prevent proper function of the staples and the stapler blade.

Intraluminal hemorrhage following a stapled anastomosis occurs if mesenteric blood vessels have been trapped in the staple line and are transected by the blade. Bleeding may be controlled by cautious electrocautery through a proctoscope or by inserting sutures through a proximal colotomy.

When the stapled anastomosis is situated at or above the cephalad margin of the anal sphincter muscles (i.e., at or above the puborectalis component of the levator muscle), fecal continence is not lost. However, because the proximal colon segment does not function as a reservoir, the patient defecates frequently during the first few months. Each peristaltic contraction results in evacuation of a small, formed

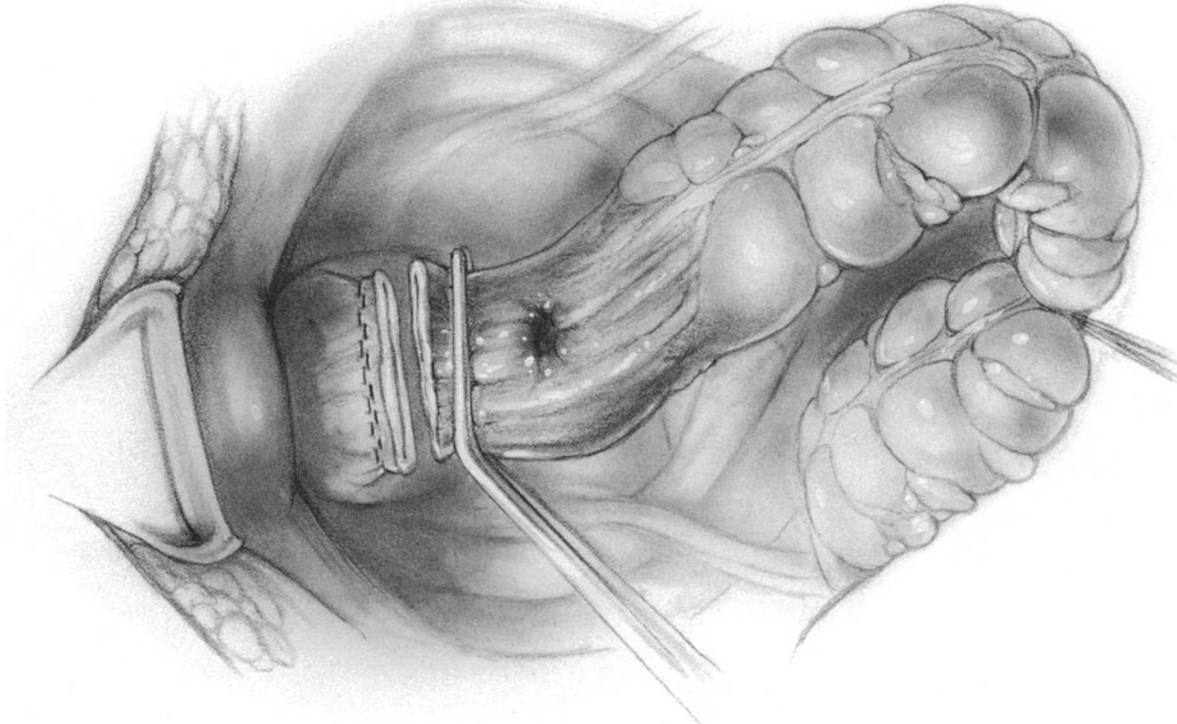

Fig. 53.36

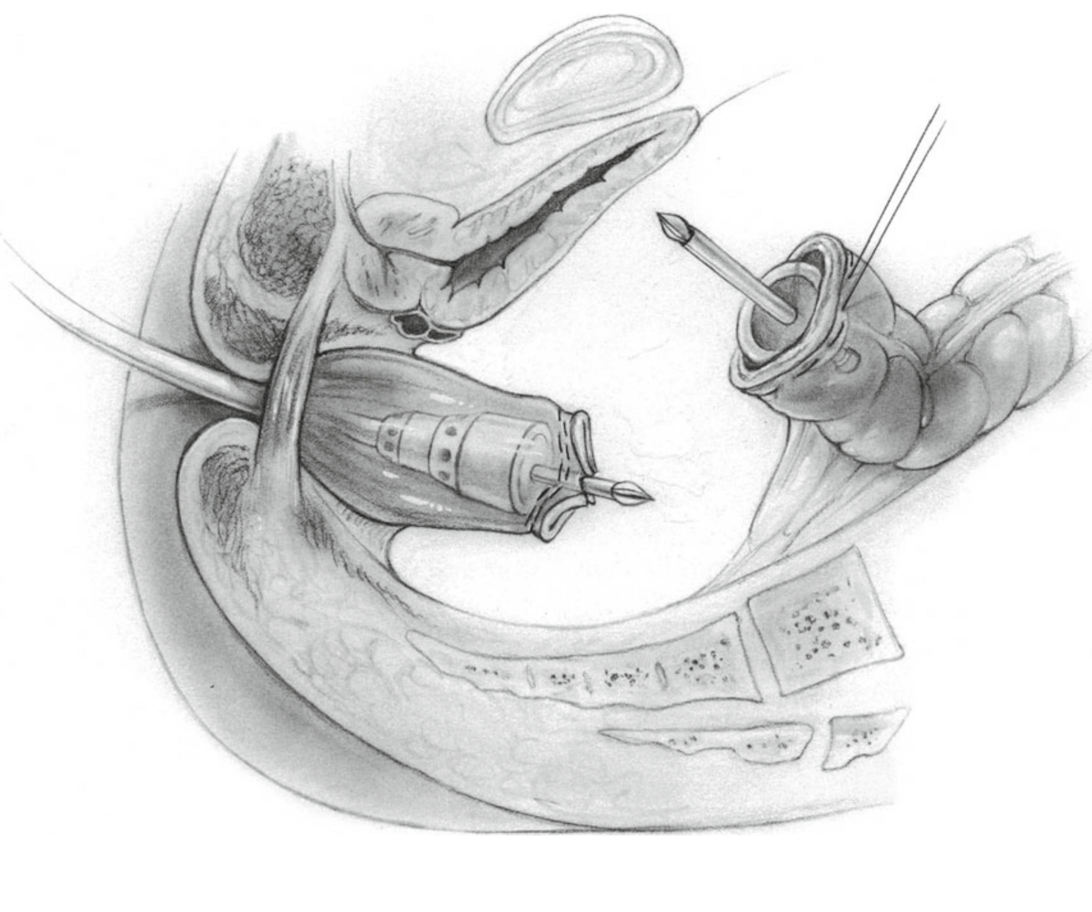

Fig. 53.37

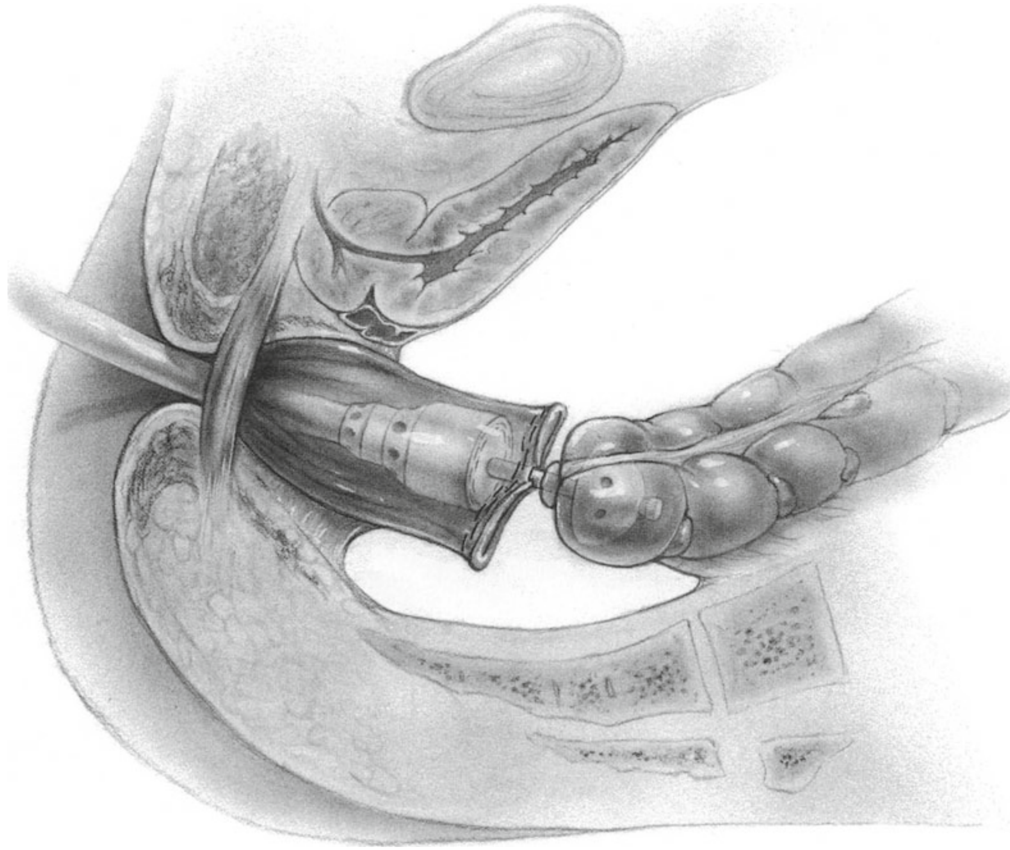

Fig. 53.38

stool; but there is no inadvertent loss of stool or liquid. On the other hand, if the anastomosis is at or below the dentate line, the loss of the internal sphincter results in some degree of fecal incontinence for 3–6 months and *sometimes permanently*.

Although a transanal approach to purse-strip insertion has been described, it can result in fecal incontinence if great care is not taken. If the transanal approach is used, make every effort to insert the purse string or whipstitch into the rectal stump in the upper segment of the anal canal to ensure retention of the internal sphincter muscle. If the rectal stitch cannot be properly applied, one can perform a transanal end-to-end sutured anastomosis by the method of Parks, which makes a point of preserving the internal sphincter muscle. *A coloanal anastomosis may be constructed by a technique similar to that described in Chap. 57 for the ileoanal pouch*.

When the rectal stump is too short to insert a purse-string stitch from above, it is usually possible to use the Roticulator stapler instead (Fig. 53.35). We are enthusiastic about the double-staple technique for colorectal anastomoses that are so low it would be difficult to use sutures. We have resected tumors 6 cm from the anal verge using the stapler with a 2 cm margin of normal tissue, performing a successful stapled anastomosis flush with the upper margin of the anal canal.

Complementary colostomy and presacral drainage should be used following a stapled anastomosis under the same conditions that would lead the surgeon to use these modalities following a sutured colorectal anastomosis. We routinely employ closed-suction presacral drainage for low extraperitoneal anastomoses.

For stapled intraperitoneal anastomoses above the pelvis, we prefer a functional end-to-end anastomosis (see Figs. 51.35, 51.36, 51.37, and 51.38) rather than the circular stapled procedure. The latter often takes more time and is prone to more technical complications than the functional end-to-end method.

Wound Closure and Drainage

Remove the wound protector drape. The surgical team should change its gloves and discard all contaminated instruments. Thoroughly irrigate the abdominal cavity and wound with an antibiotic solution. Close the incision in the usual fashion.

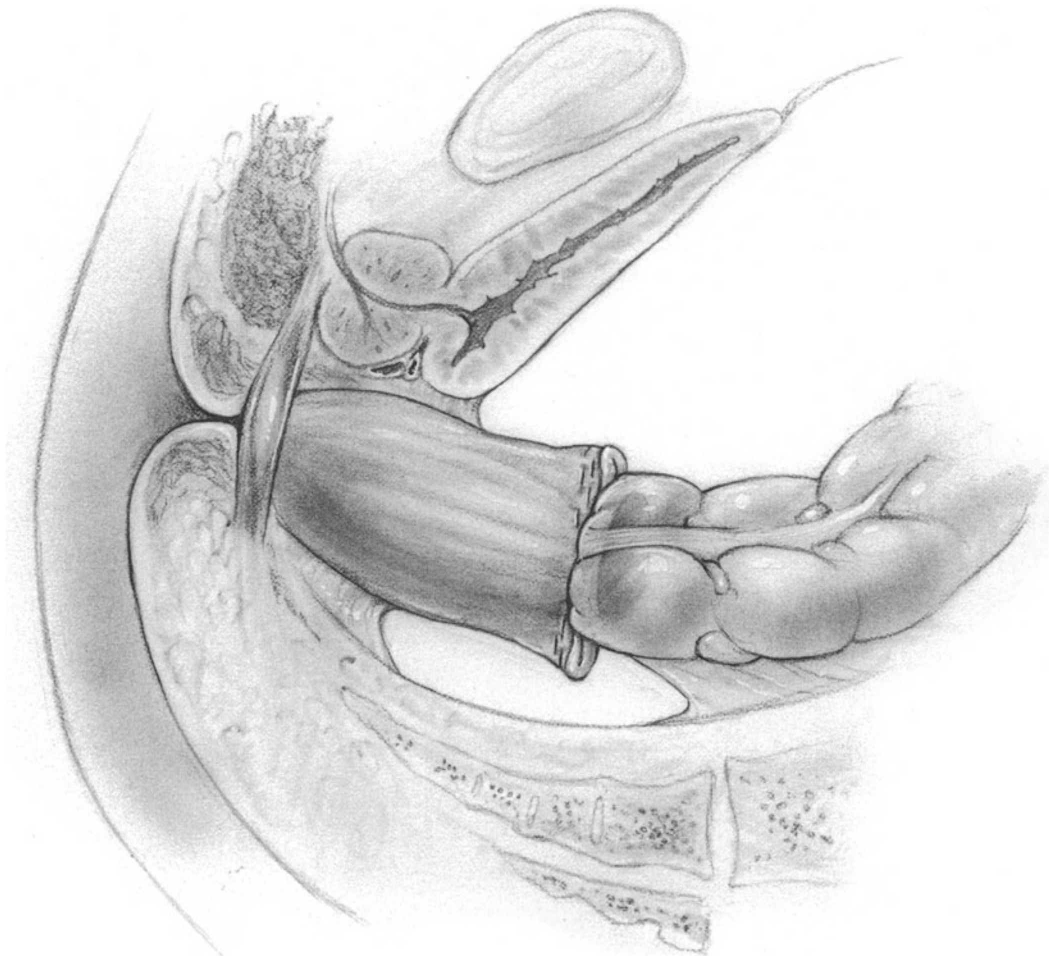

Fig. 53.39

Postoperative Care

Discontinue gastric suction as soon as possible (often in the operating room or postanesthesia care unit).

Begin oral intake as soon as possible.

Continuation of perioperative antibiotics for 24 h.

Constant bladder drainage via Foley catheter for 6–7 days.

Presacral suction catheters attached to closed-suction drainage.

Drainage catheter removed after 5 days unless there is significant drainage volume.

Postoperative chemotherapy or radiation therapy for selected patients, depending on the stage of disease – note that current practice emphasizes maximizing respectability by administering these treatments prior to surgery, whenever possible.

Complications

Bladder dysfunction may follow low anterior resection, especially in men with prostatism, but it is much less common than after abdominoperineal proctectomy. Generally, function resumes after 6–7 days of bladder drainage.

Pelvic sepsis secondary to anastomotic leakage is the most common serious complication following low colorectal anastomosis. Any patient with fever, leukocytosis, and ileus following low anterior resection should be assumed to have a leaking anastomosis and a pelvic abscess. Clinical manifestations of this complication commonly occur between the sixth and ninth postoperative days. Cautious digital examination of the rectum by the surgeon may prove to be diagnostic if the finger discloses a defect in the suture line, generally on its posterior aspect. Careful proctoscopic examination may disclose evidence of a defect in the suture line.

The presence of pelvic sepsis can almost always be confirmed by pelvic CT and can often be treated by CT-guided percutaneous catheter drainage. A patient may have sustained a pelvic abscess even in the absence of a definite defect in the suture line. Consequently, a patient who is febrile and toxic should undergo drainage of any septic process if CT-guided percutaneous catheter drainage is not successful. In some cases the patient also requires fecal diversion by transverse colostomy or loop ileostomy.

Patients with mild systemic symptoms who are suspected of having a pelvic infection may be treated by food withdrawal, intravenous antibiotics, and hyperalimentation. Occasionally, a presacral abscess drains into the rectum through the anastomosis without making the patient seriously ill. It must be remembered, however, that anastomotic leakage and pelvis sepsis constitute potentially lethal complications that often require vigorous management.

Sexual dysfunction in men may follow low anterior resection, especially in patients with large tumors and who require extensive dissection of the presacral space, lateral ligaments, and prostatic area.

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54 Abdominoperineal Resection for Rectal Cancer

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Malignancy of distal rectum or anus not amenable to sphincter-preserving techniques

Preoperative Preparation

Sigmoidoscopy and biopsy
Colonoscopy to exclude other lesions
Accurate preoperative staging, including, as appropriate:

- Computed tomography (CT) of abdomen and pelvis
- MRI scan
- Endorectal ultrasonography and other staging studies as indicated

Preoperative radiation and chemotherapy as appropriate
Carcinoembryonic antigen
Correction of anemia if necessary
Mechanical and antibiotic bowel preparation
Indwelling Foley catheter in bladder
Gastric tube
Perioperative antibiotics

Pitfalls and Danger Points

Hemorrhage

- Presacral veins
- Left iliac vein
- Middle hemorrhoidal artery
- Hypogastric arterial branches
- Gastrointestinal vessels

Rupture of rectum during dissection
Colostomy ischemia, producing postoperative necrosis
Colostomy under excessive tension, leading to postoperative retraction and peritonitis
Separation of pelvic peritoneal suture line, causing herniation and obstruction of small intestine
Inadequate mobilization of pelvic peritoneum, resulting in failure of newly constructed pelvic floor to descend completely; resulting empty space encourages sepsis
Genitourinary

- Ureteral trauma, especially during dissection in the vicinity of lateral ligaments of the rectum; inadvertent ureteral ligation, especially during reconstruction of pelvic floor
- Urethral laceration during dissection of perineum in male patients

Operative Strategy

Abdominal Phase

The initial abdominal phase of the dissection is essentially identical to that performed for a low anterior resection. See Chap. 53 for a detailed discussion of the strategy relevant to this phase, including total mesorectal excision (TME).

Colostomy

Have the proposed site marked by an ostomy therapist. Although the colostomy may be brought out through the left lower quadrant musculature, the midline abdominal incision, or the belly of the left rectus muscle, generally a left lower quadrant placement is preferred. In morbidly obese patients with an apron-like pannus, a more cephalad location (above the heavy pannus) may be preferred, as this makes it easy for the patient to see and care for the stoma. If the colostomy is

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brought out laterally, the 3–5-cm gap between the colon and the lateral portion of the abdominal wall should be closed or a retroperitoneal colostomy performed; otherwise the small bowel may become incarcerated in the lateral space. Goligher (1958) reported a method of bringing the colostomy out through a retroperitoneal tunnel to the opening in the abdominal wall sited in the lateral third of the rectus muscle a few centimeters below the umbilicus. When the peritoneal pelvic floor is suitable for closure by suturing, this technique is another satisfactory method of creating the sigmoid colostomy (see Figs. 54.19, 54.20, 54.21, and 54.22).

To prevent necrosis of the colostomy, confirm that there is adequate arterial blood flow to the distal portion of the exteriorized colon, equivalent to that required if an anastomosis were made at this point. Even in the presence of adequate arterial flow, ischemia of the colostomy may occur if an obese mesentery is constricted by a tight colostomy orifice.

Postoperative retraction of the colostomy may result if abdominal distension causes the abdominal wall to move anteriorly. For this reason the limb of colon to be fashioned into a colostomy should protrude without tension for 5 cm beyond the level of the abdominal skin before any suturing takes place.

Pelvic Floor

Because intestinal obstruction due to herniation of the ileum into a defect in the reconstructed pelvic floor is a serious complication, a number of surgeons now omit the step of resuturing the pelvic peritoneum. If no attempt is made to reperitonealize the pelvic floor, the small bowel descends to the level of the sutured levators or subcutaneous layers of the perineum. Intestinal obstruction during the immediate postoperative period does not appear to be common following this technique. However, if intestinal obstruction does occur at a later date, it becomes necessary to mobilize considerable small bowel, which is bound down by dense adhesions in the pelvis. It often results in damage to the intestine, requiring resection and anastomosis to repair it. Thus it appears logical to attempt primary closure of the pelvic peritoneum to prevent this complication, provided enough tissue is available for closure without undue tension. The peritoneal floor should be *sufficiently lax to descend to the level of the reconstructed perineum*. This eliminates the dead space between the peritoneal floor and the other structures of the perineum. As total proctectomy is done primarily to remove lesions of the lower rectum, there is no need for radical resection of the perirectal peritoneum. One should conserve as much of this layer as possible. If it appears that a proper closure is not possible, it is preferable to leave the floor entirely open. Otherwise the dead space between the peritoneal diaphragm and the perineal floor often leads to disruption of the peritoneal suture line and to bowel herniation. Creating a vascularized pedicle of omentum is a good way to fill the pelvic cavity with viable tissue and to prevent the descent of small bowel into the pelvis.

Perineal Phase

Position

Turning the patient to a prone position provides the best exposure for the surgeon but imposes a number of disadvantages on the patient. First, circulatory equilibrium may be disturbed by turning the patient who is under anesthesia. Also, changing positions prolongs the operative procedure, as it is not possible to have one member of the surgical team close the abdominal incision while the perineal phase is in process. Similar objections can be raised about the lateral Sims position.

For these reasons we favor the position described here. The patient lies supine, with the sacrum elevated on a folded sheet or sandbag and the lower extremities supported by Lloyd-Davies leg rests, causing the thighs to be widely abducted but flexed only slightly; the legs are supported and moderately flexed. This mild flexion of the thighs does not interfere in any way with the abdominal procedure, and the second assistant can stand comfortably between the patient's legs while retracting the bladder (see Fig. 53.3a, b).

Whether the abdominal and perineal phases are carried on synchronously by two operating teams or one team does the complete procedure, positioning the patient in this manner gives the surgeon the option of doing some portions of the procedure from below and then switching to the abdominal field in response to the exigencies of a particular step. It facilitates safe lateral dissection of large tumors and completes hemostasis in the pelvis. Some vessels may be easier to control from below, and others should be clamped from above. In addition, after the surgeon has completed suturing the pelvic peritoneum, suction can be applied from below to determine if there is a dead space between the pelvic floor and the perineal closure. After removing the specimen, it is fairly simple to have closure if both the abdomen and perineum proceed simultaneously.

Closure of Perineum

Primary closure of the perineum is now a routine, particularly if there has been no fecal spillage in the pelvis during the course of resection, and good hemostasis has been accomplished. Primary healing has been obtained in most of our patients operated on for malignancy when the perineum is closed per primam with insertion of a closed-suction drainage catheter. Suction applied to the catheter draws the reconstructed peritoneal pelvic floor downward to eliminate any empty space.

In patients with major presacral hemorrhage, tamponade the area with a sheet of topical hemostatic agent covered by a large gauze pack, which is brought out through the perineum. Remove the gauze in the operating room on the first or second postoperative day after correcting any coagulopathy and achieving full resuscitation.

In patients who have experienced major pelvic contamination during the operation, the perineum should be closed only partially and drained with both latex and sump drains.

In female patients, management of the perineum depends on whether one has elected to remove the posterior vagina. For small anterior malignancies, the adjacent portion of the posterior vagina may be removed with the specimen, leaving sufficient vagina for primary closure with PG. When the entire posterior vaginal wall has been removed along with large anterior lesions, the perineum should be closed with sutures to the levator muscles, subcutaneous fat, and skin. This leaves a defect at the site of the vaginal excision through which loose gauze packing should be inserted. If there is primary healing of the perineal floor, granulation fills this cavity, and vaginal epithelium regenerates in 1–3 months. Vaginal resection need not be done for tumors confined to the posterior portion of the rectum.

Dissection of Perineum

The most serious pitfall during perineal dissection is inadvertent transection of the male urethra. This can be avoided if the anterior part of the dissection is delayed until the levator muscles have been divided throughout the remainder of the circumference of the pelvis and the prostate identified. It is important not to divide the rectourethralis muscle at a point more cephalad than the plane of the posterior wall of the prostate (see Fig. 54.11). Alternatively, one should identify the transverse perineal muscles. If the dissection is kept on a plane posterior to these muscles, the urethra is out of harm's way.

Hemostasis

All bleeding during the perineal dissection can be controlled by accurate application of electrocautery. Here, as elsewhere during abdominal surgery, if electrocautery is applied to a vessel that is well isolated from surrounding fat, ligature is not necessary. Whether electrocautery is applied directly to a bleeding point or to forceps or a hemostat depends on the preference of the surgeon. With the cautery device it is possible to obtain complete control of bleeding in this area without undue loss of blood or time.

Documentation Basics

Findings
Management of pelvic floor

Operative Technique

Position

Place the patient in the supine position, with the sacrum elevated on several folded sheets or a sandbag and the thighs flexed only slightly but abducted sufficiently to allow adequate exposure of the perineum. The legs should be flexed slightly and the calves padded with foam rubber and supported in Lloyd-Davies leg rests (see Fig. 53.3a, b). If the thighs are not flexed excessively, there is no interference with performance of the abdominal phase of the operation. The second assistant should stand between the patient's legs during the abdominal phase. Bring the indwelling Foley catheter over the patient's groin, and attach it to a plastic tube for gravity drainage into a bag calibrated to facilitate measurement of hourly urine volume. In men, fix the scrotum to the groin with a suture. Close the anal canal with a heavy purse-string suture.

Carry out routine skin preparation of the abdomen, perineum, and buttocks. Drape the entire area with sterile sheets. After these steps have been completed, the operation can be performed with two teams working synchronously or by one team alternating between the abdomen and the perineum.

Incision and Exploration: Operability

Make a midline incision beginning at a point above the umbilicus and continuing to the pubis (see Fig. 53.3a). Separate the pyramidalis muscles as the pubis is approached because getting an extra 1–2 cm closer to the pubis improves the exposure significantly. Open the peritoneum and carry out a general exploration.

In most cases the resectability of a rectal carcinoma cannot generally be determined until a later step in the operation, when the presacral space is open. Accurate preoperative staging has eliminated most of these intraoperative dilemmas. When a tumor invades the sacrum posteriorly or the prostate anteriorly, attempting to core out the rectum by forcing a plane through the tumor is a fruitless and sometimes dangerous endeavor. If much tumor is left behind in the presacral space, the palliation attained is negligible because if it invades the presacral nerves it produces the most distressing of all symptoms in this disease, extreme perineal pain. On the other hand, many tumors are firmly adherent to the sacrum without having invaded it. These lesions should be resected. Cases of borderline resectability may benefit from preoperative neoadjuvant therapy. Local invasion of the ureter does not contraindicate resection, as the divided ureter at this low level can be implanted into the bladder.

Mobilization of Sigmoid, Lymphovascular Dissection, and Presacral Dissection

The abdominal phase of this operation proceeds down to the levator diaphragm, as previously outlined (see Figs. 53.4, 53.5, 53.6, 53.7, 53.8, 53.9, 53.10, and 53.11). The dissection

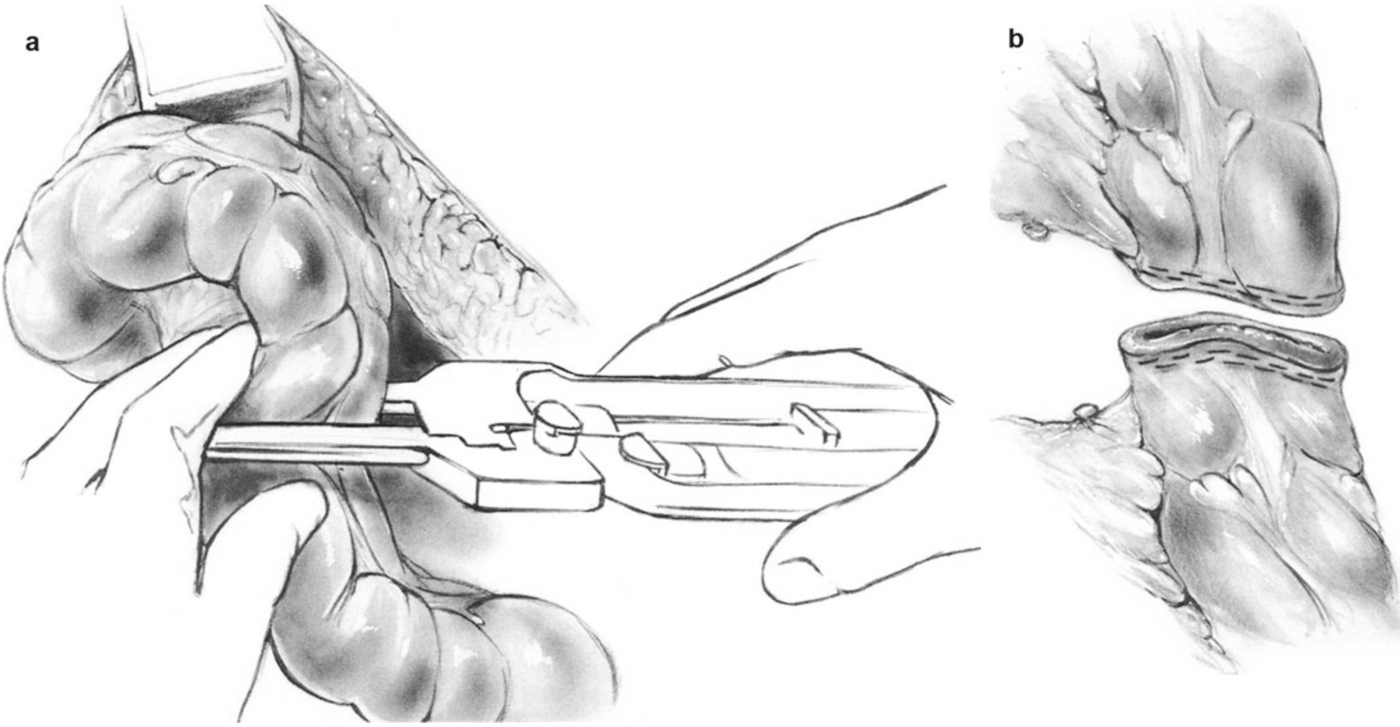


Fig. 54.1

must include the mesentery of the rectum (total mesorectal excision – TME) as outlined in Chap. 53 in order to remove all associated lymphoid tissue.

The last step in the abdominal portion of the procedure is to divide the sigmoid colon at a point that permits the proximal colon to be brought out of the abdominal incision with at least 5 cm of slack to form an end colostomy. Use the GIA stapling device, which simultaneously applies staples and divides the colon (Fig. 54.1a, b). Tie a rubber glove over the end of the distal sigmoid to preserve sterility (see Fig. 53.14a, b). After this step abandon the abdominal dissection temporarily and initiate the perineal stage.

Pelvic Hemostasis

Obtain pelvic hemostasis as previously described (see Chap. 53). Sometimes bleeding is more easily controlled after the perineal phase is completed. If massive hemorrhage is encountered and cannot be controlled, place gauze packs in the pelvis and remove them in 24–48 h through the perineum.

Perineal Dissection

The anus is already closed by a heavy, silk purse-string suture. In male patients make an elliptical incision in the skin beginning at a point 3–4 cm anterior to the anal orifice and terminating at the tip of the coccyx (Fig. 54.2). In female patients with small posterior lesions, make the incision from a point just behind the vaginal introitus to the tip of the coccyx. For anterior lesions in women, leave a patch of posterior vagina, including the posterior portion of the vaginal introitus, attached to the rectum in the region of the tumor (Figs. 54.3 and 54.4).

In all cases carry the scalpel incision down into the perirectal fat, and then grasp the ellipse of skin to be removed in three Allis clamps. While the anus is retracted to the patient's right, have the assistant insert a rake retractor to draw the skin of the perineum to the patient's left. Then incise the perirectal fat down to the levator diaphragm (Fig. 54.5). Generally, two branches of the inferior hemorrhoidal vessels appear in the perirectal fat just superficial to the levators. Each may be secured by electrocautery. Accomplish the identical procedure on the right side of the perineum.

After identifying the anococcygeal ligament at the tip of the coccyx, use electrocautery to divide this ligament transversely from its attachment to the tip of the coccyx (Figs. 54.6 and 54.7). Note at this point that if the surgeon's index finger is inserted anterior to the tip of the coccyx, it may be unable to enter the presacral space. A dense condensation of fascia (Waldeyer's fascia) attaches the posterior rectum to the presacral and precoccygeal area. If this fascia is torn off the sacrum by blunt technique, the presacral venous plexus may be entered, producing hemorrhage. Therefore, Waldeyer's fascia must be incised at the termination of the abdominal portion of the presacral dissection or at the present stage

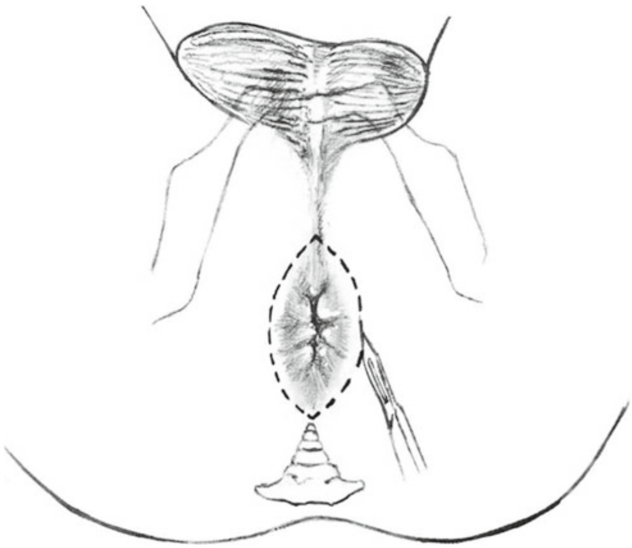


Fig. 54.2

Fig. 54.3

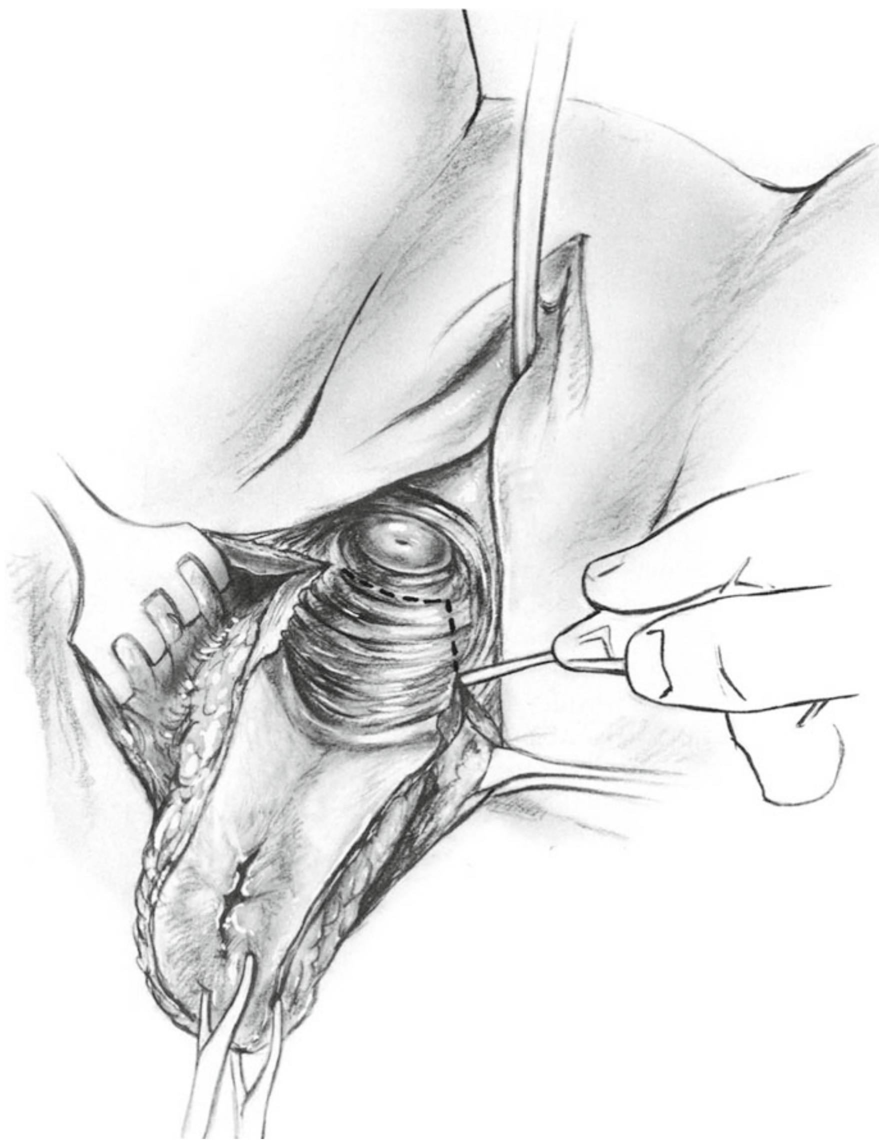


Fig. 54.4

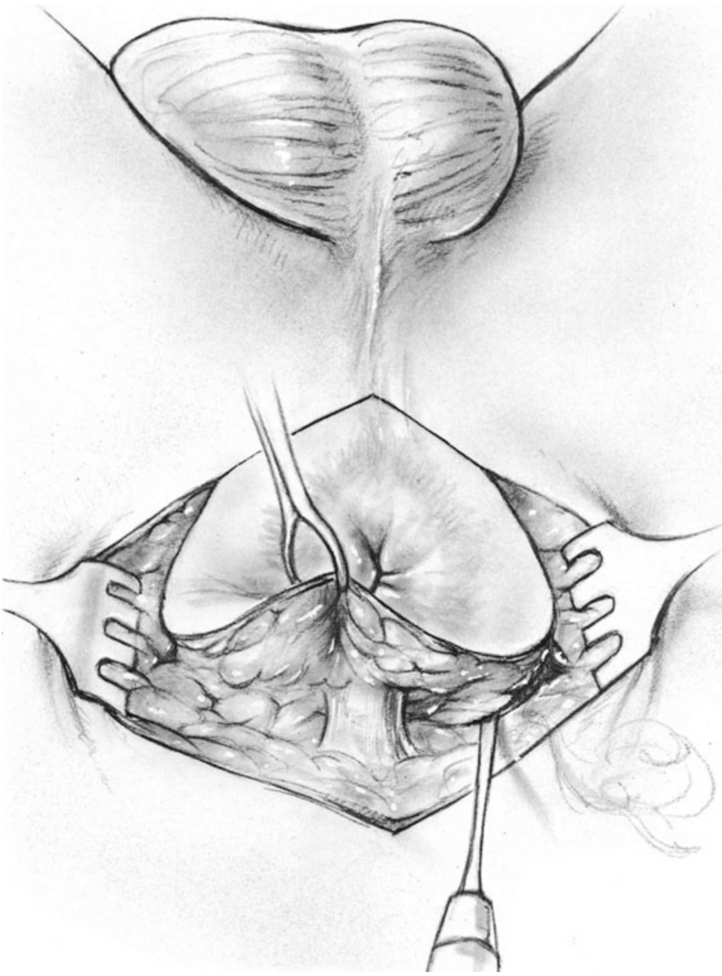


Fig. 54.5

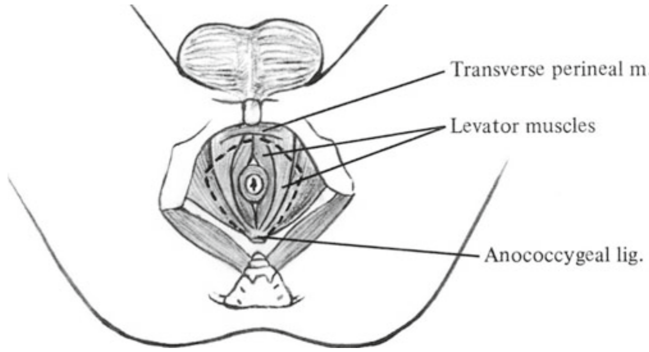


Fig. 54.6

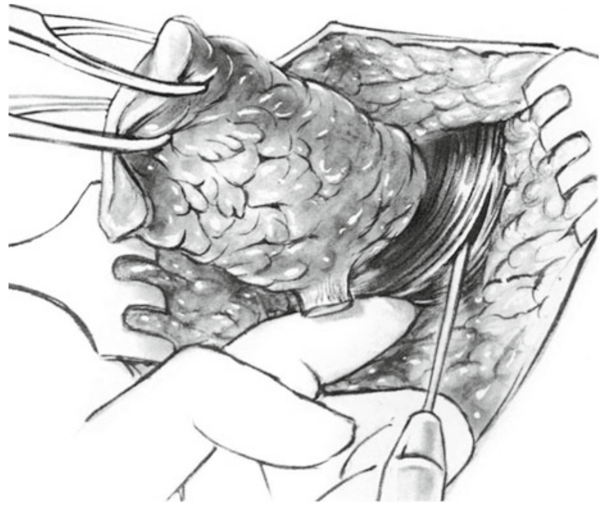


Fig. 54.7

during perineal dissection. From the perineal aspect, this is a simple maneuver, as it requires only sharp division of the fascia with a scalpel or electrocautery in the plane just deep to the anococcygeal ligament. As soon as this is accomplished, it becomes evident that the abdominal and perineal phases of the dissection have joined.

The surgeon should then insert the left index finger underneath the left side of the levator diaphragm and, with the coagulating current, transect the levator muscles upward beginning from below, leaving a portion of the diaphragm attached to the specimen (Fig. 54.7). Continue this incision in the muscular diaphragm up to the region of the puborectalis sling on the anterior aspect of the perineum but not through it.

Use the identical procedure to divide the right-hand portion of the levator diaphragm. Because the greatest danger of the perineal dissection in men is the risk of traumatizing the urethra, delay the anterior portion of the dissection until all the other landmarks in this area have been delineated. To facilitate this delineation, the transected rectosigmoid specimen may be delivered through the opening in the posterior perineum at this time (Fig. 54.8). Insert an index finger underneath the puborectalis muscle, and transect it with electrocautery (Figs. 54.8 and 54.9). The prostate was exposed during the abdominal dissection; at this time palpate it and visualize it from below. Make a projection of the plane along the posterior aspect of the prostate gland (Fig. 54.10). Where this plane crosses the rectourethralis muscle, the muscle may be transected safely and the specimen removed (Fig. 54.11). Another landmark, sometimes difficult to identify in obese patients, is the superficial transverse perineal muscles. The anterior plane of dissection should be posterior to these muscles. Finally, divide the remaining attachments to the prostate (Fig. 54.12) and remove the specimen.

The above precautions do not apply in women. If the vagina is to be preserved, the anterior dissection should follow a plane just posterior to the vagina. The wall of the vagina should not be traumatized or devascularized during this dissection, as it might well lead to a perineovaginal fistula, which is difficult to manage. It is better to excise the posterior wall of the vagina than to devascularize it partially during the dissection. If the posterior wall of the vagina is to be removed, use electrocautery to continue the perineal skin incision across the vaginal introitus (Fig. 54.4). Complete

Fig. 54.8

hemostasis is easily attained when the vagina is incised by electrocautery. Leave a patch of vagina of appropriate dimensions attached to the specimen. Irrigate the presacral space with a dilute antibiotic solution. Hemostasis should be absolute and complete and is easily accomplished using electrocautery and ligatures as one assistant works from above and the surgeon works from below.

Management of Pelvic Floor

In women whose posterior vaginal wall remains intact and in all men, the perineum may be closed per primam if there has been no fecal contamination and if hemostasis is excellent. First, accomplish presacral drainage by inserting one or two closed-suction drainage catheters, each 6 mm in diameter. Introduce one catheter through a puncture wound of the skin in the posterior portion of the perineum about 4 cm to the left of the coccyx and a second through a similar point at the

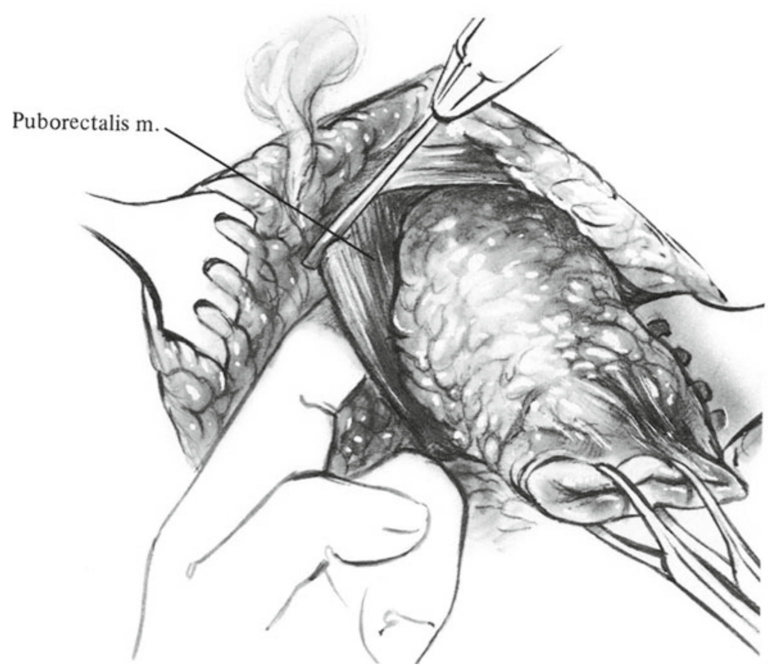


Fig. 54.9

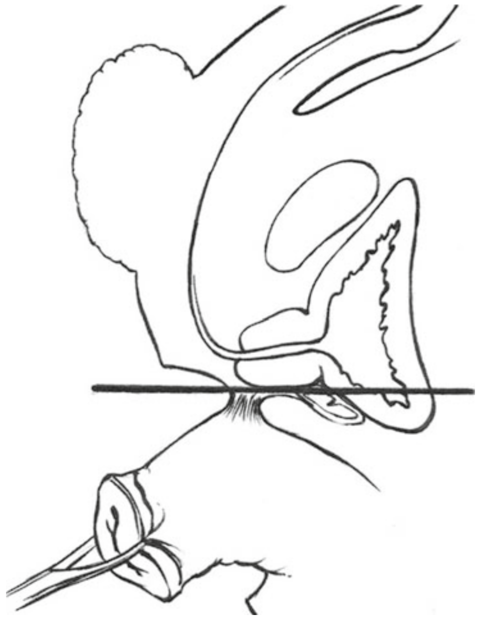


Fig. 54.10

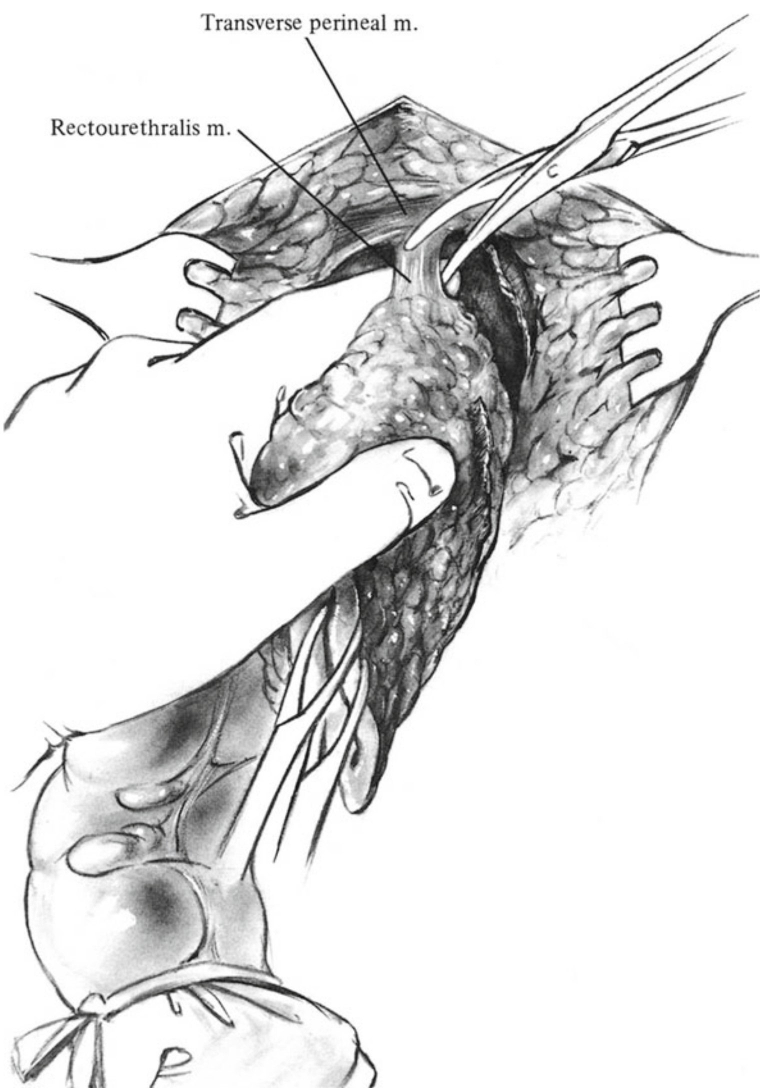


Fig. 54.11

right. Suture each catheter to the skin surrounding its exit wound (Fig. 54.13). Place the tips of the catheters in the presacral space. In some cases the posterior levator diaphragm may be partially reconstructed using 2-0 PG sutures. Accomplish the remainder of the perineal closure with one or two layers of interrupted PG to the subcutaneous fat and a subcuticular suture of 4-0 PG to close the skin. As soon as the abdominal surgeon has closed the pelvic peritoneum, apply continuous suction to the two drainage catheters to draw the peritoneum down to the newly reconstructed pelvic floor. The surgeon's aim must be to *eliminate any possible dead space* between the peritoneal closure and the pelvic floor. These closed-suction drains may also be brought out via a stab wound in the lower abdominal wall.

When the posterior vaginal wall and the specimen have been excised, attempt to fabricate a substitute posterior wall with interrupted PG sutures to the perineal fat and to the residual levator muscle (Fig. 54.14). If this can be accomplished, within a few months after the operation the vaginal mucosa grows over this newly constructed pelvic floor, restoring the vaginal tube. Pack the posterior defect loosely with sterile gauze. Bring the gauze out through the newly reconstructed vaginal introitus after the remainder of the perineal fat and skin have been closed, as described above (Fig. 54.15). If it is deemed desirable, a sump catheter can be brought out from the presacral space through the same defect, but it is not done routinely.

While the assistant is closing the perineum, the surgeon should return to the abdominal approach to dissect the pelvic peritoneum free from its surrounding attachments to the lateral pelvic walls and bladder. This enables the peritoneum to be closed without tension (Fig. 54.16). Use a continuous atraumatic suture of 2-0 PG. If there is insufficient peritoneum to permit the peritoneal diaphragm to descend to the level of the newly constructed perineal floor, leave the peritoneum completely unsutured.

Colostomy

The colostomy may be brought out through the upper portion of the midline incision, in which case it is not necessary to close the intraperitoneal gap lateral to the colostomy. Through the midline incision, at a point where 5 cm protrudes from the anterior abdominal skin surface without tension, bring out the segment of colon previously selected to form the colostomy. If this point is near the umbilicus, excise the umbilicus for more postoperative cleanliness. Close the abdominal wall with one layer of monofilament 1-0 PDS; an index finger should fit without tension between the colostomy and the next adjoining suture. Close the skin above and below the colostomy with a continuous subcuticular suture of 4-0 PG. Before closing the skin, irrigate with a dilute antibiotic solution.

Fig. 54.12

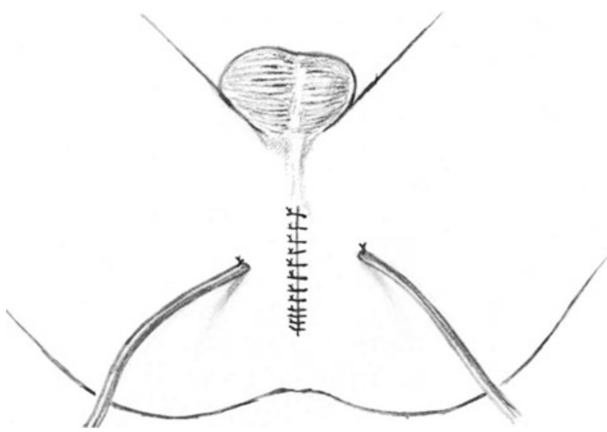


Fig. 54.13

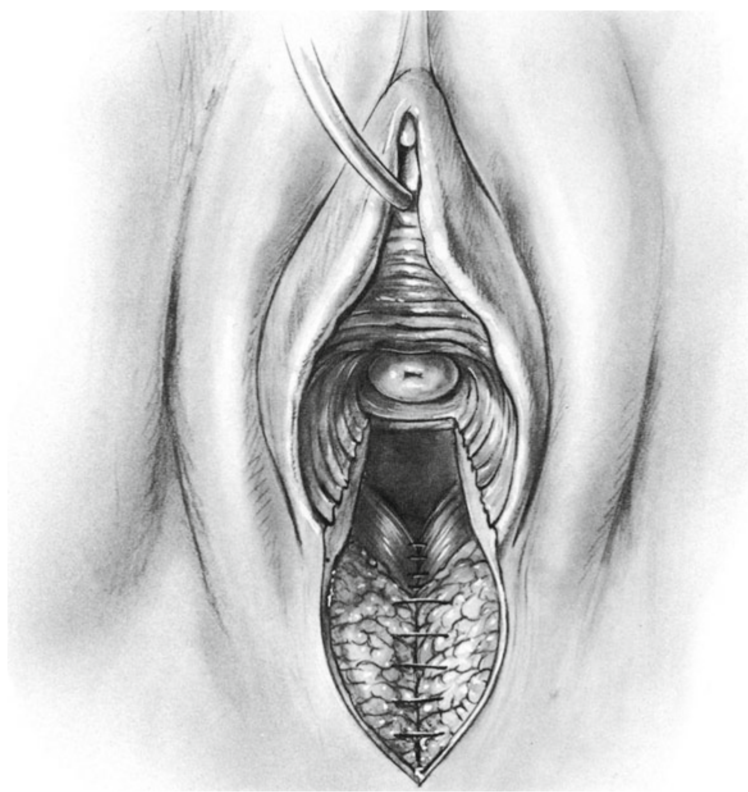


Fig. 54.14

After these steps have been completed, excise the line of staples previously used to occlude the colon. Immediately mature the colostomy, using interrupted or continuous sutures of 4-0 PG to attach the full thickness of the colon to the subcuticular plane of the skin (Figs. 54.17 and 54.18). No additional sutures are necessary to attach the colon to the fascia or to any other layer of the abdominal wall.

When the peritoneal pelvic floor is suitable for reconstruction by suturing, the retroperitoneal type of colostomy may be performed. Elevate the previously incised peritoneum of the left paracolic gutter from the lateral abdominal wall by finger dissection. Continue until a hand is freely admitted up to the point in the lateral portion of the rectus muscle that has been previously selected for the colostomy (Figs. 54.19 and 54.20), generally about 4 cm below the level of the umbilicus.

Excise a circle of skin about the size of a nickel and expose the fascia of the left rectus muscle. Make cruciate incisions in the anterior rectus fascia, separate the rectus muscle fibers bluntly, and incise the underlying posterior rectus sheath and peritoneum. The aperture in the abdominal wall should be large enough to admit two fingers.

Bring the colon through the retroperitoneal tunnel and out the opening made for the colostomy (Fig. 54.21). Begin the suture line that closes the pelvic peritoneum near the bladder. Continue this suture of 2-0 atraumatic PG in a cephalad direction, closing the entire defect by suturing the free edge of the peritoneum to the anterior seromuscular wall of the

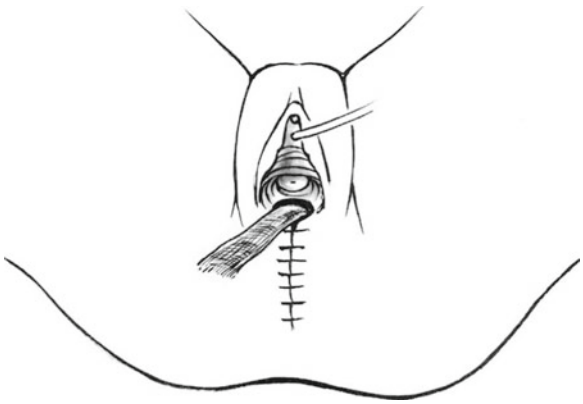
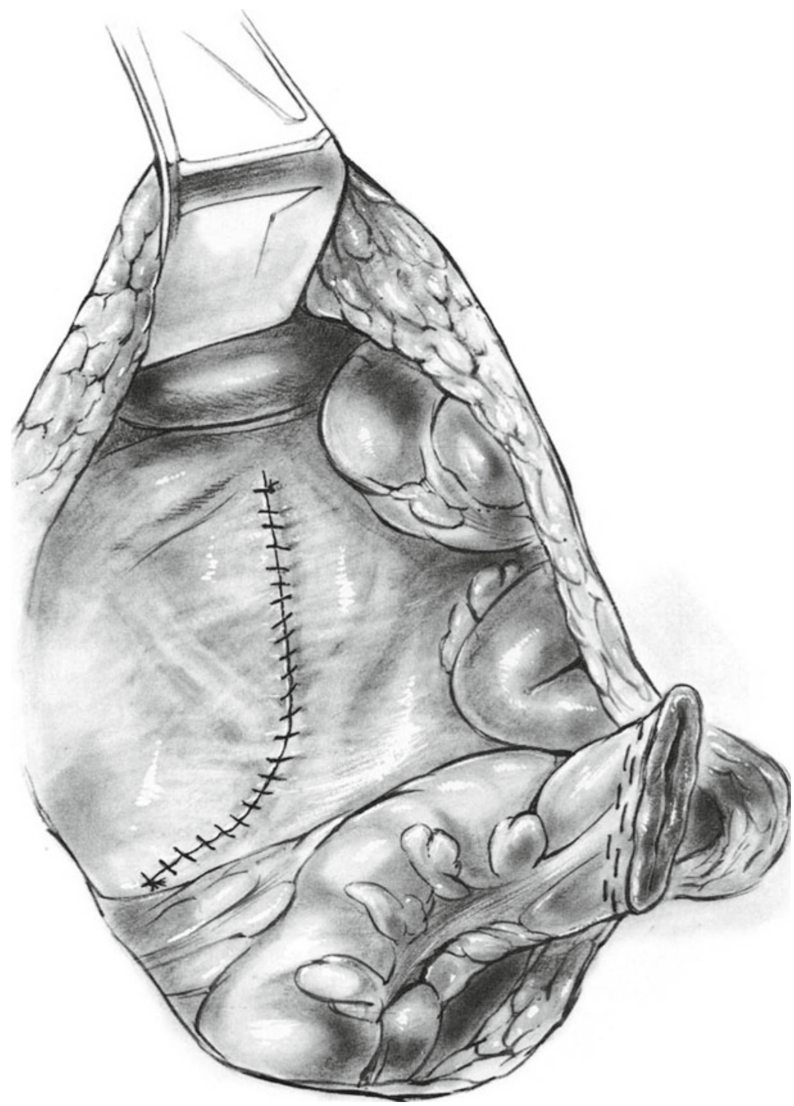


Fig. 54.15

Fig. 54.16



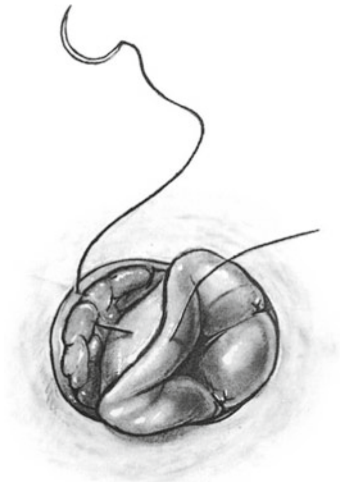


Fig. 54.17

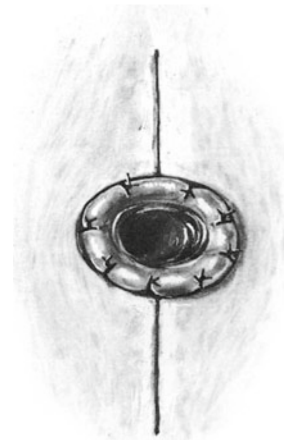


Fig. 54.18

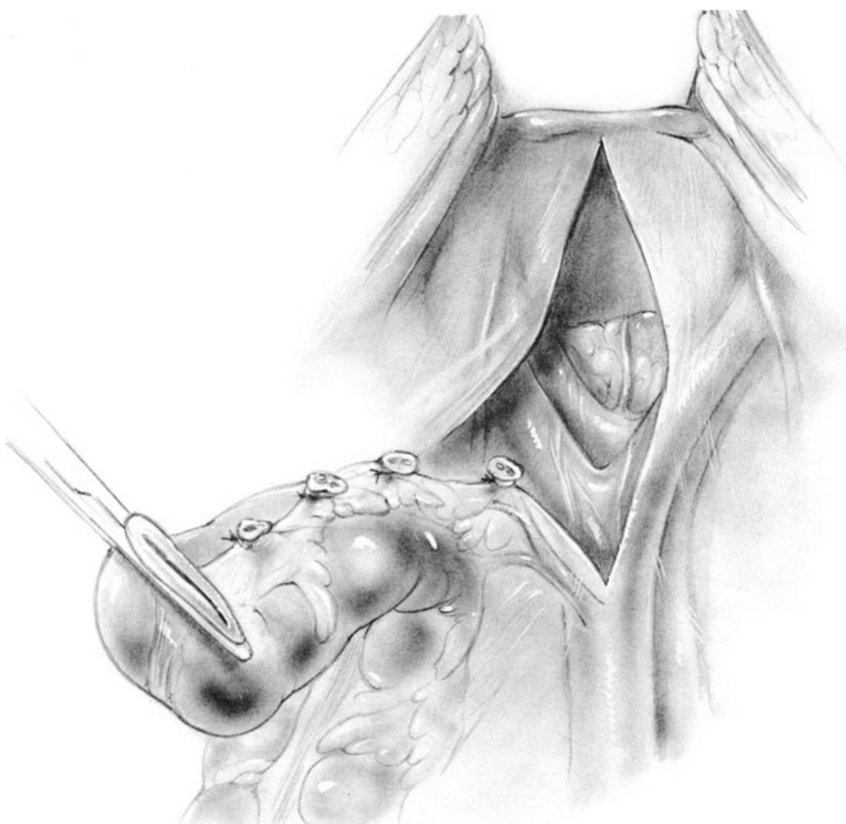


Fig. 54.19

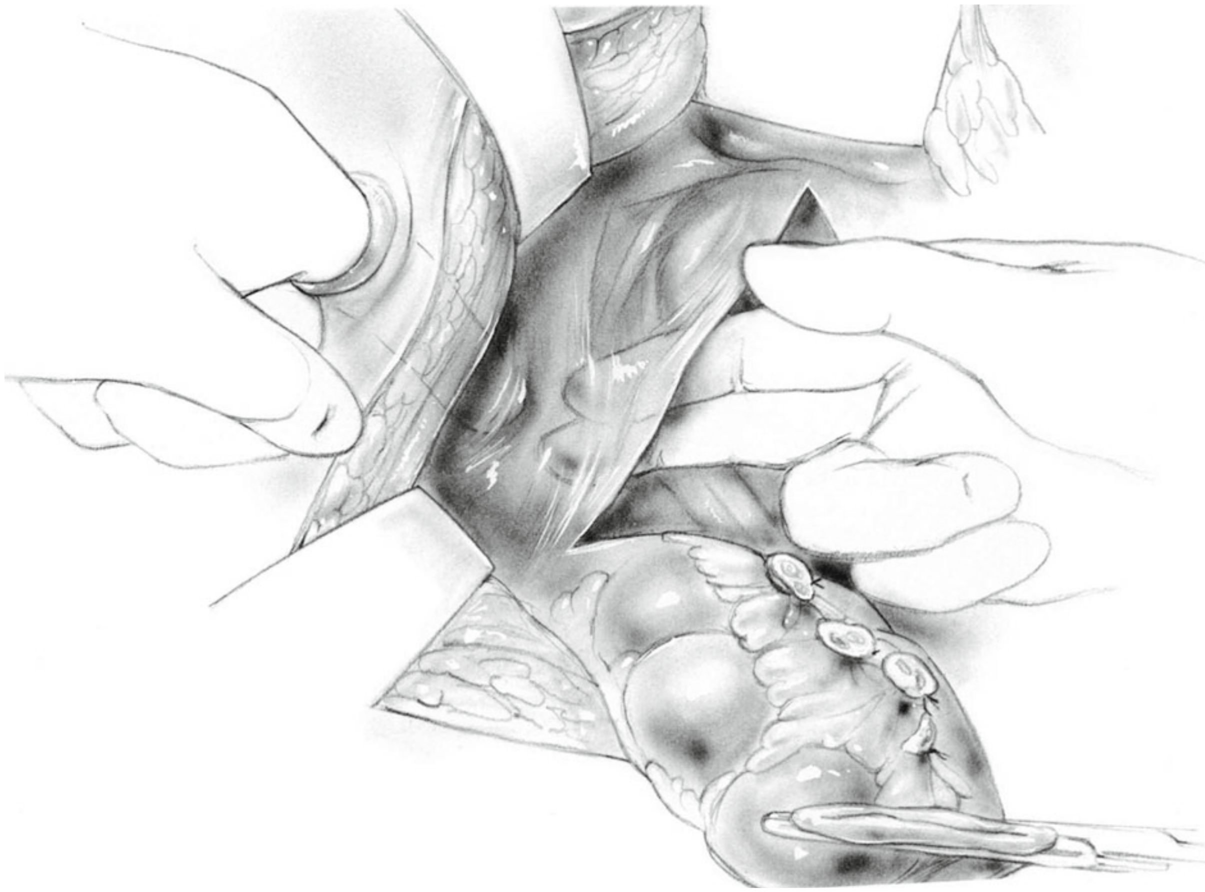


Fig. 54.20

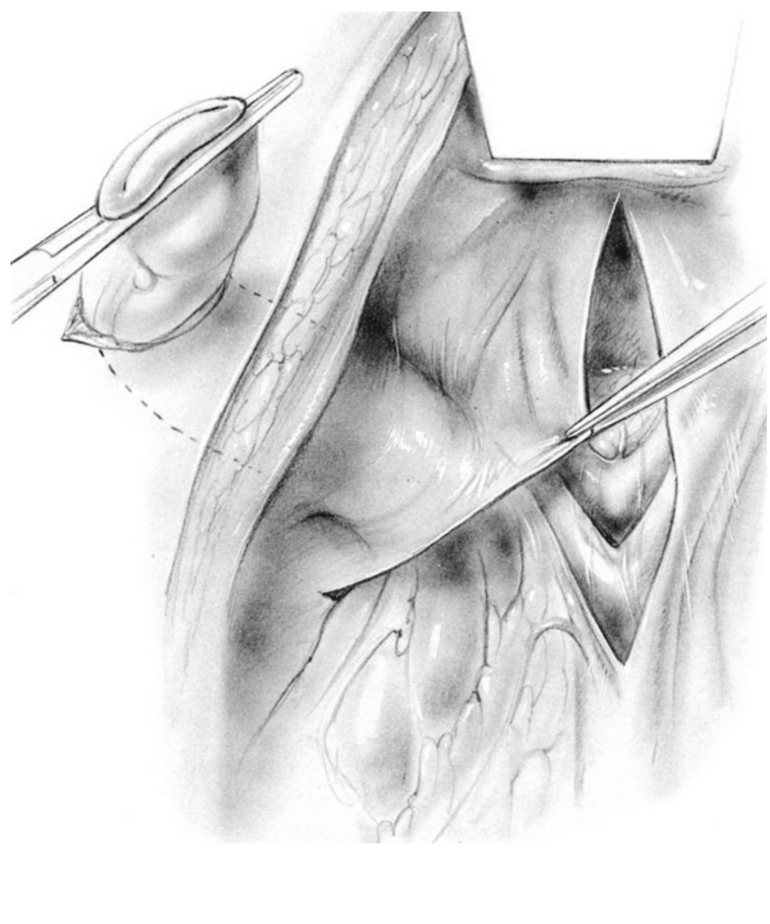
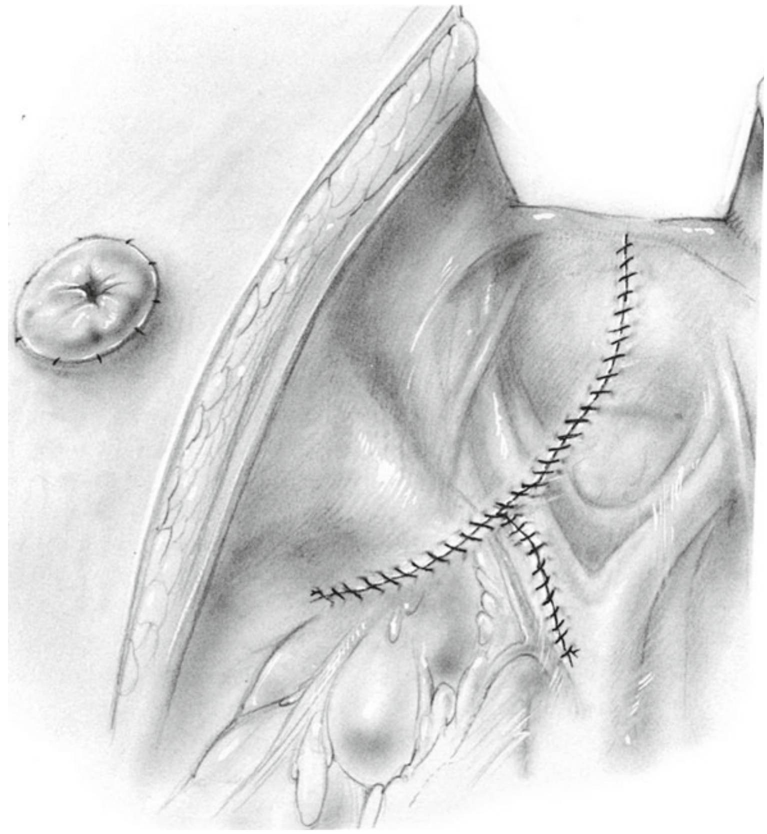


Fig. 54.21

Fig. 54.22



sigmoid colon as it enters the retroperitoneal tunnel to become a colostomy (Fig. 54.22). Then close the abdominal incision. Mature the colostomy by a mucocutaneous suture as described above. Attach a temporary colostomy bag to the abdominal wall at the conclusion of the operation.

Postoperative Care

Discontinue gastric suction as soon as possible, generally in the operating room or postanesthesia care unit.

The Foley catheter in the bladder generally remains until the seventh postoperative day.

Perineal Care

Patients who have undergone excision of the posterior vagina have a small amount of gauze packing inserted into the perineum through the residual vaginal defect. This gauze should be removed on the third day, followed by daily saline irrigation of the area. As soon as the patient can sit comfortably, initiate sitz baths daily, and discontinue irrigation.

The patients who have had large gauze packs inserted in the presacral region to control hemorrhage should be brought back to the operating room on the first or second postoperative day so the pack can be removed under general anesthesia. The sheet of topical hemostatic agent that had been applied to the sacrum is left undisturbed. The patient should be observed briefly to ascertain that the hemorrhage is under complete control. If the abdominal contents descend to occupy the cavity in the presacral space that had been created by the gauze packing, the perineal floor can be closed tightly around two closed-suction drains, as described above. If a large dead space remains, insert a sump and several latex drains and close the pelvic floor loosely around them.

Most of our patients leave the operating room with the perineum closed per primam. After perineal drainage ceases, generally on the fifth postoperative day, remove the catheters.

Administer sitz baths twice daily to provide symptomatic relief of perineal soreness. Chronic perineal sinus may occur, especially following a proctectomy for colitis. The etiology of this complication, which may persist for years, is not clear, but chronic sepsis and inadequate drainage are the probable causes. Local treatment by curettage, irrigation with a pulsating water jet, and perineal hygiene remedy most chronic sinuses. Frequent shaving is necessary to prevent loose hair from entering deep into the sinus and producing a foreign-body granuloma.

Colostomy Care

Observe the colostomy daily through the transparent bag to detect signs of possible necrosis. That the colostomy does not function during the first 6–7 days following the operation need not be a cause for concern if the patient does not develop abdominal distension or cramps. If there is no function beyond this date, abdominal radiography must be performed to rule out an obstruction of the small bowel.

The patient should begin receiving instructions about daily colostomy irrigation during the second week of hospitalization. No patient should leave the hospital before acquiring the skills necessary to perform the irrigation effectively. It is important to understand that the aim of colostomy irrigation is not simply to wash out the distal few inches of colon. Patients sometimes insert a catheter a few inches into the colon, and when the water runs into the colon they permit it promptly to run out alongside the catheter. This is ineffective. Water is instilled into the distal colon for the purpose of dilating the area sufficiently to produce a reflex peristaltic contraction that evacuates the entire distal colon. For many patients this requires injection of more than 1 l of water before they begin to feel "crampy" discomfort. At this point the catheter should be removed and the patient encouraged to keep the colostomy orifice occluded for a few more minutes, until peristalsis is well underway.

Some patients use a cone-shaped device through which the fluid channel passes, to occlude the lumen. In other cases the patient is able to occlude the lumen by lightly grasping and manually compressing the abdominal wall around the inflow catheter or cone. There are many variations in devices and techniques for colostomy management: When one fails, however, it usually is because the patient has not retained the injected fluid long enough for distension of the distal colon to occur. Without such distension there can be no reflex peristaltic contraction.

All patients must be urged to exercise extreme caution when passing the catheter or any other irrigating device to avoid the possibility of perforating the colon. This complication may occur even in patients who have had 15–20 years of experience irrigating their colostomy. It is generally heralded promptly by the onset of severe abdominal pain during the irrigation. The patient should be urged to report *immediately* for examination if pain occurs at any time during irrigation.

Complications

Acute intestinal obstruction. The small intestine may become obstructed by adhesion to the pelvic suture line or herniation through a defect in the pelvic floor. Adhesions elsewhere in the abdomen, which may occur after any abdominal procedure, can also cause obstruction. If colostomy function has not begun by the sixth or seventh postoperative day, radiographs of the abdomen should be obtained. If small bowel obstruction appears to have occurred and there is no evidence of strangulation, a *brief* trial of a long intestinal tube may be initiated. If this is not promptly successful (3–4 days), secondary laparotomy for relief of the obstruction is indicated.

Hemorrhage. Hemorrhage is rare in properly managed cases. If there is evidence of significant bleeding (by vital signs and laboratory tests or by visible bleeding from the perineal drains), prompt reoperation is preferable to expectant management.

Sepsis. Sepsis that occurs following primary closure of the perineal wound is generally not difficult to detect. It is accompanied by fever, local pain, and purulent drainage through the suction catheters. Under these conditions the perineal incision should be opened sufficiently to insert two fingers, a sump, and several latex or Penrose drains. If this measure does not relieve the infection quickly, the entire wound may be reopened and a gauze pack inserted. The gauze should be changed at least once daily.

Bladder obstruction. Because many men who undergo proctocolectomy for carcinoma are at an age when prostatic hypertrophy is common, this factor combined with the loss of bladder support in the absence of the rectum and some degree of nerve injury leads to a high incidence of urinary tract obstruction. If the obstruction cannot be managed by conservative means, urologic consultation and prostatectomy may be necessary.

Sexual dysfunction. This complication is common in males when surgery is performed for cancer. It is rare after operations for benign disease when special precautions are observed (see Chap. 58).

Colostomy complications. Ischemia, retraction, or prolapse of the colostomy may occur if the colostomy is not properly constructed. Parastomal hernia is an occasional late complication.

Chronic perineal sinus. Although a persistent sinus is rare after a properly managed resection for carcinoma, it appears to be common following operations for inflammatory bowel disease. If all the local measures fail and the sinus persists for several years, saucerization of the wound with or without split thickness skin grafting may be necessary.

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Laparoscopic Abdominoperineal Resection and Total Proctocolectomy with End Ileostomy

55

Giovanna da Silva and Steven D. Wexner

Abdominoperineal Resection Indications

Low rectal cancer (within 5 cm from the anal verge) without invasion of adjacent organs
Mid-rectal tumors in patients with poor continence
Recurrent or residual anal cancer

Preoperative Preparation

The preoperative management is exactly the same as that for laparotomy. On the day before surgery, the patients are instructed to eat a light meal at lunch, have only clear liquids after lunch, and refrain from having anything to eat or drink after midnight. Bowel preparation is undertaken using a mechanical cathartic and parenteral antibiotics. The stoma site is preoperatively marked by an enterostomal therapist. Heparin or low-molecular-weight heparin and sequential compression stockings are utilized for venous thrombosis prevention.

Pitfalls and Danger Points

Damage to the epigastric vessels during port placement
Damage to the ureters during colon mobilization
Injury to the spleen during mobilization of the splenic flexure (if performed)
Injury to the autonomic nerves during dissection near the aorta and in the pelvis
Injury to major vessels
Injury to the presacral vessels

Documentation Basics

Document extent of disease

Operative Technique

Room Setup and Trocar Placement

After induction of general anesthesia, a bladder catheter is placed into the bladder, and a nasogastric tube is inserted into the stomach. Ureteric stents may be indicated in selected cases, including previous pelvic surgery, pelvic phlegmon, large tumor, prior radiation therapy, and obesity to facilitate intraoperative identification. Place the patient in a modified lithotomy position using Allen stirrups (Allen Medical, Bedford Heights, OH). Take care to firmly secure the patient to the table as a considerable amount of Trendelenburg and tilting of the table is used during the operation. We prefer to place the patient on a beanbag. Pad and tuck both arms at the patient's sides, flex and only minimally elevate the hips and legs to avoid interference with handling of the laparoscopic instruments. Circumferentially secure the patient's chest to the table with a heavy silk tape over a foam or towel padding. As with open procedures, the anus is closed with a double purse string suture to prevent leakage of stool during perineal dissection.

Figure 55.1a shows the positioning of the monitor and surgical team. The surgeon and second assistant (camera operator) stand at the patient's right side, while the first assistant and the nurse are at the patient's left side or between the legs. Two monitors are used, one on either side of the patient.

Three ports are normally used for this procedure (Fig. 55.1b). We prefer 10–12 mm ports, which allow

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flexibility for positioning of the camera and all instruments. Place the camera port in an infra- or supraumbilical position using a Veress needle or an open Hasson technique, and then place the two remaining ports under direct vision on the right side, one in the iliac fossa and one in the right upper quadrant. Take care to visualize the epigastric vessels before port placement. An optional additional fourth 10–12 mm port can be placed at the site of the preoperatively marked colostomy.

Exploration of the Abdominal Cavity

Establish 15 mmHg of carbon dioxide pneumoperitoneum and use a 30° camera to inspect the peritoneal cavity and liver for metastases. Biopsy any suspicious lesions.

Mobilization of the Sigmoid/Rectosigmoid Colon

Place the patient in a Trendelenburg position and tilt the table right-side down to move the small bowel away from the operating field. The uterus can be suspended with a suture through the anterior abdominal wall to facilitate visualization during pelvic dissection.

Dissection of the rectosigmoid can follow a medial-to-lateral or lateral-to-medial sequence. Our preference is to utilize the same technique as is the open procedure. By using the upper right side port, the surgeon retracts the sigmoid colon with a Babcock to the right and cranially stretching the lateral peritoneum. Begin the dissection in the left pelvic brim and progress along the white line of Toldt up to the splenic flexure with an energy source device introduced through the lower port. We prefer to use a 5 mm Harmonic scalpel (Ethicon Endo-Surgery Inc, Cincinnati, Ohio) as it provides good visualization of the dissection plane and hemostasis. The retroperitoneal tissue is thus dissected from the mesocolon with identification of the gonadal vessels and left ureter, which are swept away from the area of dissection (Fig. 55.2).

Division of the Inferior Mesenteric Vessels

Identification and preparation for ligation and division of the inferior mesenteric vessels are best accomplished by retracting the sigmoid anteriorly and to the left and then scoring the peritoneum at the level of the promontory under the superior hemorrhoidal artery. Create a window and enter the presacral space. Dissection proceeds cephalad up to the confluence of the superior hemorrhoidal and left colic arteries. The hypogastric nerves can be usually identified and posteriorly reflected at this point. If high ligation of the inferior mesenteric artery is desired (such as for further colonic mobilization or if enlarged lymph nodes along the superior hemorrhoidal artery or above left colic artery are present), secure this vessel near its origin at the aorta. The inferior mesenteric vein is then ligated closed to the duodenum. We use a 10 mm LigaSure Atlas for vessels ligation. If the vessels are ligated with a stapler, a good maneuver prior to vascular division is to pass the endoscopic stapler through the closed window in order to ensure easy passage when opened (Fig. 55.3). Care is taken to visualize the ureter prior to ligation and division of the mesenteric vessels. Bleeding from the stapler line can usually be controlled by the use of clips or sutures.

Division of the Sigmoid/Descending Colon

After ligating the inferior mesenteric vessels, divide the mesosigmoid towards the sigmoid colon. Then transect the colon at a suitable point with an Endo GIA Stapler introduced through the right lower quadrant port. Check the position of

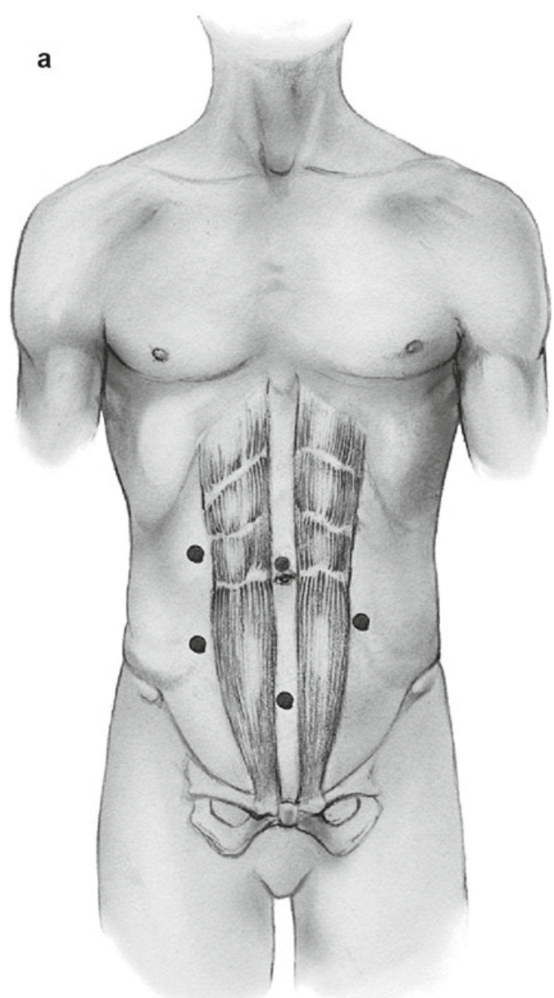


Fig. 55.1

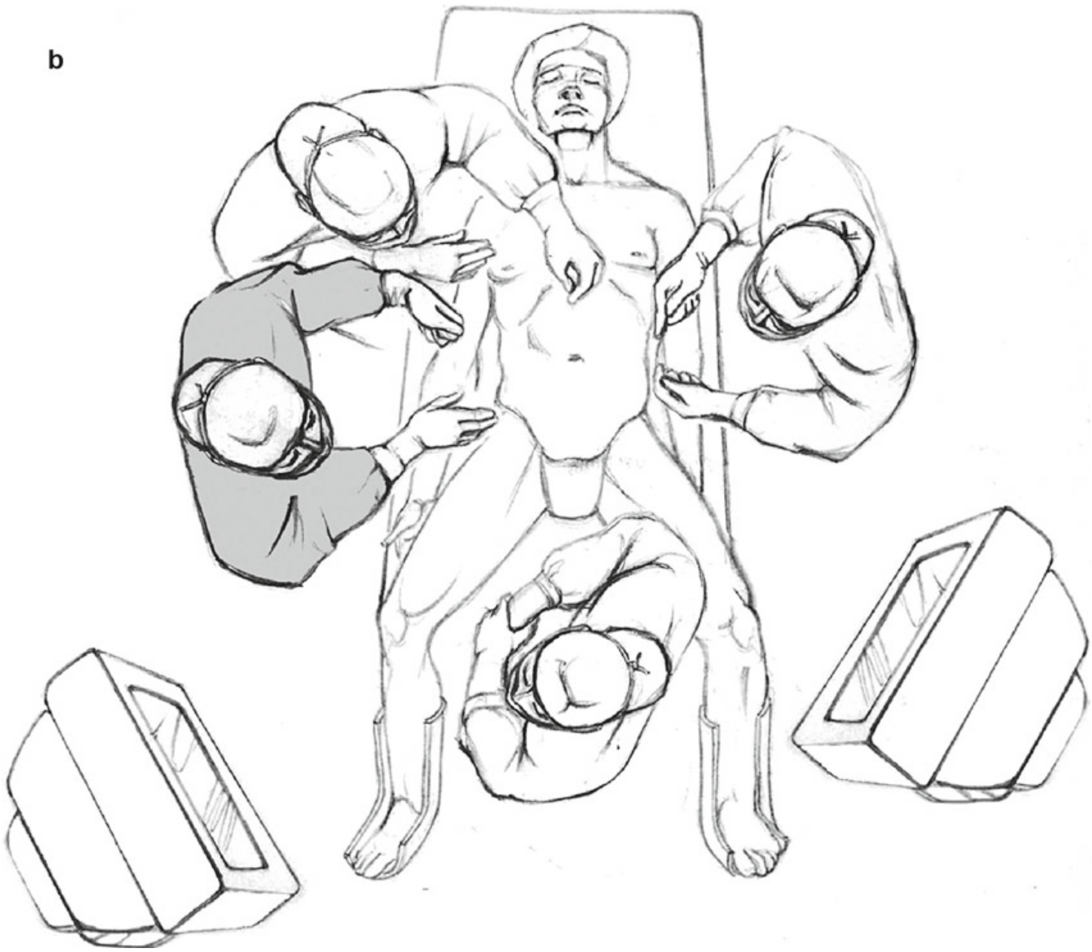


Fig. 55.1 (continued)

the stapler tip to ensure no other structure has been inadvertently grasped by the stapler (Fig. 55.4).

Rectal Mobilization

Incise the peritoneum along both sides of the rectum down to the peritoneal reflection. Initiate rectal dissection posteriorly by dissecting the mesorectum from Waldeyer's fascia in an avascular plane as low as possible down into the pelvis, while using a Babcock to grasp the upper part of the rectum and retract it cranially and anteriorly. At the level of the aortic bifurcation, the superior hypogastric plexus nerves can be identified and the right and left trunks along the pelvic side wall (Fig. 55.5). Retract the rectum to one side, then the other, to perform lateral rectal mobilization. Divide the "lateral ligaments" and medial arteries with the harmonic scalpel. Take care to preserve the inferior hypogastric plexus, which is located at the level of the ligaments. Then gently retract the rectum cephalad and mobilize its anterior aspect (Fig. 55.6).

Perineal Dissection and Specimen Removal

Perform the perineal dissection the same way that you would during the open procedure (see Chaps. 54 and 58 for cancer and benign disease, respectively). Retrieve the specimen through the perineal wound and deflate the pneumoperitoneum. Close the perineal wound in layers and reestablish pneumoperitoneum. Rinse the abdominal cavity with warm saline solution, and check it for hemostasis. Bring the proximal colon out through the left port with Babcock forceps, and fashion the terminal colostomy (Fig. 55.7); place a drain in the pelvis through the right lower port.

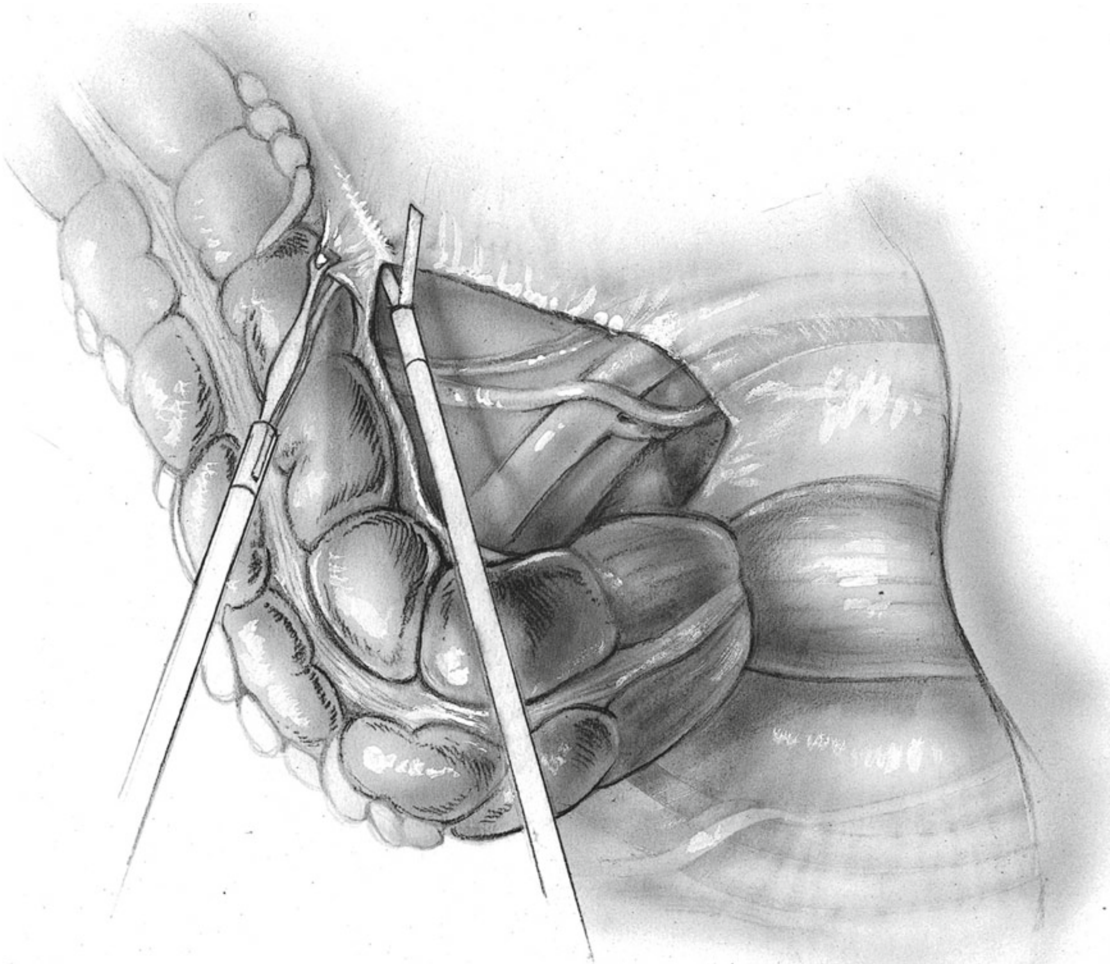


Fig. 55.2

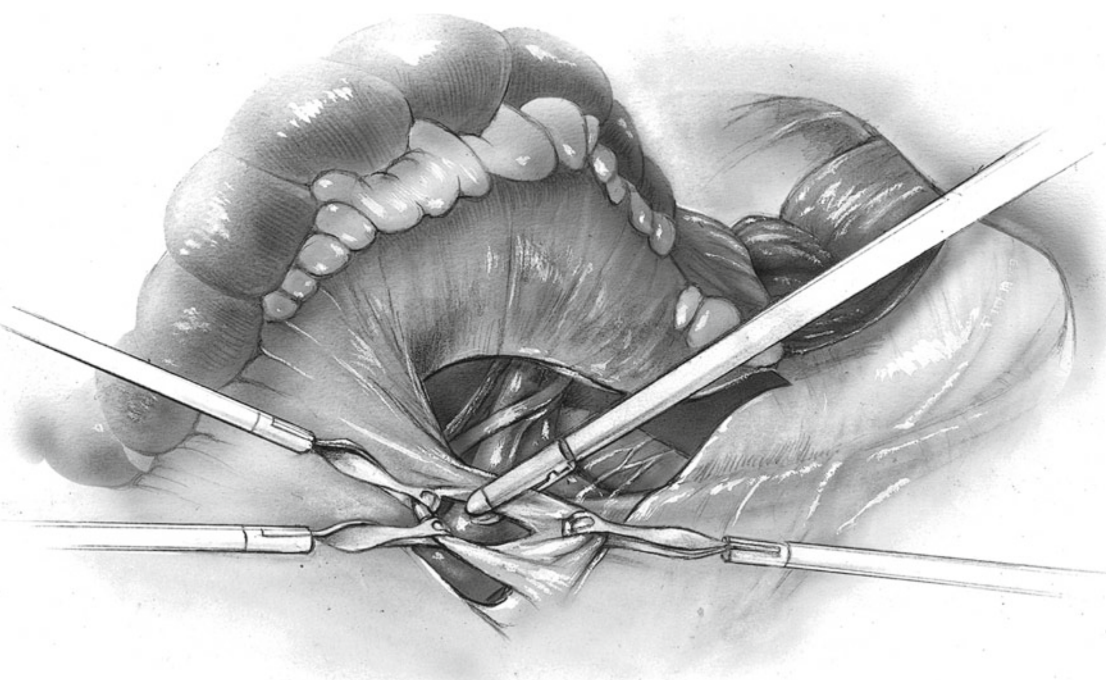


Fig. 55.3

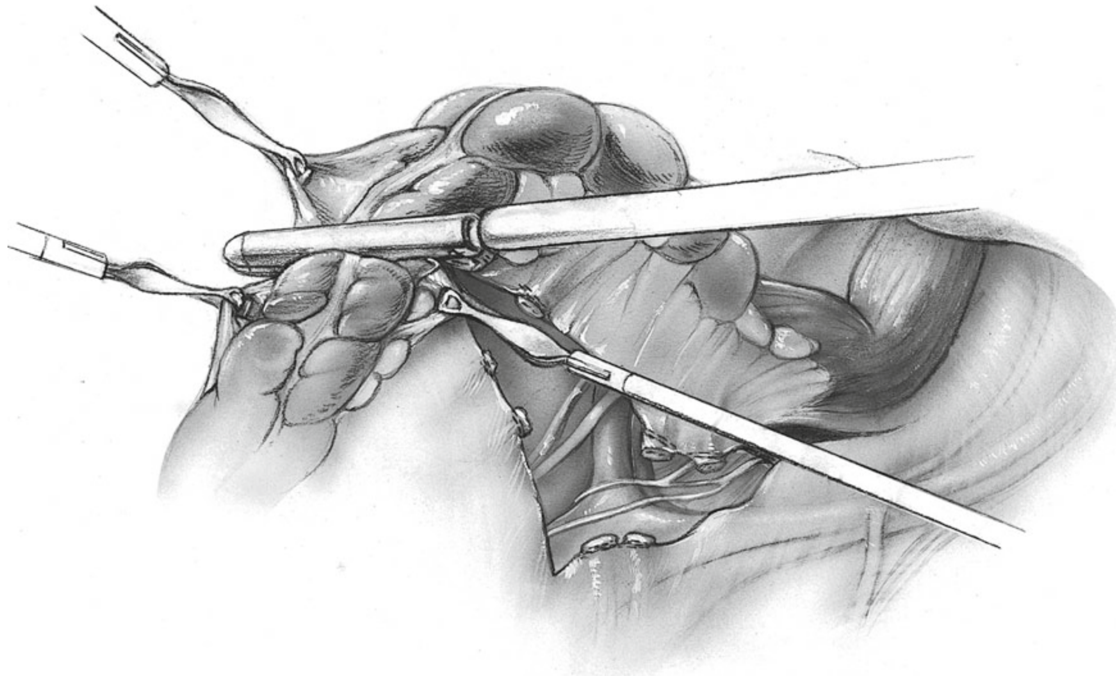


Fig. 55.4

Total Proctocolectomy with End Ileostomy Indications

Patients with extensive colonic Crohn's disease involving the rectum, with or without perianal disease

Patients with familial adenomatous polyposis or ulcerative colitis who decline or are not candidates for restorative procedure (e.g., fecal incontinence)

Preoperative Preparation

The preoperative preparation is the same as for abdominoperineal resection.

Pitfalls and Danger Points

Pitfalls are similar to those for abdominoperineal resection. In addition, duodenal injury may occur during right colon mobilization.

Operative Technique

Room Setup and Trocar Placement

The room is set up in a similar fashion as for abdominoperineal resection. After insertion of the camera port, four additional ports are generally required for the procedure, two in the left and two in the right side (Fig. 55.8). The position of the surgical team varies according to side of dissection. The surgeon stands on the opposite side of the colon being mobilized or between the patient's legs.

Dissection starts from any segment of the colon. Some surgeons prefer to mobilize the sigmoid and rectum as far as possible prior to the ascending, transverse, and descending colon to avoid difficult retraction of these structures from the pelvis once they are mobilized. We usually start the dissection from the ileocecal valve and ascending colon as in the open procedure. Retract the colon towards the midline and divide the lateral peritoneum along the white line of Toldt, extending towards the hepatic flexure. During mobilization, identify the gonadal vessels, the right ureter, and the duodenum (Fig. 55.9). Then separate the transverse colon from the greater omentum either by dividing the avascular plane along the omentocolic junction or, alternatively, by transecting the omentum (Fig. 55.10). At this point, if convenient, the right colonic vessels may be ligated close to the colon and the terminal ileum divided with an endoscopic linear cutter. Then mobilize the left colon with identification of the left ureter followed by mobilization of the splenic flexure with division of the phrenocolic, splenocolic, and renocolic ligaments (Fig. 55.11). Ligate and divide the left side vessels. If the procedure is continued laparoscopically, the rectum is dissected as described for abdominoperineal resection and the entire specimen is extracted through the perineal wound. Unlike peripheral

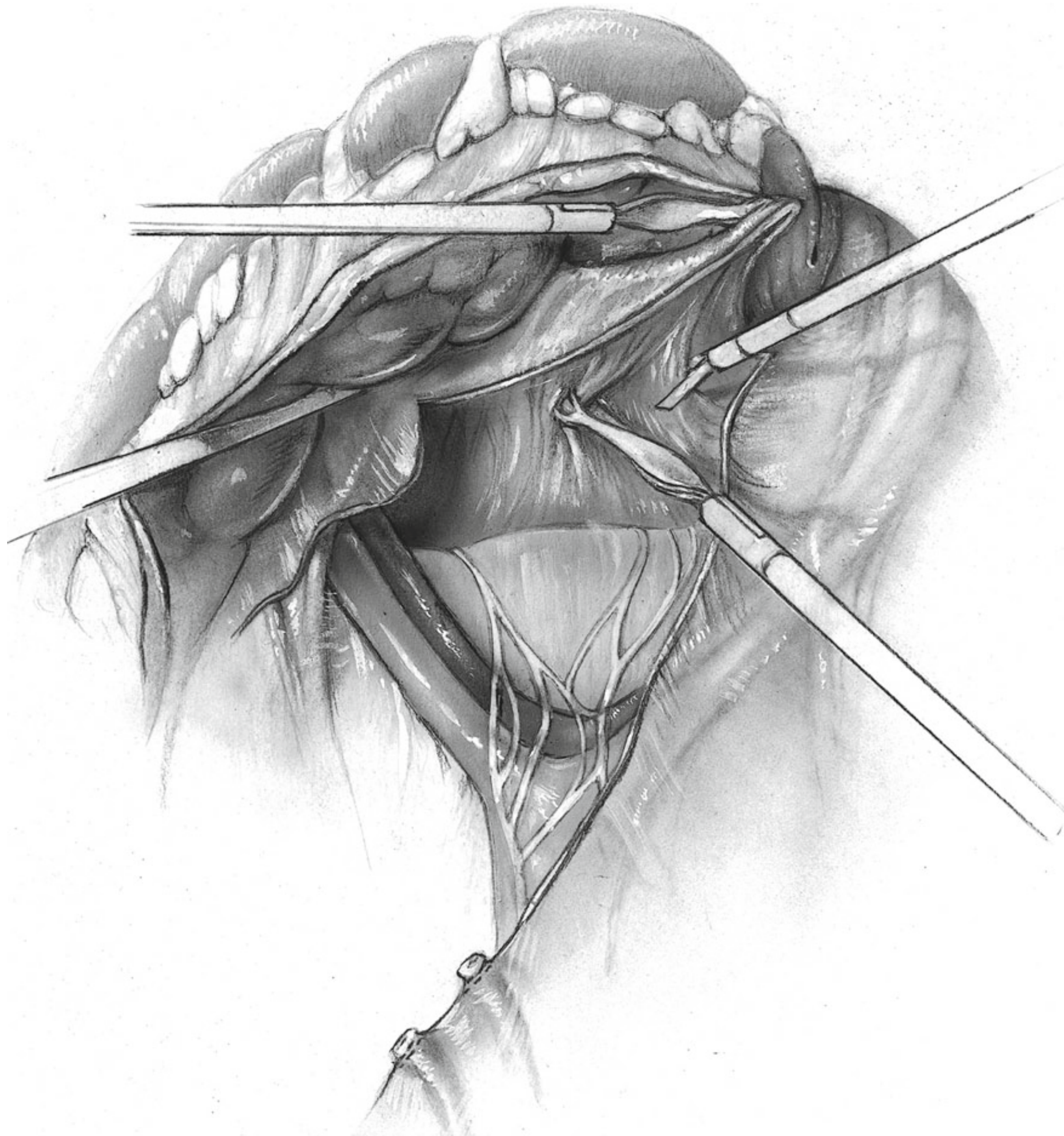


Fig. 55.5

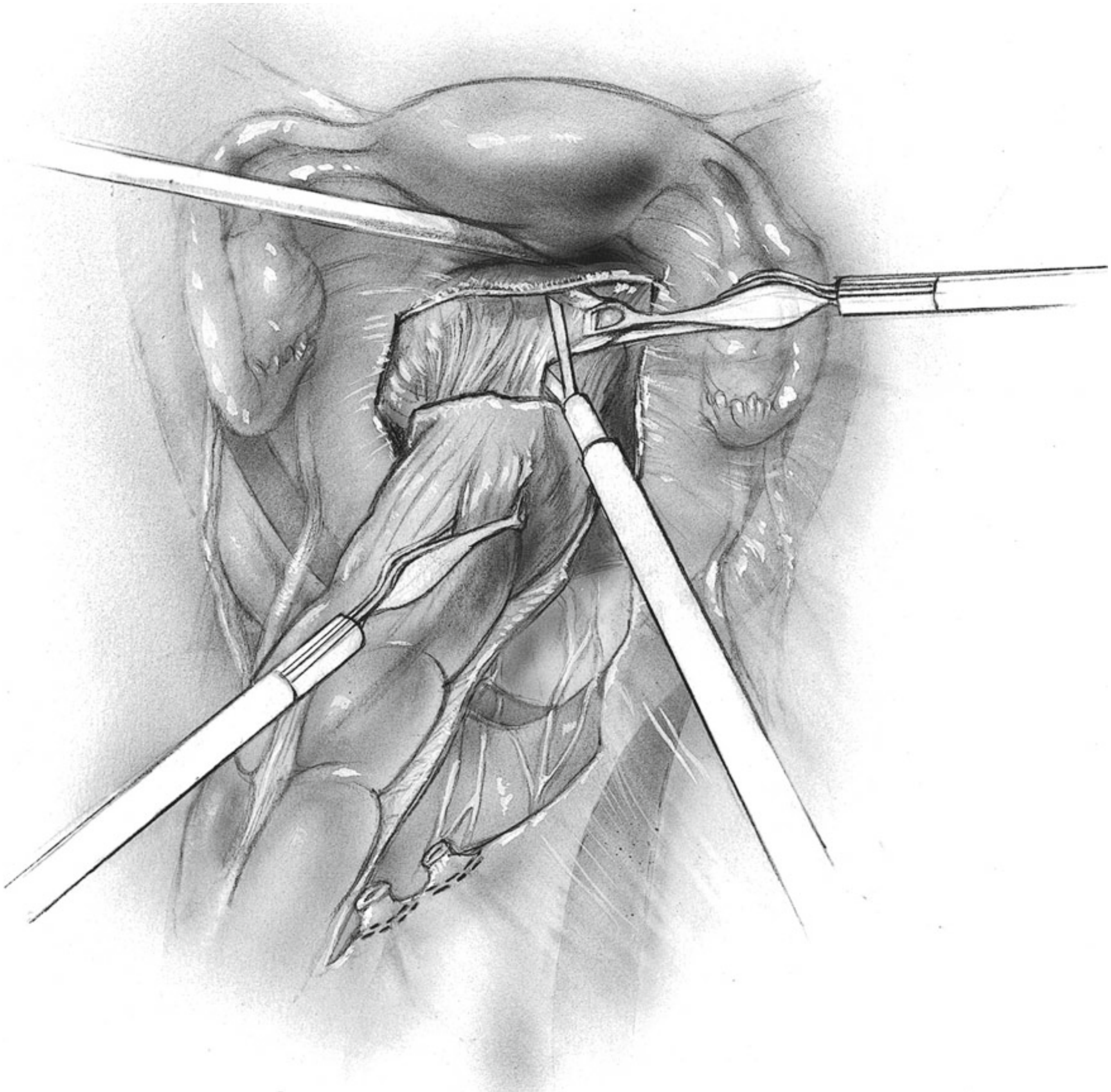


Fig. 55.6

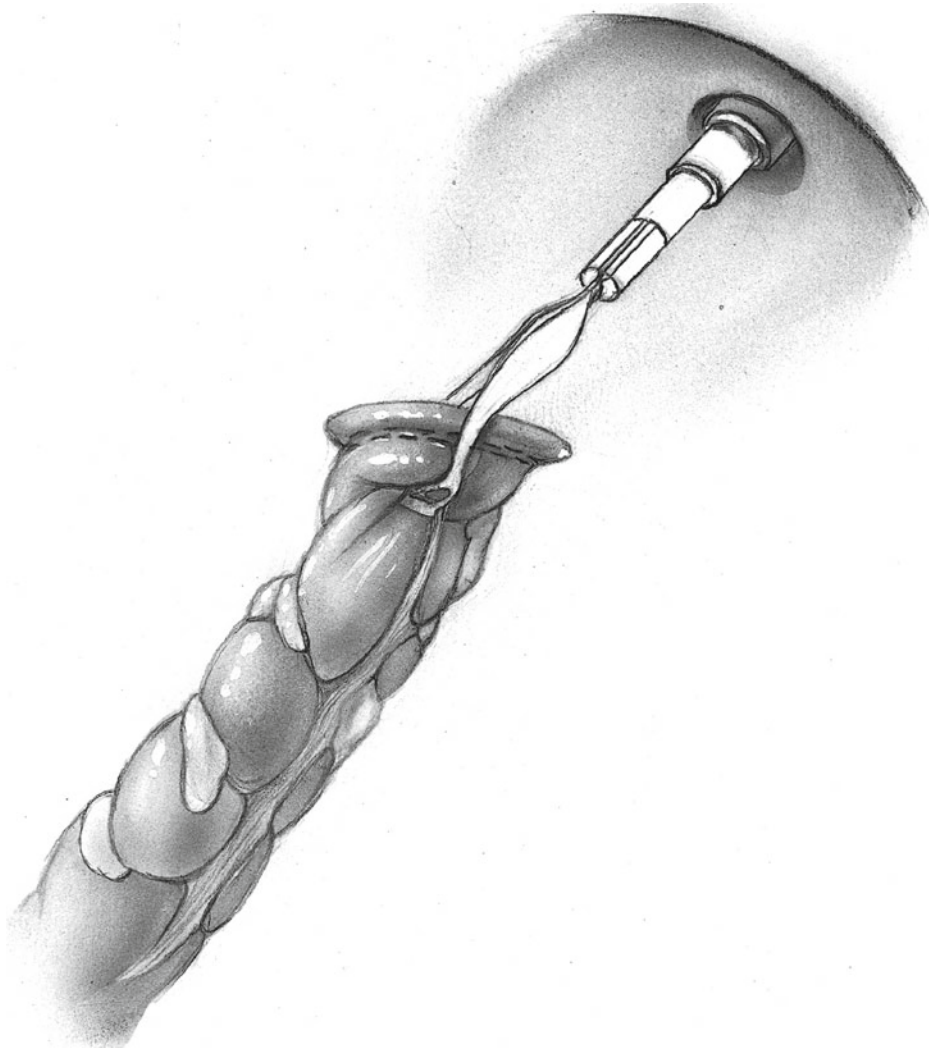


Fig. 55.7

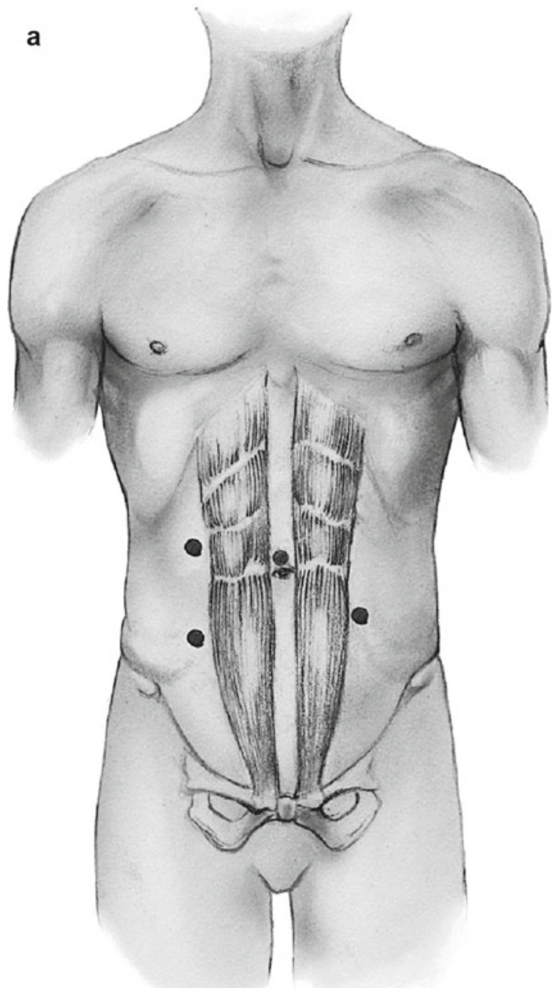


Fig. 55.8

b

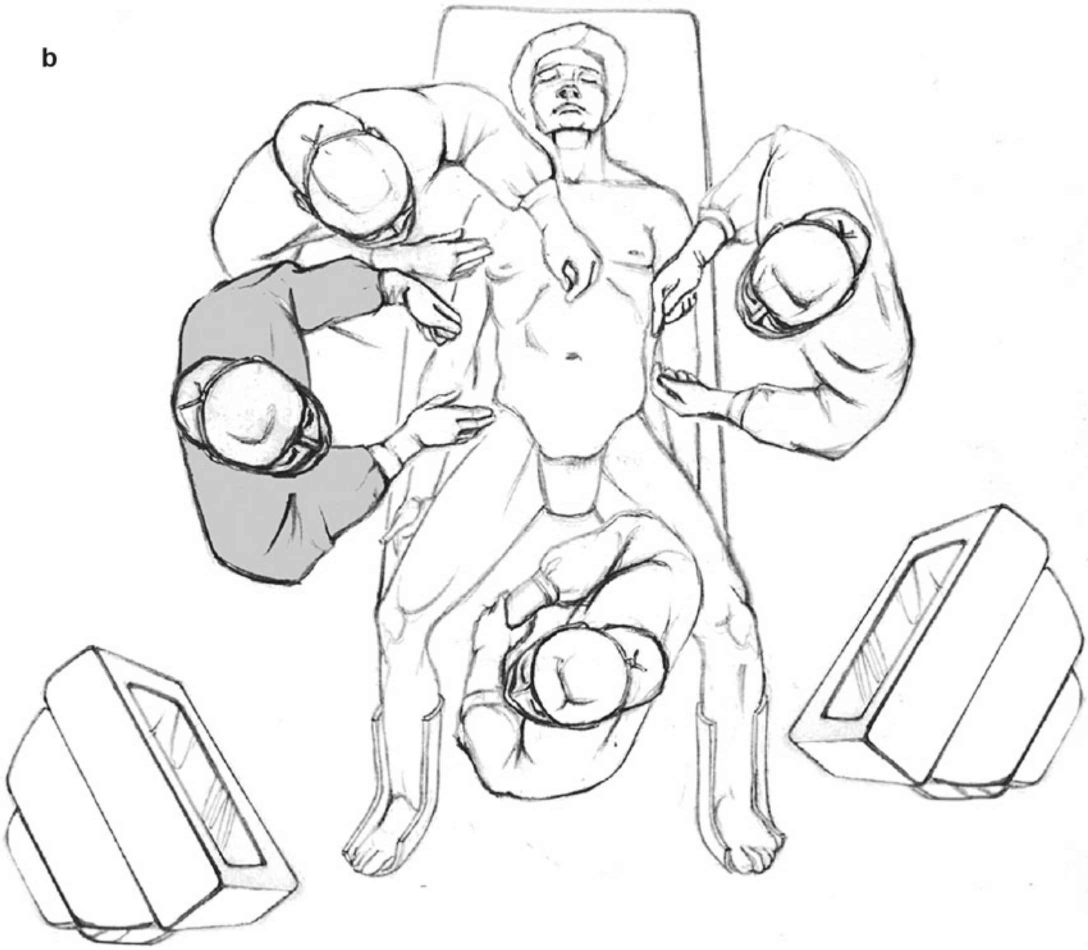


Fig. 55.8 (continued)

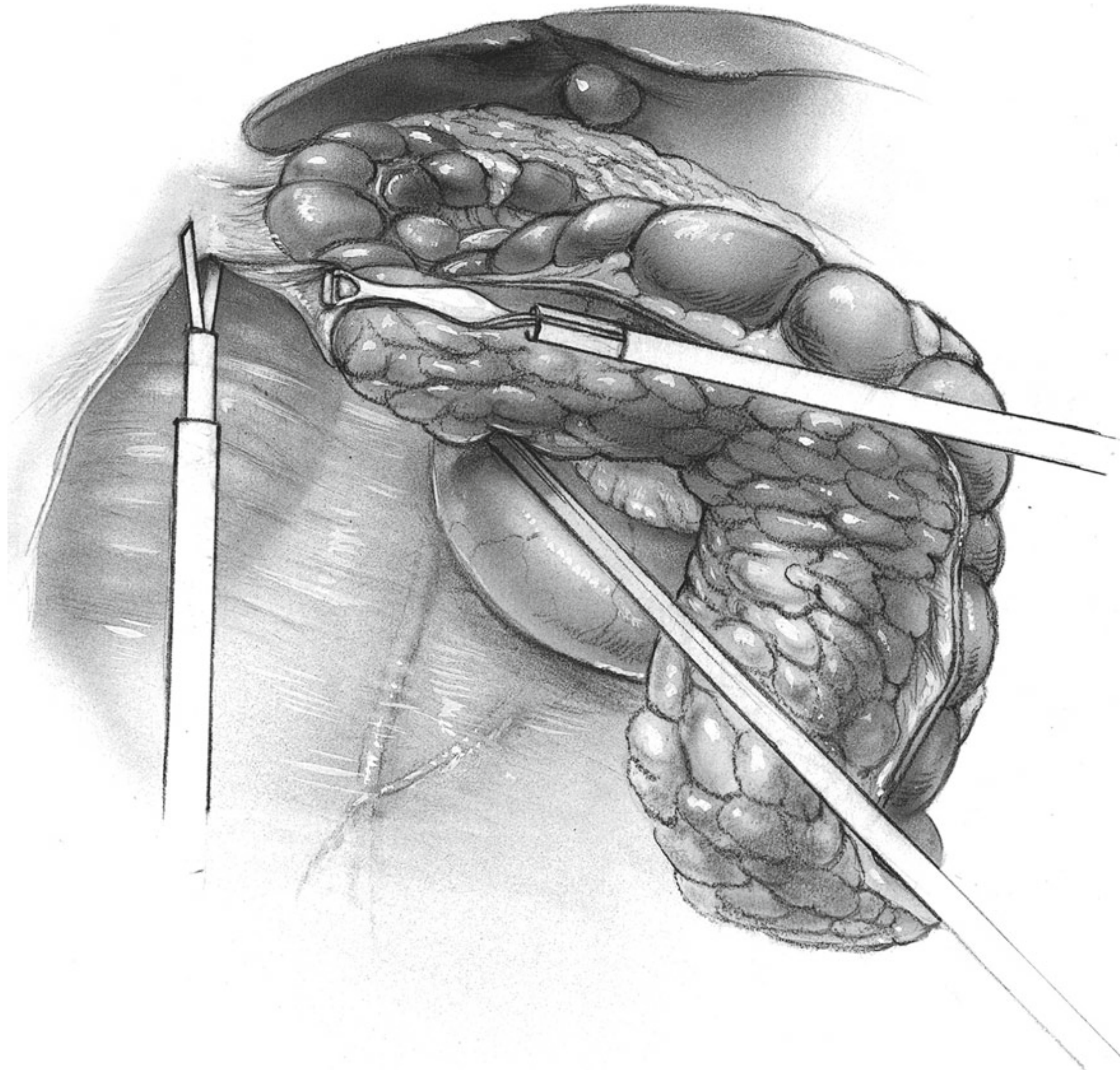
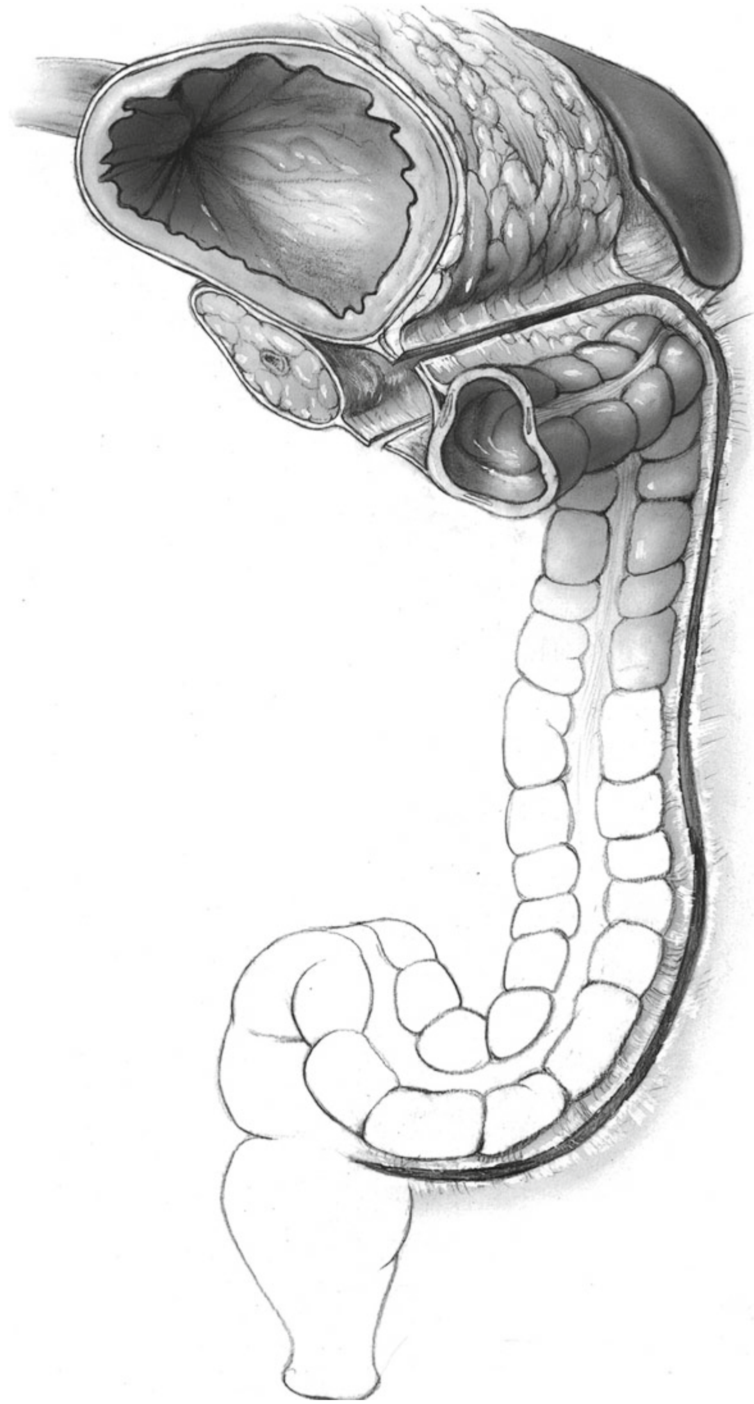


Fig. 55.9

Fig. 55.10



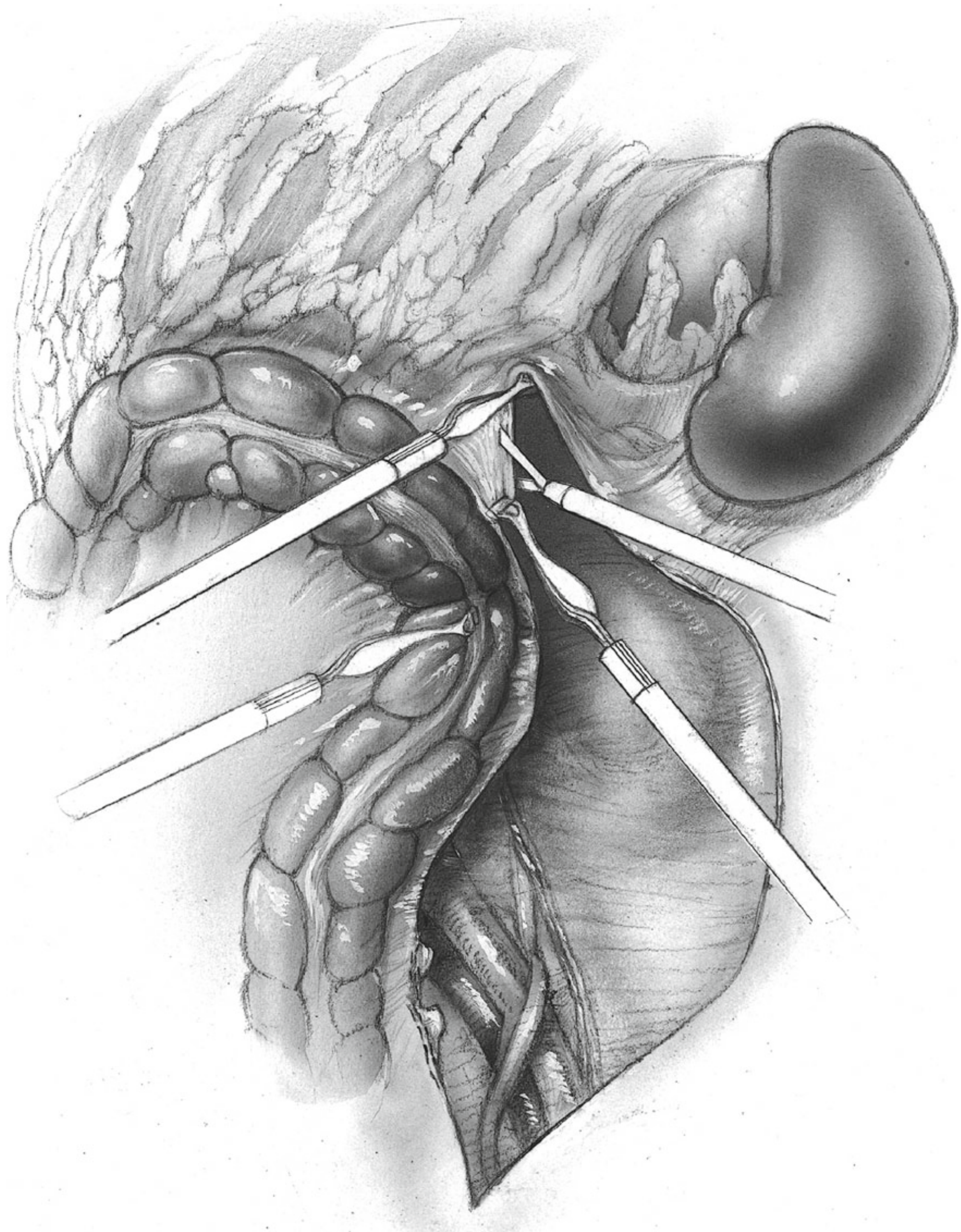


Fig. 55.11

excision for malignancy, the proctectomy is performed in an intersphincteric plane, and the remainder of the operation proceeds as described for abdominoperineal resection (see Chap. 58). Alternatively, for a hand-assisted operation, once the colon has been mobilized, make a small Pfannenstiel incision and complete the rectal dissection as in the open procedure. Exteriorize the colon and divide the ileum and mesenteric vessels extracorporeally.

Stoma-Related Complications: Retraction, Stenosis, Prolapse, and Dehydration

Postoperative small bowel obstruction
Nonhealing perineal wound

Postoperative Care

Postoperatively, the nasogastric tube is removed in the operating room. A clear liquid diet is initiated immediately after surgery, as tolerated, and advanced to a regular diet once there is passage of flatus or bowel movement through the stoma. The bladder catheter is kept in place for about 3 days. Patients can often be discharged home after 4–5 days. In patients with an end ileostomy, care is taken to strictly measure the ileostomy output and start antidiarrheal medications as needed prior to discharge.

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56 Subtotal Colectomy with Ileoproctostomy or Ileostomy

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

See Chap. 48 for discussion of issues related to the choice of operative procedure, particularly the extent of distal resection. Ileoanal anastomosis is described in the chapter which follows (Chap. 57). The laparoscopic technique is used for many patients (Chap. 55). The open technique is still required for emergency situations.

Familial polyposis

Chronic ulcerative colitis

Crohn's colitis

Ischemic colitis, fulminant Clostridium difficile colitis, and other emergency conditions requiring extensive colon resection

Preoperative Preparation

Patients with cachexia may require nutritional support.

Adrenal suppression may be present in patients who have been on steroids for a long time.

For *emergency* colectomy, restitution with blood and electrolytes should be accomplished.

Perioperative antibiotics are prescribed.

Pitfalls and Danger Points

Operative contamination of the peritoneal cavity with colonic contents, leading to sepsis (with toxic megacolon)

Improper construction of ileostomy

Operative Strategy

When choosing an emergency operative procedure for the patient with complications of inflammatory bowel disease (hemorrhage, perforation, toxic megacolon), consider both the immediate problem and the long-term result. Remember that sphincter-sparing procedures are now available for most of these patients, even when the rectum is involved by disease. Whenever possible retain the rectosigmoid, as it allows restorative proctocolectomy (see Chap. 57) to be performed at a later date.

Sepsis is not uncommon following an emergency colectomy for inflammatory bowel disease and its complications. In Crohn's disease one often finds a fistula to the adjacent bowel or to the skin. In some cases paracolic abscesses are encountered, making gross contamination of the peritoneal cavity inevitable.

When resecting the colon in cases of toxic megacolon, be aware that the colon, especially the distal transverse colon and splenic flexure, may have the consistency of wet tissue paper and can be ruptured by even minimal manipulation. This causes massive, sometimes fatal contamination of the abdominal cavity, and it must be avoided. Make no attempt to dissect the omentum off the transverse colon, as it may unseal a perforation. Elevation of the left costal margin by a Thompson retractor generally provides good exposure of the splenic flexure. Handle the colon gently, using forceps on the appendices epiploicae rather than on the colon wall. Consider decompressing the bowel before manipulating it. Intraoperative tube decompression may decrease the risk of perforating the colon and help minimize spillage if perforation occurs.

Divide the mesentery at a point of convenience nearer to the colon, rather than performing extensive mesenteric excision (as is done for malignancy). Minimize postoperative ileostomy problems by constructing an ileostomy that protrudes permanently from the abdominal wall, like a cervix, for 2 cm. This helps prevent the contents of the small bowel from leaking between the appliance and the peristomal skin.

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It also greatly simplifies the patient's task of placing the appliance accurately. Finally, close the gap between the cut edge of ileal mesentery and the lateral abdominal wall to avoid internal herniation. See Chap. 59 for additional tips on formation of a permanent ileostomy.

Documentation Basics

- Findings
- Extent of resection

Operative Technique

Placement of Ileostomy

On the day before the operation, the surgeon should obtain a faceplate from an ileostomy appliance, or some facsimile, and apply it tentatively to the patient's abdominal wall. Test proper placement with the patient sitting erect. In some patients, if the appliance is not properly placed, the rim strikes the costal margin or the anterior spine of the iliac crest. Generally, the proper location is somewhere near the outer margin of the right rectus muscle, about 5 cm lateral to the midline and 4 cm below the umbilicus. In this position the faceplate generally does not impinge on the midline scar, the umbilicus, the anterior superior spine, or the costal margin no matter what position the patient assumes. If the wafer covers the incision, we prefer a subcuticular skin closure for better skin approximation. The stoma should also be sited so the patient can see it when he or she is erect. In obese patients with a large pannus, it may be necessary to move the stoma higher on the abdomen. The input of an experienced stoma therapist is invaluable, especially if this may be a permanent stoma.

Operative Position

If there is a possibility that the colectomy and total proctectomy will be performed in one stage, position the patient in Lloyd-Davies leg rests (see Fig. 53.3a, b). Otherwise, the usual supine position is satisfactory.

Incision

We prefer a midline incision because it does not interfere with the ileostomy appliance. It also leaves the entire left lower quadrant free of scar in case ileostomy revision and reimplantation become necessary in the future. On the other hand, many surgeons use a left paramedian incision

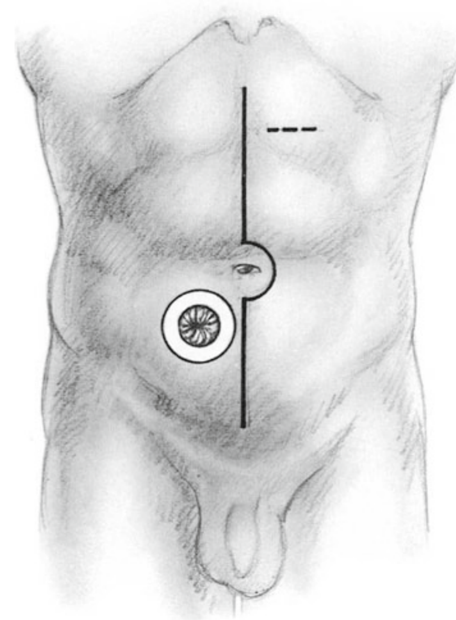


Fig. 56.1

to permit a wider margin between the ileostomy and the scar. The incision should extend from the upper epigastrium down to the pubis (Fig. 56.1). Because the splenic flexure is foreshortened in many cases of ulcerative colitis and toxic megacolon, exposure for this area is often good, with the Thompson retractor applied to the left costal margin.

Evacuation of Stool

For patients undergoing an operation for acute toxic megacolon, insert a heavy purse-string suture on the anterior surface of the terminal ileum. Make a small enterotomy in the center of the purse-string suture and pass a suction catheter through it, threading the catheter across the ileocecal valve into the cecum. After decompressing the colon, remove the tube and tie the purse-string suture.

Dissection of Right Colon and Omentum

Make an incision in the right paracolic peritoneum lateral to the cecum and insert the left index finger to elevate the avascular peritoneum, which should be divided by scissors in a cephalad direction (Fig. 56.2). If local inflammation has produced increased vascularity in this layer, use electrocautery to carry out the division. Throughout the dissection keep manipulation of the colon to a minimum. Continue the paracolic incision around the hepatic flexure, exposing the anterior wall of the duodenum.

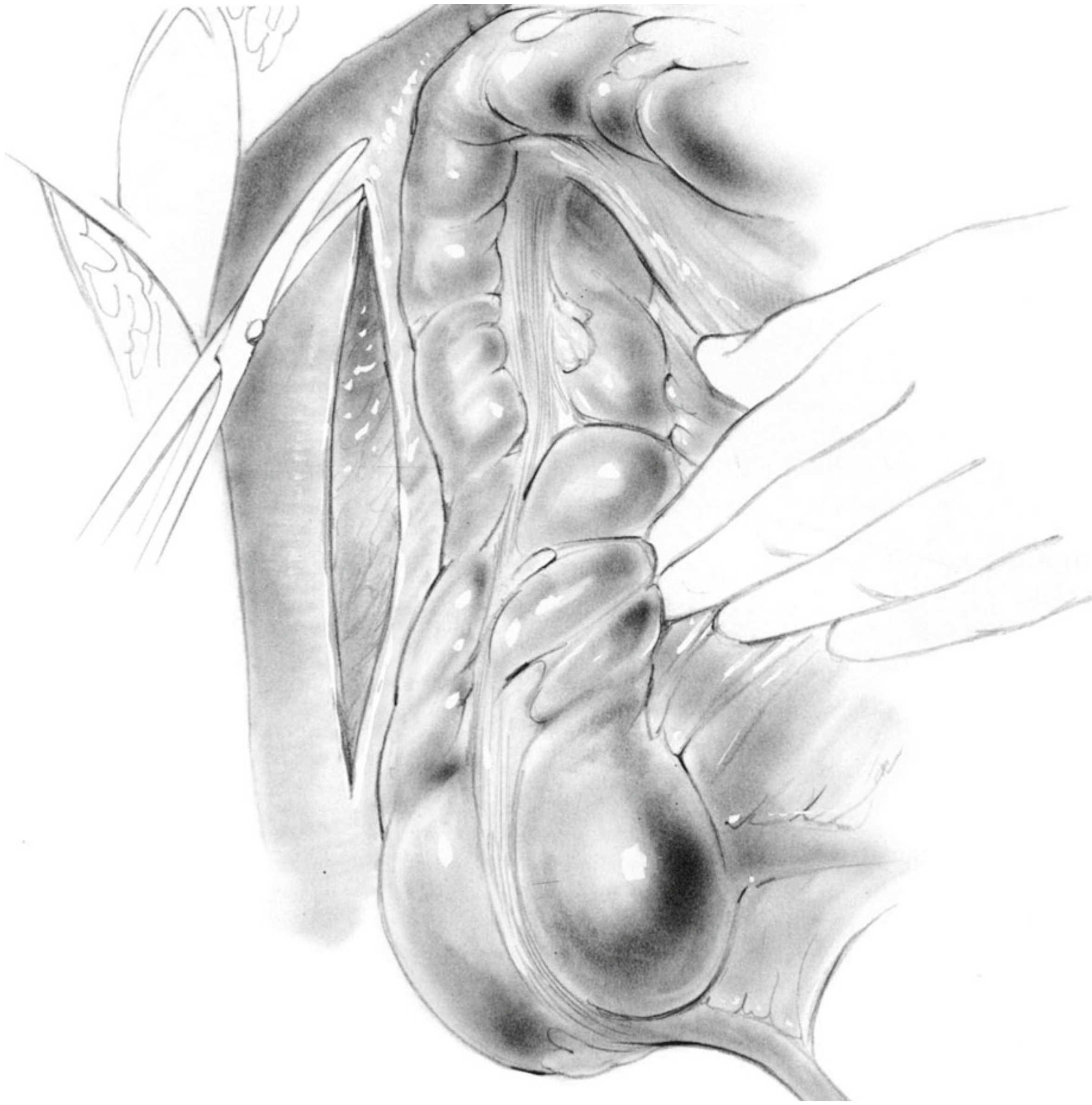


Fig. 56.2

For emergency operations for toxic megacolon, divide the omentum between Kelly hemostats 5 cm above its line of attachment to the transverse colon. If the omentum is fused to the transverse mesocolon, it may be divided simultaneously with the mesocolon in one layer. In most *elective* operations, the omentum can be dissected off the transverse colon through the usual avascular plane (Fig. 56.3).

Dissection of Left Colon

Remain at the patient's right side and make an incision in the peritoneum of the left paracolic gutter in the line of Toldt, beginning at the sigmoid. With the aid of the left hand elevate the avascular peritoneum and divide it in a cephalad direction with Metzenbaum scissors. Carry this incision up to and around the splenic flexure (Fig. 56.4). Mobilize the splenic flexure as described in Chap. 51 (see Figs. 51.5, 51.6, 51.7, and 51.8). In patients who suffer from toxic megacolon, perform this dissection with extreme caution so as not to perforate the colon.

Division of Mesocolon

Turn now to the ileocecal region. If the terminal ileum is not involved in the disease process, preserve its blood supply and select a point of transection close to the ileocecal valve.

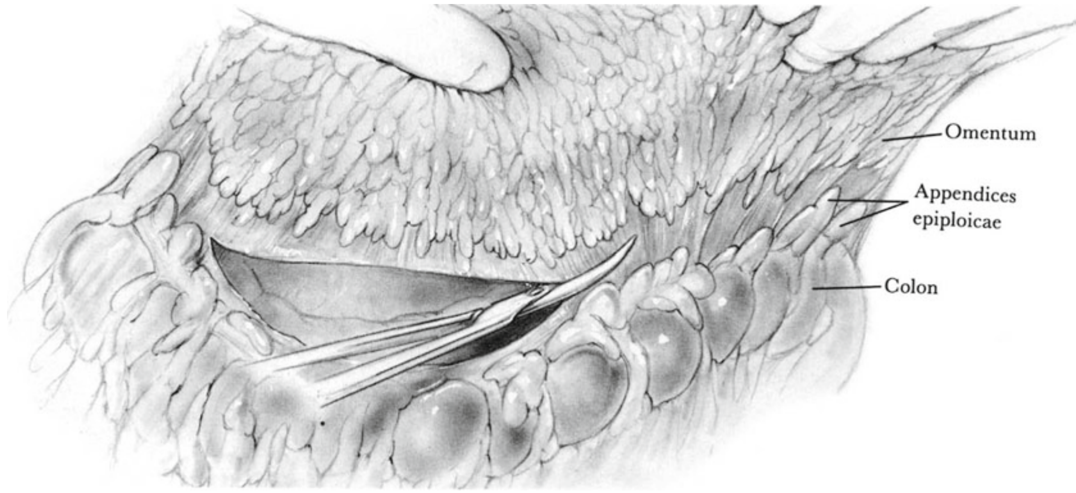


Fig. 56.3

Divide the mesocolon along a line indicated in Fig. 56.5. Because most patients who require this operation are thin, each vessel can be visualized, double clamped, and divided accurately. Ligate each vessel with 2-0 PG or silk ligatures and divide the intervening avascular mesentery with Metzenbaum scissors. In the same way, sequentially divide and ligate the ileocolic branches and the right colic, middle colic, two branches of the left colic, and each of the sigmoidal arteries.

Ileostomy and Sigmoid Mucous Fistula

The technique of fashioning a permanent ileostomy, including suturing the cut edge of the ileal mesentery to the right abdominal wall, is depicted in Figs. 59.1, 59.2, 59.3, 59.4, 59.5, 59.6, 59.7, 59.8, and 59.9. After the sigmoid mesentery has been divided up to a suitable point on the wall of the distal sigmoid, divide the colon with De-Martel clamps (as shown) or a linear cutting stapler. Bring this closed stump of the rectosigmoid through the lower pole of the incision (Fig. 56.6). Fix the rectosigmoid stump to the lower pole with a few 3-0 PG sutures, approximating the mesocolon and the appendices epiploicae to the anterior rectus fascia. Close the abdominal incision around the mucous fistula.

Alternatively, the closed distal bowel can be returned to the abdomen as a Hartmann's pouch. See Chap. 65 for additional tips on safe construction of a Hartmann's pouch.

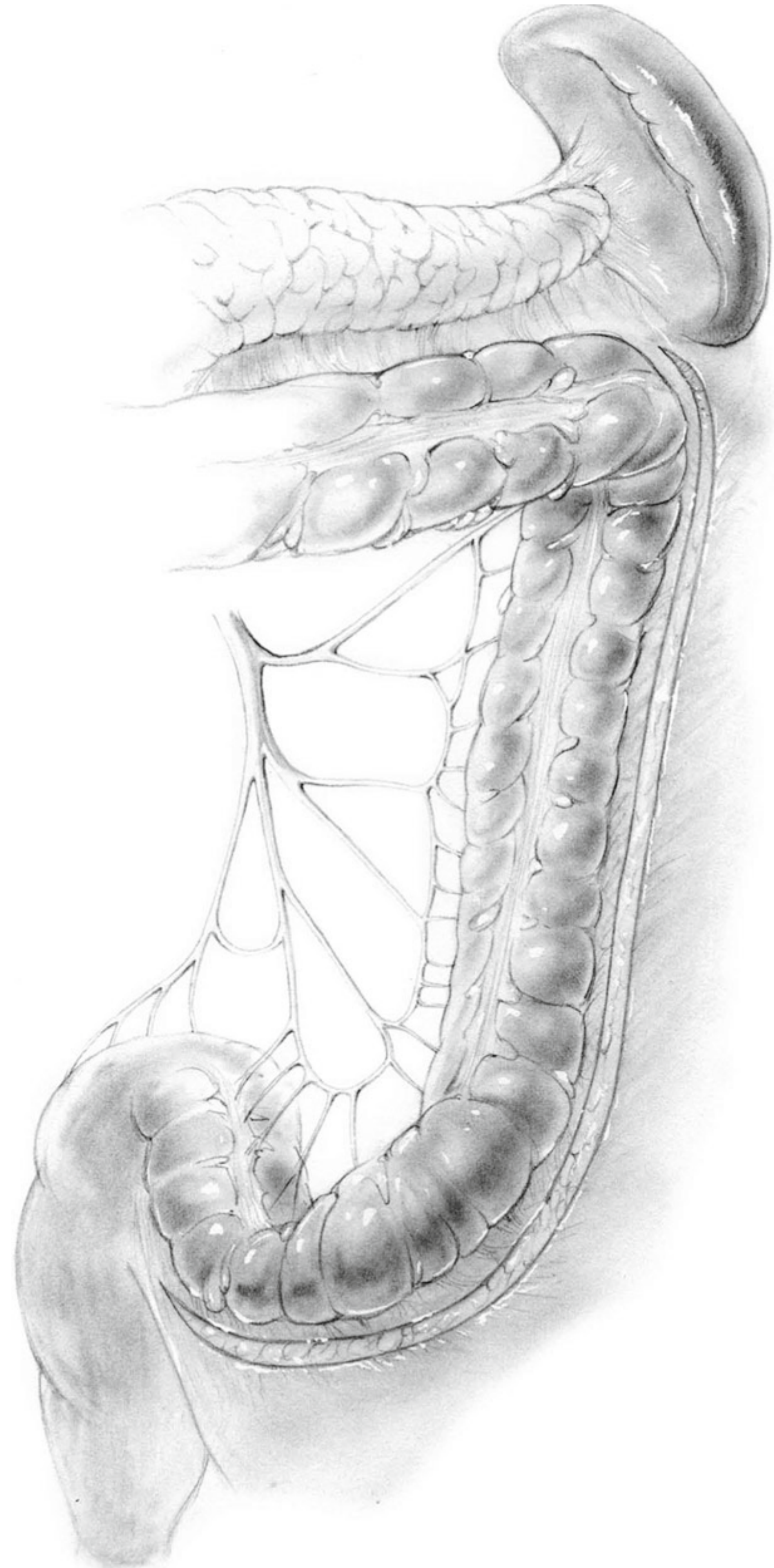
Ileoproctostomy

When an ileorectal anastomosis is elected, we prefer the side-to-end modified Baker technique (see Figs. 53.12, 53.13, 53.14, 53.15, 53.14, 53.15, 53.16, 53.17, 53.18, 53.19, 53.20, 53.21, 53.22, and 53.23) for the colorectal anastomosis because it completely eliminates issues of difference in bowel lumen and provides a general lumen. After the mesentery has been cleared at the point selected for transection of the ileum, apply transversely and fire a 55/3.5 mm linear stapler. Apply an Allen clamp to the specimen side of the ileum, and with a scalpel transect the ileum flush with the stapler. Lightly cauterize the everted mucosa and remove the stapling device. Inspect the staple line to ensure that proper B formation of the staples has occurred.

Divide the mesentery of the rectosigmoid up to the point on the upper rectum that has been selected for transection, which is generally opposite the sacral promontory. Apply a right-angle renal pedicle clamp to the colon to exclude colonic contents from the field. Dissect fat and mesentery off the serosa of the rectum at the site to be anastomosed. Make a linear scratch mark on the antimesenteric border of the ileum beginning at a point 1 cm proximal to the staple line and continuing in a cephalad direction for a distance equal to the diameter of the rectum, usually 4–5 cm.

The first layer should consist of interrupted 4-0 silk seromuscular Cushing sutures inserted by the successive bisection technique. After the sutures are tied, cut all the tails except for the two end sutures, to which small hemostats should be attached. Then make incisions on the antimesenteric border of the ileum and the back wall of the rectum (Fig. 56.7). Initiate closure of the posterior mucosal layer by inserting a double-armed 5-0 PG suture in the middle point of the posterior layer and tying it. With one needle insert a continuous locked suture to approximate all the coats of the posterior layer, going from the midpoint to the right corner of the anastomosis. Use the other needle to perform the same maneuver going from the midpoint to the left (Fig. 56.8). Amputate the specimen. Then use a continuous Cushing, Connell, or seromucosal suture to approximate the anterior

Fig. 56.4



mucosal layer, terminating the suture line at the midpoint of the anterior layer. Close the final anterior seromuscular layer with interrupted 4-0 silk Cushing sutures (Fig. 56.9). If possible, cover the anastomosis with omentum.

Approximate the cut edge of the ileal mesentery to the cut edge of the right lateral paracolic peritoneum with a continuous 2-0 atraumatic PG suture. Do not close the left paracolic gutter. Irrigate the abdominal cavity.

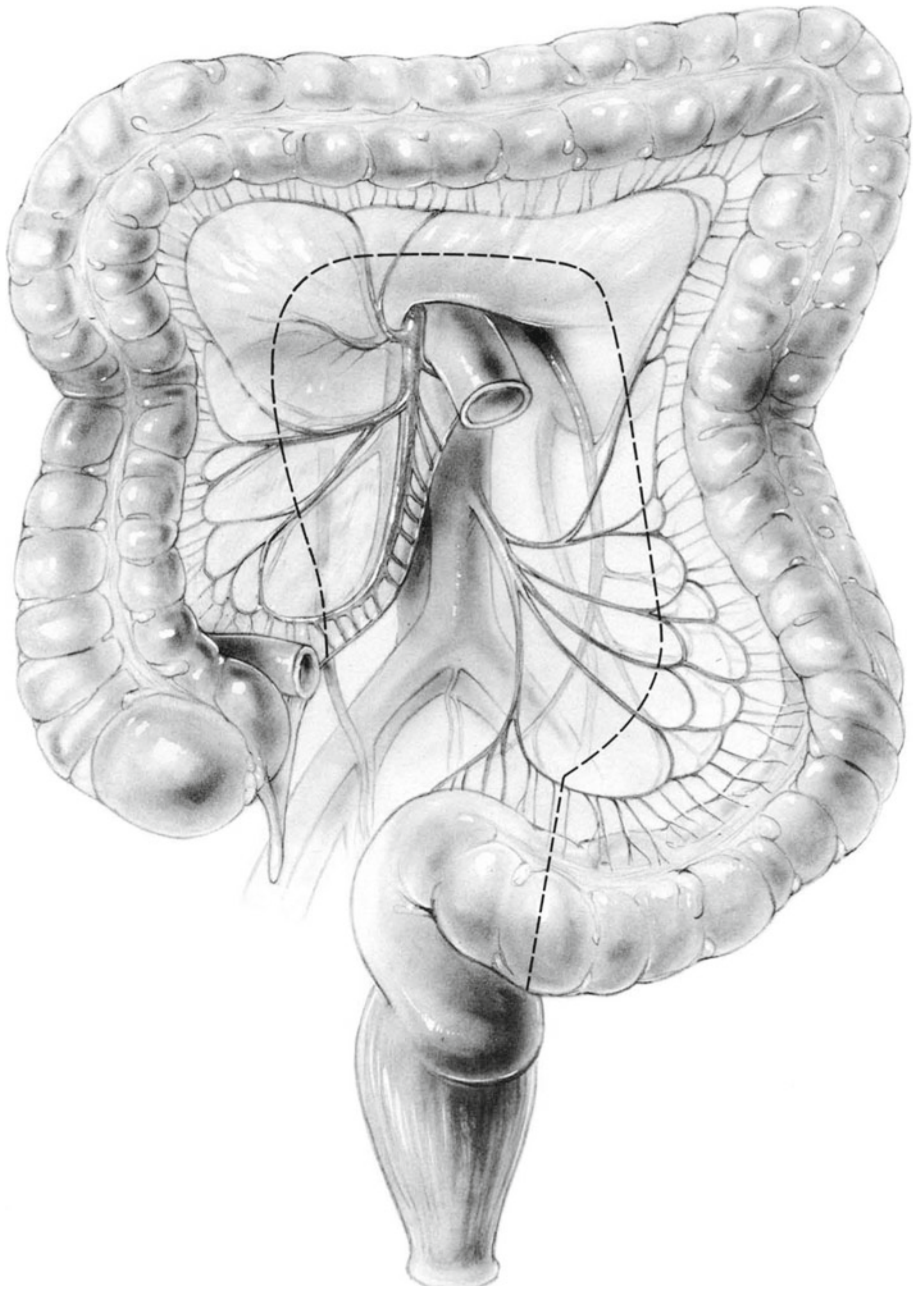


Fig. 56.5

Subtotal Colectomy Combined with Immediate Total Proctectomy

When a proctectomy is performed at the same stage as a subtotal colectomy, occlude the rectosigmoid by a layer of TA-55 staples. Apply an Allen clamp to the specimen side of the colon, which should be transected with removal of the specimen. This eliminates the colon and any source of contamination in cases of toxic megacolon. Then perform abdominoperineal proctectomy by the technique described in Chap. 58. Construct the ileostomy as depicted in Figs. 59.1, 59.2, 59.3, 59.4, 59.5, 59.6, 59.7, 59.8, and 59.9.

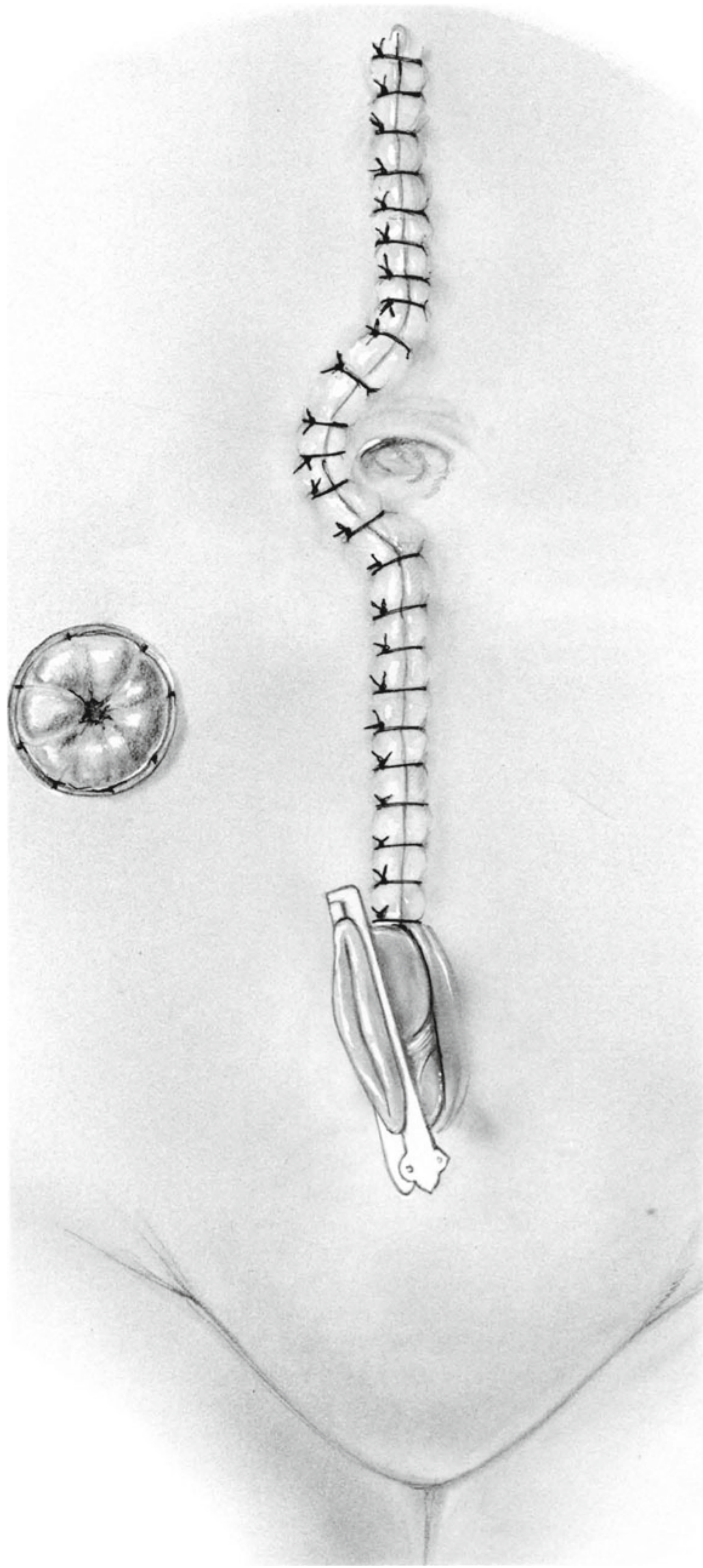
Needle-Catheter Jejunostomy

Consider performing needle-catheter jejunostomy in any patient suffering from malnutrition to permit enteral feeding immediately after surgery.

Closure of the Abdominal Incision

Close the abdominal wall in routine fashion without drains (see Chap. 3).

Fig. 56.6



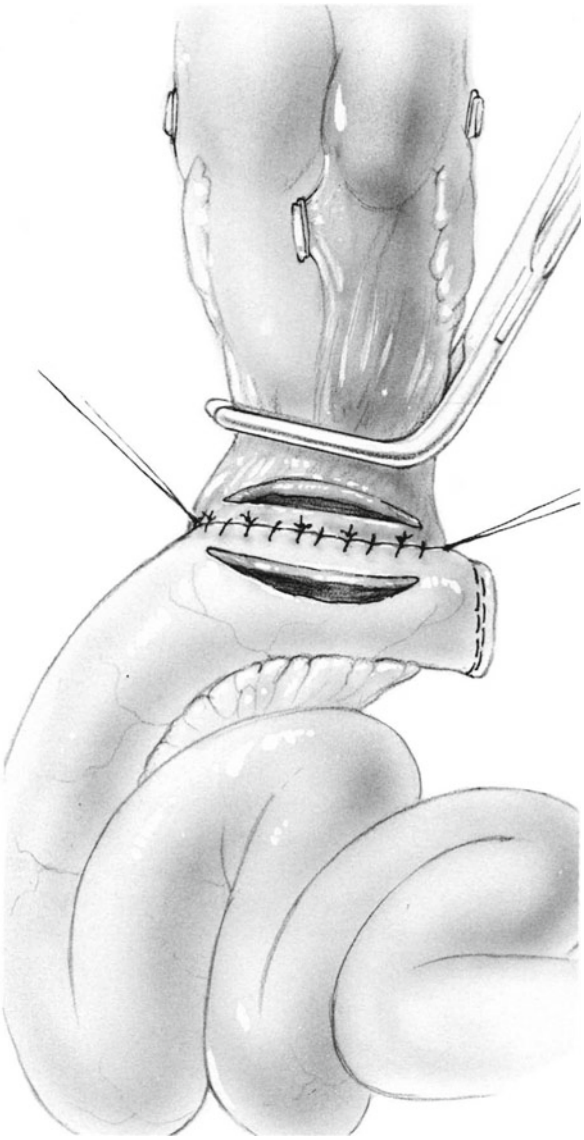


Fig. 56.7

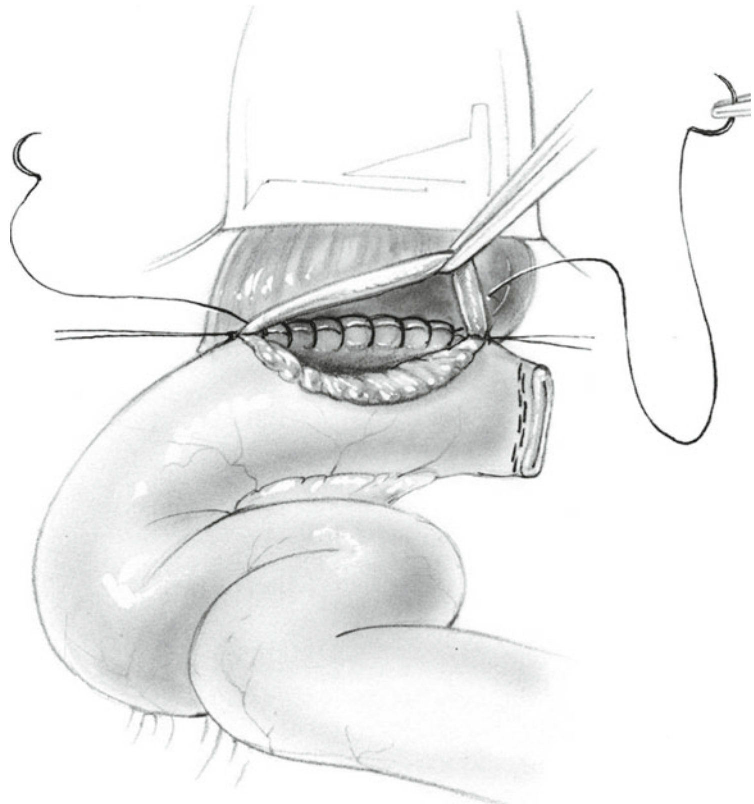


Fig. 56.8

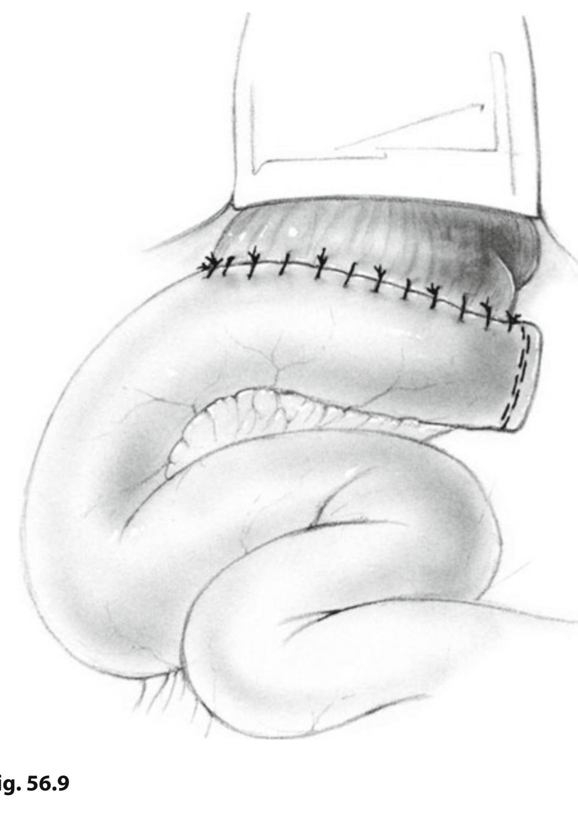


Fig. 56.9

Postoperative Care

Continue nasogastric suction (when indicated) and intravenous fluids until there is good ileostomy function. If there was no operative contamination, discontinue the operative antibiotics within 6 h. Otherwise, continue antibiotics, modifying as indicated by the operative findings and the postoperative course.

In the operating room apply a Stomahesive disk to the ileostomy after cutting a properly sized opening. Over the disk, place a temporary ileostomy bag. Instruct the patient in the details of ileostomy management and encourage him or her to join one of the organizations of ileostomates, where considerable emotional support can be derived by meeting patients who have been successfully rehabilitated.

Complications

Intra-abdominal abscess is more common after colon resection for inflammatory bowel disease than for other conditions. When signs of intra-abdominal infection appear, prompt laparotomy or percutaneous computed tomography-guided catheter drainage for evacuation of the abscess is indicated.

Intestinal obstruction due to adhesions is not rare following this group of operations because of the extensive dissection. If nonoperative treatment does not bring a prompt response, laparotomy for enterolysis becomes necessary.

Leakage of the anastomosis may follow ileoproctostomy. In case of a major leak, immediate laparotomy for a diverting loop ileostomy (see Chap. 60) followed by pelvic drainage is mandatory. Alternatively, the anastomosis may be taken down and the ileum brought out as a terminal ileostomy.

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57 Restorative Proctocolectomy with Mucosal Proctectomy and Ileal Reservoir

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Patients with chronic ulcerative colitis or familial polyposis in whom total proctocolectomy is indicated but preservation of continence is desired

Contraindications

Cohn's disease
Perianal fistulas
Rectal muscular cuff that is strictured and fibrotic, not soft and compliant

Preoperative Preparation

Treat inflammation and ulcerations of the lower rectum preoperatively. If the patient has had a subtotal colectomy and ileostomy, it may be necessary to treat the rectum with steroid enemas or free fatty acid enemas to restore rectal mucosal integrity.
Nutritional rehabilitation is applied when necessary.
Perioperative antibiotics as prescribed.
Nasogastric tube is inserted.
Foley catheter is placed in the bladder.
Endoscopy of ileum via the ileostomy is undertaken when Crohn's disease is suspected after subtotal colectomy.
If one-stage colectomy with reconstruction is anticipated, appropriate mechanical and antibiotic bowel preparation is indicated.

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Pitfalls and Danger Points

Performing an inadequate mucosectomy, which may produce a cuff abscess and possibly lead later to carcinoma
Establishing inadequate pelvic, reservoir, or anastomotic hemostasis, which may result in postoperative hemorrhage or hematoma
Injuring the nervi erigentes or the hypogastric nerves so sexual impotence or retrograde ejaculation results
Failing to diagnose Crohn's disease, resulting in Crohn's ileitis in the reservoir
Using improper technique when closing the temporary loop ileostomy (if one is utilized), which leads to postoperative leakage or obstruction

Operative Strategy

Multiple techniques have been described for restorative proctocolectomy. The method described here has served well and accomplishes maximum ablation of the abnormal mucosa. An alternative technique avoids the mucosal proctectomy altogether and creates the anastomosis between the anus and the perineal pouch by means of a double stapling technique. A roticulating linear stapler and circular stapler are used in a manner analogous to that described in Chap. 53. The anastomosis is constructed 1–2 cm above the dentate line, leaving some transitional zone epithelium behind. This double-stapled technique may be simpler in obese patients and is preferred by some surgeons. References at the end of the chapter detail operative results with various techniques and give additional technical details for other methods.

†Deceased

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Mucosectomy

The mucosectomy is performed most easily with the patient in the prone jackknife position. The dissection is expedited by injecting a solution of epinephrine (1:200,000) into the submucosal plane. It is performed as the first stage in the procedure; if the rectum is so badly diseased that mucosectomy cannot be reasonably accomplished, the operative plan must be modified. Generally, proctocolectomy is then required.

Good fecal continence can be maintained if the mucosa is dissected away from the rectum up to a point no more than 1–2 cm above the puborectalis, the upper end of the anal canal. This amount of dissection can generally be accomplished transanally with less difficulty in the adult patient than occurs when using the abdominal approach. There must be complete hemostasis in the region of the retained rectum. Generally, careful electrocoagulation can accomplish this end.

Some surgeons advocate the use of a Cavitron ultrasonic aspirator (CUSA) to facilitate the mucosal proctectomy.

Abdominal Dissection

When performing the colectomy, transect the ileum just proximal to its junction with the ileocecal valve to preserve the reabsorptive functions of the distal ileum. If a previous ileostomy is being taken down, again preserve as much terminal ileum as possible.

Rectal Dissection

When dissecting the rectum away from the sacrum, keep the dissection immediately adjacent to the rectal wall. Divide the mesenteric vessels near the point where they enter the rectum and leave the major portion of the “mesentery” behind. In this way, the hypogastric nerves are preserved.

Similarly, when the lateral ligaments are divided, make the point of division as close to the rectum as possible to avoid dividing the parasympathetic nerves essential for normal male sexual function. Anteriorly, the dissection proceeds close to the rectal wall posterior to the seminal vesicles and Denonvilliers’ fascia down to the distal end of the prostate.

Division of Waldeyer’s Fascia

In the adult patient it is not possible to expose the levator diaphragm unless the fascia of Waldeyer is divided by sharp dissection. This layer of dense fascia is attached to the anterior surface of the sacrum and coccyx and attaches to the posterior wall of the rectum. Unless it is divided just anterior to the tip of the coccyx, it is not possible to expose the lower rectum down to the level of the puborectalis muscle.

Temporary Loop Ileostomy and Ileostomy Closure

A loop ileostomy (see Chap. 60) completely diverts the fecal stream, yet is simple to close. It should be used whenever there is the slightest doubt as to the integrity of the pelvic anastomoses.

Ileoanostomy

To facilitate anastomosing the ileum or the ileal reservoir to the anus, it is helpful to flex the thighs on the abdomen to a greater extent than is usually the case when the patient is placed in the lithotomy position for a two-team abdominoperineal operation. Be certain the rectal mucosa has been divided close to the dentate line. Otherwise, it will be necessary to insert sutures high up in the anal canal where transanal manipulation of the needle is extremely difficult. Also, it is important to remove all of the diseased mucosa in this operation to eliminate the possibility of the patient developing a rectal carcinoma at a later date.

One method of achieving exposure with this anastomosis is to insert the bivalve Parks retractor with large blades into the rectum. Then draw the ileum down, between the open blades of the retractor, to the dentate line. Insert two sutures between the ileum and the anterior wall of the anus. Insert two more sutures between the ileum and the posterior portion of the dentate line. Now remove the Parks retractor. Remove the large blades from the retractor and replace them with small blades. Then carefully insert the blades of the Parks retractor into the lumen of the ileum and open the retractor slowly.

With the Parks retractor blades in place, continue to approximate the ileum to the dentate line with 12–15 interrupted sutures of 4-0 Vicryl. This requires that the retractor be loosened and rotated from time to time to provide exposure of the entire circumference of the anastomosis. Be certain to include the underlying internal sphincter muscle together with the epithelial layer of the anal canal when inserting these sutures.

An alternative, more effective method of exposing the anastomosis is to use a Gelpi retractor with one arm inserted into the tissues immediately distal to the dentate line at about 2 o’clock while the second arm of this retractor is placed at 8 o’clock. A second Gelpi retractor is inserted into the anus with one arm at 5 o’clock and the second at 11 o’clock. If the patient is properly relaxed, these two retractors ensure visibility of the whole circumference of the cut end of the anorectal mucosa at the dentate line. Then draw the ileum down into the anal canal and complete the anastomosis.

Constructing the Ileal Reservoir

We prefer a J-loop ileal reservoir constructed by making a side-to-side anastomosis in the distal segment of the ileum. We do not include the elbow of the J-loop in the staple line, thereby ensuring that there is no possibility of impairing the blood supply to the ileoanal anastomosis. The terminal end of the ileum is occluded with staples. Although it is possible to establish an ileoanal anastomosis using a circular stapler, we prefer to suture this anastomosis because we like to be sure that no rectal mucosa has been left behind.

Documentation Basics

- Findings
- Coding for these procedures is complex. Review current CPT® codes for accurate descriptors

Operative Technique

Mucosal Proctectomy Combined with Total Colectomy

When the mucosa of the distal rectum is devoid of visible ulcerations and significant inflammation, mucosal proctectomy may be performed at the same time as total colectomy. In these cases perform the colectomy as described in Chap. 56. Be certain to divide the mesentery of the rectosigmoid close to the bowel wall to avoid damaging the hypogastric and parasympathetic nerves. Also, divide the branches of the ileocolic vessels close to the cecum to preserve the blood supply of the terminal ileum. It is important to transect the ileum within 1–2 cm of the ileocecal valve. Preserving as much ileum as possible salvages some of the important absorptive functions of this organ.

Use a cutting linear stapler to divide the terminal ileum. Lightly cauterize the everted mucosa. Mobilize the entire colon down to the peritoneal reflection, following the procedures illustrated in Figs. 51.5, 51.8, 56.1, 56.2, 56.3, 56.4, and 56.5. For convenience in handling, divide the specimen with a cutting linear stapler at the sigmoid level.

Divide the rectosigmoid mesentery close to the bowel wall to avoid interrupting the hypogastric nerves (see Fig. 58.1). Divide the lateral ligaments close to the rectum and divide Denonvilliers' fascia proximal to the upper border of the prostate. Keep the dissection *close to the anterior and lateral rectal walls* in men to minimize the incidence of sexual impotence. After dividing Waldeyer's fascia (see Fig. 53.10) expose the puborectalis portion of the levator diaphragm (see Fig. 53.25).

At this time, transect the anterior surface of the rectal layer of muscularis in a transverse direction down to the mucosa. Make this incision in the rectal wall about 2–4 cm above the puborectalis muscle. Now dissect the muscular layer away from the mucosa. Injecting a solution of 1:200,000 epinephrine between the mucosa and muscularis expedites this dissection. After the muscle has been separated from 1–2 cm of mucosa anteriorly, extend the incision in the muscularis layer circumferentially around the rectum. Use Metzenbaum scissors and a peanut sponge dissector for this step. Achieve complete hemostasis by accurate electrocoagulation. Continue the mucosal dissection until the middle of the anal canal has been reached. Divide the mucosal cylinder at this point, remove the specimen, and leave an empty cuff of muscle about 2–4 cm in length above the puborectalis, which marks the proximal extent of the anal canal. If any mucosa has been left in the anal canal proximal to the dentate line, it can be removed transanally later in the operation.

Alternatively, one may perform the rectal mucosectomy prior to opening the abdomen. This method is described in the next section of this chapter.

Perineal Approach

Performing the mucosal proctectomy with the patient in the prone position affords better exposure than is available in the lithotomy position. After inducing endotracheal anesthesia, turn the patient face down and elevate the hips by flexing the operating table or by placing a pillow under the hips. Also place a small pillow under the feet and spread the buttocks apart by applying adhesive tape to the skin and attaching the tape to the sides of the operating table. Gently dilate the anus until it admits three fingers. Obtain exposure by using a large Hill-Ferguson, a narrow Deaver, or a bivalve Pratt (or Parks) retractor. Inject a solution of 1:200,000 epinephrine in saline in the plane just deep to the mucosa, immediately proximal to the dentate line around the circumference of the anal canal (Fig. 57.1). Now make a circumferential incision in the transitional epithelium immediately cephalad to the dentate line. Using Metzenbaum scissors, elevate the mucosa and submucosa for a distance of 1–2 cm circumferentially from the underlying circular fibers of the internal sphincter muscle (Fig. 57.2). Apply several Allis clamps to the cut end of the mucosa. Maintain hemostasis by accurate electrocoagulation using the needle tip attachment on the electrocautery. It is helpful to roll up two 10×20 cm moist gauze sponges soaked in a 1:200,000 epinephrine solution and insert this roll into the rectum. This step facilitates the dissection between mucosa and muscle.

Continue the dissection to a point 4–6 cm above the dentate line (Fig. 57.3). As the dissection continues cephalad, exposure is obtained by inserting two narrow Deaver retractors the assistant holds in varying positions appropriate to the area being dissected.

After an adequate tube of mucosa 4–6 cm in length has been dissected, insert a purse-string suture near the apex of the dissected mucosal tube and amputate the mucosa distal to

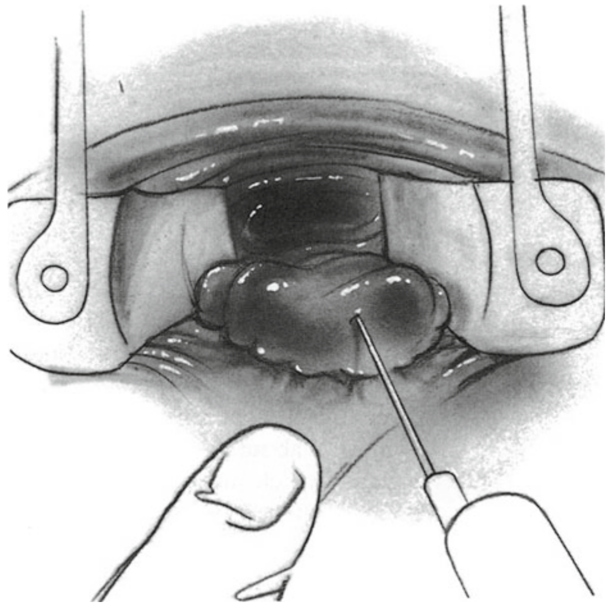


Fig. 57.1

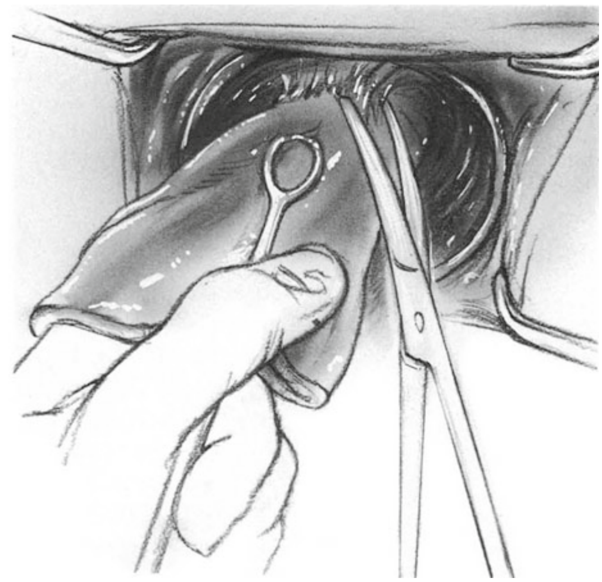


Fig. 57.3

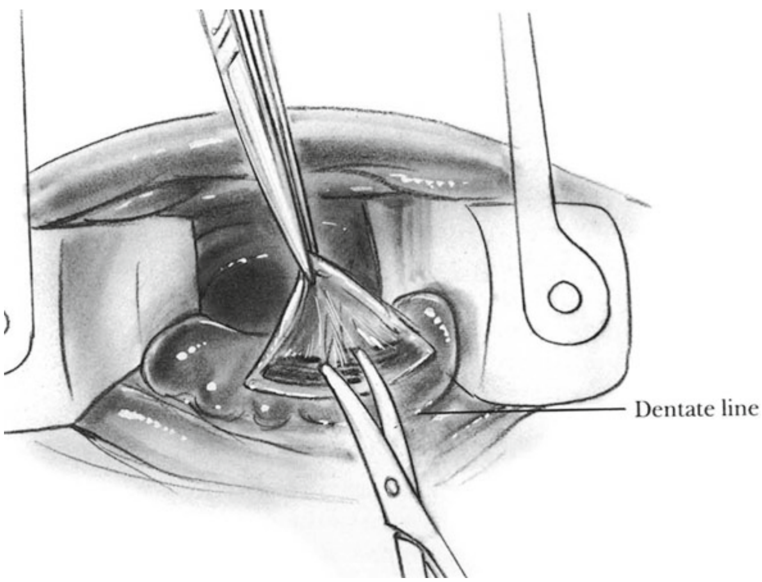


Fig. 57.2

the suture. Submit this specimen to the pathologist for frozen-section histologic examination. Insert into the denuded rectum a loose gauze pack that has been moistened with an epinephrine solution. Reposition the patient on his or her back with the lower extremities elevated on Lloyd-Davies stirrups (see Fig. 53.3a, b).

Abdominal Incision and Exposure

In patients who have undergone a previous subtotal colectomy with a mucous fistula and an ileostomy, reopen the previous long vertical incision, free all of the adhesions between the small bowel and the peritoneum, and liberate the mucous fistula from the abdominal wall. Divide the mesentery between Kelly hemostats along a line close to the posterior wall of the sigmoid and rectosigmoid until the peritoneal reflection is reached. Incise the peritoneal reflection to the right and to the left of the rectum. Continue the dissection downward and free the vascular and areolar tissue from the wall of the rectum. Then elevate the rectum out of the presacral space and incise the peritoneum of the rectovesical or rectouterine pouch (see Fig. 53.9). Keep the dissection close to the rectal wall, especially in male patients, to avoid the nervi erigentes and the hypogastric nerves. Pay special attention to dividing the lateral ligaments close to the rectum and avoid the parasympathetic plexus between the prostate and the rectum.

With a long-handled scalpel, incise Waldeyer's fascia (see Fig. 53.10) between the tip of the coccyx and the posterior wall of the rectum. Enlarge this incision with long Metzenbaum scissors. In male patients, incise Denonvilliers' fascia (see Fig. 53.11) on the anterior wall of the rectum proximal to the prostate and the seminal vesicles. Separate the prostate from the rectum. These last two maneuvers permit exposure of the levator diaphragm. Palpating the rectum at this time should enable the surgeon to detect the level at which the purse-string suture was placed in the mucosa during the first phase of this operation. If this purse-string suture is not palpable, ask the assistant to place a finger in the rectum from the perineal approach to help identify the apex of the previous mucosal dissection. Now transect the rectum with electrocautery and remove the specimen. Remove the gauze packing that was previously placed in the rectal stump and inspect the muscular cylinder, which is all that remains of the rectum. This consists of the circular muscle of the internal sphincter surrounded by the longitudinal muscle of the rectum. All of the mucosa has been removed down to the dentate line. Check for complete hemostasis.

Constructing the Ileal Reservoir

In patients who have had a previous ileostomy, carefully dissect the ileum away from the abdominal wall, preserving as much ileum as possible. Apply a 55/3.5 mm linear stapler across a healthy portion of the terminal ileum. Fire the stapler and amputate the scarred portion of the ileostomy. Lightly cauterize the everted mucosa and remove the stapling device. Now liberate the mesentery of the ileum from its attachment to the abdominal parietes. For patients who have not undergone a previous ileostomy, divide the terminal ileum with a cutting linear stapling device and divide the mesentery along the path indicated in Fig. 57.4. Freeing the small bowel mesentery from its posterior attachments (see Figs. 39.1 and 39.2) and all other adhesions may elongate the mesentery sufficiently that the ileal reservoir reaches the anal canal *without tension*.

Now select a point on the ileum about 20 cm from its distal margin that will serve as the future site of the ileoanal anastomosis. If this point on the ileum can be brought 6 cm beyond the symphysis pubis, one can be assured that there will be no tension on the anastomosis. Otherwise, further lengthen the mesentery by incising the peritoneum on the anterior and posterior surfaces of the ileal mesentery. Burnstein and associates reported that these relaxing incisions each contributed 1 cm to the length of the ileal mesentery. Obtain additional length, if necessary, by applying traction to the anticipated elbow of the J-pouch (Fig. 57.5), transilluminating the mesentery, and selectively dividing branches of the loop formed by the superior mesenteric and ileocolic arteries as shown in Fig. 57.6.

Be certain that the blood supply to the terminal ileum remains vigorous and that there is no tension on the ileoanal anastomosis. Take great care to isolate and ligate each vessel in the ileal mesentery individually, especially if the mesentery is thickened from scar tissue or obesity, to avoid postoperative bleeding. If an inadequately ligated vessel retracts into the mesentery, the resulting tense hematoma may produce ileal ischemia.

Now align the distal ileum in the shape of a U, each limb of which measures about 18 cm. Create a side-to-side stapled anastomosis between the antimesenteric aspects of the ascending and descending limbs of this U. Make a transverse stab wound 9 cm proximal to the staple line of the terminal ileum. Make a second transverse stab wound in the descending limb of ileum just opposite the first stab wound

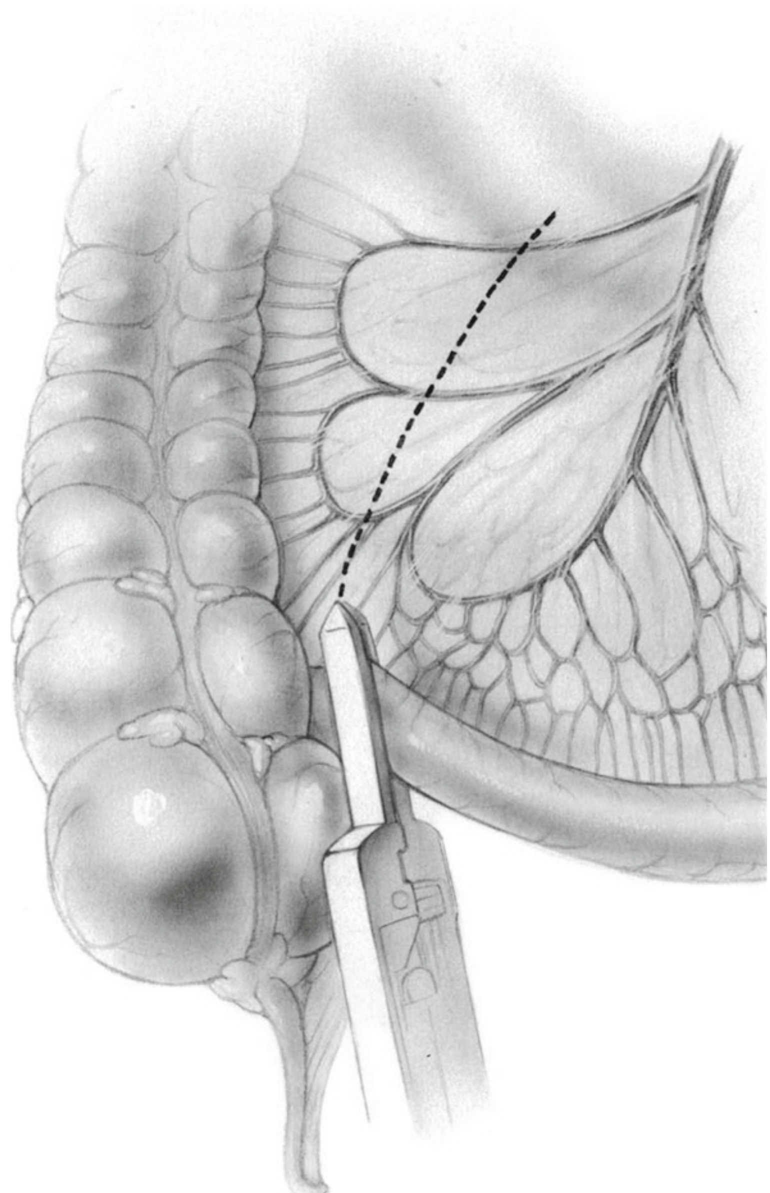
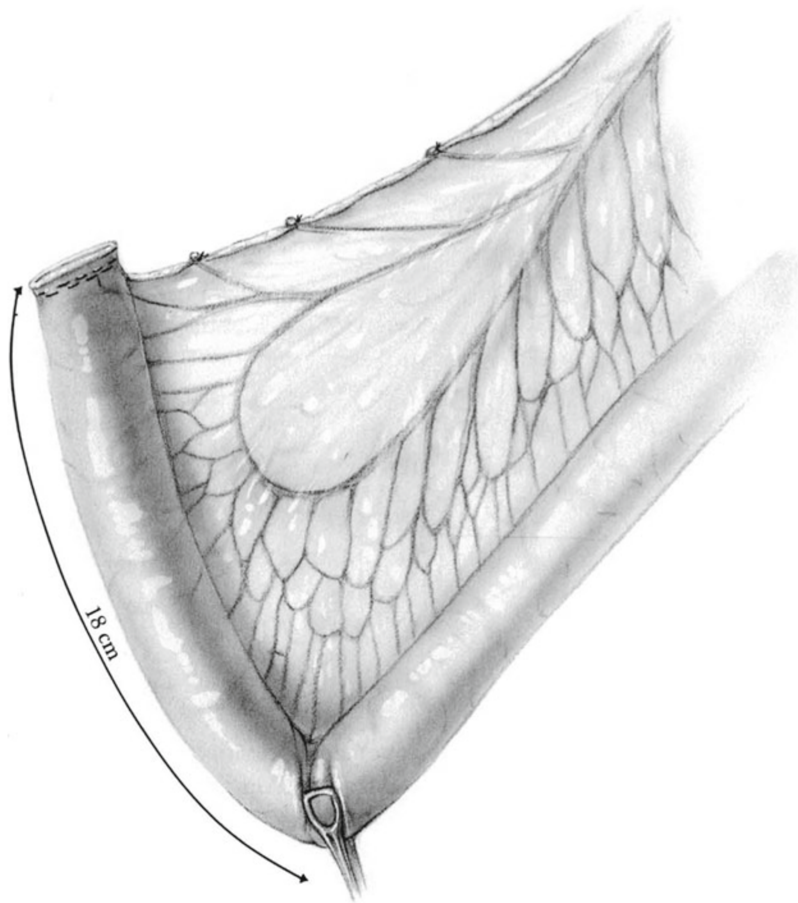


Fig. 57.4

(Fig. 57.7). Insert an 80 mm linear cutting stapler in a cephalad direction, one fork in the descending limb and one fork in the ascending limb of jejunum. Remember that this anastomosis is created on the *antimesenteric* borders of both limbs of the jejunum. Fire the stapler, creating an 8 cm side-to-side anastomosis. Withdraw the stapling device and inspect the staple line for bleeding. Electrocauterize bleeding points cautiously. Then reinsert the device into the same two stab wounds but direct the stapler in a caudal direction (Fig. 57.8). Lock the device and fire the staples. Remove the stapler and inspect for bleeding. Inspect the staple line via the stab wounds and electrocauterize the bleeding points. The patient should now have a completed side-to-side stapled anastomosis about 16 cm in length. We prefer to leave

Fig. 57.5



an intact circular loop of ileum distal to the side-to-side anastomosis to ensure that the bowel to be anastomosed has not been traumatized.

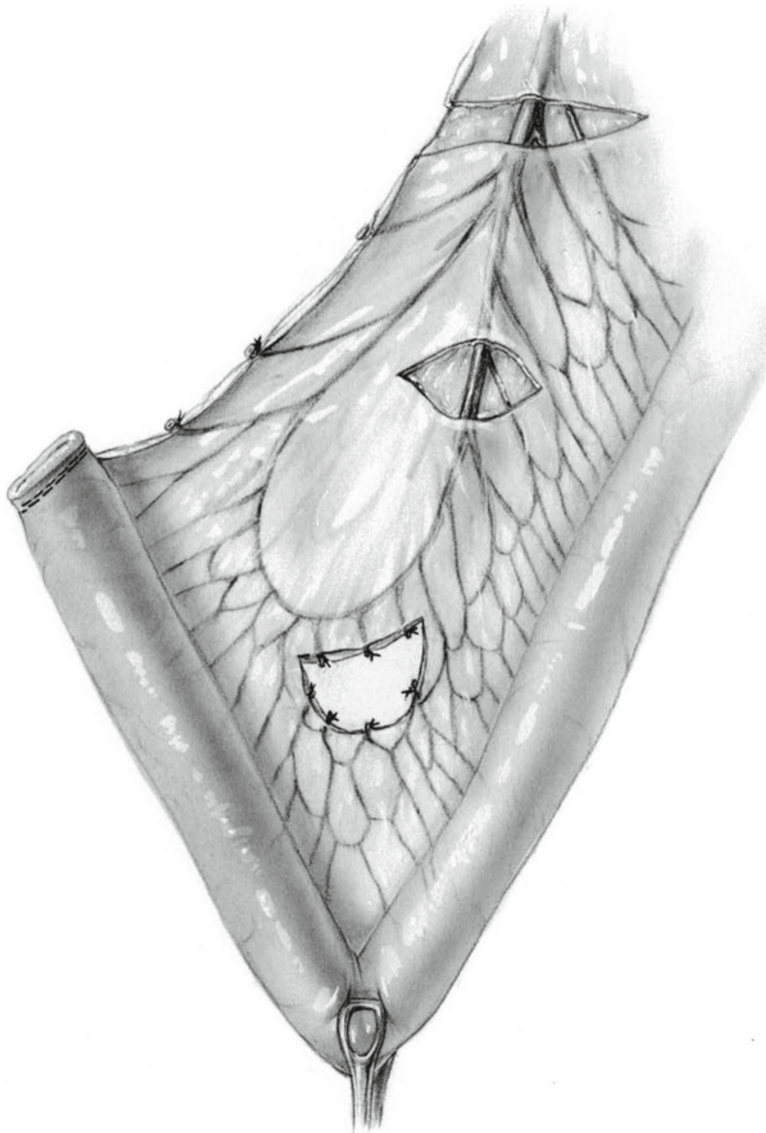
The ileal reservoir is now complete except for the remaining stab wound through which the stapling device was previously inserted. Apply Allis clamps to approximate, in a transverse direction, the walls of the ileum in preparation for transverse application of a 55/3.5 mm linear stapling device, which will accomplish everted closure of the defect. Be certain that the superior and inferior terminations of the previous staple lines are included in the stapler before firing it. Also, avoid the error of trying to fire the linear stapler when the two terminations of the previous staple lines are in exact apposition (see Figs. 49.21, 49.22, and 49.23). After firing the stapler, lightly electrocauterize the everted mucosa and carefully inspect the staple line to be sure of proper B formation (Fig. 57.9).

Alternatively, *sutures* may be used to construct the side-to-side anastomosis. Make longitudinal incisions along the antimesenteric borders of both the ascending and descending limbs of the ileum. Achieve hemostasis with electrocautery. Insert interrupted sutures to approximate the bowel walls at the proximal and distal margins of the anastomosis with 3-0 Vicryl sutures. Insert another suture at the midpoint between these two. Then use a straight atraumatic intestinal needle with 3-0 Vicryl starting at the apex of the posterior portion of the anastomosis and use a continuous locked suture, encompassing all the layers of the bowel. Accomplish closure of the anterior layer of the anastomosis by means of a continuous seromucosal or Lembert suture (see Figs. 4.13 and 4.14). Carefully inspect all aspects of the side-to-side anastomosis, both front and back, to be certain there are no defects or technical errors.

Ileoanal Anastomosis

Before passing the elbow of the ileal reservoir down through the anus, recheck the position of the pelvis and buttocks on the operating table. The perineum should project beyond the edge of the table. The simplest method for exposing the dentate line for the anastomosis is to insert two Gelpi retractors, one at right angles to the other. The prongs of the retractors should be inserted fairly close to the dentate line so the transected anorectal junction can be seen. Insert the first Gelpi retractor in the axis between 2 and 8 o'clock and the second between 5 and 11 o'clock. If exposure is not adequate, it may be helpful to readjust the stirrups so the thighs are flexed on

Fig. 57.6



the abdomen. This position makes it more convenient to apply retractors to the anus.

After making certain that hemostasis in the pelvis is complete, insert two long Babcock clamps through the anus and grasp the dependent portion of the ileal reservoir. Bring this segment of ileum into the anal canal. Be certain that the bowel has not been twisted during this maneuver and that the mesentery lies flat *without significant tension* on the planned anastomosis. Make a longitudinal incision along the dependent border of the ileal reservoir. Cauterize the bleeding points. Apply traction sutures to the incised ileum, one to each quadrant (Fig. 57.10). Construct a one-layer anastomosis between the ileum and the dentate line of the anus. Be sure to include in each stitch a 4 mm bite of underlying internal sphincter muscle as well as anal epithelium. Use atraumatic 4-0 PG or PDS sutures (Fig. 57.11). If the anal canal is deep, a double-curved Stratte needle holder is helpful. Insert the first four sutures at 12, 6, 3, and 9 o'clock. Then continue to insert sutures by the method of successive bisection (see Figs. 4.19 and 4.20). The resulting ileoanal anastomosis should be widely patent (Fig. 57.11). If desired, the ileal reservoir may now be inflated with a methylene blue solution to check for possible defects in the reservoir staple or suture lines. Figure 57.12 illustrates the completed anastomosis.

Loop Ileostomy

If there is the slightest concern about the integrity of the pelvic anastomoses, protect the pouch with a temporary diverting loop ileostomy (see Chap. 60). If the patient has a defect in the abdominal wall that remains after dismantling a previous ileostomy, it is generally possible to use the same site for

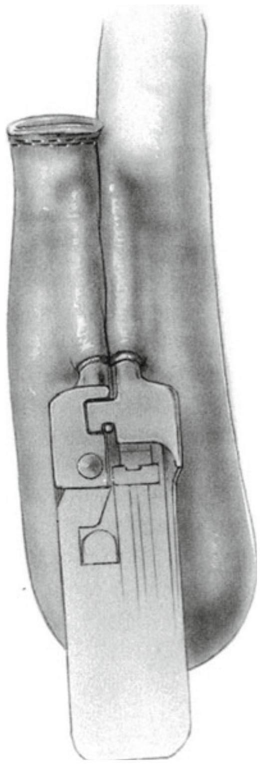


Fig. 57.7

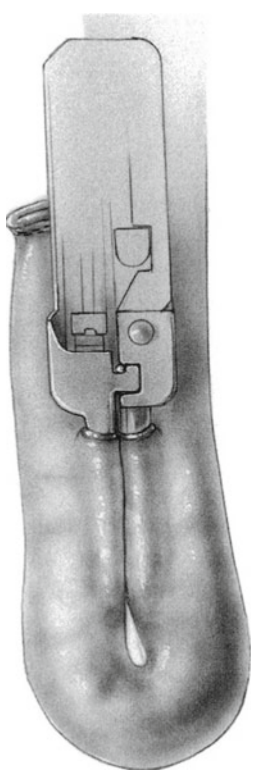


Fig. 57.8

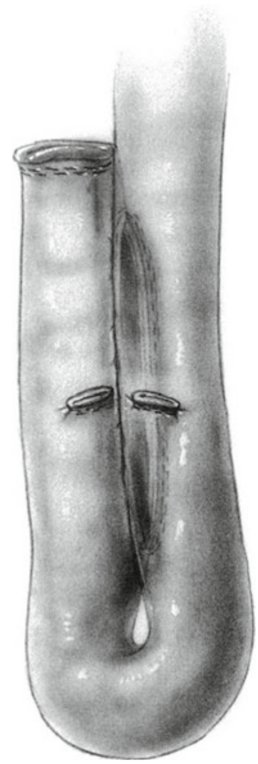


Fig. 57.9

the loop ileostomy. Insert a large Babcock clamp through the opening in the abdominal wall and grasp the antimesenteric aspect of a segment of ileum proximal to the ileal reservoir. Select a segment of ileum that does not exert any tension whatever on the ileal reservoir. Construct the loop ileostomy as described later (see Figs. 60.1, 60.2, 60.3, and 60.4).

Drainage and Closure

Hematoma or infection in the space between the rectal cuff and the ileal reservoir may produce fibrosis and impair fecal continence. Consequently, at this point in the operation, make every effort to achieve complete hemostasis in the rectal cuff and in the pelvis. Insert one or two Jackson-Pratt silicone closed-suction drains through puncture wounds in the abdominal wall down to the rectal cuff. Some believe it is important to place a layer of sutures between the proximal cut end of the rectal cuff and the ileal reservoir. Although we do not believe that these sutures can compensate for an inadequate ileoanal anastomosis, they may help prevent tension on the pouch.

Close the abdominal wall with interrupted No. 1 PDS by the modified Smead-Jones technique described in Chap. 3. Close the skin with interrupted fine nylon or skin staples. Then mature the loop ileostomy as described above if this step has not already been done.

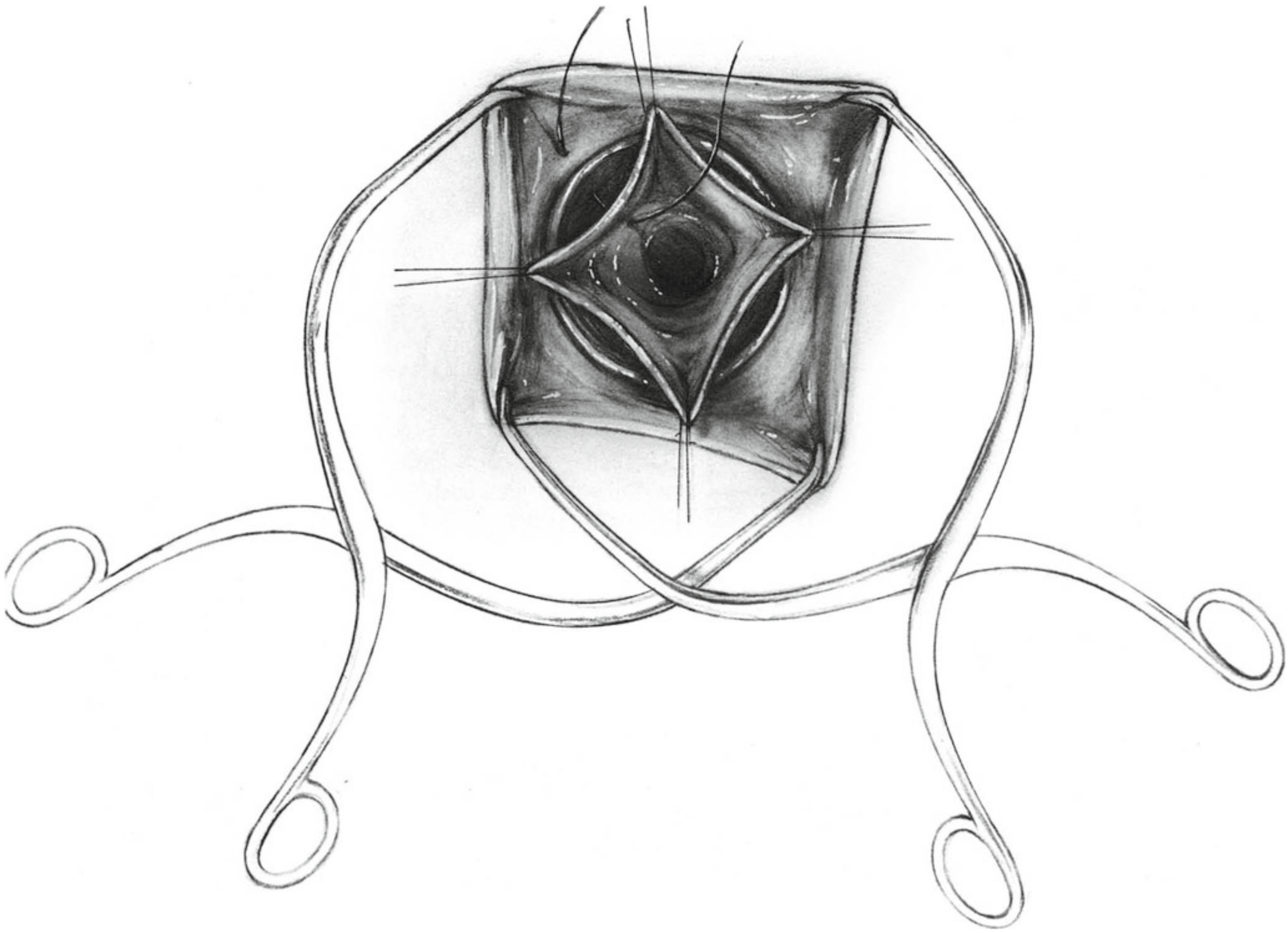


Fig. 57.10

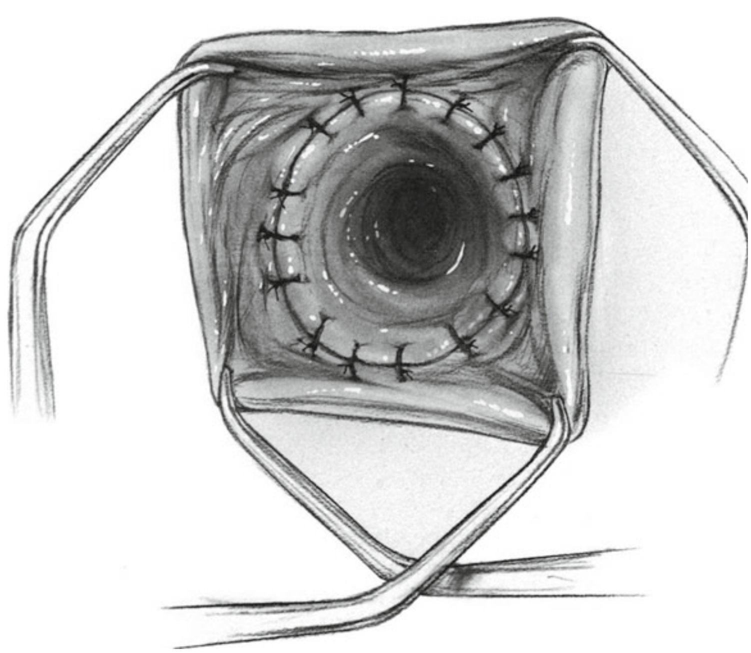


Fig. 57.11

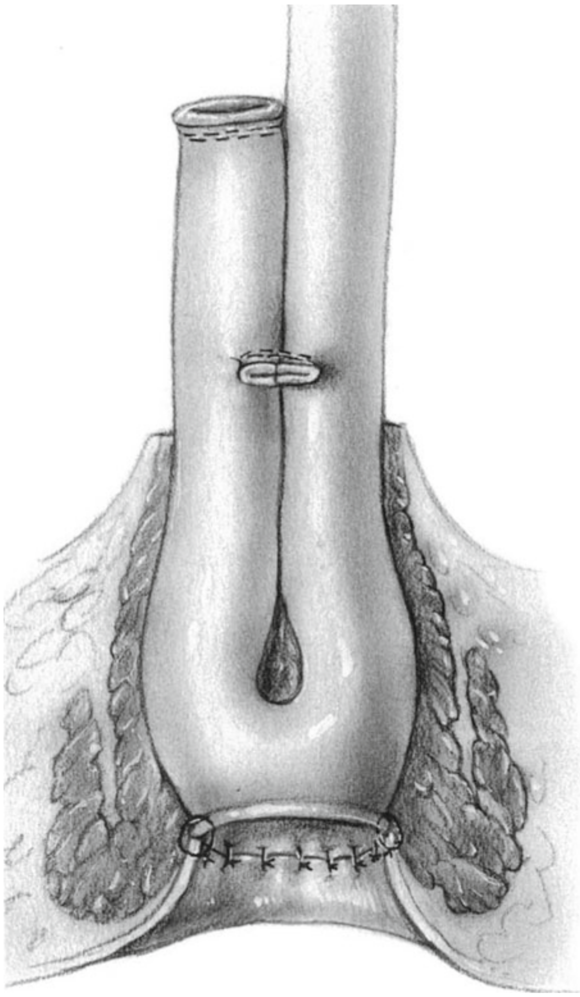


Fig. 57.12

Postoperative Care

Continue perioperative antibiotics for 24 h. Discontinue nasogastric suction as soon as possible. Remove the closed-suction drains from the pelvis between postoperative days 4 and 6, depending on the volume of drainage. (Inject 25 mg kanamycin in 25 ml saline into the drainage catheters every 8 h.)

Until the loop ileostomy is closed, perform weekly or biweekly digital examinations of the ileoanal anastomosis to prevent the development of a stricture. About 8 weeks following operation, rule out anastomotic defects by direct inspection and palpation. If there has been uneventful healing with no evidence of hematoma or sepsis in the pelvis, perform a barium enema to visualize the ileal reservoir. If both these procedures are negative, close the loop ileostomy. Following closure of the loop ileostomy, regulation of the bowel movements takes time and sometimes requires dietary adjustment and medication to achieve optimum continence.

Complications

An abscess may occur in the rectal cuff or pelvis. This complication has been reported during the early postoperative period and, remarkably, 2 and 6 months after operation in other cases. If the loop ileostomy is still in place, most cuff abscesses can be treated by drainage directly through the anastomosis. Pelvic abscesses may require laparotomy or computed tomography-guided percutaneous catheter insertion for drainage. With proper precautions postoperative sepsis is rare.

Hematoma in pelvis or in reservoir.

Anastomotic dehiscence or stricture.

Wound infection.

Urinary tract infection.

Excessive number of stools.

Fecal incontinence.

Pouchitis (more likely to occur in patients with inflammatory bowel disease). Treatment with metronidazole may be sufficient.

Pouch surveillance must be performed in patients with familial polyposis syndromes. Polyps have been known to form in the ileal reservoir.

Acute intestinal obstruction due to adhesions.

Further Reading

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Abdominoperineal Proctectomy for Benign Disease

58

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Inflammatory bowel disease, including ulcerative colitis and Crohn's colitis with intractable rectal involvement that precludes restorative proctocolectomy

Preoperative Preparation

See Chap. 57.

Pitfalls and Danger Points

Operative damage to or interruption of pelvic autonomic nerves in male patients, leading to sexual impotence or failure of ejaculation

Pelvis sepsis, especially in patients who have perineal fistulas

Inadequate management of perineal wound, resulting in a chronic perineal draining sinus

Operative Strategy

Abdominoperineal proctectomy is not a cancer operation. Resection should be conservative, and every attempt should be made to avoid damage to adjacent structures.

Transection of the hypogastric *sympathetic* nerve trunks that cross over the anterior aorta causes ejaculatory failure in men. Beyond the aortic bifurcation, these nerves diverge into two bundles going toward the region of the right and left hypogastric arteries, where they join the inferior hypogastric plexus on each side. The *parasympathetic* sacral autonomic outflow may be interrupted if the lateral ligaments are divided too far lateral to the rectum or if the nerve plexus between the rectum and prostate is damaged. Parasympathetic nerve damage results in failure of erection. Proper strategy requires that the mesentery in the region of the rectosigmoid be divided along a line just adjacent to the colon, leaving considerable fat and mesentery in the presacral space to protect the hypogastric nerves. The remainder of the pelvic dissection should be carried out as close to the rectum as possible, *especially in the region of the lateral ligaments and prostate*.

So long as there are no multiple perineal fistulas, it is generally possible to achieve primary healing of the perineum *if dead space between the closed levators and the peritoneal pelvic floor is eliminated*. Because there is no need for radical excision of the pelvic peritoneum, preserve as much of it as possible and mobilize additional pelvic peritoneum from the lateral walls of the pelvis and the bladder. If there is sufficient peritoneum to permit the pelvic peritoneal suture line to come down easily into contact with the reconstructed levator diaphragm, close this layer. Otherwise it is much better to leave the pelvic peritoneum entirely unsutured to permit the small bowel to fill this space. To aid in preventing perineal sinus formation due to chronic low-grade sepsis, insert closed-suction catheters into the presacral space and instill an antibiotic solution postoperatively.

Lyttle and Parks (1977) advocated *preservation of the external sphincter muscles*. They begin the perineal dissection with an incision near the dentate line of the anal canal and continue the dissection in the intersphincteric space between the internal and external sphincters of the anal canal. Thus the rectum is cored out of the anal canal, leaving the entire levator diaphragm and external sphincters intact. We have used this technique and found that it causes less operative trauma, minimizes dead space, and may further reduce the incidence of damage to the prerectal nerve plexus.

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Operative Technique

Abdominal Incision and Position

With the patient positioned on Lloyd-Davies leg rests, thighs abducted and slightly flexed, make a midline incision from the mid-epigastrium to the pubis (see Fig. 53.3a). If the patient has previously undergone subtotal colectomy with ileostomy and mucous fistula, free the mucous fistula from its attachments to the abdominal wall. Ligate the lumen with umbilical tape and cover it with a sterile rubber glove.

Mesenteric Dissection

Divide the mesentery between sequentially applied Kelly clamps along a line *close to the posterior wall* of the rectosigmoid. Continue the line of dissection well into the presacral space. This leaves a considerable amount of fat and mesentery behind to cover the bifurcation of the aorta and sacrum (Fig. 58.1). The fat and mesentery prevent injury to the hypogastric nerve bundles, which travel from the preaortic area down the promontory of the sacrum toward the hypogastric vessels on each side to join the hypogastric plexuses on each side (see Figs. 53.4 and 53.6).

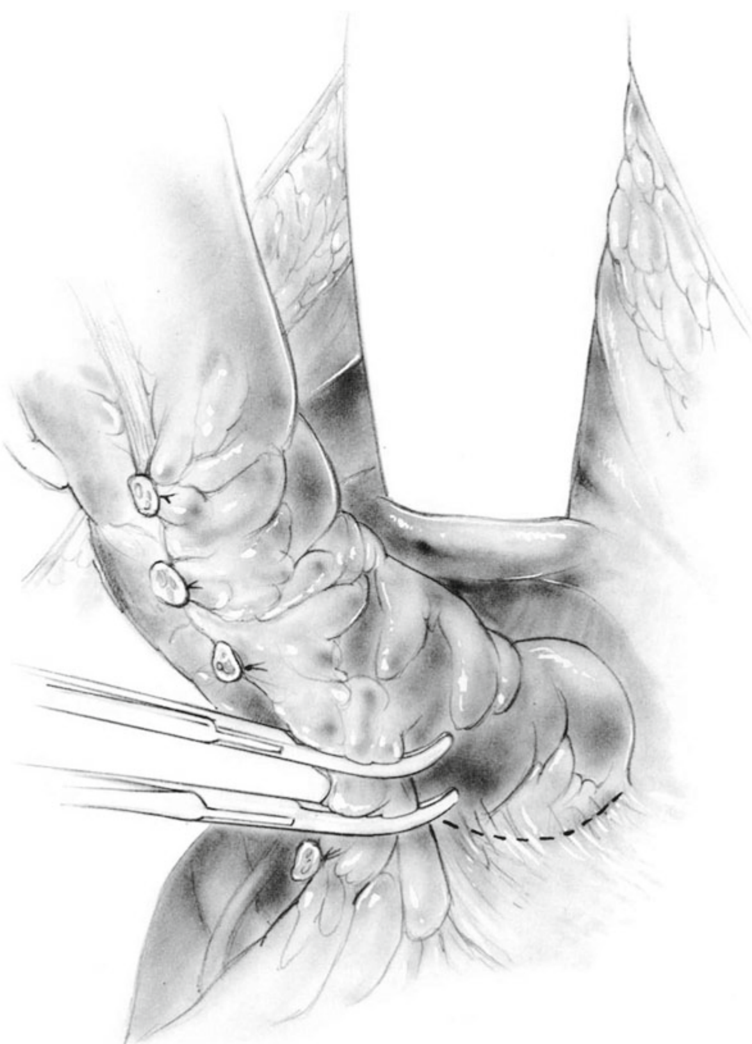

Fig. 58.1

Rectal Dissection

Incise the pelvic peritoneum along the line where the peritoneum joins the rectum, preserving as much peritoneum as possible. Accomplish this first on the right and then on the left side (see Fig. 53.5). Note the location of each ureter (see Fig. 53.6). Divide the posterior mesentery to the mid-sacral level. The posterior wall of rectum can now be seen, as at this point the blood supply of the rectum comes from the lateral wall of the pelvis. Elevate the rectum from the distal sacrum by blunt dissection and with Metzenbaum scissors incise Waldeyer's fascia close to the rectum. Draw the rectum in a cephalad direction and place the peritoneum of the rectovesical or rectouterine pouch on stretch. This peritoneum can now be divided easily with Metzenbaum scissors. Division of the lateral ligament can also be accomplished with good hemostasis by inserting a right-angle clamp underneath the ligament and dividing the overlying tissue with electrocautery (see Fig. 53.9).

With cephalad traction on the rectum and a Lloyd-Davies retractor holding the bladder forward, divide Denonvilliers' fascia at the level of the proximal portion of the prostate (see Fig. 53.11b). Keep the dissection *close to the anterior rectal wall*, which should be bluntly separated from the body of the prostate. In female patients, the dissection separates the rectum from the vagina. When the dissection has continued beyond the tip of the coccyx posteriorly and the prostate anteriorly, initiate the perineal dissection.

Perineal Incision

Close the skin of the anal canal with a heavy purse-string suture (Fig. 58.2). Then make an incision circumferentially in the skin just outside the sphincter muscles of the anus. Carry the dissection down *close* to the outer margins of the external sphincter to the levator muscles (Fig. 58.3). The inferior hemorrhoidal vessels are encountered running toward the rectum overlying the levator muscles. Occlude these vessels by electrocautery. After the incision has been deepened to the levators on both sides, expose the tip of the coccyx. Transect the anococcygeal ligament by electrocautery and enter the presacral space posteriorly. The fascia of Waldeyer, which attaches to the anterior surfaces of the lower sacrum and coccyx and to the posterior rectum, forms a barrier that blocks entrance into the presacral space from below even after the anococcygeal ligament has been divided.

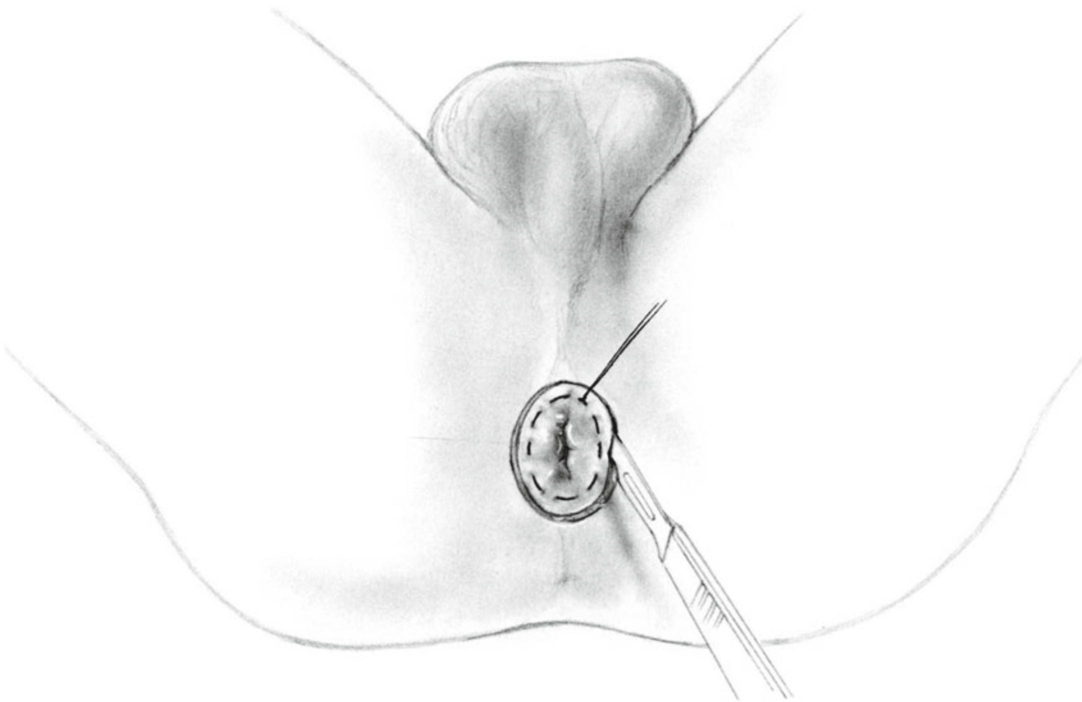

Fig. 58.2

If this fascia is elevated from the sacral periosteum by forceful blunt dissection in the perineum, venous bleeding and damage to the sacral neural components of the nervi erigentes may occur. Consequently, divide this *sharply* from above (Fig. 53.10) or below before an attempt is made to enter the presacral space from below.

Division of Levator Diaphragm

From the perineal approach, insert the left index finger into the opening to the presacral space and place it in the groove between the rectum and the levator muscles. Use electrocautery to divide the levators close to the rectum on either side. Then deliver the specimen from the presacral space down through the posterior perineum, so the anal canal is attached only anteriorly. Visualize the prostate gland. Using electrocautery, transect the puborectalis and rectourethralis muscles close to the anterior rectal wall. Carry this dissection down to the level of the prostate and remove the specimen.

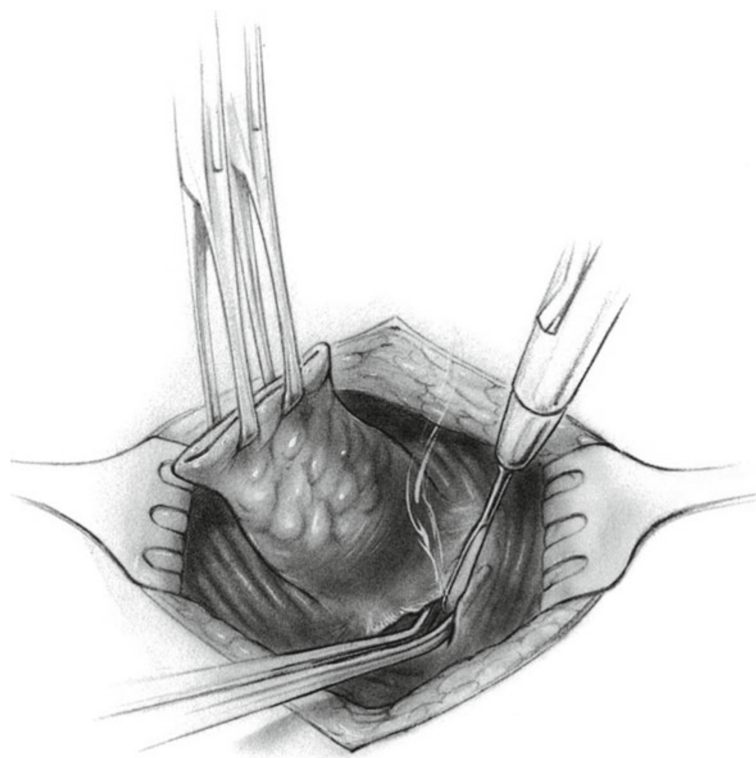

Fig. 58.3

Closure of Pelvic Floor

Insert one or two large (6 mm) plastic catheters through the skin of the perineum and the levator muscles into the presacral space for closed-suction drainage. Alternatively, these drains may be brought up from the presacral space into the pelvis and out through puncture wounds of the abdominal wall.

Close the defect in the levator diaphragm using interrupted sutures of 2-0 PG after thoroughly irrigating the pelvis with an antibiotic solution and achieving perfect hemostasis (Fig. 58.4). Close the skin with subcuticular sutures of 4-0 PG. Attach the catheters to suction for the remainder of the procedure while an assistant closes the peritoneum of the pelvic floor with continuous 2-0 PG sutures using the abdominal approach.

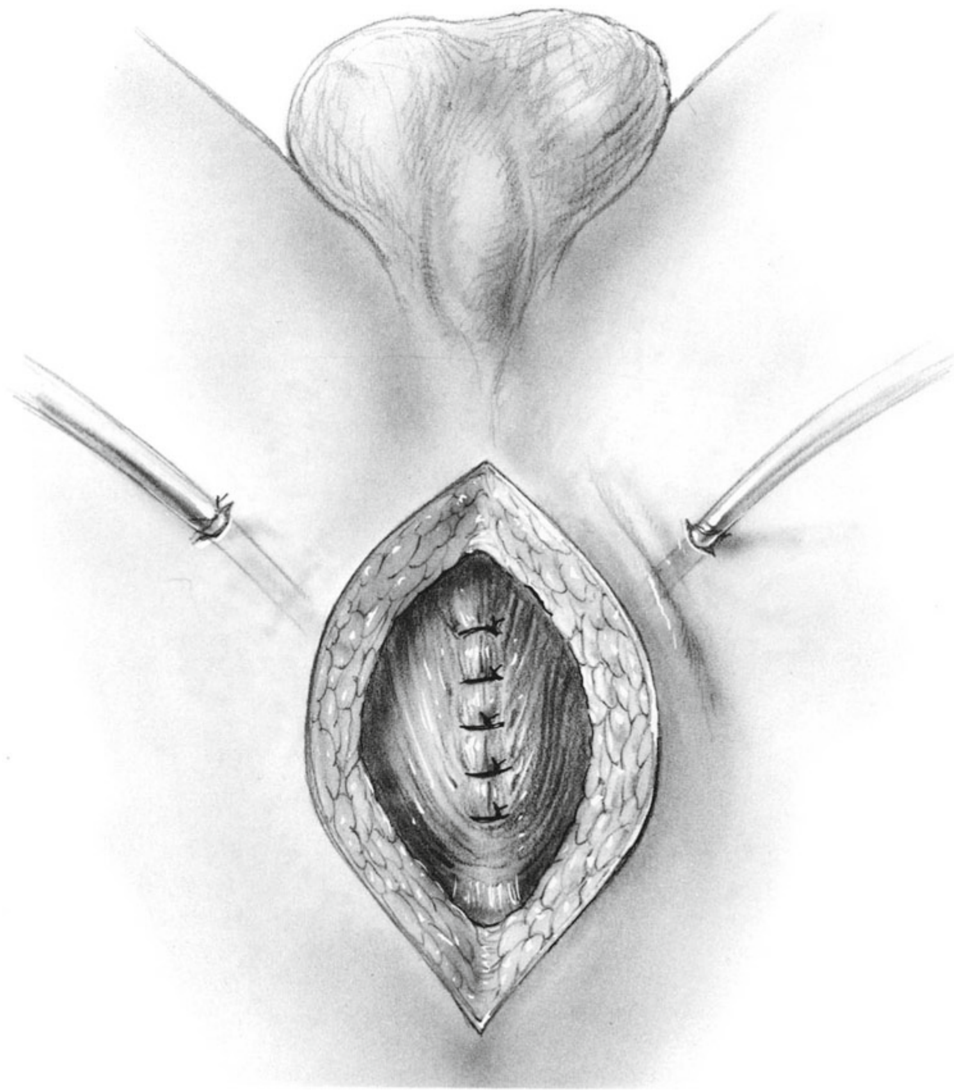

Fig. 58.4

Ileostomy

Choose a suitable site and construct a terminal ileostomy as described in Chap. 59 (if not already performed during a previous operation).

Abdominal Closure

After checking the integrity of the peritoneal pelvic suture line and making certain it is contiguous with the pelvic floor, irrigate the abdominal cavity and pelvis. Approximate the abdominal wall with interrupted sutures using the modified Smead-Jones technique.

Postoperative Care

See Chap. 54.

Complications

See Chap. 54.

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End Ileostomy

59

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

An end ileostomy is generally done in conjunction with a subtotal or total colectomy for inflammatory bowel disease. Continent alternatives (such as the Koch pouch) have been developed but generally superseded by ileoanal pouch procedures.

Occasionally, a temporary end ileostomy and mucous fistula of the distal end of the bowel are constructed after resection of a gangrenous segment of intestine or a perforated cecal lesion, when primary anastomosis is contraindicated.

Pitfalls and Danger Points

Devascularization of an excessive amount of terminal ileum, with resultant necrosis and stricture formation

Inadequate protrusion or recession of ileostomy, causing difficulties in fitting appliance

Ileocutaneous fistula resulting from a too deep stitch in the seromuscular layer of the ileum when fashioning the ileostomy

Operative Strategy

Prevention of peristomal skin excoriation (due to escape of small bowel contents underneath the faceplate of the ileostomy appliance) requires formation of a permanently protruding ileostomy. Properly performed, the ileostomy resembles the cervix of the uterus. A permanent protrusion of 2.0 cm is desirable, which allows for the likelihood that an underweight patient accumulates a subcutaneous layer of fat following successful surgery for colitis. To prevent herniation of the small bowel, close the gap between the cut edge of the ileum and the lateral abdominal wall when fashioning a permanent ileostomy. This step is also advisable when an end ileostomy is constructed as a possible temporary stoma.

Documentation Basics

- Findings, extent of resection
- Method of fixation of ostomy

Operative Technique

Preoperative Selection of Ileostomy Site

Apply the faceplate of an ileostomy appliance tentatively to various positions in the right lower quadrant of the patient to make sure it does not come into contact with the costal margin or the anterosuperior spine when the patient is in a sitting position. The faceplate should not extend beyond the midrectus line or the umbilicus. An enterostomal therapist can be of invaluable assistance during this planning phase. During emergency operations, when an ileostomy has not been contemplated, place the ileostomy approximately 5 cm to the right of the midline and about 4 cm below the umbilicus.

Incision

Because ileostomy generally is not the main part of the contemplated operation, a midline incision has already been made. Now make a circular incision in the previously selected site in the right lower quadrant and excise a circle of skin the diameter of a nickel (2 cm) (Fig. 59.1). The incision

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Fig. 59.1

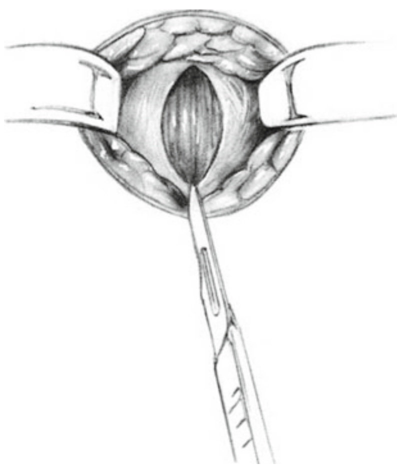

Fig. 59.2

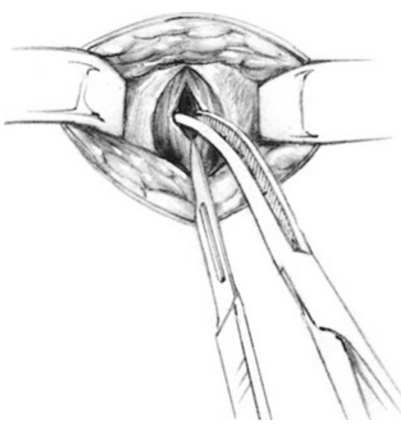

Fig. 59.3

then spontaneously stretches to the proper diameter. Make a linear incision down to the anterior rectus fascia and insert retractors to expose the fascia. Do not excise a core of subcutaneous fat unless the patient is significantly obese.

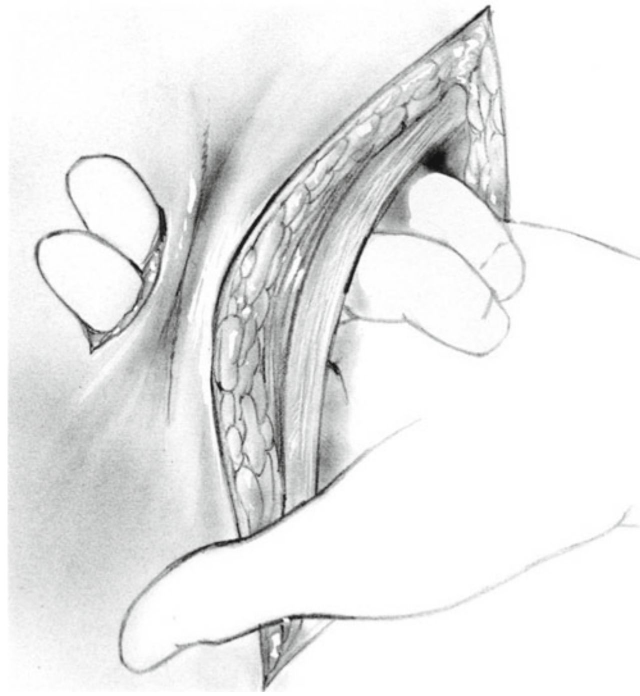

Fig. 59.4

Make a longitudinal 2 cm incision in the fascia, exposing the rectus muscle (Fig. 59.2). Separate the muscle fibers with a Kelly hemostat (Fig. 59.3) and make a longitudinal incision in the peritoneum. Then dilate the opening in the abdominal wall by inserting two fingers (Fig. 59.4).

Fashioning the Ileal Mesentery

At least 6–7 cm of ileum is required beyond the point at which the ileum meets the peritoneum if a proper ileostomy of the protruding type is to be made. More length may be required in the obese patient. If the entire mesentery is removed from this length of ileum, necrosis of the distal ileal mucosa takes place in many patients. Consequently, the portion of the ileum that passes through the abdominal wall must retain a sufficient width of mesentery to ensure vascularity. The "marginal" artery can be visualized in the mesentery within 2 cm of the ileal wall. Preserve this segment of vasculature while carefully dividing the mesentery. Complete removal of the mesentery is well tolerated at the distal 2–3 cm of the ileum.

Closure of Mesenteric Gap

Insert a Babcock clamp into the abdominal cavity through the opening made for the ileostomy. Grasp the terminal ileum with the clamp and gently bring it through this opening, with

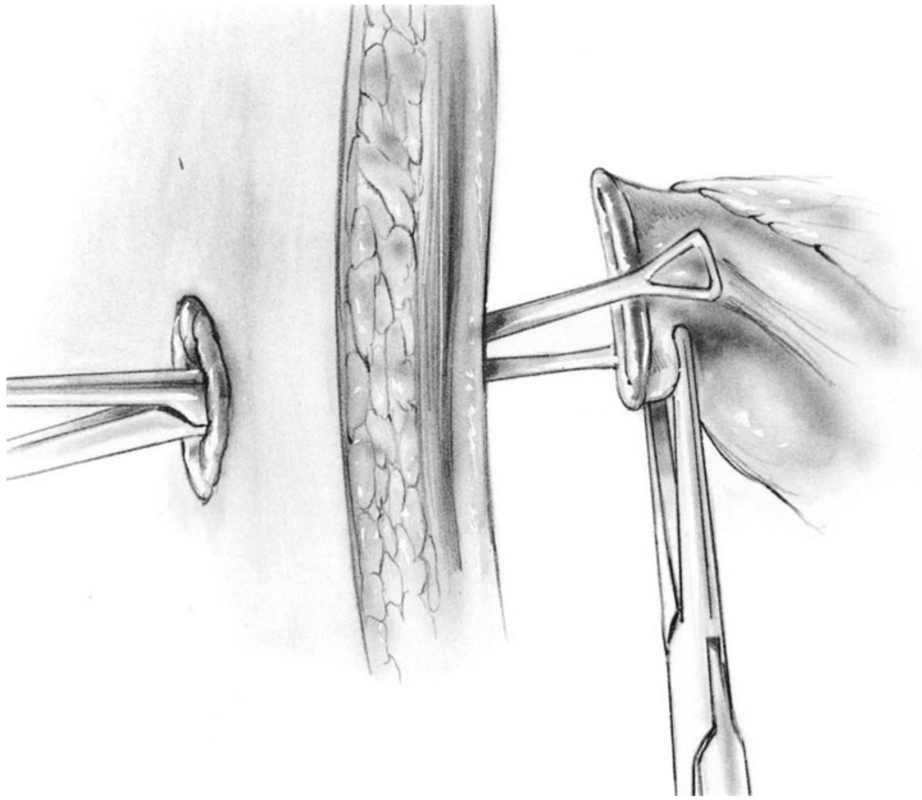

Fig. 59.5

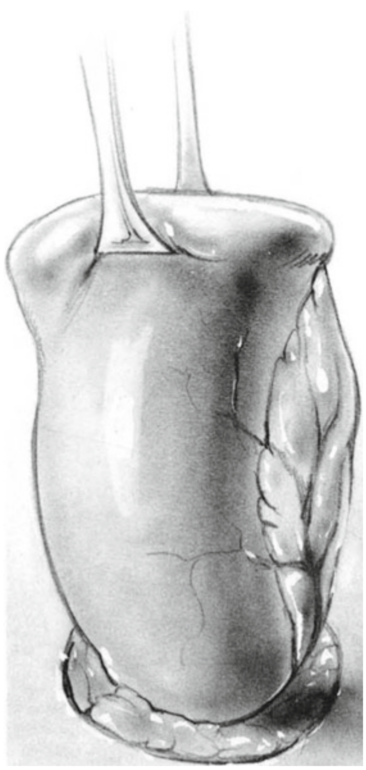

Fig. 59.6

the mesentery placed in a cephalad direction (Fig. 59.5). Place no sutures between the ileum and the peritoneum or the rectus fascia (Fig. 59.6).

Using a continuous 2-0 PG suture, suture the cut edge of the ileal mesentery to the cut edge of the paracolic peritoneum. This maneuver completely obliterates the mesenteric defect (Fig. 59.7).

Mucocutaneous Fixation of Ileostomy

Construct a "cervix" by inserting interrupted 4-0 PG sutures through the full thickness of the terminal ileum; then, using the same needle, take a shallow seromuscular bite of the lateral wall of the ileum, which is situated opposite the level of the skin. Complete the suture by taking a bite of the subcuticular layer of skin (Fig. 59.8). Temporarily hold the stitch in a hemostat and place identical stitches in each of the other quadrants of the ileostomy. After all the sutures have been inserted, tighten them gently to evert the ileum (Fig. 59.9). Then tie the sutures. Place one additional suture of the same type between each of the four quadrant sutures, completing the mucocutaneous fixation.

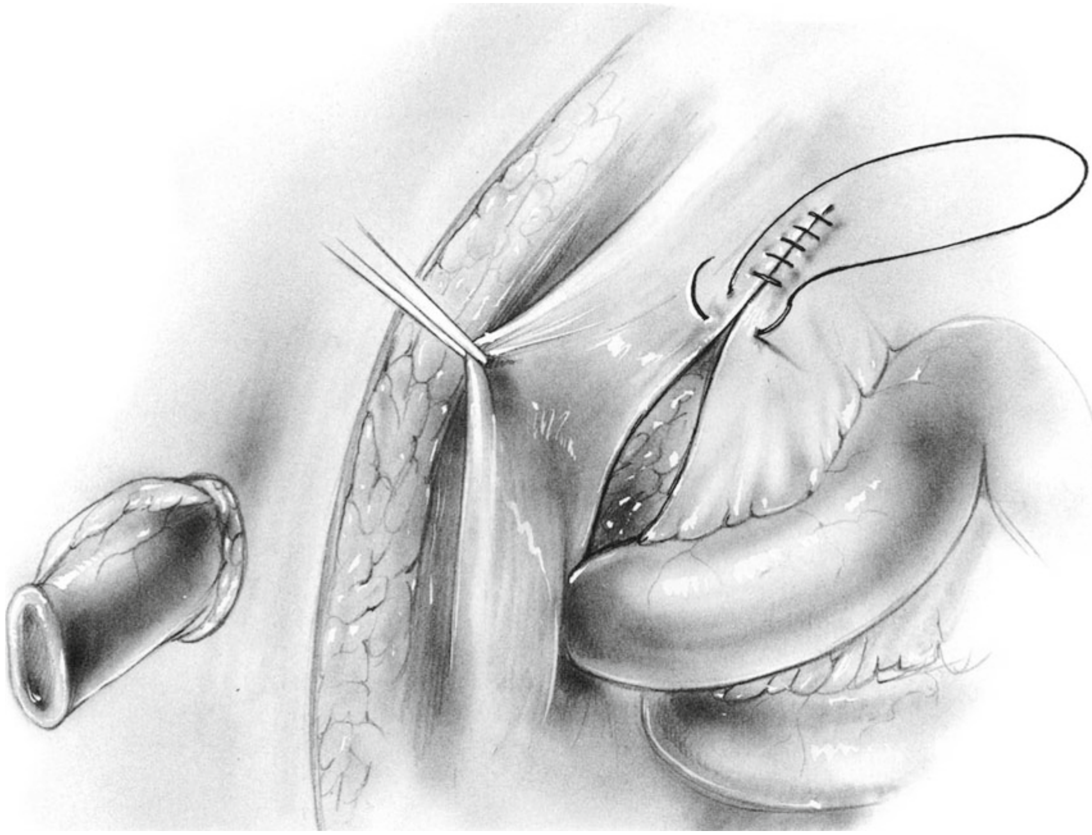

Fig. 59.7

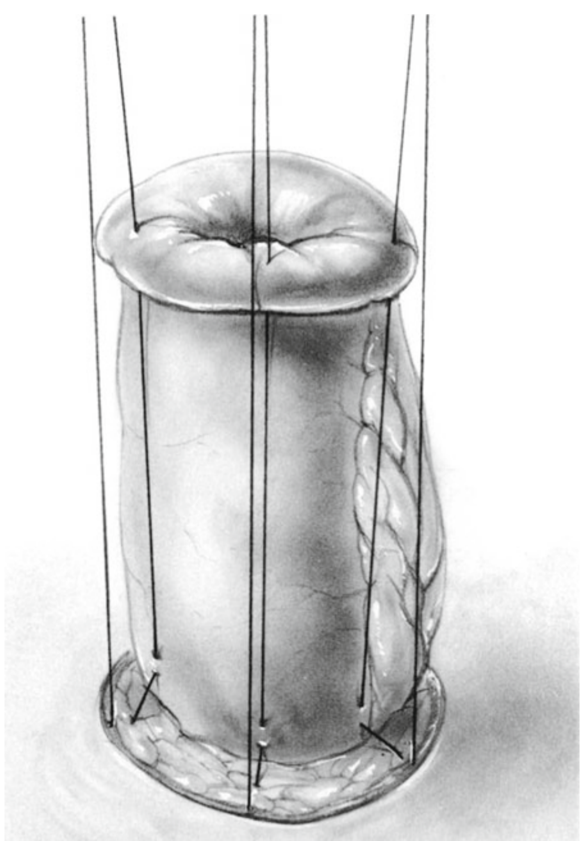

Fig. 59.8

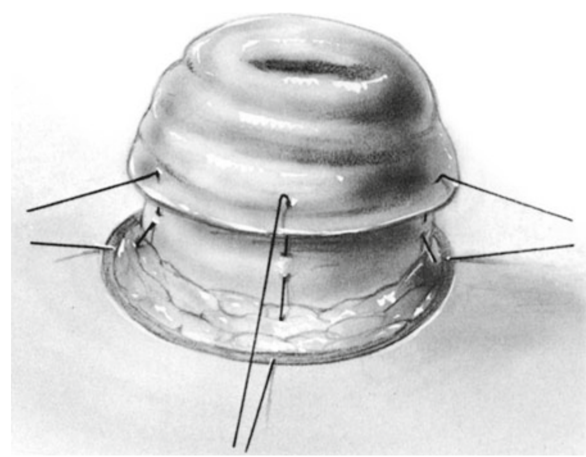

Fig. 59.9

Postoperative Care

Nasogastric suction may be required, depending on the nature of the primary procedure.

Prescribe perioperative antibiotics.

Apply a stomahesive disk to the ileostomy in the operating room; place an ileostomy bag over the disk.

Instruct the patient in ileostomy care.

Complications

Early Problems
- Occasional necrosis of the distal ileum (although rare when good technique is used)
- Peristomal infection or fistula

Late Problems
- Prolapse of ileostomy
- Stricture of ileostomy
- Obstruction of ileostomy due to food fiber
- Peristomal skin ulceration

Further Reading

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Loop Ileostomy

60

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Loop ileostomy is performed when temporary diversion of the fecal stream is required. It may be used to protect a tenuous colon anastomosis or as part of the initial treatment of severe inflammatory bowel disease.

In some patients loop ileostomy is easier to construct than end ileostomy. It allows better preservation of the blood supply to the stoma.

Pitfalls and Danger Points

If the ileum is not transected at the proper point to make the proximal stoma the dominant one, total fecal diversion is not accomplished.

See Chap. 59.

Operative Strategy

Properly performed, this technique is a good method for achieving temporary but complete diversion of the intestinal contents. Because the entire mesentery is preserved, the blood supply to the stoma is optimized. Closure can be accomplished by a local plastic procedure or by local resection and anastomosis.

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Documentation Basics

Findings and indications

Operative Technique

If a loop ileostomy is being performed as a primary procedure, a midline incision beginning at the umbilicus and proceeding caudally for 8–10 cm is adequate. Identify the distal ileum and the segment selected for ileostomy by applying a single marking suture to that segment of the ileum that will form the *proximal* limb of the loop ileostomy. This procedure can also be performed laparoscopically (see Chap. 64 and references at end).

Select the proper site in the right lower quadrant (see Chap. 59) and excise a nickel-size circle of skin. Expose the anterior rectus fascia and make a 2 cm longitudinal incision in it (see Fig. 59.1). Separate the rectus fibers with a large hemostat and make a similar vertical incision in the peritoneum (see Figs. 59.2 and 59.3). Then stretch the ileostomy orifice by inserting two fingers (see Fig. 59.4).

After this step has been accomplished, insert a Babcock clamp through the aperture into the abdominal cavity. Arrange the ileum so the proximal segment emerges on the cephalad side of the ileostomy. Then grasp the ileum with the Babcock clamp and deliver it through the abdominal wall with the aid of digital manipulation from inside the abdomen. The proximal limb should be on the cephalad surface of the ileostomy.

Confirm that there is no tension whatever on any distal anastomosis (Fig. 60.1). Position the ileum so the afferent or proximal limb of ileum enters the stoma from its cephalad aspect and the distal ileum leaves the stoma at its inferior aspect. To ensure that the proximal stoma dominates the distal stoma and completely diverts the fecal stream, transect the anterior half of the ileum at a point 2 cm distal to the apex of the loop (Fig. 60.2). Then evert the ileostomy (Fig. 60.3). Insert interrupted atraumatic sutures of 4-0 PG

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Fig. 60.1

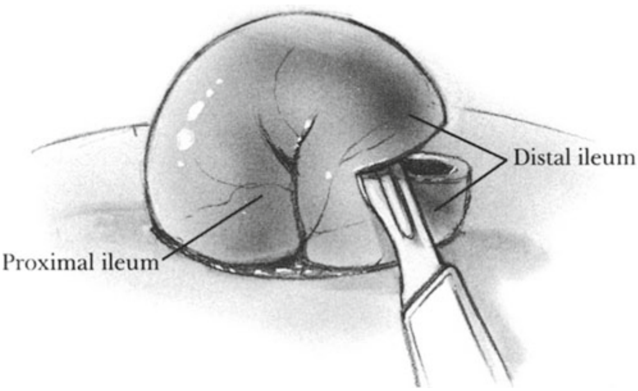

Fig. 60.2

to approximate the full thickness of the ileum to the subcuticular portion of the skin. The end result should be a dominant proximal stoma that compresses the distal stoma (Fig. 60.4). We do not suture the ileum to the peritoneum or fascia.

To minimize contamination of the abdominal cavity, it is possible to deliver the loop of ileum through the abdominal wall and then pass a small catheter around the ileum and through the mesentery to maintain the position of the ileum. Division of the ileum and suturing of the ileostomy may be postponed until the abdominal incision has been completely closed. After suturing the ileum to the subcutis, remove the catheter.

Close the abdominal wall with interrupted No. 1 PDS sutures by the modified Smead-Jones technique described in Chap. 3. Close the skin with interrupted fine nylon or skin staples. Then mature the loop ileostomy as described above if this step has not already been done.

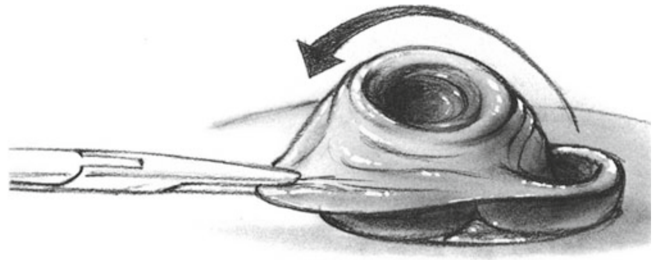

Fig. 60.3

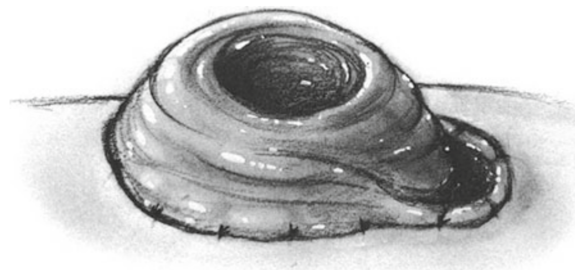

Fig. 60.4

Postoperative Care

See Chap. 59.

Complications

See Chap. 59.

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Cecostomy: Surgical Legacy Technique

61

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Cecostomy is an alternative to resection when there is impending perforation of the cecum secondary to a colonic obstruction or ileus. Colonoscopic decompression is a better alternative for cases of pseudo-obstruction. Cecostomy is used only when other methods have failed.

Preoperative Preparation

Perioperative antibiotics
Nasogastric suction
Fluid resuscitation

Pitfalls and Danger Points

Cecostomy may fail to produce adequate decompression.
Limited exploration through a small incision may miss an area of perforation elsewhere.
Fecal matter may spill into the peritoneal cavity.

Operative Strategy

There are two kinds of cecostomy. A simple tube cecostomy is constructed in a manner analogous to a Stamm gastrostomy (see Chap. 36). Even a large tube is easily plugged by fecal debris, and this kind of cecostomy primarily allows decompression of gas and liquid. The main advantage of tube cecostomy is that when the cecostomy is no longer needed, removing the tube frequently results in spontaneous closure. The skin-sutured cecostomy described here provides more certain decompression but requires formal closure. In the attempt to avoid fecal contamination of the abdominal cavity during this operation, the cecum is sutured to the external oblique aponeurosis before being incised.

Documentation Basics

Indications and findings

Operative Technique

Skin-Sutured Cecostomy

Incision

Make a transverse incision about 4–5 cm long over McBurney's point and carry it in the same line through the skin, external oblique aponeurosis, the internal oblique and transversus muscles, and the peritoneum. Do not attempt to split the muscles along the line of their fibers.

Exploration of Cecum

Rule out patches of necrosis in areas beyond the line of incision by carefully exploring the cecum. To accomplish this without the danger of rupturing the cecum, insert a 16-gauge needle attached to an empty 50 cc syringe, which releases some of the pressure. After this has been accomplished, close the puncture wound with a fine suture. Elevate the abdominal wall with a retractor to expose the anterior and lateral walls of the cecum. If the exposure is inadequate, make a larger incision. If a necrotic patch of cecum can be identified, use this region as the site for the cecostomy and excise it during the procedure.

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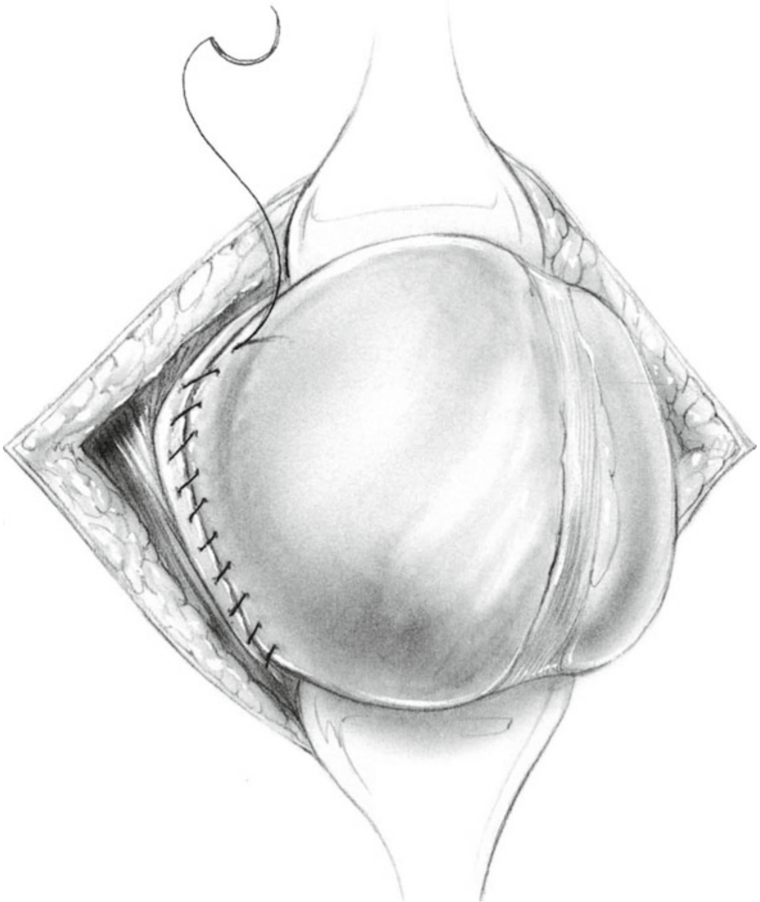

Fig. 61.1

Fig. 61.2

Cecal Fixation

Suture the wall of the cecum to the external oblique aponeurosis with a continuous 4-0 PG suture on a fine needle to prevent any fecal spillage from reaching the peritoneal cavity (Fig. 61.1). If the incision in the external oblique aponeurosis

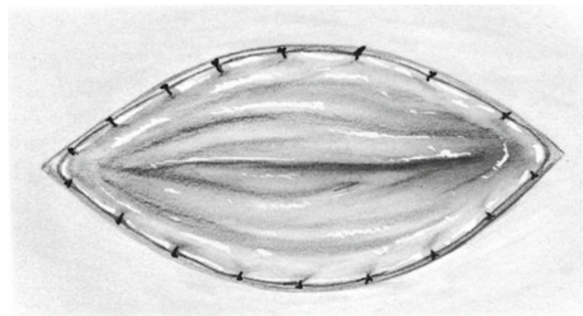

Fig. 61.3

is longer than 4–5 cm, narrow it with several PG sutures. Narrow the skin incision also to the same length with several fine PG subcuticular sutures.

Mucocutaneous Suture

Make a transverse incision in the anterior wall of the cecum 4 cm long (Fig. 61.2) and aspirate liquid stool and gas. Then suture the full thickness of the cecal wall to the subcuticular layer of the skin with a continuous or interrupted suture of 4-0 PG on an atraumatic needle (Fig. 61.3). Place a properly fitted ileostomy bag over the cecostomy at the conclusion of the operation.

Tube Cecostomy

The abdominal incision and exploration of the cecum for a tube cecostomy are identical to those done for a skin-sutured cecostomy. Insert a purse-string suture in a circular fashion on the anterior wall of the cecum using 3-0 atraumatic PG. The diameter of the circle should be 1.5 cm. Insert a second purse-string suture outside the first, using the same suture material. Then make a stab wound in the middle of the purse-string suture; insert a 36 F soft rubber tube into the suture and for about 5–6 cm into the ascending colon. Tie the first purse-string suture around the rubber tube; then tie the second purse-string suture so as to invert the first. It is helpful if several large side holes have been cut first in the distal 3–4 cm of the rubber tube.

Select a site about 3 cm above the incision for a stab wound. Bring out the rubber tube through this stab wound and suture the cecum to the peritoneum around the stab wound. Use four interrupted 3-0 PG atraumatic sutures to keep the peritoneal cavity free of any fecal matter that may leak around the tube.

Close the abdominal incision in a single layer by the modified Smead-Jones technique using interrupted 1-0 PDS sutures. Do not close the skin wound; insert several 4-0 nylon interrupted skin sutures, which will be tied 3–5 days after operation.

Postoperative Care

Manage the skin-sutured cecostomy in the operating room by applying an adhesive-backed ileostomy-type disposable plastic appliance to it. The tube cecostomy requires repeated irrigation with saline to prevent it from being plugged by fecal particles. It may be removed after the tenth postoperative day if it is no longer needed.

Complications

The major postoperative complication of this procedure is peristomal sepsis, as the possibility of bacterial contamination of the abdominal incision cannot be completely eliminated. Nevertheless, peristomal sepsis is much less common than one would anticipate with an operation of this type.

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Transverse Colostomy

62

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Relief of obstruction due to lesions of the left colon
Diversion of fecal stream
Complementary to left colon anastomosis (largely superceded by loop ileostomy for this purpose)

Preoperative Preparation

Before performing a colostomy for colonic obstruction, confirm the diagnosis by barium enema, colonoscopy, or computed tomography (CT) of the abdomen.
Use a preoperative flat radiograph of the abdomen to identify the position of the transverse colon relative to a fixed point, such as a coin placed over the umbilicus.
Apply fluid resuscitation.
Place a nasogastric tube.
Prescribe perioperative antibiotics.

Pitfalls and Danger Points

Performing colostomy in error for diagnoses such as fecal impaction or pseudo-obstruction (which might respond to nonoperative management).
Be certain the "ostomy" is, in fact, being constructed in the transverse colon, not in the redundant sigmoid colon, jejunum, or even the gastric antrum.
With advanced colonic obstruction, be aware of the possibility of impending cecal rupture for which transverse colostomy is an inadequate operation unless the cecum is seen to be viable.

Operative Strategy

Choice of Procedure

Loop ileostomy is a better alternative for many patients. When a temporary ostomy is required as an isolated procedure, laparoscopic (rather than open) construction may be feasible. The application of laparoscopic techniques may be limited if significant bowel distension or hemodynamic instability exists. See references at the end of this chapter.

Impending Rupture of Cecum

For routine cases of left colon obstruction, with the diagnosis confirmed by barium enema radiography, the colon may be approached through a small transverse incision in the right rectus muscle. This incision should be made for the colostomy alone; the rest of the abdominal cavity does not have to be explored. Exceptions to this policy should be made for patients with a sigmoid volvulus, those suspected to have ischemic colitis or perforation, and those in whom an advanced obstruction threatens cecal rupture.

When impending rupture is suspected, direct visual inspection of the cecum is mandatory. This may be accomplished with a midline laparotomy incision or a transverse right lower quadrant incision made over the cecum. Cecal necrosis or perforation mandates resection, usually with ileostomy and mucous fistula.

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Diversion of Fecal Stream

Contrary to widespread medical opinion, it is not necessary to construct a double-barreled colostomy with complete transection of the colon to divert the stool from entering the left colon. A long (5 cm) longitudinal incision on the antimesenteric wall of the transverse colon, followed by immediate maturation, allows fecal diversion due to prolapse of the posterior wall. This results in functionally separate distal and proximal stomas. If concern about adequacy of diversion persists, a stapler can be fired across the distal segment (but this will require resection and anastomosis for closure).

Documentation Basics

- Findings and indications
- Stapled across distal end or not?

Operative Technique

Incision

Make a transverse incision over the middle and lateral thirds of the upper right rectus muscle (Fig. 62.1). Ideally the length of the skin incision equals the length of the longitudinal incision to be made in the colon (5–6 cm). To accomplish this, it is necessary to identify the level at which the transverse colon crosses the path of the right rectus muscle. It may be done on a preoperative flat radiograph of the abdomen, followed by confirmation using percussion of the upper abdomen in the operating room. Make the transverse incision sufficiently long to accomplish accurate identification of the transverse colon. The incision will be partially closed, leaving a 5-cm gap to accommodate the colostomy.

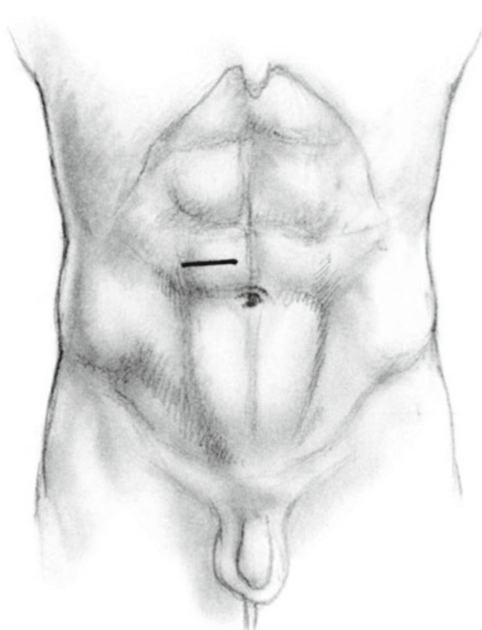

Fig. 62.1

When the transverse colostomy is to precede a subsequent laparotomy for removal of colon pathology, begin the transverse incision 2 cm to the right of the midline and extend it laterally. If this is done, the colostomy does not prevent the surgeon from using a long midline incision for the second stage of the operation.

After the skin incision is made, incise the anterior rectus fascia with a scalpel. Insert a Kelly hemostat between the muscle belly and the posterior rectus sheath. Incise the rectus muscle transversely over the hemostat with coagulating electrocautery for a distance of 6 cm. Then enter the abdomen in the usual manner by incising the posterior rectus sheath and peritoneum.

Identification of Transverse Colon

Even though the transverse colon is covered by omentum, in the average patient the omentum is thin enough that the colon can be seen through it. Positive identification can be made by observing the taenia. Divide the omentum for 6–7 cm over the colon. If colon is not clearly visible, extend the length of the incision.

Exteriorize the omentum and draw it in a cephalad direction; its undersurface leads to its junction with the transverse colon. At this point, make a window in the overlying omentum so the transverse colon may protrude through the incision. Then replace the omentum into the abdomen.

Immediate Maturation of Colostomy

In patients with colon obstruction, the transverse colon is often so tensely distended; it is difficult to deliver the anterior wall of the colon from the abdominal cavity without causing damage. To solve this problem, apply two Babcock clamps 2 cm apart to the anterior wall of the transverse colon. Insert a 16-gauge needle attached to a low-pressure suction line into the colon between the Babcock clamps (Fig. 62.2). After gas has been allowed to escape through the needle, the colon can be exteriorized easily.

The incision in the abdominal wall should be about 6 cm long. If it is longer than 6 cm, close the lateral portion with interrupted No. 1 PDS sutures of the Smead-Jones type. Shorten the skin incision with interrupted 4-0 nylon skin sutures as needed.

Make a 5- to 6-cm longitudinal incision along the anterior wall of the colon, preferably in the taenia (Fig. 62.3). Aspirate the bowel gas. Irrigate the operative field with 0.1 % kanamycin solution. Then suture the full thickness of the colon wall to the *subcuticular* layer of the skin with 4-0 PG sutures, either interrupted or continuous (Fig. 62.4). Attach a disposable ileostomy or colostomy bag to the colostomy.

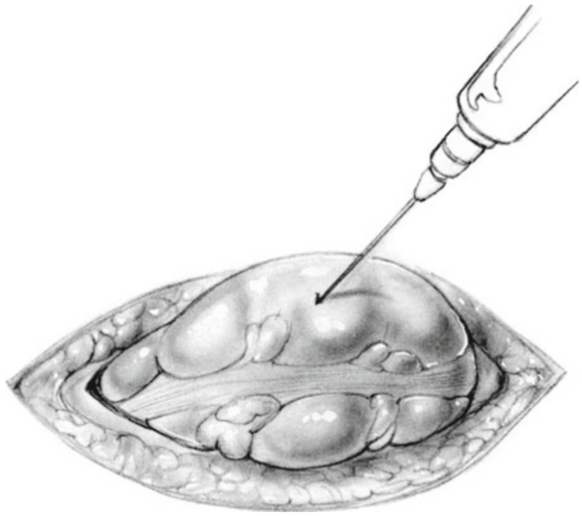

Fig. 62.2

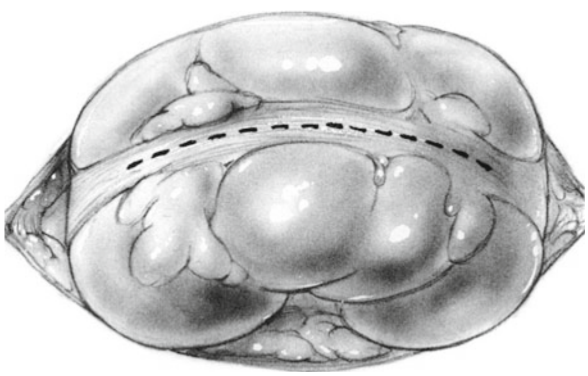

Fig. 62.3

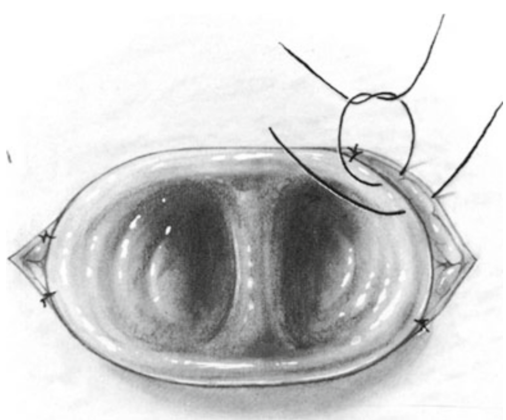

Fig. 62.4

Modification of Technique Using a Glass Rod

We prefer not to interrupt the suture line between the colon and skin by use of a glass rod or ostomy bridge. In markedly obese patients who have a short mesentery, a modified glass rod technique may be used to prevent retraction while keeping the colocutaneous suture line intact. Make a stab wound through the skin at a point about 4 cm caudal to the midpoint of the proposed colostomy. By blunt dissection pass a glass or plastic rod between the subcutaneous fat and the anterior rectus fascia, proceeding in a cephalad direction. Pass the rod deep to the colon and have it emerge from a second stab wound 4 cm cephalad to the colostomy (Fig. 62.5). This technique permits the subcutaneous fat to be protected from postoperative contamination by stool and greatly simplifies application of the colostomy bag.

An alternative to the solid rod is a thick Silastic tube, 6 mm in diameter, such as a nonperforated segment of a closed-suction drain tube. We prefer this method because it produces minimal inflammatory tissue response. However, because this tube is soft, it must be fixed to the skin of the two stab wounds with nylon sutures.

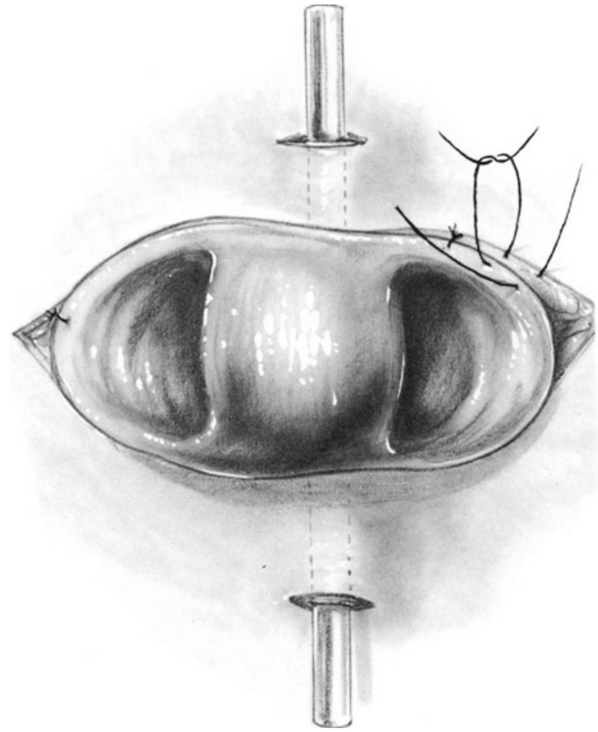

Fig. 62.5

Stapled Distal Segment

In some cases where absolute certainty about fecal diversion is desired, the surgeon may choose to fire a linear non-cutting stapler across the distal colon. This will require resection and anastomosis for colostomy closure, but provides the best assurance complete diversion. Be absolutely certain as to orientation of bowel loop, as stapling the proximal segment would be disastrous, and document the staple line in the operative note to inform surgeon at time of closure.

Postoperative Care

In the operating room, apply a plastic disposable adhesive-type colostomy bag.

Apply nasogastric suction until the colostomy functions.

Complications

Peristomal sepsis is surprisingly uncommon. Treatment requires local incision and drainage. Massive sepsis would require moving the colostomy to another site.

Prolapse of the defunctionalized limb is fairly common when a loop colostomy is allowed to remain for months or years. It is managed by resection of the colostomy with restoration of gastrointestinal continuity or conversion to an end colostomy. Careful tacking of both limbs at the peritoneal level helps prevent this complication but renders mobilization and subsequent closure more difficult.

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Closure of Temporary Loop Colostomy or Ileostomy

63

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

A temporary ostomy should be closed when it is no longer needed. Anastomotic healing and absence of a distal obstruction should be demonstrated by contrast studies. Loop ostomies may be closed by the techniques described in this chapter.

Preoperative Preparation

Barium colon enema radiography to demonstrate patency of distal colon and integrity of any distal anastomoses.
Nasogastric tube is optional.
Routine mechanical and antibiotic bowel preparation (saline enemas to cleanse the inactivated left colon segment may be required as well).
Perioperative systemic antibiotics.

Pitfalls and Danger Points

Suture-line leak
Intra-abdominal abscess
Wound abscess

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Operative Strategy

To avoid suture-line leakage, use only healthy, well-vascularized tissue for ostomy closure. Adequate lysis of the adhesions between the transverse colon and surrounding structures allows a sufficient segment of transverse colon to be mobilized, avoiding tension on the suture line. If necessary, the incision in the abdominal wall should be enlarged to provide exposure. If the tissue in the vicinity of the colostomy has been devascularized by operative trauma, do not hesitate to resect a segment of bowel and perform an end-to-end anastomosis instead of a local reconstruction. Proper suturing or stapling of healthy colon tissue and minimizing fecal contamination combined with perioperative antibiotics help prevent formation of abscesses. These same principles apply for closure of a loop ileostomy.

Infection of the operative incision is rather common following colostomy closure, owing in part to failure to minimize the bacterial inoculum into the wound. Another phenomenon that contributes to wound infection is retraction of subcutaneous fat that occurs around the colostomy. This can produce a gap between the fascia and the epidermis when the skin is sutured closed, creating dead space. Avoid this problem by leaving the skin open at the conclusion of the operation.

Operative Technique

Incision

Throughout this chapter, transverse colostomy closure is described and illustrated. The same principles apply for closure of a loop ileostomy.

Occlude the colostomy by inserting small gauze packing moistened with povidone-iodine solution. Make an incision in the skin around the colostomy 3–4 mm from the mucocutaneous junction (Fig. 63.1). Continue this

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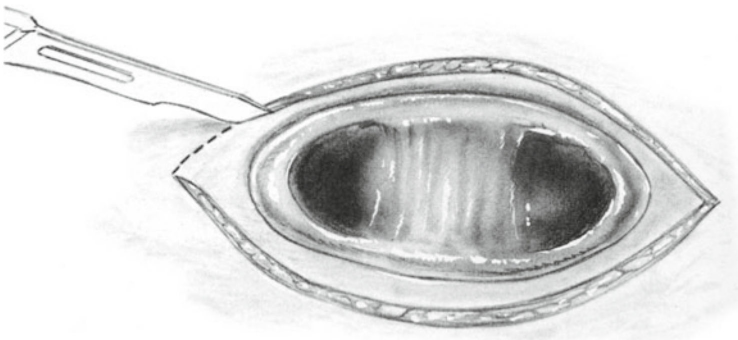

Fig. 63.1

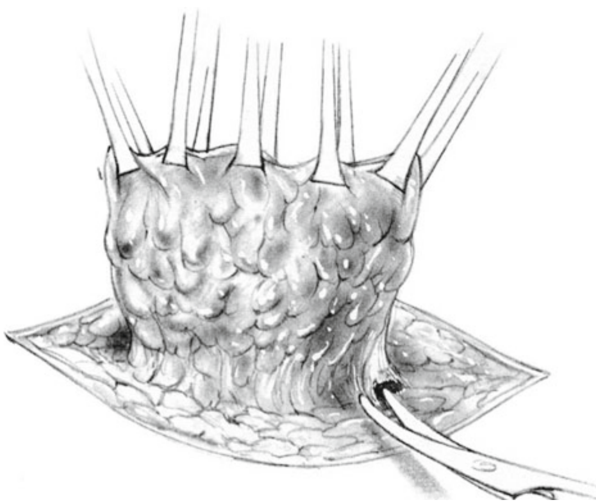

Fig. 63.2

incision parallel to the mucocutaneous junction until the entire colostomy has been encircled. Applying three Allis clamps to the lips of the defect in the colon expedites this dissection and helps prevent contamination. Deepen the incision by scalpel dissection until the seromuscular coat of colon can be identified. Then separate the serosa and surrounding subcutaneous fat by Metzenbaum scissors dissection (Fig. 63.2). Perform this dissection with meticulous care to avoid trauma to the colon wall. Continue down to the point where the colon meets the anterior rectus fascia.

Fascial Dissection

Identify the fascial ring and use a scalpel to dissect the subcutaneous fat off the anterior wall of the fascia for a width of 1–2 cm until a clean rim of fascia is visible all around the colostomy. Then dissect the colon away from the fascial ring until the peritoneal cavity is entered.

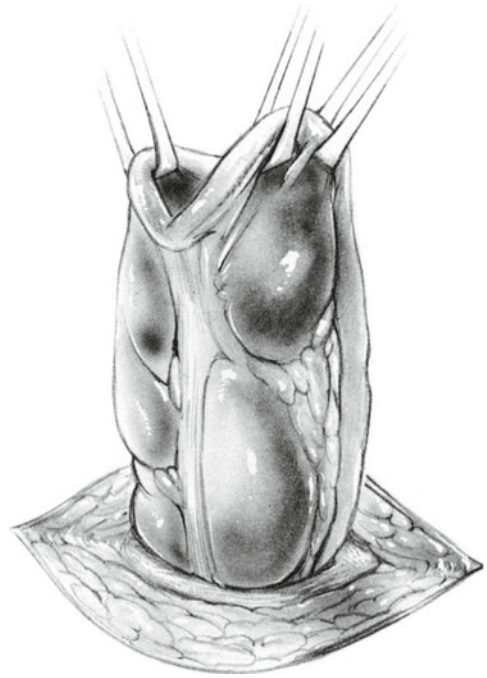

Fig. 63.3

Peritoneal Dissection

Once the peritoneal cavity has been identified, it is often possible to insert an index finger and gently dissect the transverse colon away from the adjoining peritoneal attachments. Using the index finger as a guide, separate the remainder of the colon from its attachments to the anterior abdominal wall. This can often be accomplished without appreciably enlarging the defect in the abdominal wall. However, if any difficulty whatever is encountered while freeing the adhesions between the colon and peritoneum, extend the incision laterally by dividing the remainder of the rectus muscle with electrocautery for a distance adequate to accomplish the dissection safely.

Closure of Colon Defect by Suture

After the colostomy has been freed from all attachments for a distance of 5–6 cm (Fig. 63.3), detach the rim of skin from the colon. Carefully inspect the wall of the colon for injury. A few small superficial patches of serosal damage are of no significance so long as they are not accompanied by devascularization. In most cases, merely freshening the edge of the colostomy by excising a rim of 3–4 mm of scarred colon reveals healthy tissue.

The colon wall should now be of relatively normal thickness. In these cases the colostomy defect, which resulted from a longitudinal incision in the transverse colon at the

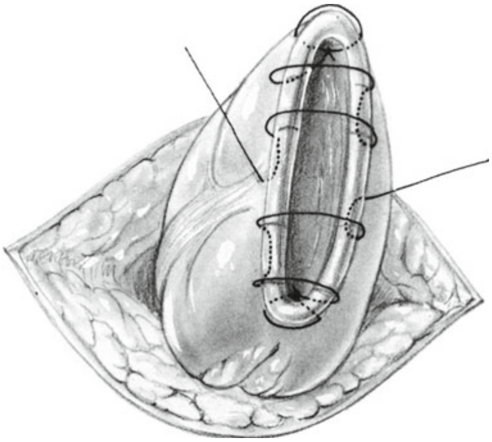

Fig. 63.4

initial operation, should be closed in a transverse direction. Initiate an inverting stitch of 4-0 PG on an atraumatic curved needle at the caudal margin of the colonic defect and pursue it as a continuous Connell or continuous Cushing suture to the midpoint of the defect (Fig. 63.4). Then initiate a second suture of the same material on the cephalad margin of the defect and continue it also to the midpoint; terminate the suture line here (Fig. 63.4). Invert this layer with another layer of interrupted 4-0 silk atraumatic seromuscular Lembert sutures (Fig. 63.5). Because of the transverse direction of the suture line, the lumen of the colon is quite commodious at the conclusion of the closure. There should be no tension whatever on this suture line. Finally, irrigate the operative field and reduce the colon into the abdominal cavity.

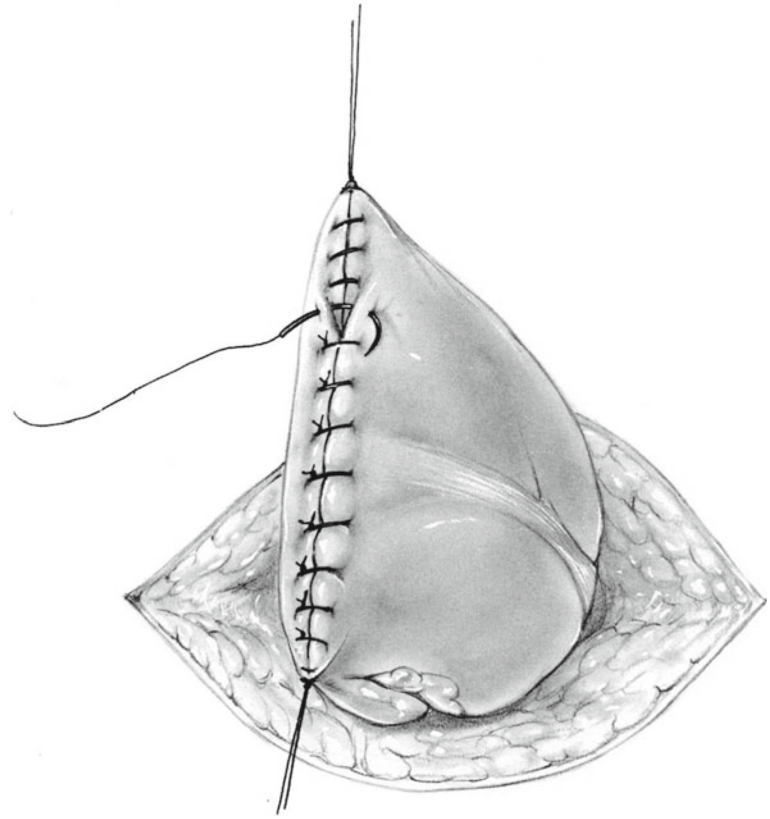

Fig. 63.5

Closure of Colonic Defect by Staples

If the colon wall is not so thick that compressing it to 2 mm produces necrosis, stapling is an excellent method for closing the colon defect. Align the defect so the closure can take place in a transverse direction. Place a single guy suture to mark the midpoint of the transverse closure (Fig. 63.6) and apply Allis clamps to approximate the colon staple line with the bowel wall in eversion.

Carry out stapling by triangulation with two applications of the 55 mm linear stapling device, rather than attempting a single application of a 90 mm device. This minimizes the chance of catching the back wall of the colon in the staple line. First, apply the stapler across the everted mucosa supported by the Allis clamps on the caudal aspect of the defect and the guy suture. Fire the staples and use Mayo scissors to excise the redundant everted mucosa flush with the stapler. Leave the guy suture at the midpoint of the closure intact.

Make the second application of the 55 mm linear stapler with the device positioned deep to the Allis clamps on the cephalad portion of the defect (Fig. 63.7). It is important to position the guy suture to include the previous staple line in this second line of staples, ensuring that no gap exists between the two staple lines. Then fire the staples. Remove any redundant mucosa by excising it with Mayo scissors flush with the stapler. Lightly electrocoagulate the everted mucosa. Carefully inspect the integrity of the staple line to

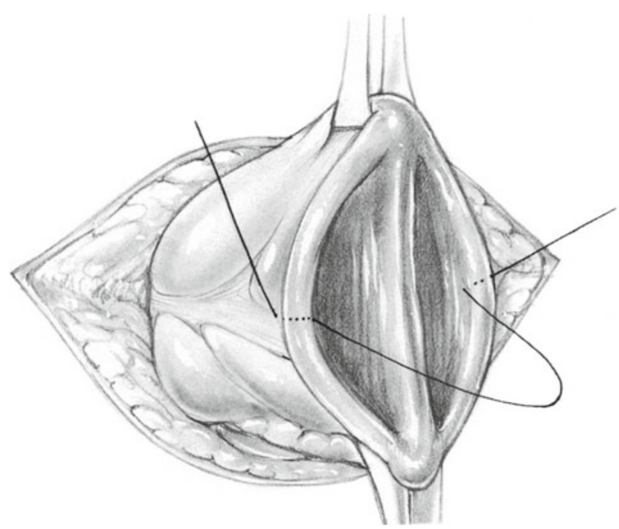

Fig. 63.6

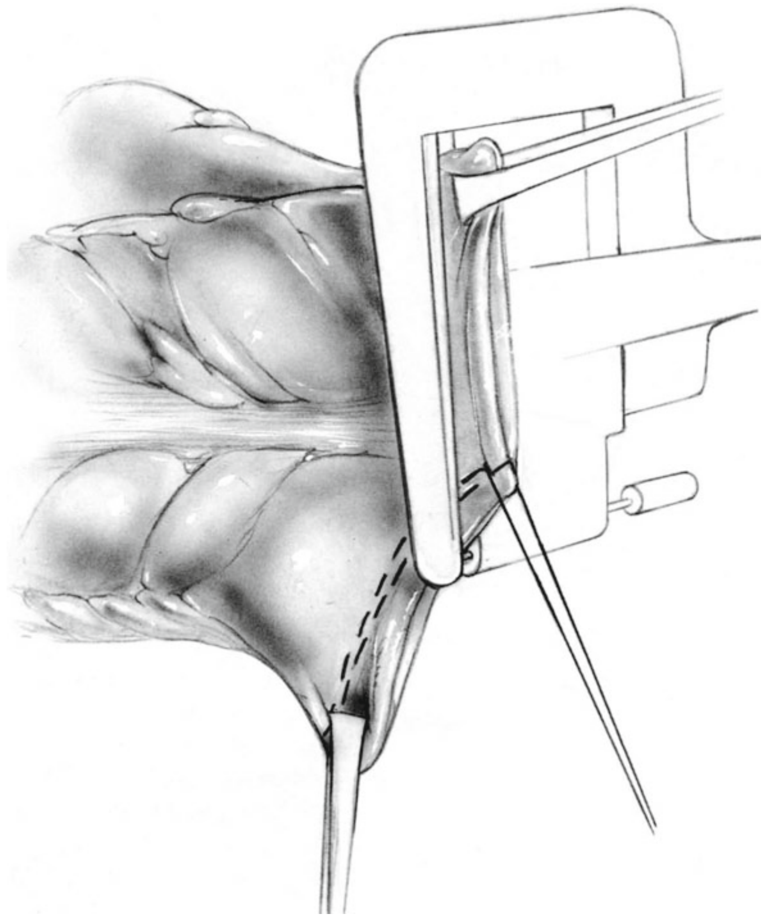

Fig. 63.7

ensure that proper B formation has taken place. It is important, especially with stapling, to ascertain that no tension is exerted on the closure.

Resection and Anastomosis of Colostomy

Whenever the tissue is of inadequate quality for simple transverse closure, enlarge the incision in the abdominal wall and resect a segment of colon. Mobilize a sufficient section of the right transverse colon, occasionally including the hepatic flexure. Dissect the omentum off the transverse colon proximal and distal to the defect. After the proximal and distal segments of the colon have been sufficiently mobilized and the traumatized tissue excised, an end-to-end anastomosis can be constructed by the usual two-layer suture technique (see Figs. 51.18, 51.19, 51.20, 51.21, 51.22, 51.23, 51.24, 51.25, and 51.26) or the staple technique (see Figs. 51.35, 51.36, 51.37, and 51.38).

Closure of Abdominal Wall

Irrigate the area with a dilute antibiotic solution and apply an Allis clamp to the midpoint of the abdominal wall on the caudal and cephalad aspects of the wound. Then close the incision by the modified Smead-Jones technique (see Chap. 3).

Management of Skin Wound

Frequently the colostomy can be closed without enlarging the skin incision, which was no longer than 5–6 cm. There is a high incidence of wound infection following primary closure of the skin. In such cases we simply insert loosely packed gauze into the subcutaneous space, which we allow to heal by granulation and contraction. If desired, several interrupted vertical mattress sutures of nylon may be inserted, but do not tie them until the eighth or tenth postoperative day. Keep the subcutaneous tissue separated with moist gauze packing and approximate the skin by previously placed sutures or tape strips when healthy granulation tissue has formed.

Postoperative Care

Apply nasogastric suction if necessary.

Systemic antibiotics are not continued beyond the perioperative period unless there was serious wound contamination during surgery.

Complications

Wound infection

Abdominal abscess

Colocutaneous fistula

Further Reading

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64 Laparoscopic Stoma Construction and Closure

Dan Enger Ruiz and Steven D. Wexner

Indications

Laparoscopic stoma construction indications are the same as for open techniques. All patients have an indication for diversion of the fecal stream.

Contraindications

Patients with severe restrictive pulmonary disease for whom the carbon dioxide pneumoperitoneum may create intolerable acidosis
Bulky lesions that require large incisions for delivery of the specimen
Obesity (male more than female, because of the short fat mesentery commonly found in obese males)
Intraabdominal adhesions
Bleeding disorders
Pregnancy (the enlarged uterus can obstruct the view of the videolaparoscope)

Preoperative Preparation

It is essential to mark the stoma site (stoma nurse therapist interview if at all possible).
Educate the patient about stoma function and lifestyle modifications.
Colon preparation for elective procedures facilitates bowel grasping and evaluation with laparoscopic instruments when searching for a polyp or a tumor.

Pitfalls and Danger Points

Appropriate stoma location
Appropriate fascial opening to avoid outlet obstruction or prolapse and herniation
Injury to solid organs (spleen and liver) when dissecting the colon
Ureteral injury
Adequate orientation of the bowel (as mesentery must not be torsed)

Operative Strategy

It is essential to have a perfect location of a permanent stoma to avoid further complications. Mark the stoma site with a patient in standing (the belt and pants level is an important factor in males), sitting, and laying down position. The decisions for construction of a colostomy or ileostomy, as well as for loop or end, are also important. A loop stoma does not divert the stream completely as an end stoma, and the ileostomies are less well tolerated in elderly patients because of increase electrolytes imbalance. However, loop ileostomies are chosen over colostomies to protect a low anastomosis due to less major complications on its closure. Moreover, performing a loop colostomy places the marginal artery in danger during stoma closure, potentially devascularizing the distal colon and the anastomosis. The segment of intestine chosen for ostomy formation must reach to the skin without tension, and the mesentery must not be twisted during stoma formation.

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Documentation Basics

- Ileostomy or colostomy
- Loop or end
- Details of fixation (especially important for temporary stomas)

Operative Technique

Loop Ileostomy

Room and Trocar Placement (Fig. 64.1)

We recommend a modified Hassan technique. Grasp the fascia with Kocher clamps and make a 1 cm vertical incision in it. Enter the peritoneum bluntly with a Kelly or Tonsil clamp. Confirm entrance into the peritoneum and place stay sutures to secure the canula during the procedure. Produce pneumoperitoneum. The surgeon stands on the side opposite the stoma site. Next, place a 10–12 mm trocar placed at the stoma site, generally on a line between the umbilical scar and the superior anterior iliac spine going through rectus muscle (making sure to avoid the inferior epigastric vessels). Place an additional 5 mm port either on the right upper quadrant or suprapubic/right lower quadrant to facilitate the dissection if adhesions are encountered (Fig. 64.2).

Choosing a Loop of Terminal Ileum

Place the patient in Trendelenburg with the right side up (20–30° tilt) to displace the small bowel out of the pelvis.

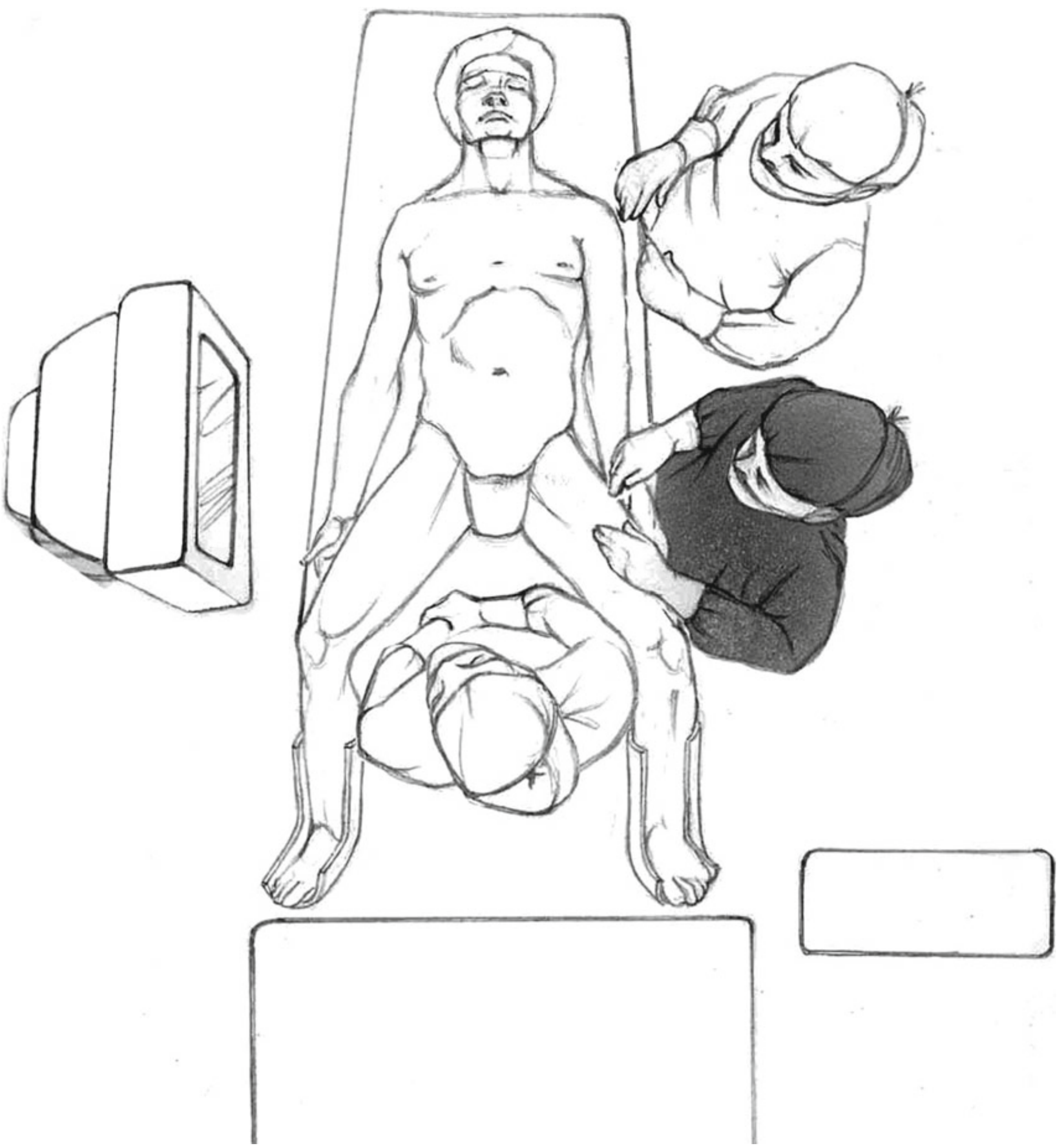


Fig. 64.1 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

Use a 10 mm Babcock-type clamp to identify an appropriate loop of ileum 20 cm from the ileocecal valve. Lift this into the stoma site to verify that it is free of tension and not rotated. If the ileum does not reach easily toward the stoma site, mobilize the cecum and appendix by dissecting along the line of Toldt.

Bringing the Ileostomy Out

After gently grasping of the chosen ileum, deflate the pneumoperitoneum. Create a 2 cm circular skin incision at the stoma site and bring the loop outside through this (Fig. 64.3). Use the loop of bowel to occlude the stoma site, allowing reinsufflation of the abdomen. Recheck for bleeding, bowel, and mesentery orientation (Fig. 64.4). The ostomy is mature using standard techniques.

Transverse Loop Colostomy

Room and Trocar Placement (Figs. 64.5 and 64.6)

Position the patient supine or in the modified lithotomy position, with both arms tucked.

The surgeon stands at the right side or between the legs if lithotomy position is used. Place the monitors on the right and left side at the level of the patient's shoulder.

Create pneumoperitoneum through a supraumbilical modified Hassan technique. Place two trocars: one on the left and one on the right upper quadrant. The transverse colon usually reaches the chosen stoma site on the abdominal wall; rarely the splenic or hepatic flexure will need to be dissected. Bring the greater omentum cephalad and detach it from the colon; usually an energy device is used to promote better homeostasis if extensive dissection needed to be done. Fashion a circular ostomy site in the desired position. Gently grasp the transverse colon with a Babcock and bring it to the surface through this incision. Check hemostasis and orientation as previously described. Mature the stoma in the standard fashion.

Sigmoid Loop Colostomy

Room and Trocar Placement (Figs. 64.7 and 64.8)

Position the patient supine or in the modified lithotomy position, with both arms tucked. The surgeon stands at the right side of the patient. Place the monitor on left side of the patient at the level of the patient's hip/knee. Place the patient in Trendelenburg position with left side up 30° to move the small bowel out of the pelvis and expose the sigmoid colon

Dissecting the Lateral Attachment of the Colon

In many cases the sigmoid colon must be mobilized from its lateral peritoneal attachment to achieve ideal stoma site location. In this case, place a 5 mm port in the left upper quadrant or suprapubic location. Use an energy device to dissect from the inferior lateral part of the sigmoid until the splenic flexure, if needed to assure a secure and traction-free colostomy. If the patient is in modified lithotomy position, the surgeon then can move in between the patient's legs to facilitate the splenic flexure dissection.

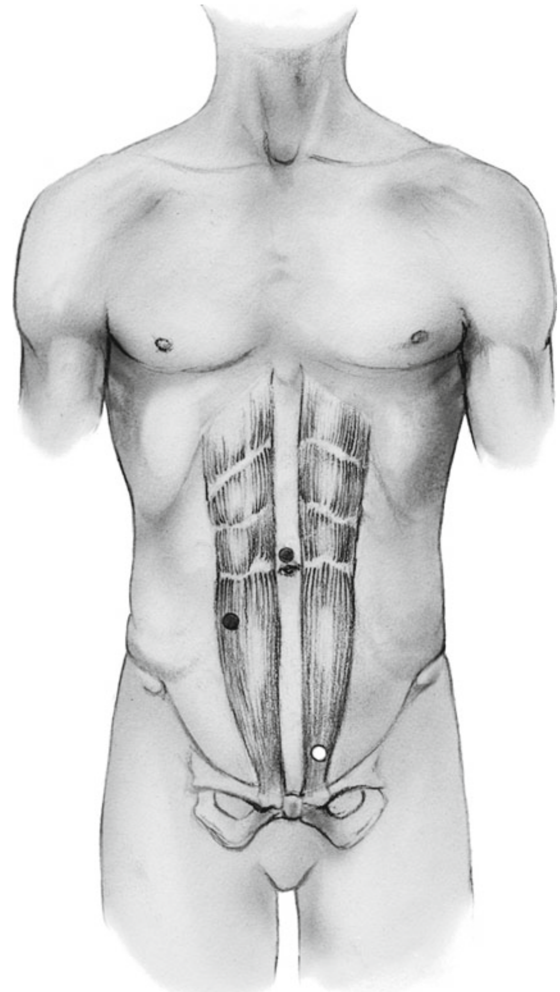


Fig. 64.2 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

Exteriorizing the Sigmoid (Fig. 64.9)

After mobilizing the sigmoid colon, grasp the desired loop of sigmoid with a 10 mm Babcock clamp. Resect the skin circular stoma site, incising the fascia with at least a 2–3 cm cruciate extension. Deflate pneumoperitoneum and pull out the sigmoid colon. Reinsufflate the abdomen and confirm correct position of the stoma, hemostasis, and lack of traction or torsion on the mesentery. The construction and maturation of the stoma follows a standard fashion and can be totally diverting stapled (open proximal end and create a small vent on the distal end, taking care to double check proximal and distal orientation) or a simple loop colostomy.

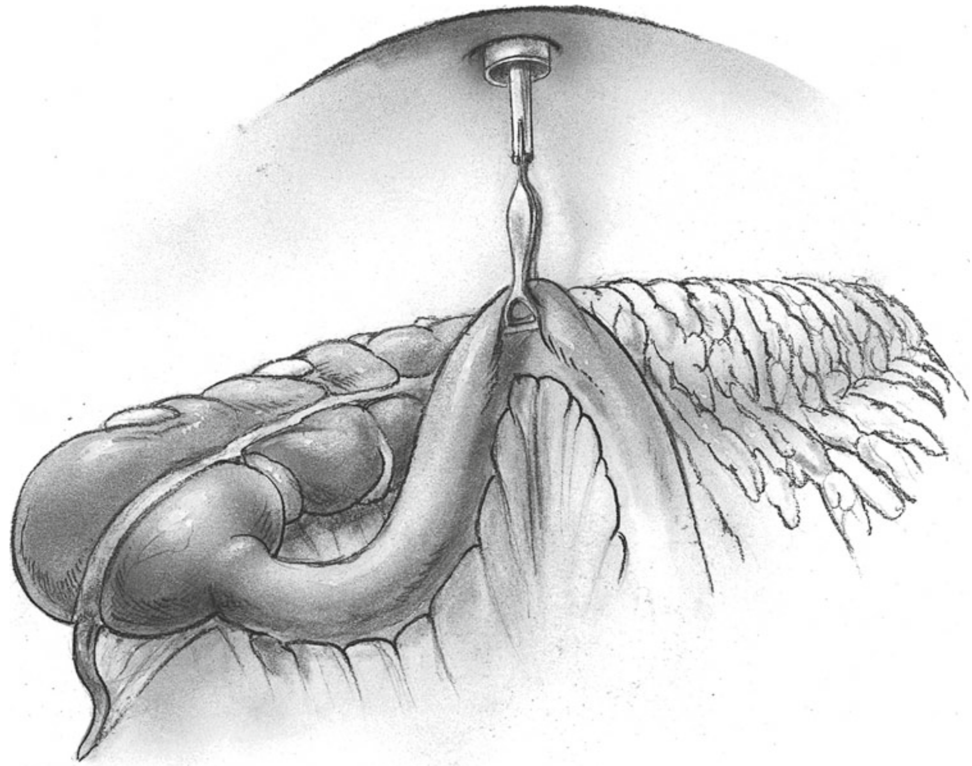


Fig. 64.3 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

Sigmoid Colon Resection with End Colostomy (Hartmann's procedure)

Room and Trocar Placement

The room setup and trocar placement are the same as for sigmoid colostomy, described above. Position the patient supine or in the modified lithotomy position, with both arms tucked. The surgeon stands at the right side of the patient. Place the monitor on left side of the patient at the level of the patient's hip/knee. Place the patient in Trendelenburg position with left side up 30° to move the small bowel out of the pelvis and expose the sigmoid colon.

Establish pneumoperitoneum through the umbilicus using a modified Hassan's technique. Place the second port at the stoma site and the third port contralateral to the stoma site. In case of extensive adhesions, the contralateral port facilitates dissection of those adhesions.

Identification of the Ureter

The identification of the ureter can be facilitated by inserting ureteral stents or by beginning the incision of the peritoneum cephalad toward the origin of the inferior mesenteric artery. Sweep the vessels ventrally away from the preaortic hypogastric plexus (which is swept dorsally to prevent injury). Mobilize the sigmoid colon from lateral to medial and identify and protect the gonadal vessels and the ureter (Fig. 64.7).

Incision of the Mesocolon and Division of the Sigmoid Colon

Ensure that colon can be mobilized to the anterior abdominal wall and create a window in the mesentery. The division of the bowel can be done intracorporally with a linear endoscopic stapler, or, if the sigmoid colon is very mobile, the stapler can be used outside the cavity (Figs. 64.10 and 64.11).

After dividing the bowel, divide the mesentery with a vascular linear stapler or an energy device. The proximal bowel is matured and usual fashion, and the distal colon can be matured as a mucous fistula or the distal end can be stapled and left in the cavity, usually after resection of the diseased segment.

Exteriorization of the Proximal Sigmoid Colon

Pull the proximal segment through the ostomy site, resect if desired, and mature the stoma as previously described (Fig. 64.12).

Hartmann's Take Down

Room and Trocar Placement (Figs. 64.13 and 64.14)

Position the patient supine or in the modified lithotomy with both arms tucked. Use the same trocar positions as described for Hartmann's procedure. The surgeon stands at the right side of the patient. Place the monitor on left side, at the level of the patient's hip/knee. Place the patient in Trendelenburg

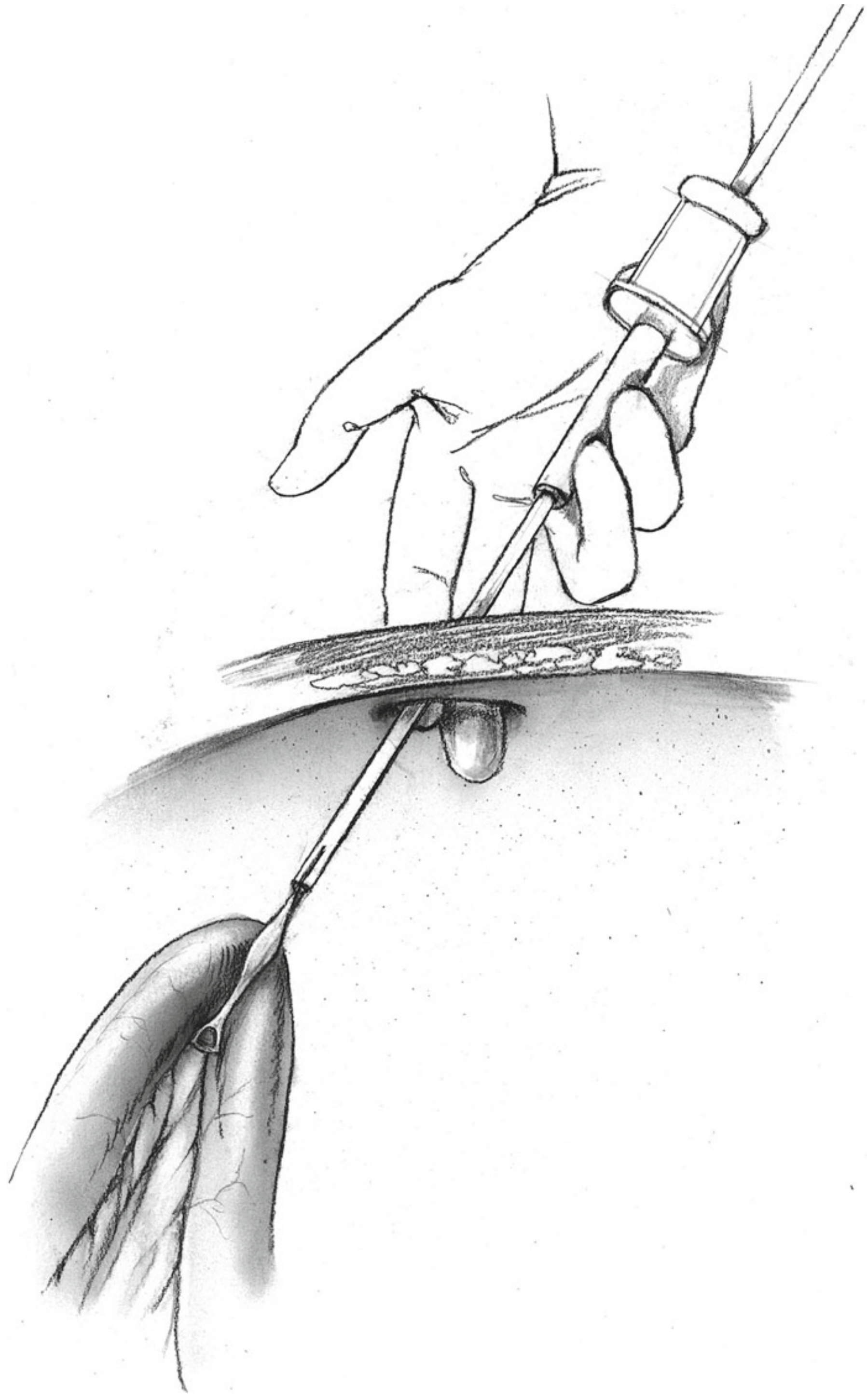


Fig. 64.4 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

position with left side up 30° to move the small bowel and expose the sigmoid colon. The reverse position will be needed if splenic flexure mobilization is required.

Stoma Mobilization

Gently irrigate the rectum with a soft rubber catheter with warm saline solution. Mobilize the stoma in the usual fashion from outside the abdomen. Trim it as needed. Then create a purse string suture and place the anvil of a 29 cm circular stapler (29 cm) into the stoma. Next, return the proximal colon and the anvil to the peritoneal cavity. Create pneumoperitoneum through a site away from the old incision, usually through the right upper abdomen. Under direct visual guidance using sharp or energy device, lyse midline adhesions and place the supraumbilical trocar. Either completely close the stoma site or close it

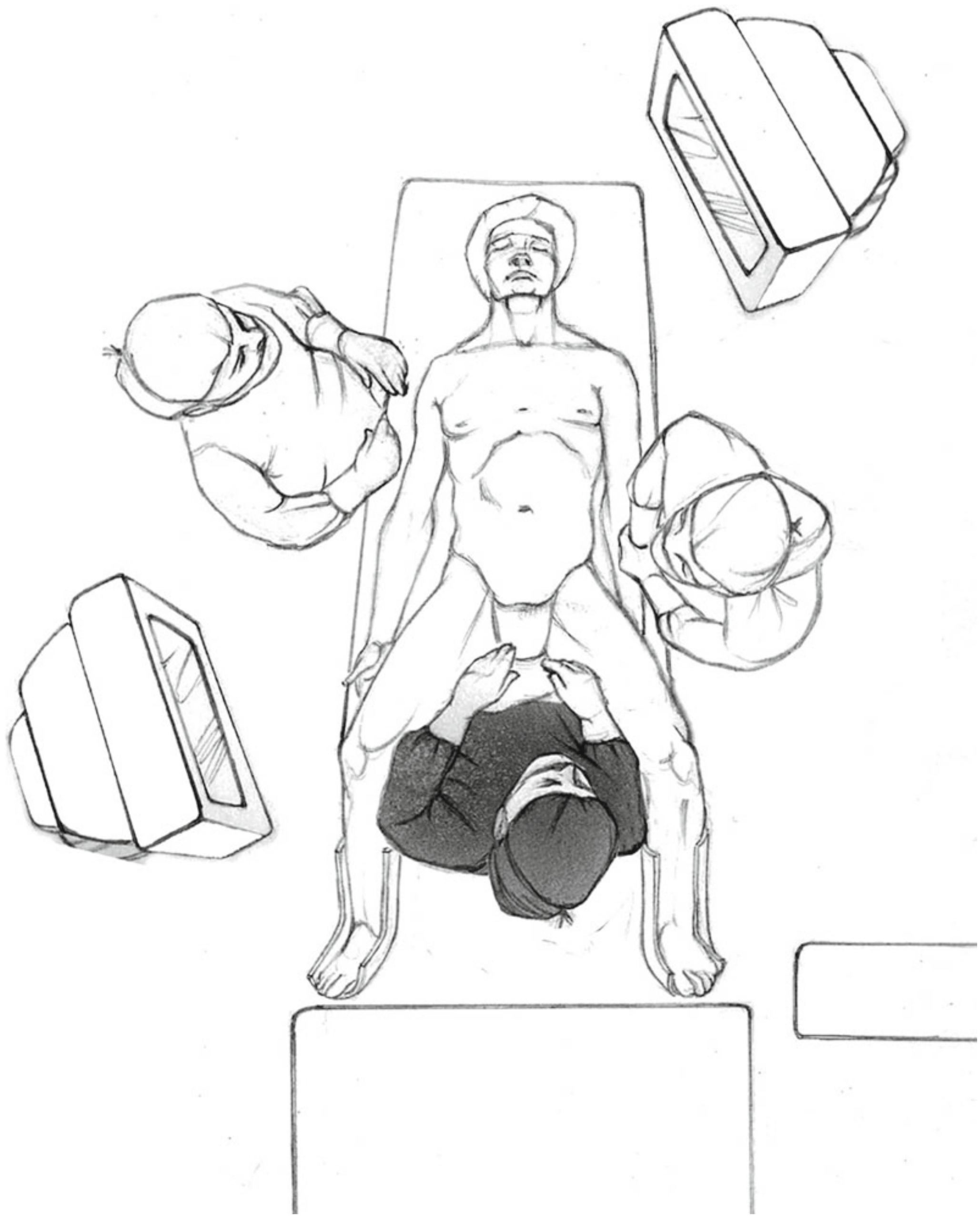


Fig. 64.5 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

around a 5-mm trocar that can be removed without further closure at the end. Additional 5-mm trocars are usually placed in the right iliac fossa and right upper abdomen as previously noted.

Mobilization of the Splenic Flexure

Mobilize the splenic flexure and take down the transverse colon to ensure adequate length and free tension anastomosis. The use of an energy device is recommended as it provides excellent hemostasis. This mobilization proceeds as described earlier (see Chap. 52).

Dissecting the Rectal Stump

Dissect the rectal stump free of adhesions or any small bowel loops to ensure a safe stapled anastomosis. If it is difficult to find the stump, use a rigid sigmoidoscopy to guide the dissection as well as following any nonabsorbable sutures left on the stump from previous surgery (Fig. 64.15). The rectal stump is then circumferentially mobilized for 3–5 cm from the surrounding pelvic tissues. Any residual sigmoid colon should be resected to ensure anastomosis of the descending colon to the rectum when dealing with diverticular disease. A preoperative contrast enema is useful in this regard.

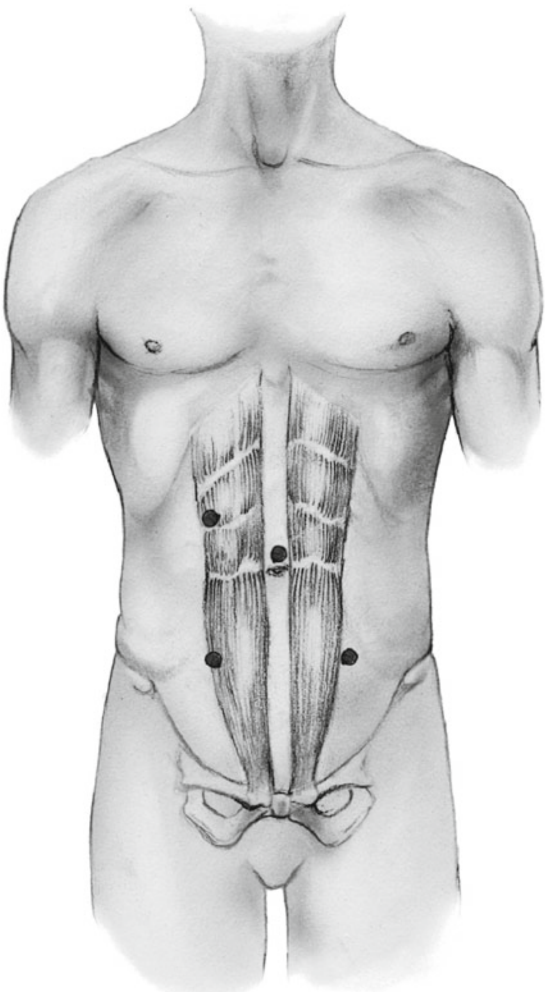


Fig. 64.6 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

Performing the Anastomosis

Before proceeding with the anastomosis, make sure that the descending colon can be brought down to the ideal place of anastomosis without tension. Then insert a 29-cm circular stapler through the rectum and pass the spike through the stump. Engage the anvil. Double check for lack of tension and appropriate orientation (lack of rotation). The anastomosis is better viewed from the lateral port site. See Chap. 52 for further details.

Testing the Anastomosis

After firing the stapler and retracting it gently from the rectum, gently occlude the proximal bowel and check the anastomosis with insufflation of the rectum with air and submersion of the anastomosis under warm saline (bubble test). Inspect the stapler donuts for completeness. If using a rigid or flexible sigmoidoscope, direct visualization of the anastomosis can be done.

Postoperative Care

Whenever an ostomy is created, apply a transparent ostomy pouch in the operating room to permit direct visualization of the quality of the mucosa of the stoma during the postoperative period. Dark or very edematous mucosa needs to be evaluated further. To ensure the viability of the stoma three techniques can be used: (1) direct vision with a anoscope, (2) gently insert the blunt end of a glass blood drawing tube (with the stopper removed) and shine a light through this to inspect the mucosa below the fascia, and (3) use the same glass tube and insert a bronchoscope into the tube to evaluate the mucosa above and below the fascia. If there is any doubt as to the viability of the mucosa below the fascial layer, revise the stoma.

Complications

Stoma Site Complications

- Edema
- Infection
- Bleeding
- Stenosis
- Necrosis
- Parastomal hernia
- Prolapse
- Skin dermatitis from intestinal content leakage

General Complications

- Wound infection
- Port site bleeding
- Anastomosis dehiscence
- Obstruction
- Ileus
- Hernia

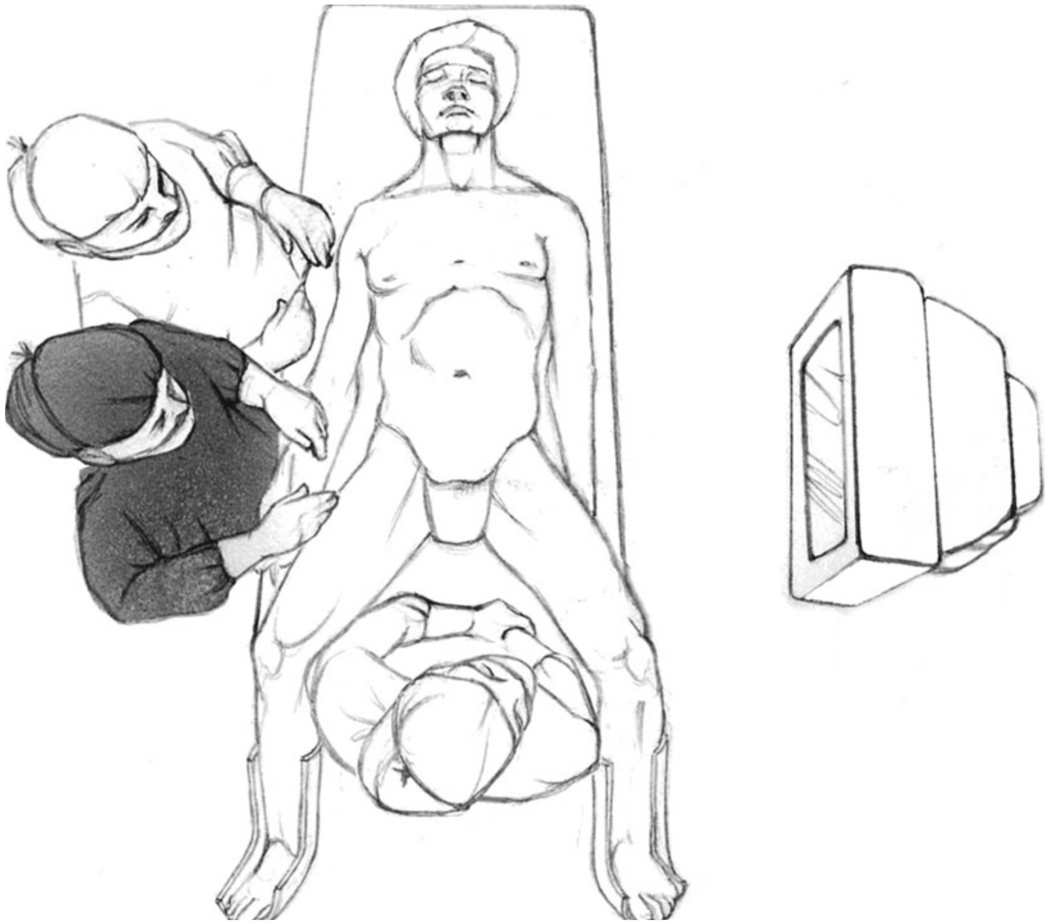


Fig. 64.7 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

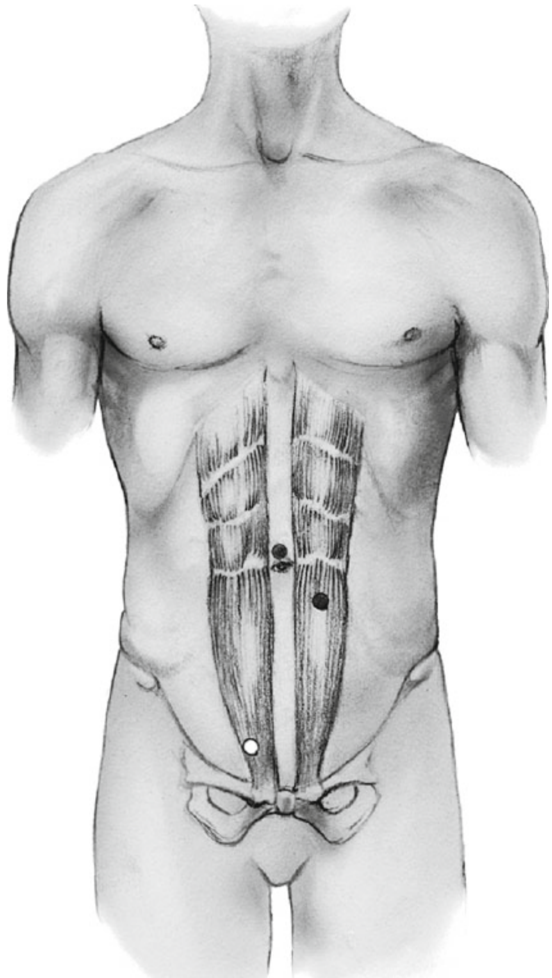


Fig. 64.8 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

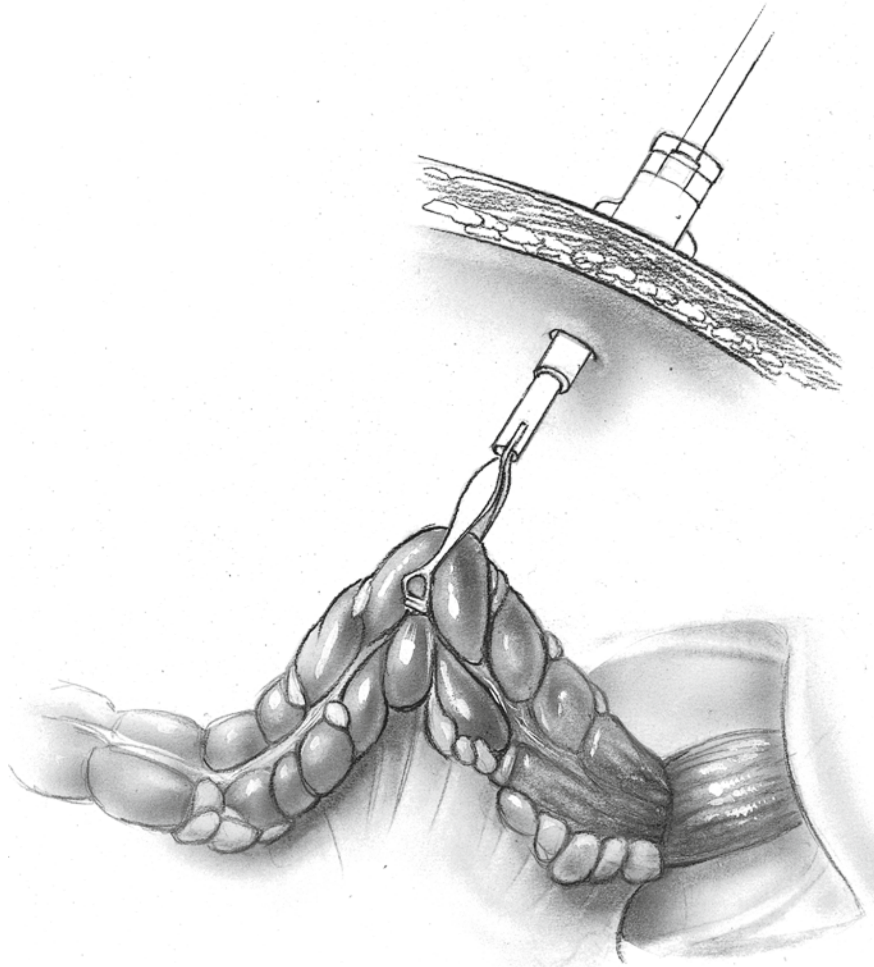
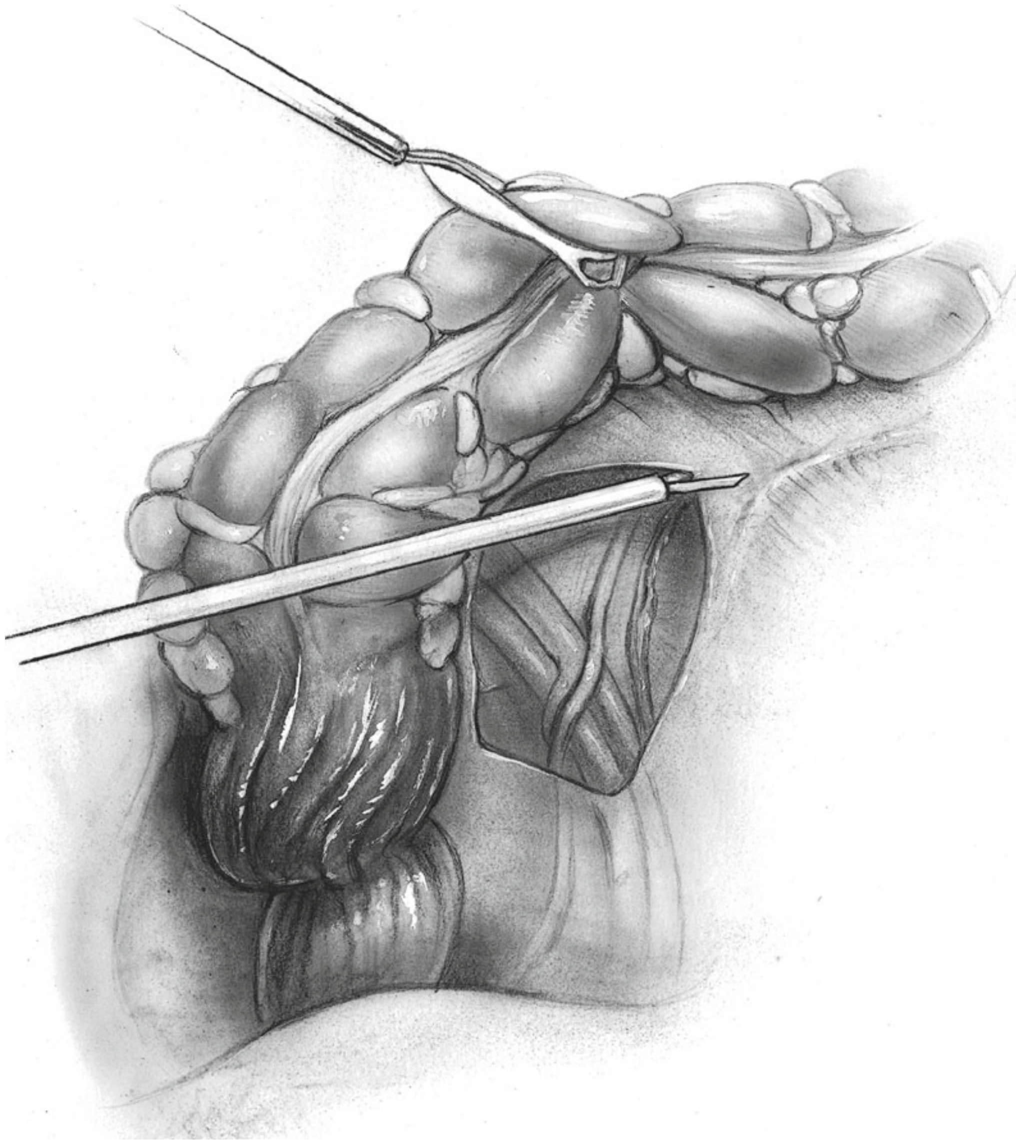


Fig. 64.9 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission



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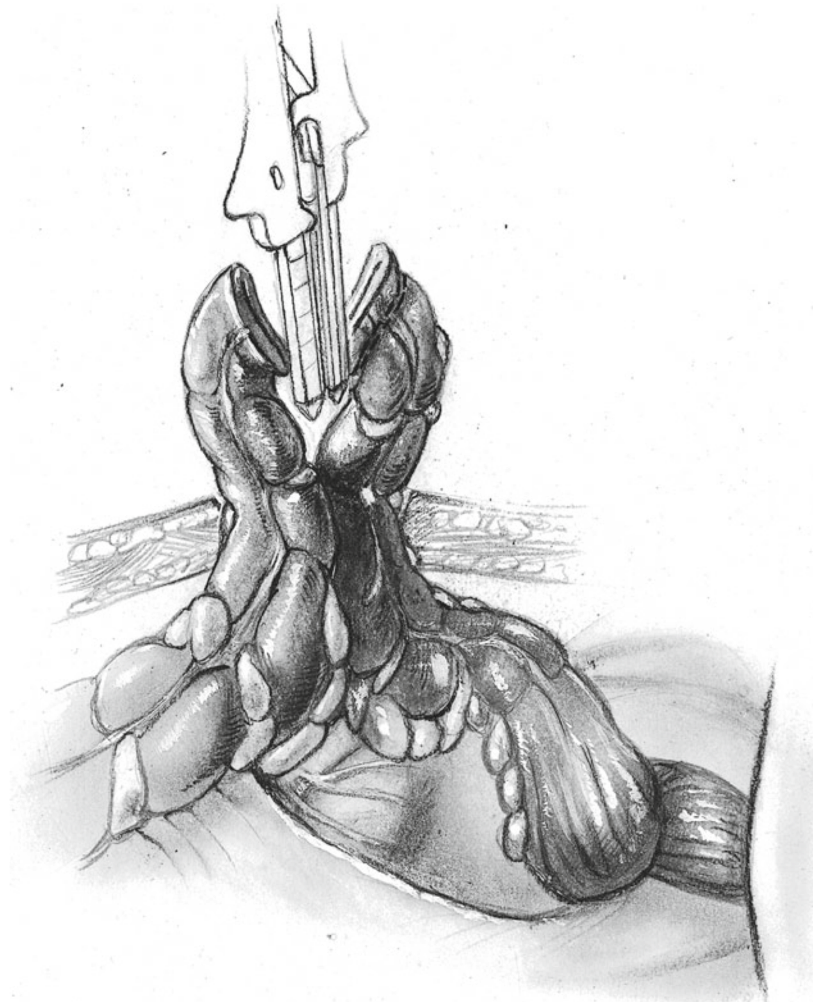
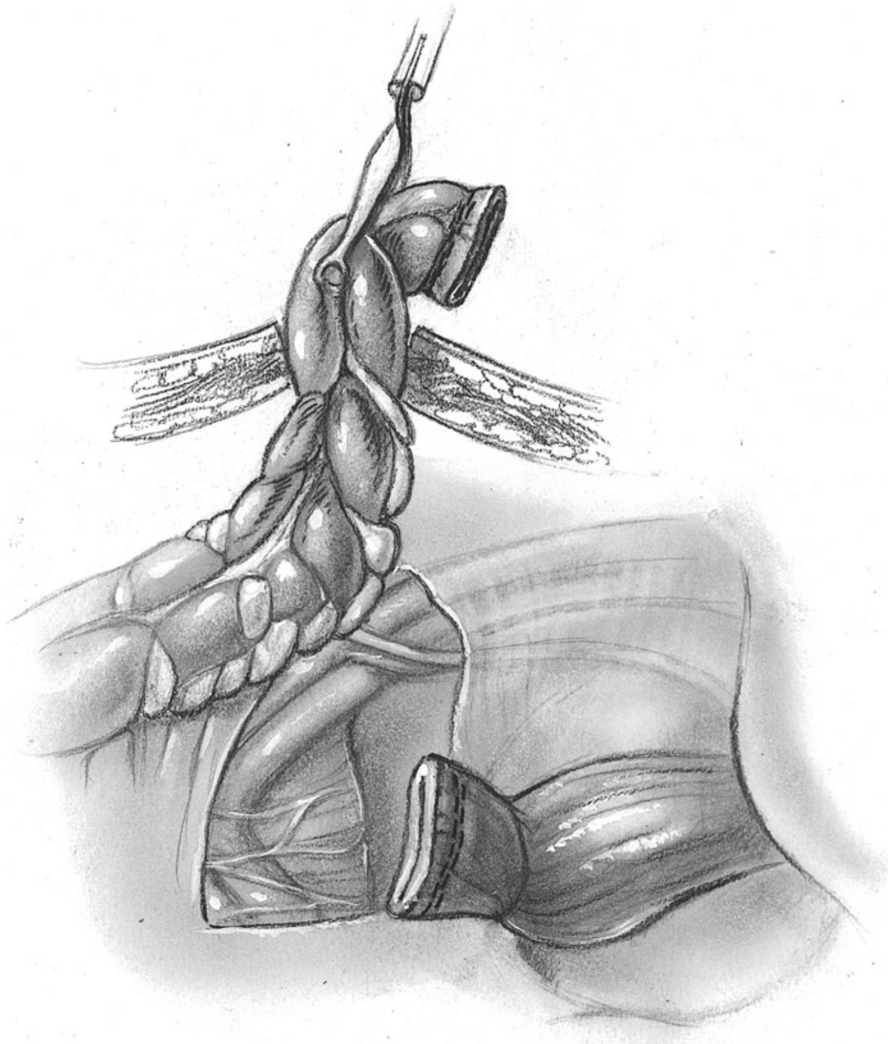


Fig. 64.11 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission



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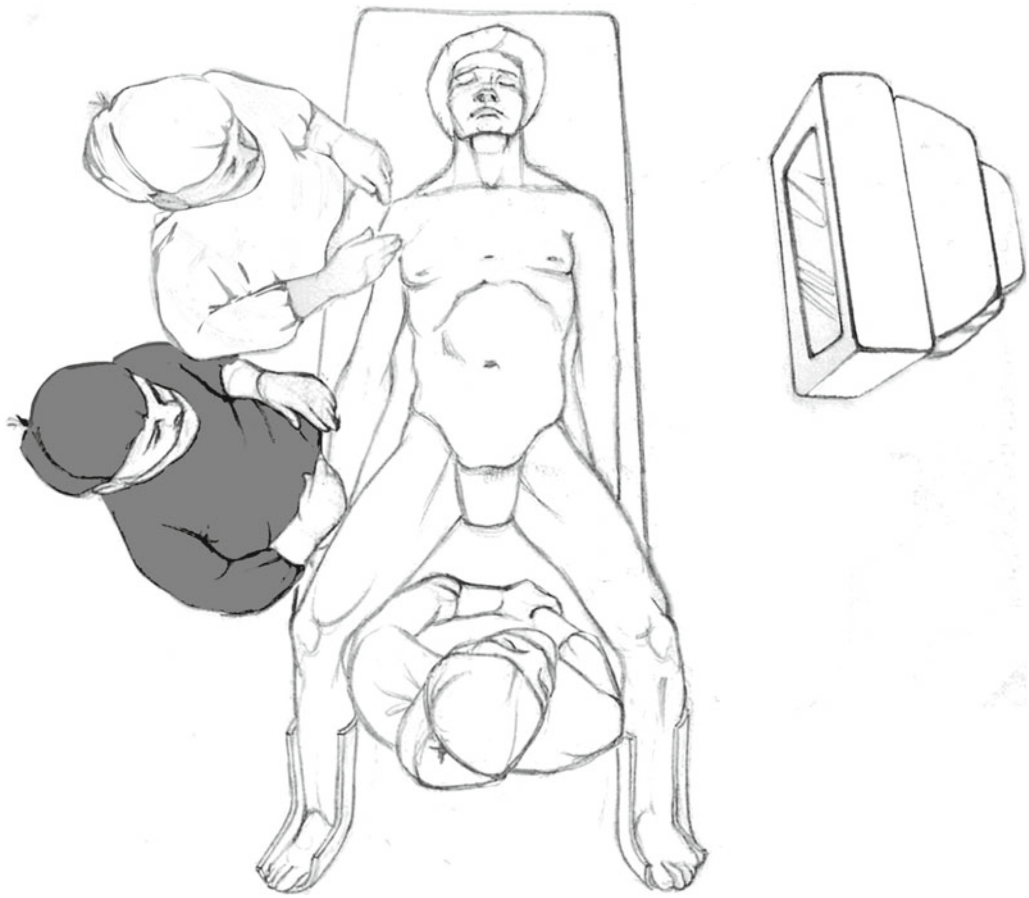

Fig. 64.13 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

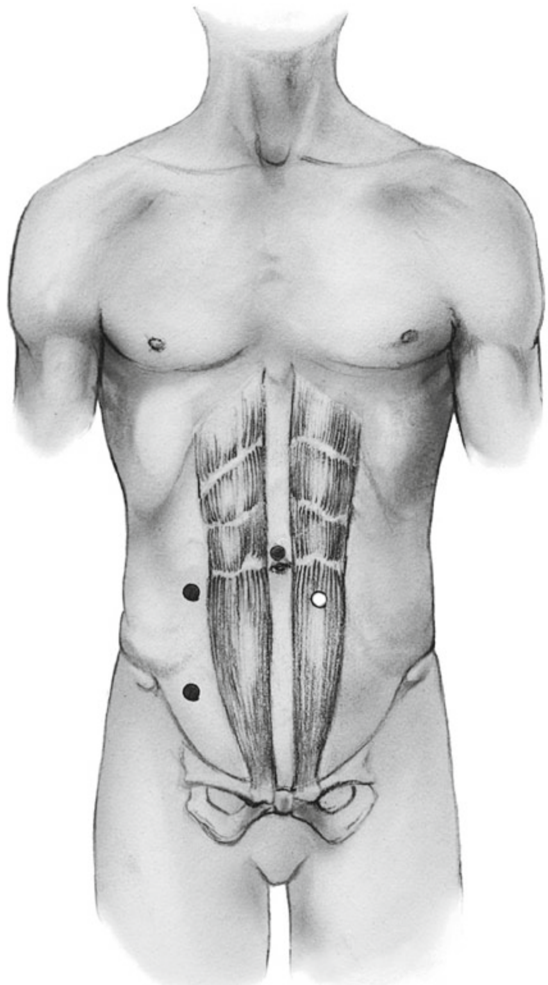

Fig. 64.14 From Scott-Conner EH, editor. Chassin's operative strategy in colon and rectal surgery. New York: Springer Science + Business Media; 2006, with permission

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Surgery for Colonic Diverticulitis and Other Benign Conditions of the Left Colon (Hartmann's Procedure)

65

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Elective
- Recurrent diverticulitis
- Colovesical fistula

Urgent
- Diverticular abscess or phlegmon unresponsive to medical management
- Complete colon obstruction
- Suspicion of coexistent carcinoma

Emergent
- Spreading or generalized peritonitis
- Massive hemorrhage

Preoperative Preparation

See Chap. 48.

Operative Strategy

This operation is used primarily for diverticular disease. It may also be used during emergency surgery for lower gastrointestinal bleeding. In the latter case, it is crucial to localize the bleeding source before surgery. In many cases, nonoperative techniques are successful in stopping the bleeding, so surgery is only required when nonoperative means fail.

The operative technique for resecting the left colon and for the anastomosis is similar to that described for left colectomy for carcinoma but with a number of important exceptions.

1. Because there is no need to perform a high lymphovascular dissection in the absence of cancer, the mesentery may be divided at a point much closer to the bowel unless the mesentery is so inflamed and edematous it cannot hold ligatures.
2. In most cases, it is not necessary to elevate the rectum from the presacral space, as this area is rarely the site of diverticula. The anastomosis can be done at the promontory of the sacrum.
3. Though it is important to remove the greatest concentration of diverticula, in elderly patients, it is not necessary to perform an extensive colectomy just because there are some innocent diverticula in the ascending or transverse colon. The site selected for anastomosis should be free of diverticula and gross muscle hypertrophy.
4. Primary anastomosis should be performed only if the proximal and distal bowel segments selected for anastomosis are free of cellulitis and of marked muscle hypertrophy. If an abscess has been encountered in the pelvis, so that the anastomosis would lie on the wall of an evacuated abscess cavity, it is wise to delay the anastomosis for a second-stage operation.

Documentation Basics

- Findings
- Extent of resection
- Anastomosis versus Hartmann's pouch versus mucous fistula

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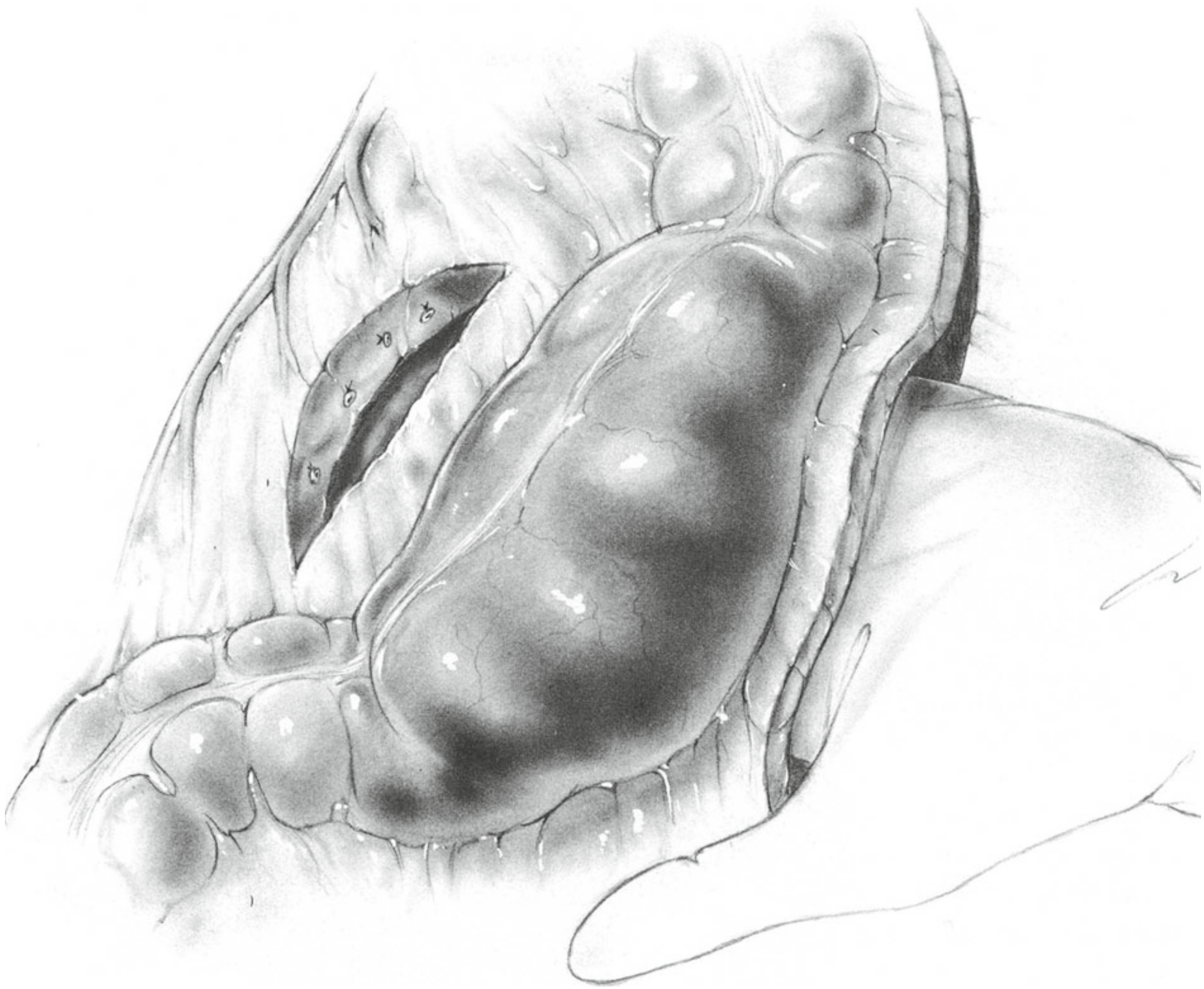

Fig. 65.1

Operative Technique

Primary Resection and Anastomosis

Incision

Make a midline incision from the upper epigastrium to the pubis.

Liberation of Sigmoid and Left Colon

Initiate the dissection in the region of the upper descending colon by incising the peritoneum in the paracolic gutter. Then insert the left hand behind the colon (Fig. 65.1) in an area above the diverticulitis to elevate the mesocolon. This allows you to begin the dissection in an area that is relatively free of inflammation. Continue the incision in the paracolic peritoneum down to the descending colon and sigmoid to the brim of the pelvis.

At this point, to safeguard the left ureter from damage, it is essential to locate it in the upper portion of the dissection, where the absence of inflammation simplifies its identification. Then trace the ureter down into the pelvis. It may have to be dissected off an area of fibrosis in the sigmoid. When this dissection has been completed, the sigmoid is free down to the promontory of the sacrum. Some surgeons will have ureteral stents placed before surgery to maximize the chances of identifying the ureters and promptly repairing any injury to the ureter that might occur.

Division of Mesocolon

In elective cases, the mesentery generally can be divided serially between Kelly hemostats at a point no more than 4–6 cm from the bowel wall (Fig. 65.1). Initiate the line of division at a point on the left colon that is free of pathology. This sometimes requires liberation of the splenic flexure and distal transverse colon. Continue the dissection to the rectosigmoid. Remove the specimen after applying Allen clamps.

Anastomosis

Perform an open-type anastomosis in one or two layers or by stapling as described in Chap. 51 (see Figs. 51.12, 51.13, 51.14, 51.15, 51.16, 51.17, 51.18, 51.19, 51.20, 51.21, 51.22, 51.23, 51.24, 51.25, 51.26, 51.27, 51.28, 51.29, 51.30, 51.31, 51.32, 51.33, 51.34, 51.35, 51.36, 51.37, and 51.38). In rare cases, it is necessary to make the anastomosis at a lower level, where the ampulla of the rectum is significantly larger in diameter than the proximal colon. In that case, a side-to-end Baker anastomosis is preferable, as described in Chap. 53 (see Figs. 53.12, 53.13, 53.14, 53.15, 53.16, 53.17, 53.18, 53.19, 53.20, 53.21, and 53.22).

Abdominal Closure

In the absence of intra-abdominal or pelvic abscesses, close the abdomen in the useful fashion (see Chap. 3). Intraperitoneal drains are not needed.

Primary Resection with End Colostomy and Mucous Fistula

If it is decided to delay the anastomosis for a second stage, it is not necessary to excise every bit of inflamed bowel, as this frequently requires a Hartmann's pouch at the site of the rectosigmoid transaction and makes the second stage more difficult than if a mucous fistula can be constructed. In almost every case, proper planning of the operation permits exteriorization of the distal sigmoid as a mucous fistula, which can be brought out through the lower margin of the midline incision after a De Martel clamp or stapled closure is secured (Fig. 65.2). If this is not feasible, staple the distal sigmoid and allow it to return to the pelvis as described in the next section.

Divide the mesocolon to preserve the vascularity of the mucous fistula or Hartmann's pouch. Then bring out an uninflamed area of the descending colon as an end colostomy through a separate incision in the lateral portion of the left rectus muscle and excise the intervening diseased colon. The second stage of this operation—removal of the colostomy and mucous fistula and anastomosis of the descending colon to the rectosigmoid—may be carried out after a delay of several weeks.

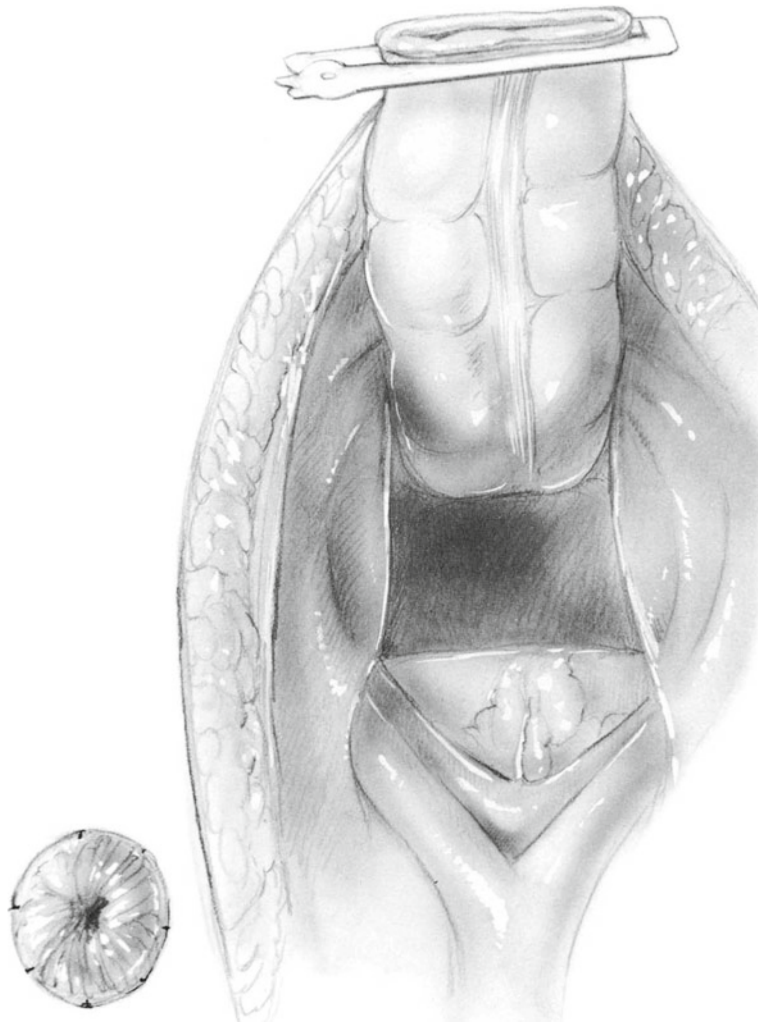

Fig. 65.2

Emergency Sigmoid Colectomy with End Colostomy and Hartmann's Pouch

Indications

For patients suffering generalized or spreading peritonitis secondary to perforated sigmoid diverticulitis, a conservative approach with diverting transverse colostomy and local drainage is associated with a mortality rate of more than 50 %. Immediate excision of the perforated bowel is necessary to remove the septic focus. Following this excision, the preferred procedure is a mucous fistula and end colostomy. However, if excising the perforated portion of the sigmoid leaves an insufficient amount of distal bowel with which to form a mucous fistula, Hartmann's operation is indicated. It is not wise to attempt to create a mucous fistula by extensive presacral dissection in the hope of lengthening the distal segment, as it only opens new planes to potential sepsis.

Preoperative Preparation

Preoperative preparation primarily involves rapid resuscitative measures using intravenous fluids, blood, and antibiotics, as some patients are admitted to the hospital in septic shock. Complete colon preparation may not be possible, although many patients are given a modified dose of

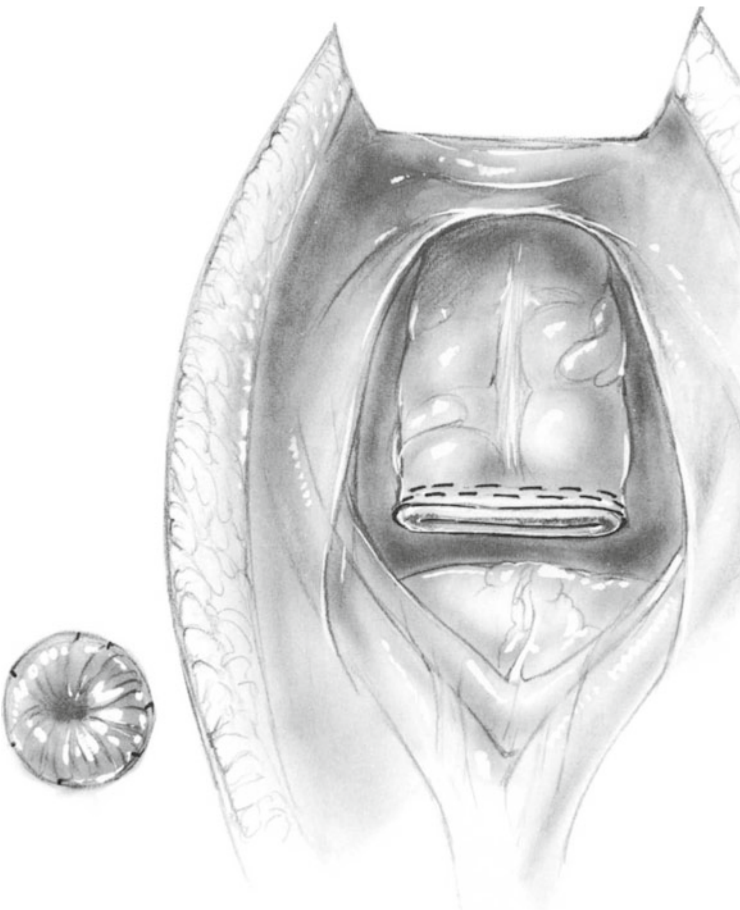

Fig. 65.3

GoLYTELY for colonic cleansing. Nasogastric suction and bladder drainage with a Foley catheter should be instituted.

Operative Technique

Incision and Liberation of Left Colon

The steps for incision and liberation of the left colon are identical to those described above. It is essential to find the proper retromesenteric plane by initiating the dissection above the area of maximal inflammation. Once this has been achieved, with the left hand, elevate the sigmoid colon and the diseased mesocolon (generally the site of a phlegmon) so the left paracolic peritoneum may be incised safely (Fig. 65.1). Again, it is essential to identify the left ureter in the upper abdomen to safeguard it from damage. Sometimes a considerable amount of blood oozes from the retroperitoneal dissection, but it can often be controlled by moist gauze packs while the dissection continues. After the left colon has been liberated, divide the mesentery serially between hemostats, as above.

Hartmann's Pouch

Often with acute diverticulitis, the rectosigmoid is not involved to a great extent in the inflammatory process. Mesenteric dissection should be terminated at this point. If the rectosigmoid is not excessively thick, occlude it by applying a 65/4.8 mm linear stapler. Place an Allen clamp on the specimen side of the sigmoid and divide the bowel flush with the stapler. After the stapling device is removed, there should be slight oozing of blood through the staples, which is evidence that excessively thickened tissue has not been necrotized by using the stapling technique on it (Fig. 65.3).

If the tissue is so thick that compression to 2 mm by the stapling device would result in necrosis, the technique is contraindicated. The rectal stump should then be closed by a continuous layer of locked sutures of 3-0 PG. Invert this layer with a second layer of continuous 3-0 PG Lembert sutures. Suture the apex of the Hartmann's pouch to the pelvic fascia near, or if possible higher than, the promontory of the sacrum to prevent retraction low into the pelvis, which would make a secondary anastomosis more difficult. Some surgeons will "tag" the Hartmann's pouch with one or two Prolene sutures with the tails left long to facilitate subsequent dissection.

End Colostomy

Use an uninflamed area of the left colon for an end colostomy. In a patient who is desperately ill, the colostomy may be brought out through the upper portion of the midline incision if it can save time. Otherwise, bring it out through a transverse incision over the lateral portion of left rectus muscle. The incision should admit two fingers. Bring out the cut end of the colon and immediately suture it with 4-0 PG, either interrupted or continuous, to the subcuticular layer of the skin incision.

Wound Closure

Any rigid abscess cavities that cannot be excised should be managed by insertion of sump drains. If no rigid abscess walls have been left behind, the abdomen should be copiously irrigated and closed in the usual fashion without drainage. The skin can be managed by delayed primary closure.

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Ripstein Operation for Rectal Prolapse: Surgical Legacy Procedure

66

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Complete prolapse of the rectum

Preoperative Preparation

Mechanical and antibiotic bowel preparation
Colonoscopy or barium colon enema to exclude other pathology
Foley catheter in bladder
Perioperative antibiotics

Pitfalls and Danger Points

Excessive constriction of the rectum by mesh, which may result in partial obstruction or, rarely, erosion of mesh into the rectal lumen
Disruption of suture line between mesh and presacral space
Presacral hemorrhage

Operative Strategy

The Ripstein operation uses permanent polypropylene mesh to fix the rectum to the presacral fascia, thereby restoring the normal posterior curve of the rectum and eliminating intussusception and prolapse. This operation is indicated only in patients who are not also suffering from significant constipation. Constipated patients do better with resection of the redundant sigmoid colon and colorectal anastomosis with sutures attaching the lateral ligaments of the rectum to the sacral fascia. For many patients, including those with significant medical comorbidities, a perineal procedure (see Chap. 74) is preferable.

Many variations have been described. They differ primarily in use of mesh or simple suture fixation, type of material, and extent of mesh wrap (partial versus total). Some surgeons will combine a resection of the redundant segment of colon with a rectopexy. Laparoscopic procedures have been described (see references).

To prevent undue constriction of the rectum when the mesh is placed around it, *leave sufficient room to pass two fingers behind the rectum* after the mesh has been fixed in place. The success of the Ripstein operation is *not predicated on any degree of constriction* of the rectum. It suffices if the mesh simply prevents the rectum from advancing in an anterior direction away from the hollow of the sacrum.

The site on the rectum selected for placing the mesh is important. The upper level of the mesh should be 5 cm below the promontory of the sacrum, which requires opening the rectovesical or rectouterine peritoneum. In most cases the lateral ligaments of the rectum need not be divided. Avoid damage to the hypogastric nerves in the presacral area, especially in male patients.

Documentation Basics

- Extent of mobilization
- Combined with resection?
- Mesh used or not?
- What type of mesh?
- Extent of wrap

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Operative Technique

Incision

A midline incision between the umbilicus and pubis provides excellent exposure in most patients. In young women the operation is accompanied by improved cosmetic results if it is performed through a Pfannenstiel incision. That incision is useful in other situations, so it is described in detail here. Place the 12- to 15-cm long Pfannenstiel incision just inside the public hairline, in the crease that goes from one anterior superior iliac spine to the other (Fig. 66.1). With the scalpel, divide the subcutaneous fat down to the anterior rectus sheath and the external oblique aponeurosis. Divide the anterior rectus sheath in the line of the incision about 2 cm above the pubis (Fig. 66.2). Extend the incision in the rectus sheath laterally in both directions into the external oblique aponeurosis. Apply Allis clamps to the cephalad portion of this fascial layer and bluntly dissect it off the underlying rectus muscles almost to the level of the umbilicus (Fig. 66.3). Separate the rectus muscles in the midline, exposing the preperitoneal fat and peritoneum. Grasp the fat and peritoneum in an area sufficiently cephalad to the bladder to not endanger that organ. Incise the peritoneum, open the abdominal cavity, and explore it for coincidental pathology. A moderate Trendelenburg position is helpful.

Fig. 66.1

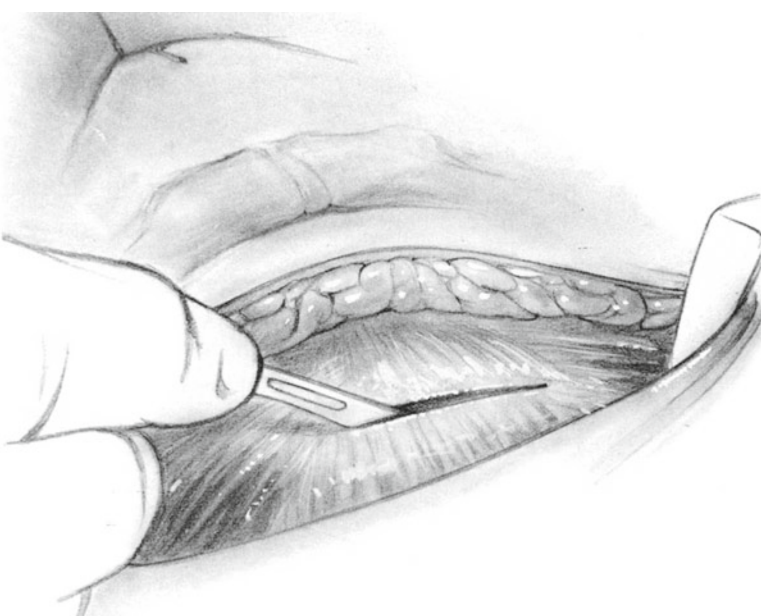

Fig. 66.2

Incision of Pelvic Peritoneum

Retract the small intestine in a cephalad direction. Make an incision in the pelvic peritoneum beginning at the promontory of the sacrum and proceed along the left side of the mesorectum down as far as the cul-de-sac. Identify the left ureter.

Make a second incision in the peritoneum on the right side of the mesorectum, where the mesorectum meets the pelvic peritoneum. Extend this incision also down to the cul-de-sac and identify and preserve the right ureter. Join these two incisions by dividing the peritoneum at the depth of the rectovesical or rectouterine pouch using Metzenbaum scissors (see Figs. 53.4, 53.5, and 53.6). Frequently, the cul-de-sac is deep in patients with rectal prolapse. Further dissection between the rectum and the prostate or vagina is generally not necessary.

Presacral Dissection

For rectal prolapse the rectum can be elevated with ease from the hollow of the sacrum. Enter the presacral space via a Metzenbaum dissection, a method similar to that described for anterior resection (see Chap. 53), but keeping the dissection close to the rectum to avoid nerve injury. Take the usual precautions to avoid damage to the presacral veins. Inspect the presacral area for hemostasis, which should be perfect before the procedure is continued.

Application of Mesh

Fit a section of Prolene mesh measuring 5 × 10 or 5 × 12 cm into place overlying the lower rectum. The upper margin

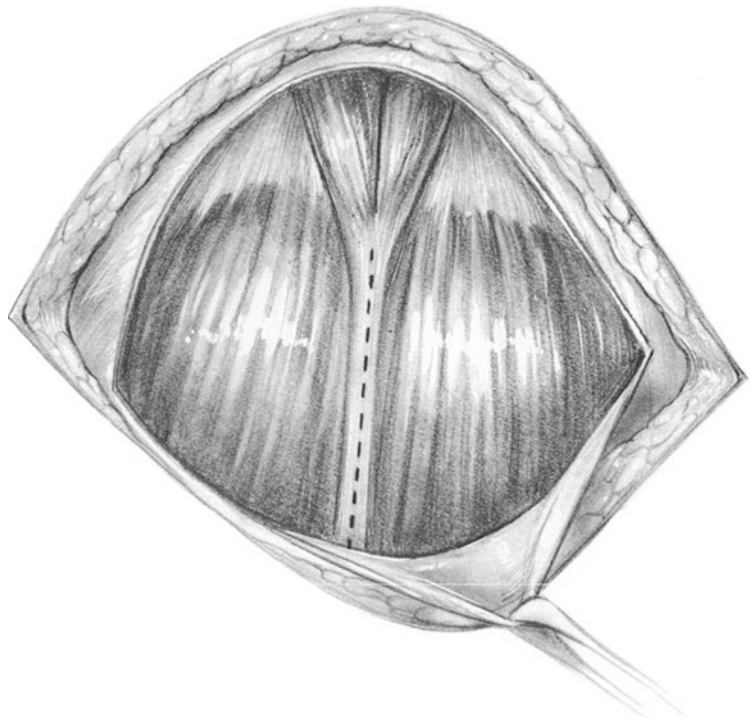

Fig. 66.3

of the mesh should lie over the rectum at a point 4–5 cm below the sacral promontory. Using a small Mayo needle, insert three interrupted sutures of 2-0 Prolene or Tevdek into the right margin of the mesh and attach the mesh to the sacral periosteum along a line about 1–2 cm to the right of the mid-sacral line. Use the same technique to insert three interrupted sutures in the left lateral margin of the mesh and through the sacral fascia and periosteum (Fig. 66.4a). Tie none of these sutures yet, but apply a hemostat to each of them temporarily. After all six sutures have been inserted, have the assistants draw them taut. Then insert two fingers between the rectum and sacrum to check the tension of the mesh, thereby ensuring that there will be no constriction of the rectum (Fig. 66.4b). Now tie all six sutures. Use additional sutures of 4-0 atraumatic Prolene or Tevdek to attach both the proximal and distal margins of the mesh to the underlying rectum, so there is no possibility of the rectum sliding forward underneath the mesh.

Because there is a significant incidence of severe constipation and narrowing of the lumen by the mesh, Nicosia and Bass described fixation of the mesh to the presacral fascia using sutures or a fascial stapler. The mesh is then *partially* wrapped around and sutured to the rectum, leaving the anterior third of the rectal circumference free to dilate as necessary (Figs. 66.5 and 66.6).

Closure of Pelvic Peritoneum

Irrigate the pelvic cavity. Close the incision in the pelvic peritoneum with a continuous suture of 2-0 atraumatic PG (Fig. 66.7).

Wound Closure

To close the Pfannenstiel incision, grasp the peritoneum with hemostats and approximate it with a continuous 2-0 atraumatic PG suture. Use several sutures of the same material loosely to approximate the rectus muscle in the midline. Close the transverse incision in the rectus sheath and external oblique aponeurosis with interrupted sutures of atraumatic 2-0 PG. Close the skin with a continuous 4-0 PG subcuticular suture.

Generally, no pelvic drains are necessary. If hemostasis is not perfect, bring a 6 mm Silastic catheter out from the presacral space through a puncture wound in the lower abdomen and attach it to a closed-suction device (Fig. 66.5).

Postoperative Care

Nasogastric suction is not necessary.

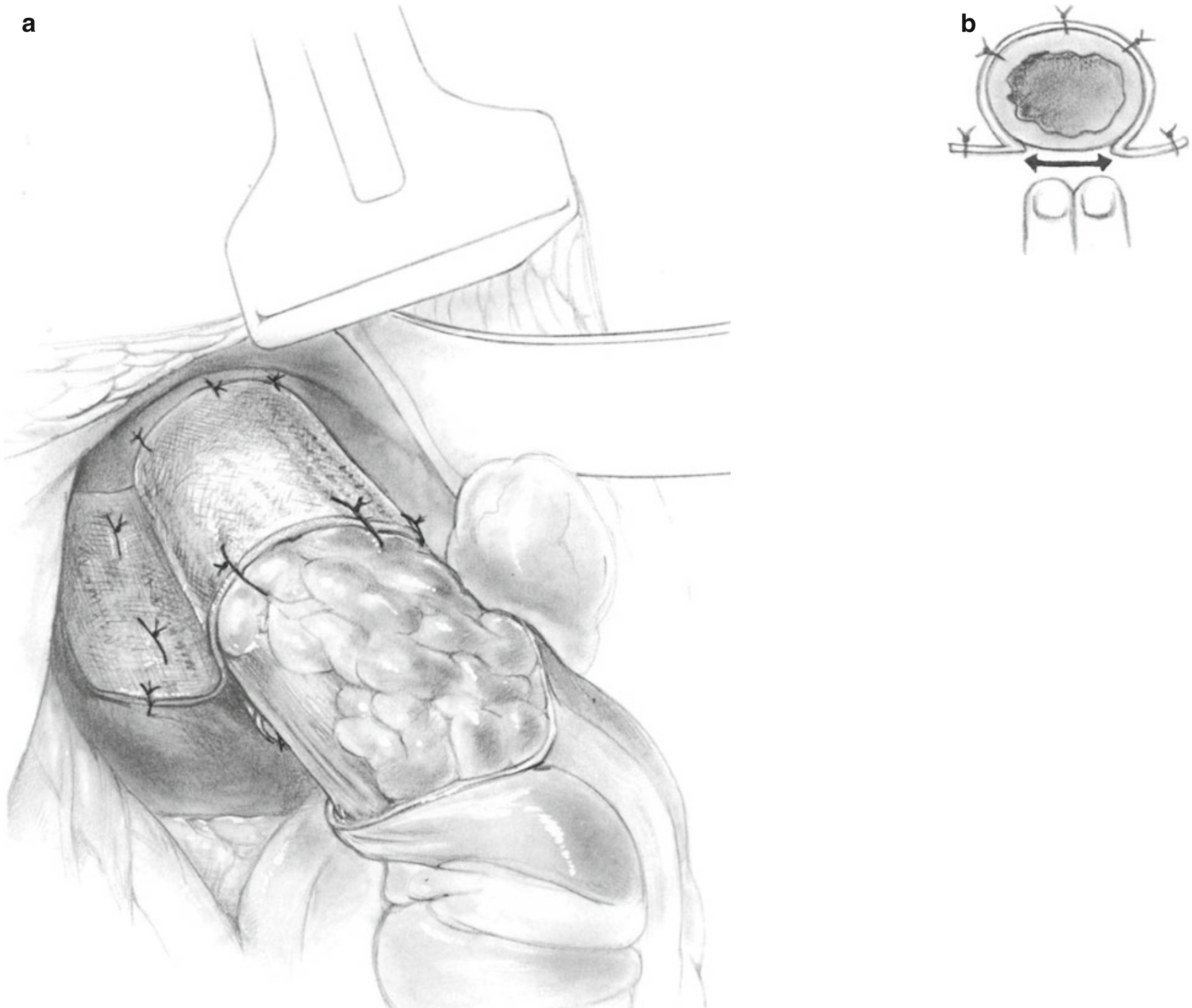

Fig. 66.4

Complications

Most patients who have a complete prolapse have suffered from years of *constipation*. They may have to continue the use of laxatives, although in some cases there is a definite improvement in the patient's bowel function following the operation.

Fecal incontinence—the result of many years of dilatation of the anal sphincters due to repeated prolapse—is also common among these patients. Correction of the prolapse does not automatically eliminate incontinence. This condition is alleviated over time in more than 30 % of patients who are placed on a regimen of high fiber and muscle-strengthening exercises, occasionally supplemented with biofeedback.

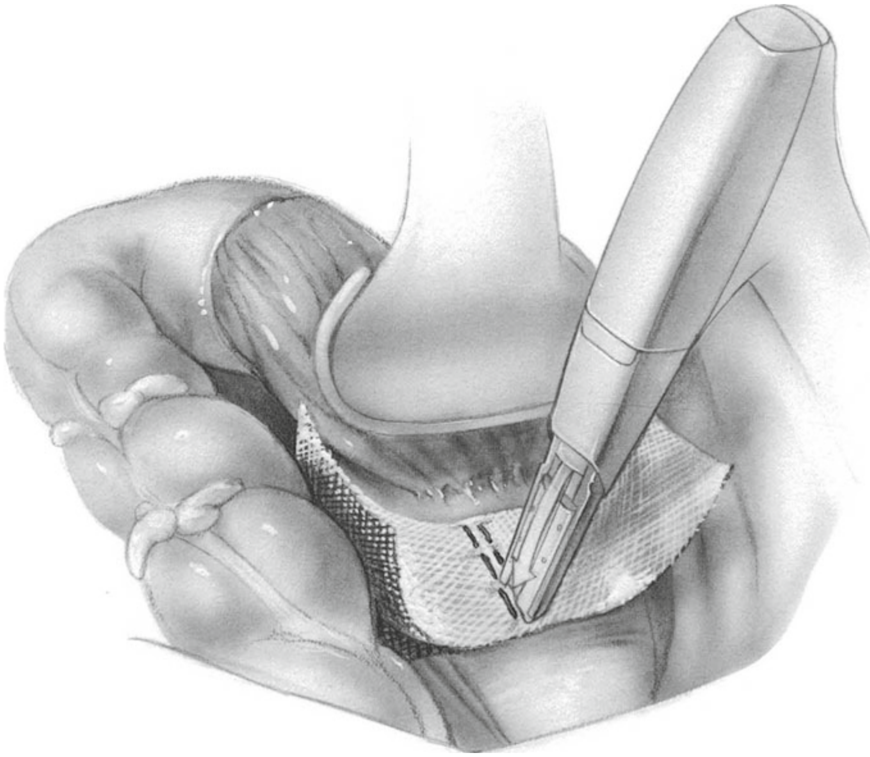

Fig. 66.5

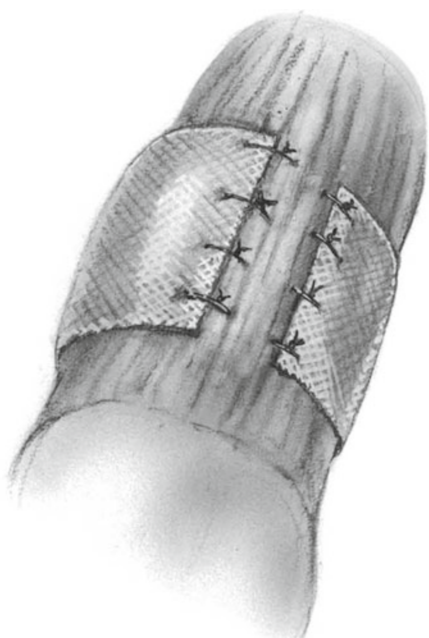

Fig. 66.6

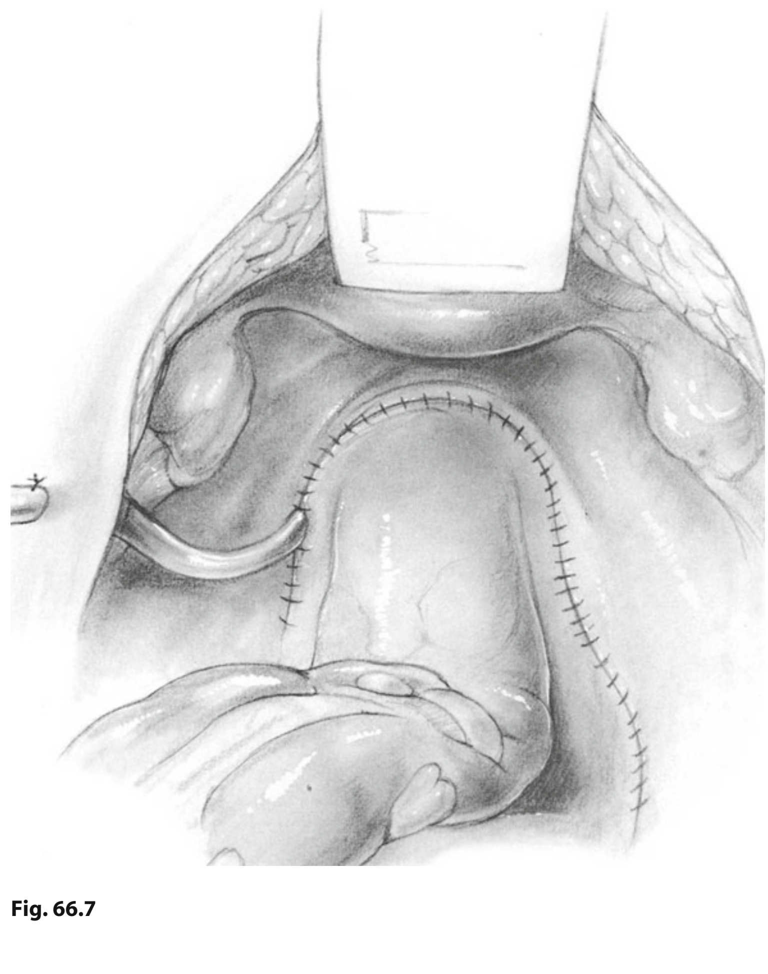

Fig. 66.7

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Part VI

Anus, Rectum, and Pilonidal Region

67 Concepts in Surgery of the Anus, Rectum, and Pilonidal Region

Muneera R. Kapadia and John W. Cromwell

Anatomy and Physiology

The anorectum is a particularly complicated region and function is dependent on many variables. In order to effectively treat disease of the anus and rectum, it is critical to have a solid understanding of the anatomy and physiology of the region.

The anal canal is typically 3–4 cm in length and represents the terminal segment of the gastrointestinal tract. It extends from the anorectal junction to the anal verge, which represents the edge of the anal orifice. Distal to the anal verge, the skin is pigmented and contains hair follicles and glands. Within the anal canal is the dentate line, a wavy demarcation which represents the mucocutaneous junction. Proximal to the dentate line is transitional epithelium; distal to the dentate line is anoderm made up of squamous epithelium, and therefore, there is cutaneous sensation in this area. Along the dentate line are anal glands and crypts.

Hemorrhoids are sinusoidal fibrovascular cushions which exist in the submucosal space of the anal canal. Hemorrhoids that occur proximal to the dentate line are termed internal hemorrhoids, whereas those that occur distal to the dentate line are termed external hemorrhoids. Hemorrhoids are part of normal anatomy that contribute to baseline anal continence. In addition, during times of increased intra-abdominal pressure, such as during coughing or sneezing, the vascular cushions engorge, maintaining continence.

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The anal canal is surrounded by cylindrical muscles that make up the anal sphincter: internal anal sphincter and external anal sphincter (Fig. 67.1). The internal anal sphincter is made up of smooth muscle and is contiguous with the smooth muscle of the rectum. It is supplied by sympathetic and parasympathetic nerves and thus is under involuntary control. The internal anal sphincter provides half of the resting anal tone, which is the baseline muscle tone which maintains anal continence during periods of inattention. The remainder is contributed by the external anal sphincter and the puborectalis muscles. The external anal sphincter surrounds the internal anal sphincter and is made up of cylinder of skeletal muscle. The innervation is derived from the sacral and pudendal nerves. In response to increased abdominal pressure (such as coughing and sneezing) or rectal distention, the external anal sphincter and puborectalis muscles contract reflexively and voluntarily to increase anal tone and maintain fecal continence. The levator ani muscles are broad muscles that make up the pelvic floor.

Several potential spaces exist around the anal canal (Fig. 67.1). The space between the internal and external anal sphincter is termed the intersphincteric space. The intersphincteric space is contiguous with the perianal space which surrounds the external portion of the anus circumferentially. Lateral to the external sphincter muscle on each side is the ischiorectal space which is also bound by the levator ani muscles superiorly and the ischial tuberosities laterally. These two ischiorectal spaces connect posteriorly though the deep postanal space, which lies between the levator ani and the anococcygeal ligament. The supralevator space, as the name suggests, lies superior to the levator ani muscles in a horseshoe shape around the rectum.

Anorectal Examination

Complete anorectal examination includes visual inspection, digital rectal examination, anoscopy, and proctoscopy. Patient positioning in the office setting can be either left

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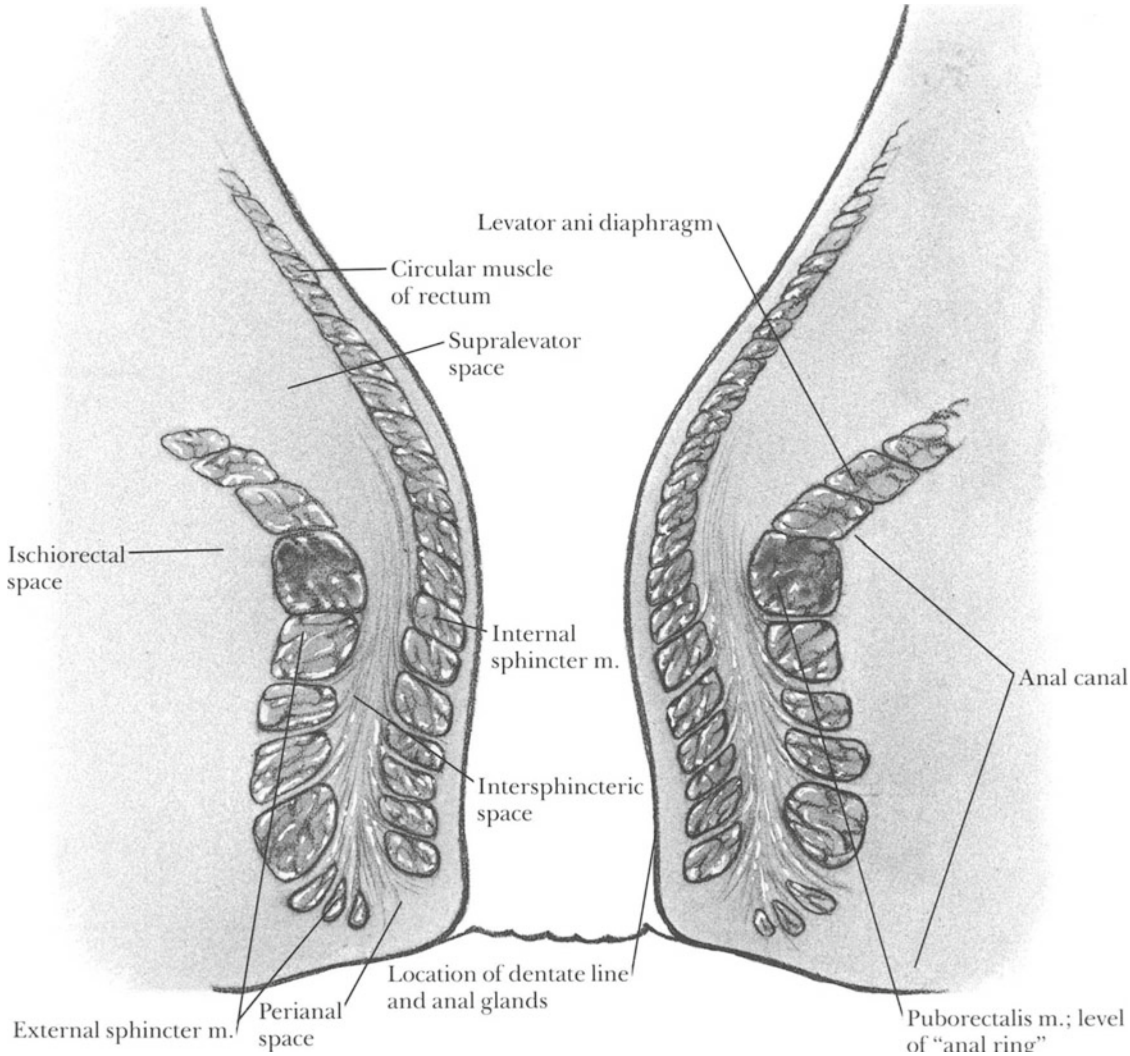

Fig. 67.1

lateral decubitus or prone jackknife if a Ritter table is available. Good lighting is paramount. Inspection of the anal area is the first portion of the anorectal examination and should be done with the buttocks retracted laterally. Abnormal masses, scarring, swelling, erythema, fluctuance, fissures, and hemorrhoidal enlargement or thrombosis should be noted. The next step is the digital rectal examination which should be performed with a lubricated gloved finger. The anal canal is examined for masses, induration, stricturing, or the presence of a rectocele. Baseline anal tone should be noted and the patient is asked to squeeze their anal sphincter in order to evaluate anal squeeze function. Next, anoscopy is performed to further evaluate the anal canal. Several types of anoscopes are available and should be utilized according to operator preference. Anoscopic examination assists evaluating the mucosa of the distal rectum and anal canal. Hemorrhoidal disease and mucosal abnormalities can be evaluated. Proctoscopy, either rigid or flexible, should be utilized to evaluate the rectum. Administration of a saline enema prior to the examination facilitates mucosal evaluation.

Ambulatory Management

Many common anorectal conditions such as hemorrhoidal rubber band ligation can be managed in the office setting. The components for successful treatment in this setting include a willing patient, an appropriate environment, and the correct instrumentation. Patients with severe anorectal pain precluding adequate examination are unlikely candidates for office treatment and should be treated with adequate anesthesia in an appropriate setting.

The need for excellent lighting cannot be understated and the absence of headlights or procedural lighting can be a significant barrier to performing anorectal procedures in the office setting. The prone jackknife position is most often used for treatment in this setting. If a table for prone positioning is not available or the patient is unable to accommodate this position, the Sims' position may be used with the patient on their left side, left leg extended and right leg flexed. A trained assistant is invaluable for exposing the gluteal crease, supporting the anoscope, passing instruments, and comforting the patient.

Local Anesthesia for Anorectal Procedures

Local anesthesia can be used for office procedures alone or combined with sedation for procedures performed in the operating room. A common technique involves injection of bupivacaine (0.25 %) with epinephrine (1:200,000). Buffering the anesthetic solution with 0.5 ml of 8.4 % sodium bicarbonate immediately before injection decreases pain. Five ml of anesthetic solution is injected into each quadrant of the subcutaneous tissues around the anus. This is followed by injecting 10 ml of solution just lateral to each side of the anal sphincter.

Operating Room Positioning

For operative anorectal surgery, both high-lithotomy and prone-jackknife positioning are used. Both positions offer different advantages and disadvantages. Lithotomy position is preferred from the standpoint of anesthesia, as it is perceived to be safer in the intubated patient. In the author's experience, most anorectal procedures can be done well in this position. Prone- jackknife positioning has a distinct advantage when dealing with anterior rectal pathology such as performing transanal excision of an anterior rectal lesion, as the operator is looking down on the lesion. This position must also be used for the treatment of pilonidal disease as the upper gluteal crease is not exposed in high-lithotomy position.

Clinical Conditions: Symptoms and Management Concepts

Hemorrhoids

Hemorrhoidal disease is the most common anorectal complaint for which patients present to physicians, and often the actual diagnosis is unrelated to hemorrhoids. Hemorrhoids are a normal part of anorectal anatomy, but they can enlarge secondary to chronic straining. When internal hemorrhoids enlarge, the overlying mucosa can become thin and friable which leads to bleeding with minimal trauma. This bleeding is typically painless and bright red in nature. It may range from a small amount on the toilet paper to dripping in the toilet bowl, but it is typically self-limited. Chronic straining can also lead to prolapse of internal hemorrhoidal tissue. Severity of internal hemorrhoids is categorized according to degree of prolapse. First-degree internal hemorrhoids do not exhibit any prolapse with straining. Second-degree internal hemorrhoids prolapse with straining, but spontaneously reduce. Third-degree internal hemorrhoids prolapse but reduce only with manual pressure. Fourth-degree internal hemorrhoids are not reducible. Degree of prolapse is best evaluated by asking the patient to sit on the commode and simulate having a bowel movement.

Treatment of internal hemorrhoids varies based on the degree of prolapse. All patients should be placed on bulking agents and instructed to drink plenty of fluids in order to minimize straining and regulate stool consistency. Often, this may be all that is required to treat first-degree internal hemorrhoids. If bleeding persists or prolapse is present, additional therapy may be necessary. There are several office-based procedures which are popular for treating internal hemorrhoids, and these include sclerotherapy, infrared coagulation, and rubber band ligation, which is our preference. Rubber band ligation involves placement of a strangulating rubber band on the redundant rectal mucosa. This procedure removes some of the redundant mucosa but more importantly fixes the mucosa to the underlying submucosa hopefully thereby preventing prolapse. These therapies are most successful with first- or second-degree internal hemorrhoids. Persistent symptoms after rubber band ligation require hemorrhoidectomy. Typically, third- and fourth-degree internal hemorrhoids as well as mixed internal and external hemorrhoids also require hemorrhoidectomy. This can be performed as a conventional excisional hemorrhoidectomy or, in selected cases, the so-called stapled hemorrhoidectomy or procedure for prolapsed hemorrhoids (PPH) may be employed. PPH removes mucosal tissue circumferentially and creates a mucosal anastomosis. It is therefore typically performed in patients with circumferential and more extensive internal hemorrhoidal disease.

Similar to internal hemorrhoids, external hemorrhoids can enlarge with chronic straining. External hemorrhoids are generally asymptomatic, but when thrombosis occurs, patients present with an acutely painful perianal lump. Thrombosis is often associated with pregnancy or exertion, such as lifting or straining. Within the first 72 h of onset, surgical excision may be performed to hasten recovery. Thrombosed hemorrhoids usually consist of multiple small thrombi; therefore, incision and drainage is generally ineffective and should be avoided. After this time period, the thrombosis usually begins to soften and become less painful. At this stage, it is generally recommended that treatment consist of supportive measures including sitz baths, pain control, and avoidance of constipation. With enlargement of the vascular cushions of the external hemorrhoids, the overlying skin can become redundant leading to the development of external hemorrhoidal tags. These are typically asymptomatic and require no treatment. Large skin tags may cause significant hygiene problems and secondary skin irritation and may be treated by excision.

Anorectal Suppurative Diseases

Most anorectal abscesses are thought to originate in the anal glands and crypts around the dentate line and represent enteric bacteria. While most abscesses occur in healthy individuals, risk factors include diabetes, Crohn's disease, perianal surgery, and human immunodeficiency virus positivity. There are four types of anorectal abscesses, and classification depends on anatomic location. Intersphincteric abscesses occur between the internal and external sphincter muscles. Perianal abscesses occur around the anus just under the perianal skin and are the most common type of anorectal abscess. Ischiorectal abscesses occur in the ischiorectal space. Because the ischiorectal spaces on either side of the anus are connected posteriorly through the deep postanal space, an ischiorectal abscess can present as a horseshoe abscess which nearly encircles the anorectum. Supralevator abscesses occur superior the levator ani muscle. These abscesses may be a result of anal cryptoglandular infection versus an intra-abdominal process.

The most common presentation for an anorectal abscess is severe constant anorectal pain, erythema, warmth, induration, and fluctuance. Fever and elevated white blood cell count may be present. However, depending on the location of the abscess, these symptoms may not be present. For example, intersphincteric abscesses typically present with pain and a normal external anal examination. Similarly, patients with a supralevator abscess present with a normal external anal examination. Digital rectal examination may reveal a rectal fullness suggestive of an abscess. Physical exam is sufficient for diagnosing most anorectal abscesses. Imaging is an important adjunct when a complex disease is suspected, there is early recurrence of a previously drained abscess, or an abscess is suspected but the external physical examination is normal. Computed tomography and magnetic resonance imaging are the most common imaging modalities utilized.

Appropriate treatment of anorectal abscesses includes incision and drainage. Straightforward abscesses can be treated in the office, emergency department, or operating room settings, depending on size, severity, and patient discomfort. Drainage is typically performed by incising the skin overlying the abscess as close to the external sphincter as possible. However, there are a few special circumstances which must be noted, and these are best treated in the operating room. Intersphincteric abscesses should be drained by internal sphincterotomy. Horseshoe abscess are treated by draining the deep postanal space and counter-incisions in the ischiorectal fossa. Treatment of supralevator abscess

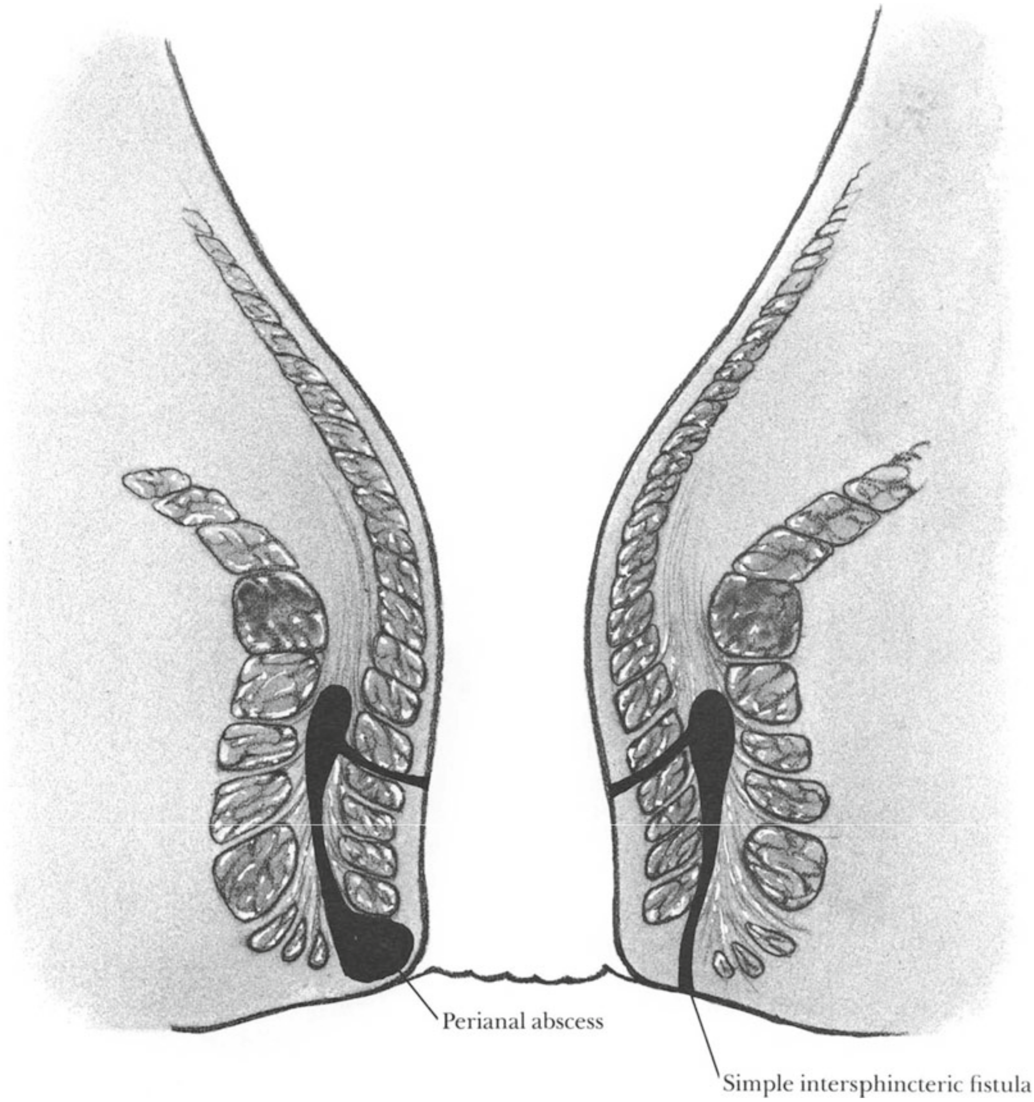

Fig. 67.2

depends on the source of the infection. Antibiotics are not indicated in the treatment of anorectal abscesses unless the patient is immunocompromised, there is a significant systemic response, or there is associated cellulitis.

Approximately one-third of patients with an anorectal abscess will subsequently develop an associated anal fistula. It is important to warn patients about this possibility at the time of abscess drainage. Anal fistulas can be defined according to the relationship to the external sphincter. Intersphincteric fistulas (Fig. 67.2) travel between the internal and external sphincter. Trans-sphincteric fistulas (Fig. 67.3) traverse part or all of the external sphincter. Suprasphincteric fistulas (Fig. 67.4) result from supralevator abscess and the tract surrounds the puborectalis and external sphincter muscles. Extrasphincteric fistulas (Fig. 67.5) originate above the level of the levators and pass through the ischiorectal fossa to the perianal skin.

Recurrent or chronic pain and drainage are the common symptoms associated with anal fistulas. On examination, an external fistula opening is usually visible and located at the previous site of incision and drainage. Patients with a suspected fistula should be evaluated in the operating room. Examination should include proctoscopy to rule out inflammation of the anorectum. Anoscopy is critical to identify the internal opening of the fistula, which is most often located at the dentate line. Fistula probes and hydrogen

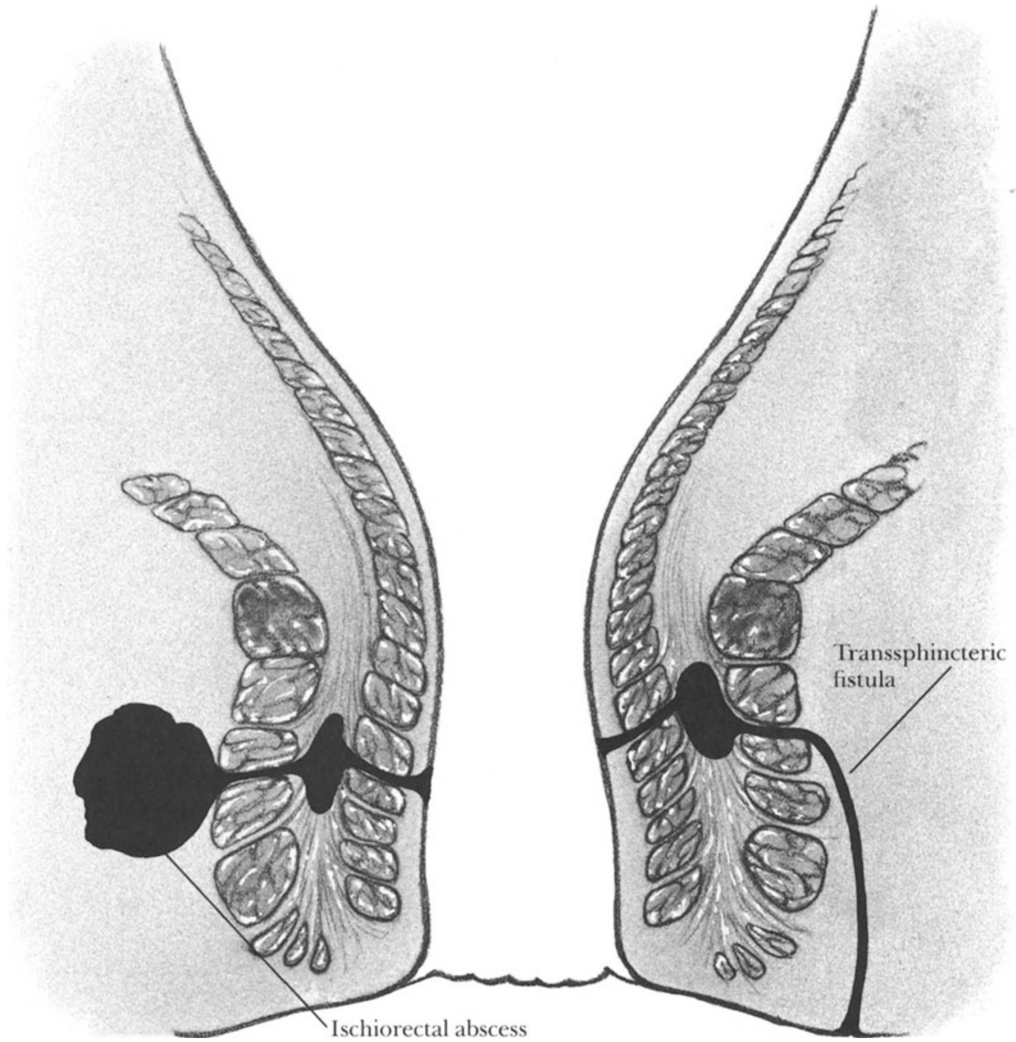

Fig. 67.3

peroxide can be used to elucidate the fistula tract. If the fistula tract cannot be determined, imaging studies such as ultrasound or magnetic resonance imaging of the pelvis may be helpful. It is critical to determine the amount of anal sphincter distal to the fistula tract as this determines the treatment options.

If the fistula tract involves less than 30 % of the anal sphincter, primary fistulotomy can be performed with good results. In female patients with anterior fistulas, patients with poor anal continence, patients with Crohn's disease, or patients with fistulas involving a significant portion of anal sphincter, primary fistulotomy should be avoided. For these patients, a draining seton should be placed to facilitate sepsis resolution and maturation of the tract. Cutting setons should be avoided. Following seton placement, definite fistula repair can be attempted. Several approaches have been described for fistula repair: fistula plug, fibrin glue, anorectal advancement flap, or ligation of intersphincteric fistula tract (LIFT) procedure.

Anal Fissure

Anal fissures are epithelial defects within the anal canal. Current theory regarding the etiology of typical anal fissures is that the spasm of the sphincteric mechanism results in decreased blood flow to the lining of the anal canal and that the resultant relative ischemia produces poor healing. They are most often caused by the trauma of defecation and should never extend above the level of the dentate line or out onto the anal verge. The biomechanics of the anal canal are such that most fissures occur in the midline posteriorly or, less commonly, anteriorly. Fissures occurring in the lateral position are uncommon and termed atypical. They are generally due to other pathophysiology including Crohn's disease, lymphogranuloma venereum, HIV or other viral infection, or being immunocompromised. These fissures may also be unusually broad or deep.

Pain from anal fissures originates both from pain at the site of injury and also from spasm of the internal and external

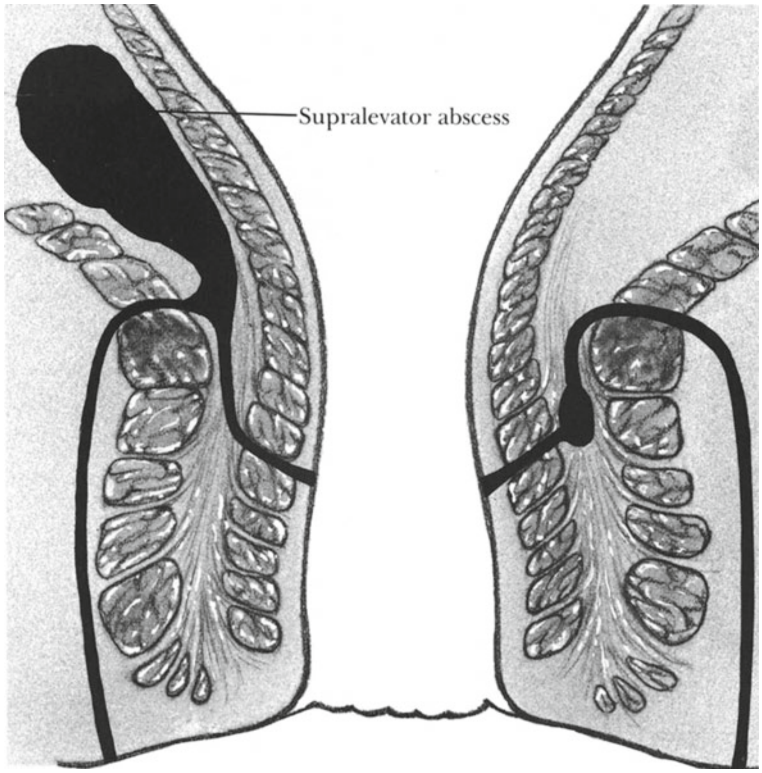

Fig. 67.4

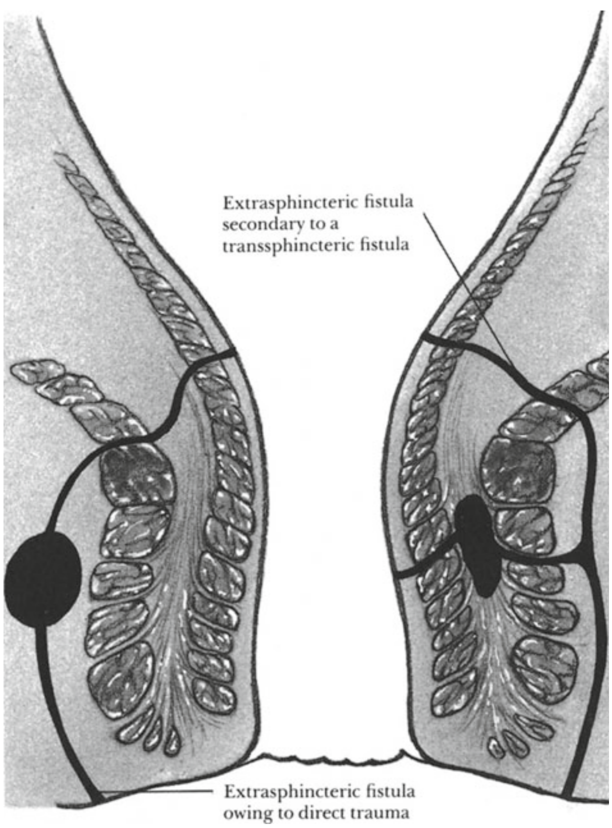

Fig. 67.5

anal sphincters. Despite this spasm, it should be possible to see an anal fissure by gently spreading the skin of the anal verge and lower anal canal.

Anal fissures usually cause painful bowel movements and some degree of rectal bleeding. Reducing the anal canal pressure medically or by dividing a portion of the internal sphincter increases anal canal blood flow and promotes healing of the anal fissure. Medical therapy of an anal fissure should almost always precede surgical therapy. Stool-bulking agents such as psyllium seed or methylcellulose in quantities sufficient to provide bulky soft stools reliably are the mainstays of medical therapy. The goal with these agents is to achieve a relatively atraumatic stool consistency without diarrhea. Stool softeners may also be helpful in achieving this goal, but laxatives should be avoided.

Topical calcium-channel blockers in the form of diltiazem gel (2 %) or nifedipine gel (0.3 %) are highly effective when applied to the perianal skin TID and combined with an effective bowel regimen. Persistence of a painful anal fissure for 6 weeks on good medical therapy or development of a complication such as infection constitutes an indication for lateral internal sphincterotomy. Alternatively, chemodenervation of the anal sphincter using botulinum toxin injection in either an office or operative setting may be used without causing permanent alteration of anal sphincter function. This treatment may be preferred in patients with impaired fecal continence.

Fissures that fail to respond to therapy or those that are associated with plaques or an exophytic mass should undergo biopsy to rule out dysplasia or malignancy. Atypical fissures are generally treated by addressing the underlying pathophysiology.

Anal Stenosis

Anal stenosis is a pathologic constriction of the anal canal. The most common etiologies include prior anorectal surgery, external-beam radiation therapy, Crohn's disease, and neoplasm. Patients with anal stenosis often complain of constipation, ribbonlike stools, painful defecation, and the inability to perform enemas.

Patients with severe anal stenosis may require proximal fecal diversion prior to other management of the stenosis. For patients with Crohn's disease and neoplasm, the underlying condition should be the focus of initial management.

For mild anal stenosis, a bowel regimen and manual anal dilatation may be sufficient to provide relief from difficult defecation. For more severe forms of stenosis, manual dilatation will be too difficult or painful for the patient to perform and may be done by the surgeon under anesthesia. Severe stenosis is unlikely to have a durable result from dilatation, however.

The mainstay of surgical treatment of anal stenosis is anoplasty, during which a vascularized skin flap from the perianal and buttock region is advanced into the anal canal after dividing the anal constriction. The skin flap is then secured in the anal canal with sutures. Following healing of the flap, anal dilatation is often performed to maintain long-term patency.

Rectal Prolapse

Rectal mucosal prolapse may occur with hemorrhoidal disease (see above). Full-thickness rectal prolapse is different. This is recognized by concentric folds of rectal mucosa as apposed to a mucosal rosette. Both perineal and abdominal operations are available to correct the problem and are included in this text. Young, physiologically fit patients may be best served by a transabdominal operation, although more recently this has been challenged. Transabdominal approaches usually include rectopexy. Older patients may be better served with a perineal operation. The perineal operations provide better control of prolapse with less morbidity than the old Thiersch procedure (included as a surgical legacy procedure).

Pilonidal Disease

Pilonidal disease is not an anorectal disease in the purest sense. Its association with anorectal disease is only by proximity. Pilonidal disease is a term used to describe infections that originate in the gluteal cleft. It is currently thought to be an acquired rather than a congenital disorder. The precise sequence of events is debated, but there is an agreement that the shape of the gluteal cleft and its effect on loose hair in this region leads to penetration of hair underneath the skin. This leads to formation of chronic subcutaneous abscesses that contain hair. Multiple infectious episodes create multiple openings along the midline and lateral to it that can mimic other anal conditions. The variety of operations that have been described for this condition suggest that there is no solitary infallible procedure for cure. Current trends are toward less radical surgery. Avoidance of a midline wound, removal of the foreign material from the abscess cavity, and removal of hair in the region of the gluteal cleft by shaving or tweezing seem to be important elements for obtaining a healed wound.

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Rubber Band Ligation of Internal Hemorrhoids

68

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Symptomatic (bleeding or prolapsed) internal hemorrhoids situated above the area in the anal canal, which is innervated by somatic sensory nerves.

The procedure for prolapsed hemorrhoids (see Chap. 70) has emerged as a surgical alternative that provides a slightly lower recurrence rate than rubber band hemorrhoidectomy. Rubber band ligation is an office procedure that may be performed at slightly lower cost.

Pitfalls and Danger Points

Applying a rubber band in an area supplied by somatic sensory nerves

Failure to recognize the delayed complication of pelvic sepsis

Operative Strategy

To avoid postoperative pain, apply the rubber band to a point *at least 5–6 mm above the dentate line*. In some patients, a margin of 5–6 mm is not sufficient to avoid pain. These patients can be identified by pinching the mucosa at the site of the proposed application of the band. If the patient has pain when the mucosa is pinched, apply the band at a higher level where the mucosa is not sensitive or abandon the rubber banding procedure.

If the patient has severe pain after the rubber band has been applied, remove the rubber band immediately using fine-tipped forceps and sharp pointed scissors. If this removal is delayed until several hours after the application, surrounding edema often makes the procedure difficult if not impossible without anesthesia and without causing bleeding.

Documentation Basics

- Findings
- Number and location of hemorrhoids banded

Operative Technique

Perform sigmoidoscopy to rule out other possible sources of rectal bleeding. With the patient in the knee-chest position, insert a fenestrated anoscope (e.g., Hinkel-James type) that permits the internal hemorrhoid to protrude into the lumen of the anoscope. A lighted anoscope is a great convenience. Inspect the circumference of the anal canal. Try to identify the hemorrhoid that caused the bleeding. If this is not possible, identify the largest internal hemorrhoid. Insert the curved Allis tissue forceps into the anoscope and pinch the mucosa around the base of the hemorrhoid to identify an insensitive area. Ask the assistant to hold the anoscope in a steady position. Now inspect the McGivney rubber band applicator. Be sure that two rubber bands have been inserted into their proper position on the drum of the applicator. Ask the patient to strain. With the left hand, pass the drum up to the *proximal* portion of the hemorrhoid. Insert the angled tissue forceps through the drum.

When grasping the rectal mucosa, be sure to grasp it along the cephalad surface of the hemorrhoid at point A (not point B) in Fig. 68.1. If this is done, the rubber band does not encroach on the sensitive tissue at the dentate line. Draw the

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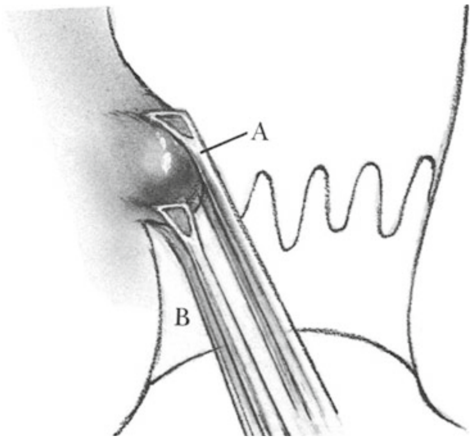

Fig. 68.1

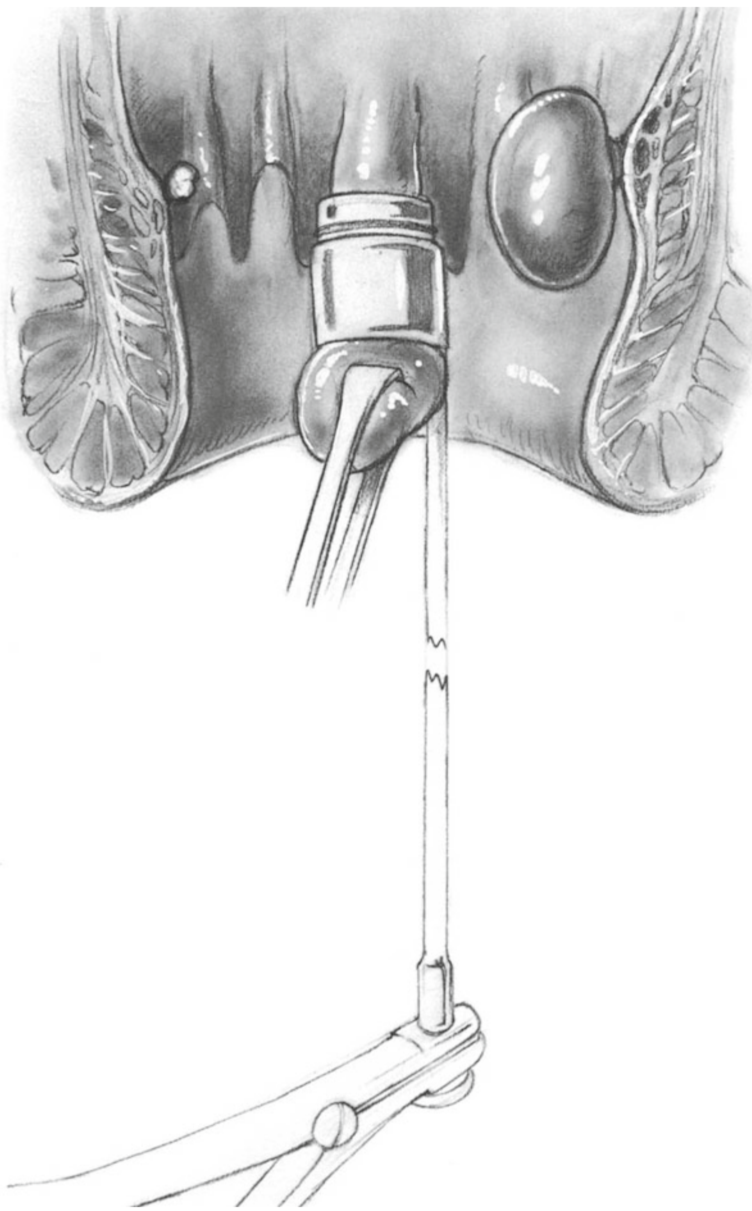

Fig. 68.2

mucosa into the drum and simultaneously press the drum against the wall of the rectum (Fig. 68.2). When the McGivney applicator is in the proper position, compress the handle of the applicator. Remove the tissue forceps and the McGivney applicator from the anoscope. The result should be a round purple mass of hemorrhoid about the size of a cherry and strangulated by the two rubber bands at its base.

Tchirkow et al. (1982) recommended injecting 1–2 ml of a local anesthetic (we use 0.25 % bupivacaine or lidocaine with epinephrine 1:200,000), using a 25-gauge needle, into the banded hemorrhoid. This maneuver appears to lessen some of the postoperative discomfort and may accelerate sloughing of the strangulated mass.

Nivatvongs and Goldberg (1982) advocate applying the band to redundant rectal mucosa just proximal to the hemorrhoid. Insert the slotted anoscope and ask the patient to strain. The redundant rectal mucosa just *proximal to the hemorrhoid* bulges into the slot of the anoscope. Apply the band to this mucosa as detailed above.

In general, only one hemorrhoid is treated at each office visit. Have the patient return in about 3 weeks for the second application. Rarely are more than three applications necessary. Applying two or three bands at one sitting often causes significant discomfort.

Postoperative Care

Inform the patient that postoperatively he or she may feel a vague discomfort in the area of the rectum accompanied by mild tenesmus, especially for 1–2 days after the procedure. Prescribe mild nonconstipating analgesic medication. Apprehensive patients do well if this medication is supplemented by a tranquilizer such as diazepam.

Warn the patient prior to the procedure that on rare occasions sometime between the seventh and tenth postoperative days, when the slough separates, there may be active bleeding into the rectum. A serious degree of bleeding requiring hospitalization occurs in no more than 1–2 % of cases.

Prescribe a stool softener such as Colace. For constipated patients, Senokot-S (two tablets nightly) helps to keep the stool soft and stimulates colonic peristalsis.

Patients may return to their regular occupation when they so desire.

Complications

Sepsis

This dreaded complication is distinctly rare, but can be fatal. The typical patient suffering postbanding sepsis complains of rectal pain and urinary retention on the third or fourth postoperative day. The physical examination and leukocyte count at this time may be normal. During the next day or two, edema of the rectum, perineum, or lower abdominal wall may develop and can be confirmed by computed tomography (CT).

Proctoscopic examination at this stage demonstrates marked edema of the rectum and necrosis at the sites of banding; fever and leukocytosis are also notable at this time, and death is not far off. At autopsy, marked rectal and pelvic edema, sometimes phlegmonous, is common, occasionally accompanied by a small rectal or pelvic abscess. Shemesh et al. theorized that following band ligation transmural ischemic necrosis of the tissue enclosed in the band allowed egress of bowel bacteria into the surrounding pelvic soft tissues. Although the blood cultures were all negative in the reported cases, postmortem bacterial cultures revealed coliform bacteria and, in one case, *Clostridium perfringens*, *Clostridium sporogenes*, and *Bacteroides* (O'Hara 1980).

All the patients who survived this complication were treated as soon as they presented with pain and urinary symptoms. Intensive, early treatment with intravenous antibiotics aimed at clostridia, other anaerobes, and gram-negative rods is essential. Patients who undergo banding must be told that if they experience urinary symptoms, fever, or pain 1–4 days after the procedure, they must promptly return to the surgeon for hospital admission to receive immediate antibiotic treatment, even if physical signs at that time are negligible.

Pain

If *severe* pain occurs upon application of the band, remove the band promptly before the patient leaves the office. Treat a *mild* degree of vague discomfort with medication.

Bleeding

If the patient sustains a mild degree of blood spotting in the stool when the slough separates a week or 10 days after the banding, treat it expectantly. If the patient has lost more than a few hundred milliliters, admit the patient to the hospital for proctoscopy. Suction out all the clots and identify the bleeding point. In some cases the bleeding point can be grasped with Allis tissue forceps and a rubber band again applied to the area. Alternatively, under general or local anesthesia, use either electrocautery or a suture to control the bleeding.

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69 Hemorrhoidectomy

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Persistent bleeding or protrusion
Symptomatic second- and third-degree (combined internal-external) hemorrhoids
Symptomatic hemorrhoids combined with mucosal prolapse
Strangulation of internal hemorrhoids
Early stage of acute thrombosis of external hemorrhoid

Contraindications

Portal hypertension
Inflammatory bowel disease
Anal malignancy

Preoperative Preparation

Advise patients to discontinue aspirin and other nonsteroidal antiinflammatory agents.
A sodium phosphate packaged enema (Fleet) is adequate cleansing for most patients.
Sigmoidoscopy, colonoscopy, or both are done as indicated by the patient's symptoms.
Routine preoperative blood coagulation profile (partial thromboplastin time, prothrombin time, platelet count) is performed if there is any suspicion of liver disease.
Preoperative shaving of the perianal area is preferred by some surgeons but is not necessary.

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Pitfalls and Danger Points

Narrowing the lumen of the anus, thereby inducing anal stenosis
Trauma to sphincter
Failing to identify associated pathology (e.g., inflammatory bowel disease, leukemia, portal hypertension, coagulopathy, squamous carcinoma of the anus)
Failure to manage postoperative bowel function

Operative Strategy

Avoiding Anal Stenosis

The most serious error when performing hemorrhoidectomy is failure to leave adequate bridges of mucosa and anoderm between each site of hemorrhoid excision. If a minimum of 1.0–1.5 cm of viable anoderm is left intact between each site of hemorrhoid resection, the risk of developing anal stenosis is minimized. Preserving viable anoderm is much more important than removal of all external hemorrhoids and redundant skin.

One method of preventing anal stenosis is to insert a large anal retractor, such as the Fansler or large Ferguson, after resecting the hemorrhoids. If the incisions in the mucosa and anoderm ("closed hemorrhoidectomy") can be sutured with the retractor in place, anal stenosis should not occur if good bowel function is maintained postoperatively.

Achieving Hemostasis

Traditionally, surgeons have depended on mass ligature of the hemorrhoid "pedicle" for achieving hemostasis. This policy ignores the fact that small arteries penetrate the internal sphincter and enter the operative field. Also, numerous vessels are divided when incising the mucosa to dissect the

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pedicle. In fact, the concept of a "pedicle" as being the source of a hemorrhoidal mass is largely erroneous. A hemorrhoidal mass is not a varicose vein situated at the termination of the portal venous system. It is a vascular complex with multiple channels fed by many small vessels. Therefore it is important to control bleeding from each vessel as it is transected during the operation. A convenient method for accomplishing this goal is careful, accurate application of coagulating electrocautery. As pointed out by Goldberg and associates (Goldberg et al. 1980), much of the bleeding comes from the mucosal incision. Therefore, it is well to achieve perfect hemostasis before suturing the defect following hemorrhoid excision.

Associated Pathology

Even though hemorrhoidectomy is a minor operation, a complete history and physical examination are necessary to rule out important systemic diseases such as leukemia. Leukemic infiltrates in the rectum can cause severe pain and can mimic hemorrhoids and anal ulcers. Operating erroneously on an undiagnosed acute leukemia patient is fraught with the dangers of bleeding, failure to heal, and sepsis. Crohn's disease must also be ruled out by history, local examination, and sigmoidoscopy, as well as biopsy in doubtful situations.

Another extremely important condition sometimes overlooked during the course of hemorrhoidectomy is squamous cell carcinoma of the anus. It may resemble nothing more than a small ulceration on what appears to be a hemorrhoid. Any hemorrhoid that demonstrates a break in the continuity of the overlying mucosa should be suspected of being a carcinoma, as should any ulcer of the anoderm, except for the classic anal fissure located in the posterior commissure. Before scheduling hemorrhoidectomy, biopsy all ulcerations and atypical lesions of the anal canal. It is prudent to submit label each hemorrhoid by location and submit for pathological examination.

Documentation Basics

Coding for anorectal procedures is complex. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (American Medical Association 2013). In general, it is important to document:

- Findings
- Internal versus external hemorrhoids
- Presence or absence of strangulation
- Ligation versus excision versus incision
- Closure of mucosa

Operative Technique

Closed Hemorrhoidectomy

Local Anesthesia

Choosing an Anesthetic Agent

A solution of 0.5 % lidocaine (maximum dosage 80 ml) or 0.25 % bupivacaine (maximum dosage 80 ml) combined with epinephrine 1:200,000 and 150–300 units of hyaluronidase is effective and has extremely low toxicity. Because perianal injection of these agents is painful, premedicate the patient 1 h before the operation with an intramuscular injection of some combination of narcotic and sedative (e.g., Demerol and a barbiturate or Innovar, 1–2 ml). Alternatively, give diazepam in a dose of 5–10 mg intravenously just before the perianal injection.

Techniques of Local Anesthesia

With the technique originally introduced by Kratzer (1974), the anesthetic agent is placed in a syringe with a 25-gauge needle. The needle should be at least 5 cm in length. Initiate the injection at a point 2–3 cm lateral to the middle of the anus. Inject 10–15 ml of the solution in the *subcutaneous* tissues surrounding the right half of the anal canal including the area of the anoderm at the anal verge. Warn the patient that this injection may be quite painful. Repeat this maneuver through a needle puncture site to the left of the anal canal. After placing a slotted anoscope in the anal canal, insert the needle into the tissues just underneath the anoderm and into the plane between the submucosa and the internal sphincter 3–4 cm deep into the anal canal (Fig. 69.1). If the injection creates a wheal in the mucosa similar to that seen in the skin after an intradermal injection, the needle is in a too-shallow position. An injection into the proper submucosal plane produces no visible change in the overlying mucosa. Inject 3–4 ml of anesthetic solution during the course of withdrawing the needle. Make similar injections in each of the four quadrants until the subdermal and submucosal tissues of the anal canal have been surrounded with anesthetic agent. It should require no more than 30–40 ml of anesthetic solution. Satisfactory relaxation of the sphincters is achieved without the need to inject solution directly into the muscles or to attempt to block the inferior hemorrhoidal nerve in the ischiorectal space. Wait 5–10 min for complete relaxation and anesthesia.

In 1982, Nivatvongs described a technique to minimize pain (Nivatvongs 1982). It consisted, first, of inserting a small anoscope into the anal canal. Make the first injection into the *submucosal* plane 2 mm *above* the dentate line. Because of the difference in sensory innervation of the mucosa above the dentate line, injection here does not

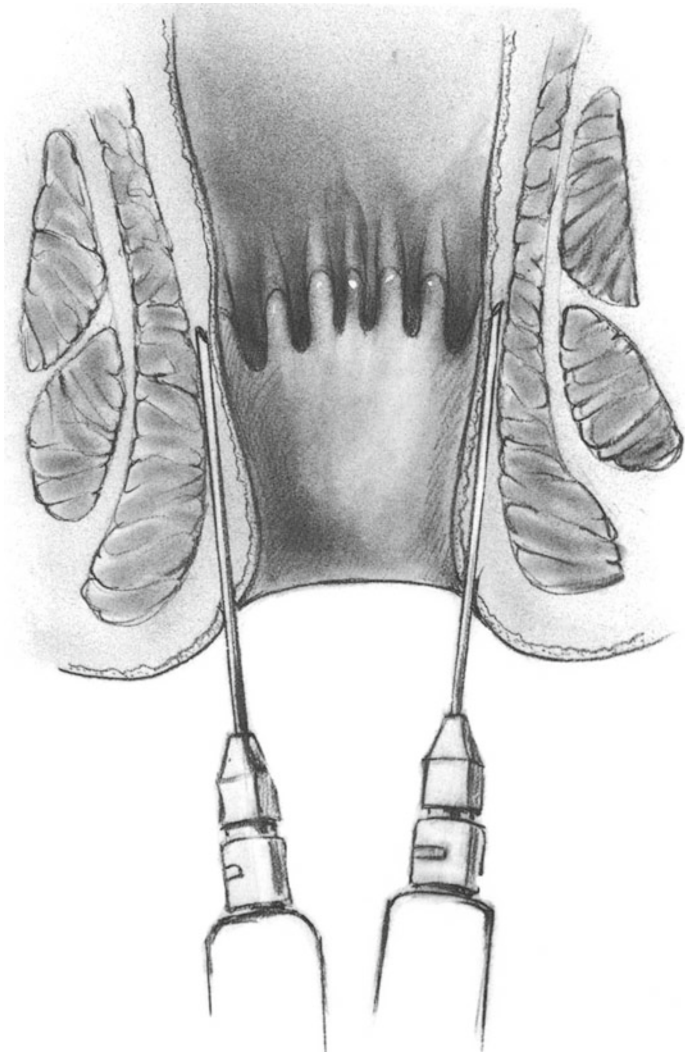

Fig. 69.1

produce acute pain. Inject 2–3 ml of anesthetic solution and then an equal amount of solution in each of the remaining three quadrants of the anus. Remove the anoscope and insert a well lubricated index finger into the anal canal. Use the tip of the index finger to massage the anesthetic agent from the submucosal area down into the tissues underneath the anoderm. Repeat this maneuver with respect to each of the four injection sites. By spreading the anesthetic agent distally, this maneuver serves to anesthetize the highly sensitive tissues of the anoderm just distal to the dentate line. When this has been accomplished, make another series of injections 2 mm *distal* to the dentate line. Inject 2–3 ml of solution underneath the anoderm and the subcutaneous tissues in the perianal region through four sites, one in each quadrant of the anus. Then use the index finger again to massage the tissues of the anal canal to spread the anesthetic solution circumferentially around the anal and perianal area. In some cases additional anesthetic agent is necessary for complete circumferential anesthesia. An average of 20–25 ml of solution is required. Nivatvongs stated that this technique provides excellent relaxation of the sphincters and permits operation such as hemorrhoidectomy to be accomplished without general anesthesia. For a lateral sphincterotomy, it is not necessary to anesthetize the entire circumference of the anal canal when using this technique. Inject only the area of the sphincterotomy.

Intravenous Fluids

Because local anesthesia has few systemic effects, it is not necessary to administer a large volume of intravenous fluid during the operation. If large volumes of fluid are administered intraoperatively, the bladder becomes rapidly distended. In the presence of general anesthesia or even heavy sedation during local anesthesia, the patient is not sufficiently alert to have the desire to void. By the time the patient is alert, the bladder muscle has been stretched and may be too weak to empty the bladder, especially if the patient also has anal pain and some degree of prostatic hypertrophy. This can cause postoperative urinary retention, requiring catheterization. All of this can be prevented by avoiding general anesthesia and heavy premedication and by limiting the dosage of intravenous fluids to 100–200 ml during and after hemorrhoidectomy.

Positioning the Patient

We prefer to place the patient in the semiprone jackknife position with either a sandbag or rolled-up sheet under the hips and a small pillow to support the feet. It is not necessary to shave the perianal area; if the buttocks are hirsute, shave this area. Then apply tincture of benzoin. When this solution has dried, apply wide adhesive tape to the buttock and attach the other end of the adhesive strap to the operating table. In this fashion lateral traction is applied to each buttock, affording excellent exposure of the anus.

The alternative lithotomy position is preferred by some surgeons. This allows full access to the airway by anesthesia personnel. The surgeon generally sits to operate, and the operative field is vertical rather than horizontal.

Incision and Dissection

Gently dilate the anal canal so it admits two fingers. Insert a bivalve speculum such as the Parks retractor or a medium-size Hill-Ferguson retractor. One advantage of using the medium Hill-Ferguson retractor is that it approximates the diameter of the normal anal canal. If the defects remaining in the mucosa and anoderm can be sutured closed with the retractor in place following hemorrhoid excision, no

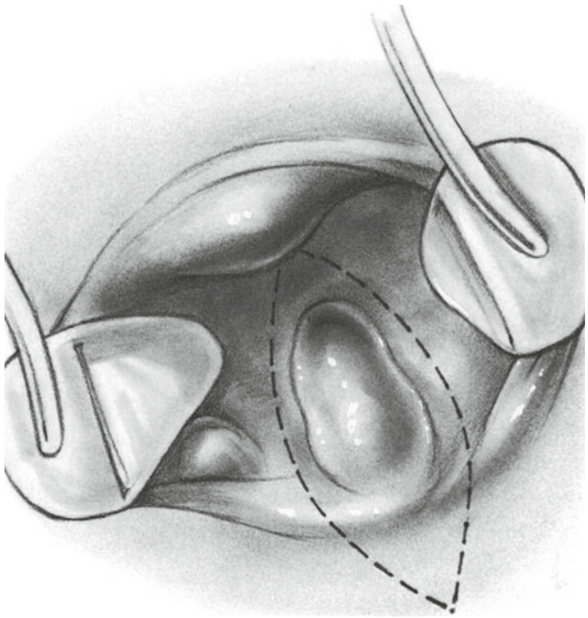

Fig. 69.2

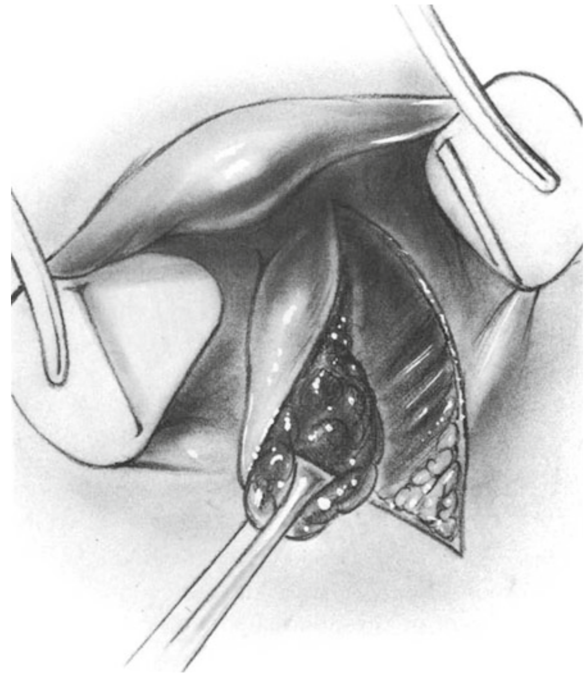

Fig. 69.3

narrowing of the anal canal occurs. Each of the hemorrhoidal masses can be identified by rotating the retractor and applying countertraction to the skin of the opposite wall of the anal canal. Generally, three hemorrhoidal complexes are excised: one in the left midlateral position, another in the right anterolateral position, and the third in the right posterolateral location. Avoid placing incisions in the anterior or posterior commissures. Grasp the most dependent portion of the largest hemorrhoidal mass in a Babcock clamp. Then make an incision in the anoderm outlining the distal extremity of the hemorrhoid (Fig. 69.2) using a No. 15 (Bard-Parker) scalpel. If the hemorrhoidal mass is unusually broad (>1.5 cm), do not excise all of the anoderm and mucosa overlying the hemorrhoid. If each of the hemorrhoidal masses is equally broad, excising all of the anoderm and mucosa overlying each of the hemorrhoids results in inadequate tissue bridges between the sites of hemorrhoid excision. In such a case incise the mucosa and anoderm overlying the hemorrhoid in an elliptical fashion. Then initiate a submucosal dissection using small, pointed scissors to elevate the mucosa and anoderm from the portion of the hemorrhoid that remains in a submucosal location. Carry the dissection of the hemorrhoidal mass down to the internal sphincter muscle (Fig. 69.3). After incising the mucosa and anoderm, draw the hemorrhoid away from the sphincter, using blunt dissection as necessary, to demonstrate the lower border of the internal sphincter. This muscle has whitish muscle fibers that run in a transverse direction. A thin bridge of fibrous tissue is often seen connecting the substance of the hemorrhoid to the internal sphincter. Divide these fibers with a scissors. Dissect the hemorrhoidal mass for a distance of about 1–2 cm above the dentate line where it can be divided with the electrocoagulator (Fig. 69.4). Remove any residual internal hemorrhoids from underneath the adjacent mucosa. Achieve complete hemostasis, primarily with careful electrocoagulation. It is not necessary to clamp and suture the hemorrhoidal "pedicle," although many surgeons prefer to do so (Fig. 69.5). It is helpful to remove all the internal hemorrhoids, but we do not attempt to extract fragments of external hemorrhoids from underneath the anoderm, as this step does not appear necessary. Most of these small external hemorrhoids disappear spontaneously following internal hemorrhoidectomy.

After complete hemostasis has been achieved, insert an atraumatic 5-0 Vicryl suture into the apex of the hemorrhoidal defect. Tie the suture and then close the defect with a continuous locking suture taking 2- to 3-mm bites of mucosa on each side (Fig. 69.6). Also include a small bit of the underlying internal sphincter muscle with each pass of the needle. This maneuver serves to force the mucosa to adhere to the underlying muscle layer and thereby helps prevent mucosal prolapse and recurrent hemorrhoids. Continue the suture line until the entire defect has been closed. Now repeat the same dissection for each of the other two hemorrhoidal masses. Close each of the mucosal defects by the same technique (Fig. 69.7). Be certain not to constrict the lumen of the anal canal. The rectal lumen should admit a Fansler or a large Ferguson rectal retractor after the suturing is completed. To avoid anal stenosis remember that the ellipse of mucosa-anoderm excised with each hemorrhoidal mass must be relatively narrow. Also remember that if the

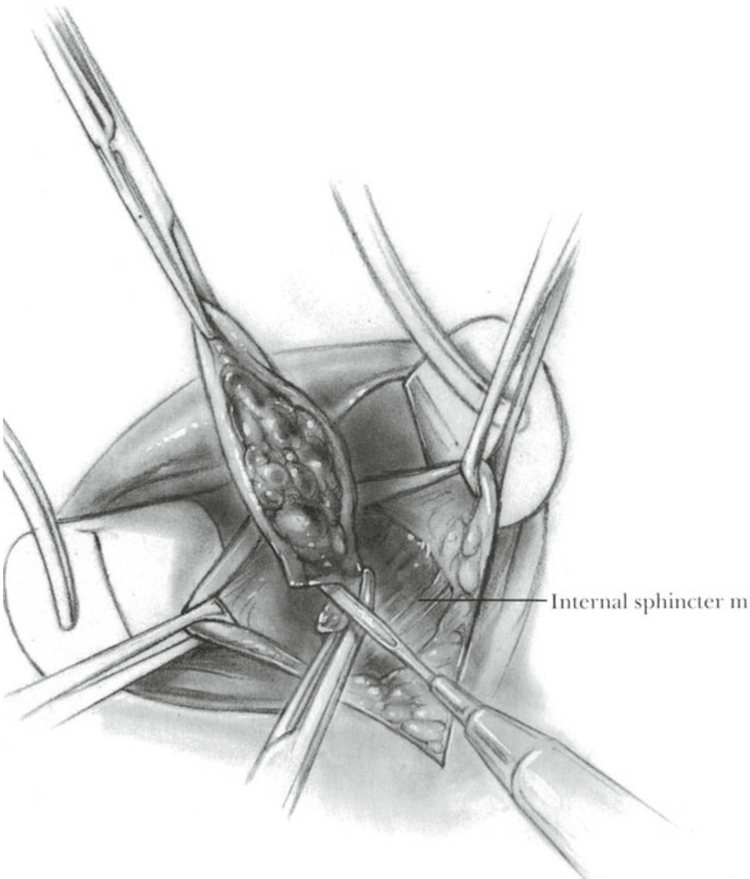

Fig. 69.4

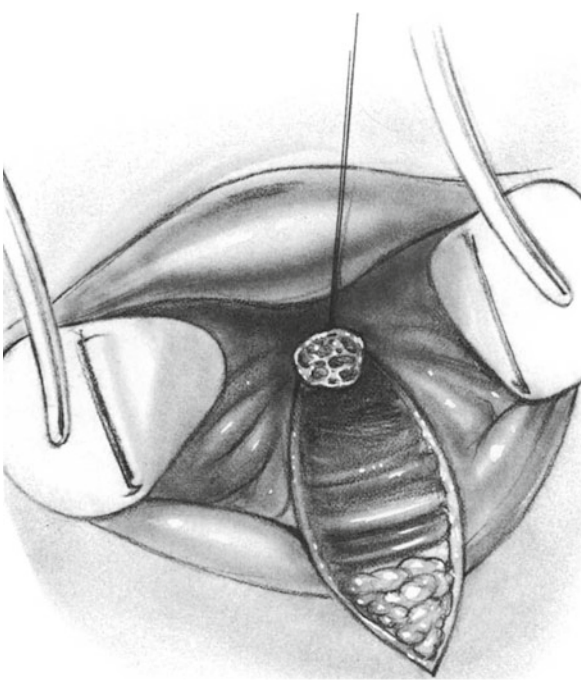

Fig. 69.5

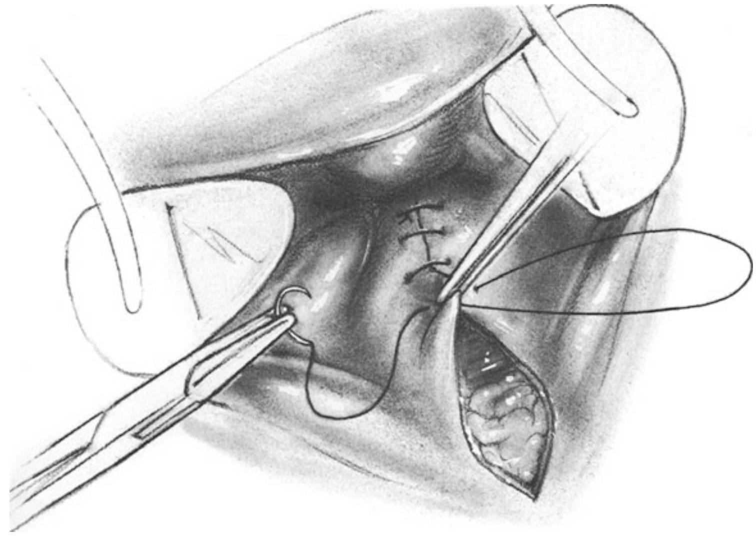

Fig. 69.6

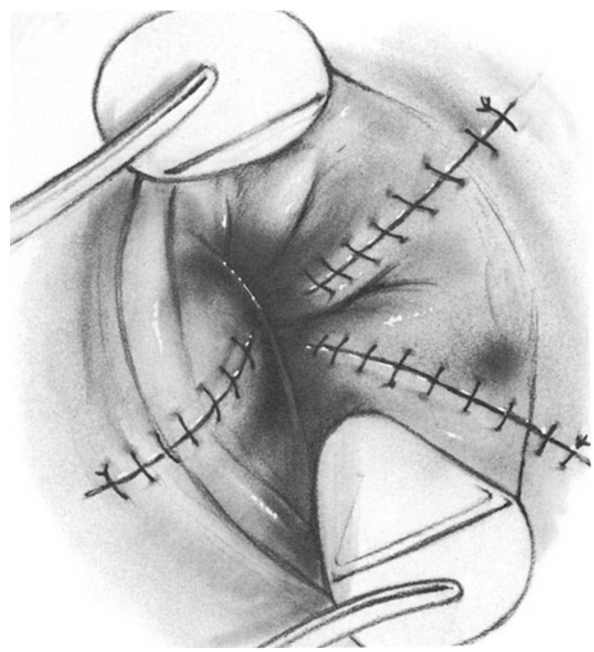

Fig. 69.7

tissues are sutured under tension, the suture line will undoubtedly break down.

A few patients have some degree of anal stenosis in addition to hemorrhoids. Under these conditions, rather than forcibly dilating the anal canal at the onset of the operation, perform a partial lateral internal sphincterotomy to provide adequate exposure for the operation. This is also true for patients who have a concomitant chronic anal fissure.

For surgeons who prefer to keep the skin unsutured for drainage, modify the above operative procedure by discontinuing the mucosal suture line at the dentate line, leaving the

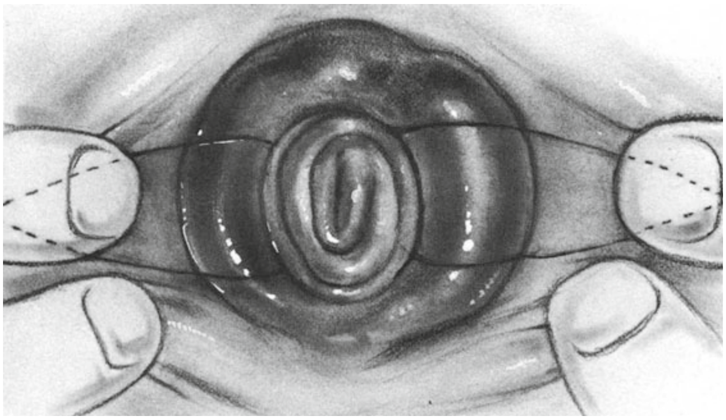

Fig. 69.8

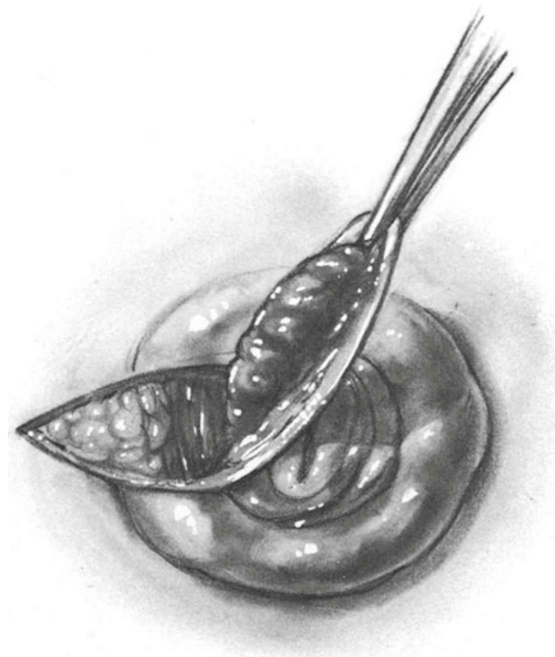

Fig. 69.9

defect in the anoderm unsutured. It is also permissible not to suture the mucosal defects at all after hemorrhoidectomy (see above).

Radical Open Hemorrhoidectomy

Incision

Radical open hemorrhoidectomy is restricted to patients who no longer have three discrete hemorrhoidal masses but in whom all of the hemorrhoids and prolapsing rectal mucosa seem to have coalesced into an almost circumferential mucosal prolapse. For these patients the operation excises the hemorrhoids, both internal and external, the redundant anoderm, and prolapsed mucosa from both the left and right lateral portions of the anus, leaving 1.5 cm bridges of intact mucosa and anoderm at the anterior and posterior commissures. With the patient in the prone position, as described above for closed hemorrhoidectomy, outline the incision on both sides of the anus as shown in Fig. 69.8.

Excising the Hemorrhoidal Masses

Elevate the skin flap together with the underlying hemorrhoids by sharp and blunt dissection until the lower border of the internal sphincter muscle has been unroofed (Fig. 69.9). This muscle can be identified by its transverse whitish fibers. Now elevate the anoderm above and below the incision to enucleate adjacent hemorrhoids that have not been included in the initial dissection (Fig. 69.10). This maneuver permits removal of almost all the hemorrhoids and still allows an adequate bridge of anoderm in the anterior and posterior commissures.

After the mass of hemorrhoidal tissue with overlying mucosa has been mobilized to the level of the normal location of the dentate line, amputate the mucosa and hemorrhoids with electrocautery at the level of the dentate line. This leaves a free edge of rectal mucosa. Suture this mucosa to the underlying internal sphincter muscle with a

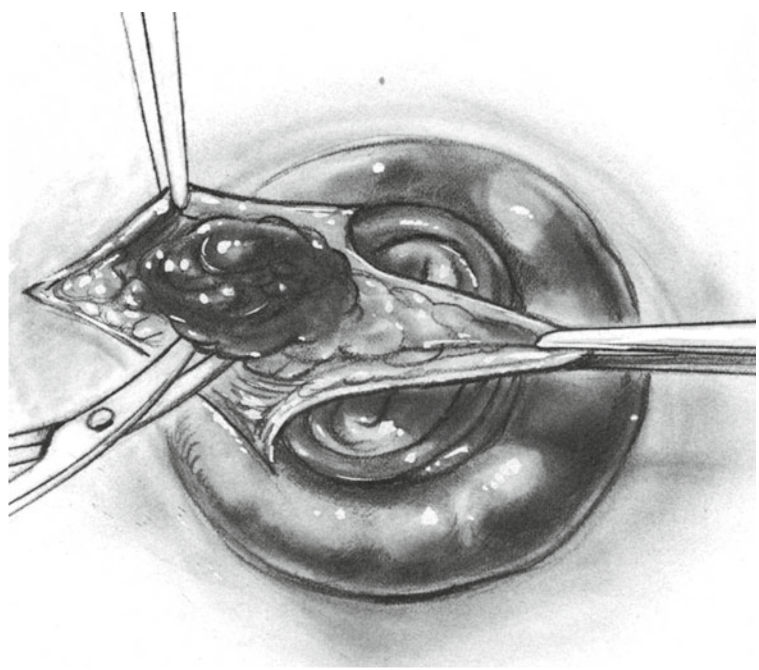

Fig. 69.10

continuous 5-0 atraumatic Vicryl suture, as illustrated in Fig. 69.11, to recreate the dentate line at its normal location. Do not bring the rectal mucosa down to the area that is normally covered by anoderm or skin, as it would result in continuous secretion of mucus, which would irritate the perianal skin.

Execute the same dissection to remove all of the hemorrhoidal tissue between 1 and 5 o'clock on the right side and reattach the free cut edge of rectal mucosa to the underlying internal sphincter muscle, as depicted in Fig. 69.12. There may be some redundant anoderm together with some external hemorrhoids at the anterior or posterior commissure of the anus. Do not attempt to remove every last bit of external hemorrhoid as it would jeopardize the viability of the anoderm in the commissures. Unless viable bridges, about 1.5 cm each in width, are preserved in the anterior and posterior commissures, the danger of a postoperative anal stenosis far outweighs the primarily cosmetic ill effect of leaving behind a skin tag or an occasional external hemorrhoid.

Ensure that hemostasis is complete using electrocautery and occasional suture ligatures of fine PG or chromic catgut. Some surgeons also insert a small piece of rolled-up Gelfoam into the anus at the completion of the procedure. This roll, which should not be more than 1 cm in thickness, serves to apply gentle pressure and to encourage coagulation of minor bleeding points that may have been overlooked. The Gelfoam need not be removed, as it dissolves when the patient starts having sitz baths postoperatively. Apply a sterile dressing to the perianal area.

Anal packing with anything more substantial than the 1 cm roll of soft Gelfoam should not be necessary, as hemostasis with electrocautery should be meticulous. Large gauze or other rigid packs are associated with increased postoperative pain and urinary retention.

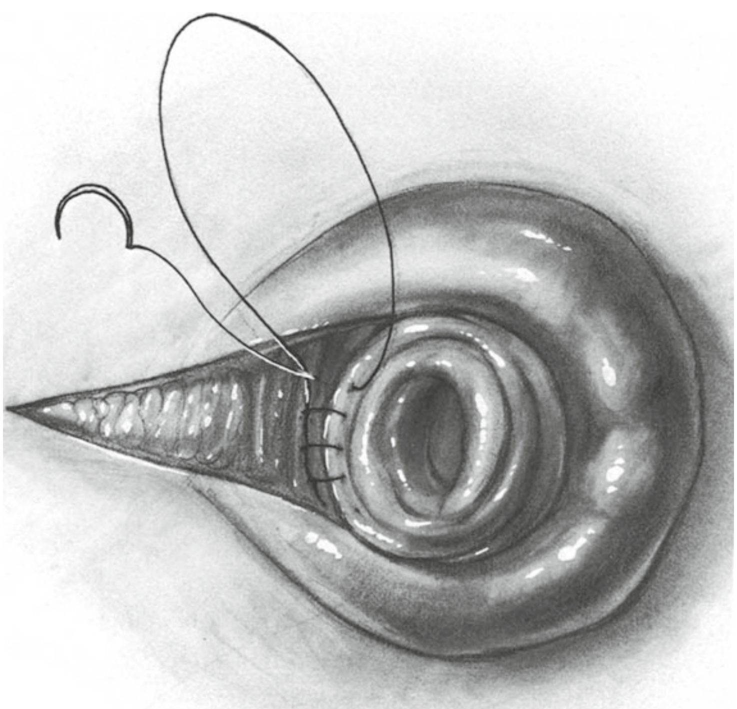

Fig. 69.11

Postoperative Care

Encourage ambulation the day of operation.

Prescribe analgesic medication preferably of a nonconstipating type.

Prescribe Senokot-S, Metamucil, or mineral oil while the patient is in the hospital. After discharge, limit the use of cathartics because passage of a well formed stool is the best guarantee the anus will not become stenotic. In patients with severe chronic constipation, dietary bran and some type of laxative or stool softener is necessary following discharge from the hospital.

Order warm sitz baths several times a day, especially following each bowel movement.

Discontinue intravenous fluids as soon as the patient returns to his or her room and initiate a regular diet and oral fluids as desired.

If the patient was hospitalized for the hemorrhoidectomy, he or she is generally discharged on the first or second postoperative day. Most patients tolerate hemorrhoidectomy in the ambulatory outpatient setting.

Complications

Serious bleeding during the postoperative period is rare if complete hemostasis has been achieved in the operating room. However, if bleeding is brisk, the patient should probably be returned to the operating room to have the bleeding point suture ligated. Most patients who experience major

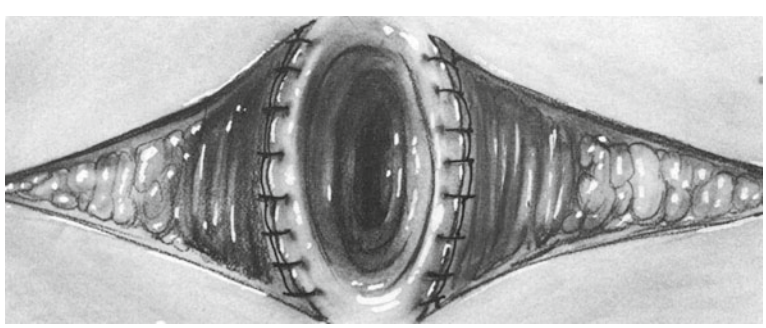

Fig. 69.12

bleeding after discharge from the hospital have experienced a minor degree of bleeding before discharge. About 1 % of patients present with hemorrhage severe enough to require reoperation for hemostasis, generally 8–14 days following operation. If the bleeding is slow but continues or if no bleeding site is identified, the patient should be evaluated for coagulopathy, including that caused by platelet dysfunction.

If for some reason the patient is not returned to the operating room for the control of bleeding, it is possible to achieve at least temporary control by inserting a 30 ml Foley catheter into the rectum. The Foley balloon is then blown up, and downward traction is applied to the catheter. Reexploration of the anus for surgical control of bleeding is far preferable.

Infection occurs but is rare.

Skin tags follow hemorrhoidectomy in 6–10 % of cases. Although no treatment is required, for cosmetic purposes a skin tag may be excised under local anesthesia as an office procedure when the operative site has healed completely.

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Procedure for Prolapse and Hemorrhoids

70

Shauna Lorenzo-Rivero

Indications

Grade II internal hemorrhoids
Grade III internal hemorrhoids
Grade IV internal hemorrhoids (selective or individualized only)
Partial thickness internal rectal prolapse

Documentation Basics

- Document indications
- Document palpation of vagina in female patient

Preoperative Preparation

Diagnostic studies: anoscopy and visualization of patient straining on the commode (colonoscopy, defecagraphy, dynamic MRI—if indicated):

- NPO, intravenous fluids
- Perioperative antibiotics maybe used, but not necessary
- Enema

Pitfalls and Danger Points

Inadequate protection of the anal canal with the retractor leading to placement of staple line too close to the dentate line and postop pain
Inadvertent full thickness transection rather than mucosal transection only
Inadvertent retraction or transection of vagina in female patients causing rectovaginal fistula
Inadequate control of blood vessels at staple line
Inadvertent complete closure of the rectum
Poorly placed staple line too proximal to hemorrhoidal apex leading to inadequate resection

Operative Strategy

Anesthesia and Positioning

General anesthesia is preferable. A paralytic agent is recommended prior to the "critical 3 minutes" when the stapler will be closed. This avoids Valsalva and straining which could lead to bleeding and avulsion. Place the patient in the prone jackknife position with soft support of the shoulders, hips, and knees. The hips should be higher than any other body part in this position in flexion with 30° Trendelenburg.

Anal Dilation and Placement of the Retractor

A pudendal nerve block provides both anesthesia and paralysis of the anal sphincter for dilation. Without the nerve block, placing the retractor may be difficult and may cause injury, since the internal sphincter is contracted at rest Perform digital rectal exam before placing the anal retractor with obturator. Take great care to assure the retractor covers the dentate line completely and circumferentially before securing it in place.

Purse String Suture Placement and Transection of the Rectal Mucosa

Be careful to remove and replace the obturator when placing the purse string, rather than simply turning it clockwise. This avoids pulling the mucosa and creates a more complete

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purse string circumferentially. At the posterior midline, pay particular attention to the placement of the fenestrated obturator and the placement of sutures to avoid suturing the anterior wall of the rectum instead of the intended posterior wall.

Remove the fenestrated obturator and replace it with the fully open PPH-03 stapler (Ethicon, Johnson & Johnson, Cincinnati, OH). Modification of this technique is necessary for the HEM stapler (Covidien, Mansfield, MA).

While closing the stapler, carefully palpate the posterior vaginal wall in female patients to avoid catching it in the jaws of the stapler. If this is a concern, open the stapler. Cut the purse string suture and remove the stapler. Start again. Creating an iatrogenic rectovaginal fistula is inexcusable.

During the "critical 3 minutes," avoid patient Valsalva; otherwise, the mucosa may be avulsed leading to profuse bleeding. This must be corrected by manually suturing the mucosal defect for hemostasis and may lead to stenosis if circumferential.

Operative Technique

Anal Dilation and Placement of the Retractor

Use local anesthetic to place a pudendal nerve block bilaterally with or without a perianal block by palpating the ischial tuberosity, directing the needle in that direction, aspirating, and then injecting, followed by injecting in the direction of the anus in a fanning motion into the subcutaneous tissue. Perform a digital rectal exam and place the anal retractor with obturator to cover the dentate line (Fig. 70.1). Secure the retractor with perianal stay sutures. The obturator should be replaced with the fenestrated obturator to facilitate placement of the purse string suture 4 cm from the dentate line or just proximal to the apices of the hemorrhoidal pedicles.

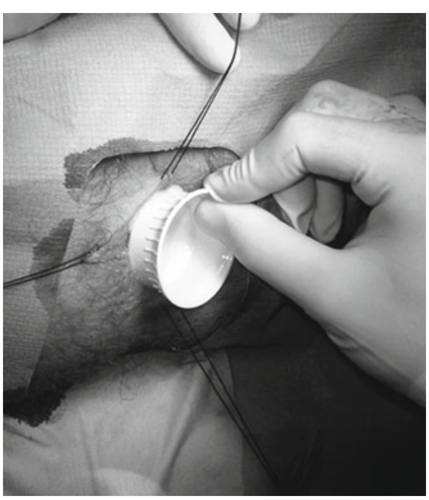

Fig. 70.1

Fig. 70.2

Purse String Suture Placement and Transection of the Rectal Mucosa

Once the fenestrated obturator is in proper position, the purse string suture is placed with mucosal bites using 2-0 Prolene suture beginning at the anterior midline and progressing in quadrants (Fig. 70.2), taking care to remove and replace the obturator rather than simply turn it clockwise. This avoids pulling the mucosa and creates a more complete purse string circumferentially. At the posterior midline, pay particular attention to the placement of the fenestrated obturator and the placement of sutures to avoid suturing the anterior wall of the rectum instead of the intended posterior wall. Complete the purse string by ending the stitch where it started without overlap. The fenestrated obturator is removed and replaced with the fully open PPH-03 stapler (Ethicon, Johnson & Johnson, Cincinnati, OH). Modification of this technique is necessary for the HEM stapler (Covidien, Mansfield, MA). Tie the purse string suture around the shaft of the anvil (Fig. 70.3), taking care to assure the entire anvil is proximal to the purse string. An extra stitch may be placed 180° opposite the purse string knot to assure the purse string is secure and even circumferentially. Then bring out the two suture ends through the eyelets of the stapler using the hook. Secure them with a surgeon's knot. While maintaining distal traction on the suture, start to close the stapler by allowing the stapler to enter the anus rather than pulling the mucosa to the stapler (Fig. 70.4). Once the marker is centered in the green window of the handle, hold it in position for 60 s. Take this opportunity to manually palpate the posterior vaginal wall to avoid catching it in the

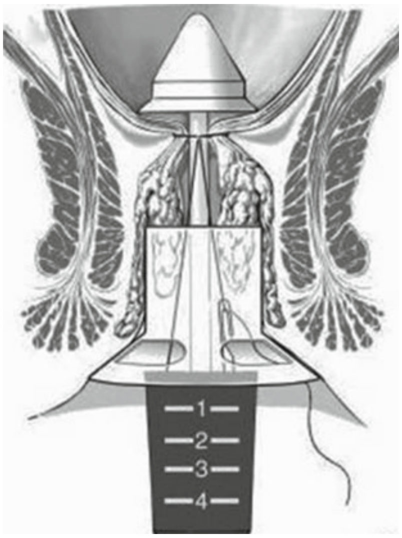

Fig. 70.3

Fig. 70.4

jaws of the stapler. Then continue to close the stapler until the marker passes through the window and hold for an additional 60 s. It is imperative during these "critical 3 minutes" the patient does not Valsalva to avoid avulsing the mucosa. Then remove the safety and fire and hold the stapler in position for 60 sections. At this point, release the stapler handle and turn 1 full turn to partially open the anvil. Remove the stapler from the anus. Open the anvil and cut the rectal mucosa to pass it off the table for pathologic evaluation.

Inspection for Hemostasis and Removal of Retractor

Replace the fenestrated obturator in the anal canal, and use saline irrigation to assess for hemostasis. Any bleeding from the staple line should be reinforced with figure of 8 absorbable sutures. If additional sutures have been placed, visually inspect the staple line circumferentially until hemostasis is deemed acceptable. Cut the perianal stay sutures and remove all retractors.

Dress the wound with 4×4 gauze and a peripad.

Postoperative Care

Postoperative antibiotics need not be administered. The patient is discharged from the recovery room with PO narcotics. Minimize IV fluid to avoid urinary retention. If the patient is unable to void within 6 h of the procedure, place a Foley catheter for 24 h. Sitz baths will aid in pelvic muscle relaxation and decrease pain, as well as improve hygiene. Fiber bulk-forming laxatives or stool softeners are imperative in decreasing pain and avoiding constipation. Most patients recover well in 2 weeks.

Complications

Postoperative *hemorrhage* occurs with increased abdominal pressure or Valsalva with straining. If this does not abate with conservative measures, it is necessary to return to the operating room for an exam under anesthesia and hemostasis. The patient should be observed for 23 h to assure no further bleeding.

Postoperative pelvic *sepsis* is the most feared postoperative complication of any hemorrhoidal procedure. Symptoms of increasing pain, urinary retention, and fever are typical and should be treated immediately with hospital admission, IV fluid and antibiotics, and Foley catheter drainage.

Wound infection is less serious. The patient will complain of a possible foul-smelling mucous discharge and failure of resolution of pain over time.

Postoperative pain is due to the staple line being too close to the dentate line or stapling the anoderm. A patient should expect discomfort, a sensation of distention, or a perception of the need to defecate during recovery.

This can lead to *stenosis* or contracture of the healing staple line. This presents as constipation or obstructive defecation and can be treated with dilation or stricturoplasty.

Continued postoperative pain past several weeks can be due to a *retained staple*. Staples by themselves are not painful, but a malpositioned or partially open staple can induce discomfort, especially with defecation, and therefore, should be removed.

Fecal incontinence may result from anal dilation, even though the anal sphincter itself is not cut or directly injured. Removing a portion of the internal hemorrhoids and mucosa can cause decreased sensation, soiling, or incontinence by remove some of the sensory receptors in this area. Incontinence of solid stool is rare with normal preoperative continence; however, incontinence of gas or liquid stool is more common.

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Anorectal Fistula and Pelvirectal Abscess: Seton Placement

71

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Drainage of any anorectal abscess is indicated *as soon as the diagnosis is made*. There is no role for conservative management because severe sepsis can develop and spread before fluctuance and typical physical findings appear. This is especially true in diabetic patients.

Recurrent or persistent drainage from a perianal fistula calls for repair.

Weak anal sphincter muscles are a relative *contraindication* to fistulotomy, especially in the unusual cases in which the fistulotomy must be performed through the anterior aspect of the anal canal. Absence of the puborectalis muscle in the anterior area of the canal causes inherent sphincter weakness in this location. This category of case is probably better suited for treatment by inserting a seton or by an advancement flap, especially in women.

Preoperative Preparation

Cathartic the night before operation and saline enema on the morning of operation

Preoperative anoscopy and sigmoidoscopy

Colonoscopy, small bowel radiography series, or both when Crohn's enteritis or colitis is suspected

Antibiotic coverage with mechanical bowel preparation if an advancement flap is contemplated

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Pitfalls and Danger Points

Failure to diagnose anorectal sepsis and to perform early incision and drainage

Failure to diagnose or control Crohn's disease

Failure to rule out anorectal tuberculosis or acute leukemia

Induction of fecal incontinence by excessive or incorrect division of the anal sphincter muscles

Operative Strategy

Choice of Anesthesia

Because palpation of the sphincter mechanism is a key component of the surgical procedure, a light general anesthetic is preferable to a regional anesthetic.

Localizing Fistulous Tracts

Goodsall's Rule

When a fistulous orifice is identified in the perianal skin posterior to a line drawn between 3 o'clock and 9 o'clock, the internal opening of the fistula is almost always found in the posterior commissure in a crypt approximately at the dentate line. Goodsall's rule also states that if a fistulous tract is identified anterior to the 3 o'clock/9 o'clock line, its internal orifice is likely to be located along the course of a line connecting the orifice of the fistula to an imaginary point exactly in the middle of the anal canal. In other words, a fistula draining in the perianal area at 4 o'clock in a patient lying prone is likely to have its internal opening situated at the dentate line at 4 o'clock. There are exceptions to this rule. For instance, a horseshoe fistula may drain anterior to the anus but continue in a posterior direction and terminate in the posterior commissure.

†Deceased

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If the external fistula opening is more than 3 cm from the anal verge, be suspicious of unusual pathology. Look for Crohn's disease, tuberculosis, or other disease processes such as hidradenitis suppurativa or pilonidal disease.

Physical Examination

First, attempt to identify the course of the fistula in the perianal area by palpating the associated fibrous tract. Insert the gloved index finger into the anal canal and gently "pinch" the tissue between the dentate line and perianal skin with index finger and thumb. A tract may be palpable as a region of thickening. Second, carefully palpate the region of the dentate line. The site of origin is often easier to feel than it is to see. Next, insert a bivalve speculum into the anus and try to identify the internal opening by gentle probing at the point indicated by Goodsall's rule. If the internal opening is not readily apparent, do not make any false passages. The most accurate method for identifying the direction of the tract is gently to insert a blunt malleable probe, such as a lacrimal duct probe, into the fistula with the index finger in the rectum. In this fashion it may be possible to identify the internal orifice by palpating the probe with the index finger in the anal canal.

Injection of Dye or Hydrogen Peroxide

On rare occasions injection of a blue dye may help identify the internal orifice of a complicated fistula. Some surgeons have advocated the use of hydrogen peroxide instead of a blue dye. These agents allow one to perform multiple injections without the extensive tissue staining that follows the use of blue dye. Before performing elective surgery for a fistula, delineate the anatomy with endorectal ultrasound or MRI scans as needed.

Preserving Fecal Continence

As mentioned in the discussion above, the puborectalis muscle (anorectal ring) must function normally to preserve fecal continence following fistulotomy. Identify this muscle accurately before dividing the anal sphincter muscles during the course of a fistulotomy. Use local anesthesia with sedation or general anesthesia for the fistulotomy. If the fistulous tract can be identified with a *probe preoperatively*, the surgeon's index finger in the anal canal can identify the anorectal ring without difficulty, especially if the patient is asked to tighten the voluntary sphincter muscles.

If there is any doubt about the identification of the anorectal ring (the proximal portion of the anal canal), do not complete the fistulotomy; rather, insert a heavy silk or braided polyester ligature through the remaining portion of the tract. Tie the ligature loosely with five or six knots without completing the fistulotomy. When the patient is examined in the awake state, it is simple to determine whether the upper border of the seton has encircled the anorectal ring or there is sufficient puborectalis muscle (1.5 cm or more) above the seton to complete the fistulotomy by dividing the muscles enclosed in the seton at a later stage. If no more than half of the external sphincter muscles in the anal canal have been divided, fecal continence should be preserved in patients with formed stools and a normally compliant rectum. An exception would be those patients who had a weak sphincter muscle prior to operation.

Fistulotomy Versus Fistulectomy

When performing surgery to cure an anal fistula, most authorities are satisfied that incising the fistula along its entire length constitutes adequate therapy. Others have advocated excision of the fibrous cylinder that constitutes the fistula, leaving only surrounding fat and muscle tissue behind. The latter technique leaves a large open wound, however, which takes much longer to heal. Moreover, much more bleeding is encountered during a fistulectomy than a fistulotomy. Hence there is no evidence to indicate that excising the wall of the fistula has any advantages.

Combining Fistulotomy with Drainage of Anorectal Abscess

For patients with an acute ischiorectal abscess, some have advocated that the surgical procedure includes a fistulotomy simultaneous with drainage of the abscess. After the pus has been evacuated, a search is made for the internal opening of the fistulous tract and then the tract is opened. This combination of operations is contraindicated for two reasons. First, many of our patients who undergo simple drainage of an abscess never develop a fistula. It is likely that the internal orifice of the anal duct has become occluded before the abscess is treated. These patients do not require a fistulotomy. Second, acute inflammation and edema surrounding the abscess make accurate detection and evaluation of the fistulous tract extremely difficult. There is great likelihood that the surgeon will create false passages that may prove so disabling to the patient that any time saved by combining the drainage operation with a fistulotomy is insignificant. We presently drain many anorectal abscesses in the office under local anesthesia, in part because this method removes the temptation to add a fistulotomy to the drainage procedure.

Documentation Basics

Coding for anorectal procedures is complex. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (see references at the end). In general, it is important to document:

- Findings
- Any associated abscess?
- Number of fistulous tracts
- Relationship to sphincters
- Fistulotomy or not?
- Seton or not?

Operative Technique

Anorectal and Pelvirectal Abscesses

Perianal Abscess

When draining an anorectal abscess, it is important to excise a patch of overlying skin so the pus drains freely. The typical perianal abscess is located fairly close to the anus, and often drainage can be performed under local anesthesia. Packing is rarely necessary and may impede drainage.

A Malecot catheter can be placed in the cavity and sewn in place in patients with recurrent abscesses or Crohn's disease in whom continued problems may be anticipated. After 10 days, ingrowth of tissue keeps the Malecot in place without sutures. This serves as a temporizing procedure prior to fistulotomy in patients without Crohn's disease. It may be used as a permanent solution for the difficult Crohn's patient with perianal fistula disease.

Ischiorectal Abscess

The ischiorectal abscess is generally larger than the perianal abscess, develops at a greater distance from the anus, and may be deep seated. Fluctuance on physical examination may be a late sign. Early drainage under general anesthesia is indicated. Make a cruciate incision over the apex of the inflamed area close to the anal verge so any resulting fistula is short. Excise enough of the overhanging skin to permit free drainage and evacuate the pus. Explore the abscess for loculations.

Intersphincteric Abscess

Many physicians fail to diagnose an intersphincteric abscess until the abscess ruptures into the ischiorectal space and forms an ischiorectal abscess. A patient who complains of persistent anal pain should be suspected of harboring an intersphincteric abscess. This is especially true if, on inspecting the anus with the buttocks spread apart, the physician can rule out the presence of an anal fissure. Examination under anesthesia may be necessary to confirm the diagnosis. Digital examination in the unanesthetized patient may indicate at which point in the anal canal the abscess is located. found that 61 % of the intersphincteric abscesses occurred in the posterior quadrant of the anal canal. In half their patients a small mass could be palpated in the anal canal with the index finger inside the canal and the thumb just outside. Occasionally an internal opening draining a few drops of pus is identified near the dentate line. A patient may have both an anal fissure and an intersphincteric abscess.

Under local or general anesthesia, carefully palpate the anal canal. Then insert a bivalve speculum and inspect the circumference of the anus to identify a possible fissure or an internal opening of the intersphincteric abscess. After identifying the point on the circumference of the anal canal that is the site of the abscess, perform an internal sphincterotomy by the same technique as described in Chap. 72 for an anal fissure. Place the internal sphincterotomy directly over the site of the intersphincteric abscess. Explore the cavity, which is generally small, with the index finger. If the abscess has been properly unroofed, simply reexamine the area daily with an index finger for the first week or so postoperatively. Uneventful healing can be anticipated unless the abscess has already penetrated the external sphincter muscle and created an undetected extension in the ischiorectal space.

Pelvirectal Supralevator Abscess

An abscess above the levator diaphragm is manifested by pain (gluteal and perineal), fever, and leukocytosis; it often occurs in patients with diabetes or other illnesses. Pus can appear in the supralevator space by extension upward from an intersphincteric fistula, penetration through the levator diaphragm of a transsphincteric fistula, or direct extension from an abscess in the rectosigmoid area. When there is obvious infection in the ischiorectal fossa secondary to a *transsphincteric* fistula, manifested by local induration and tenderness, make an incision at the dependent point of the ischiorectal infection (Fig. 71.1). The incision must be large enough to explore the area with the index finger. It may be necessary to incise the levator diaphragm from below and to enlarge this opening with a long Kelly hemostat to provide adequate drainage of the supralevator abscess. After thoroughly irrigating the area, insert gauze packing.

In pelvirectal abscesses arising from an *intersphincteric* fistula, one is often able to palpate the fluctuant abscess by inserting the index finger high up in the rectum. Aspirate the region of fluctuation under general anesthesia. If pus is

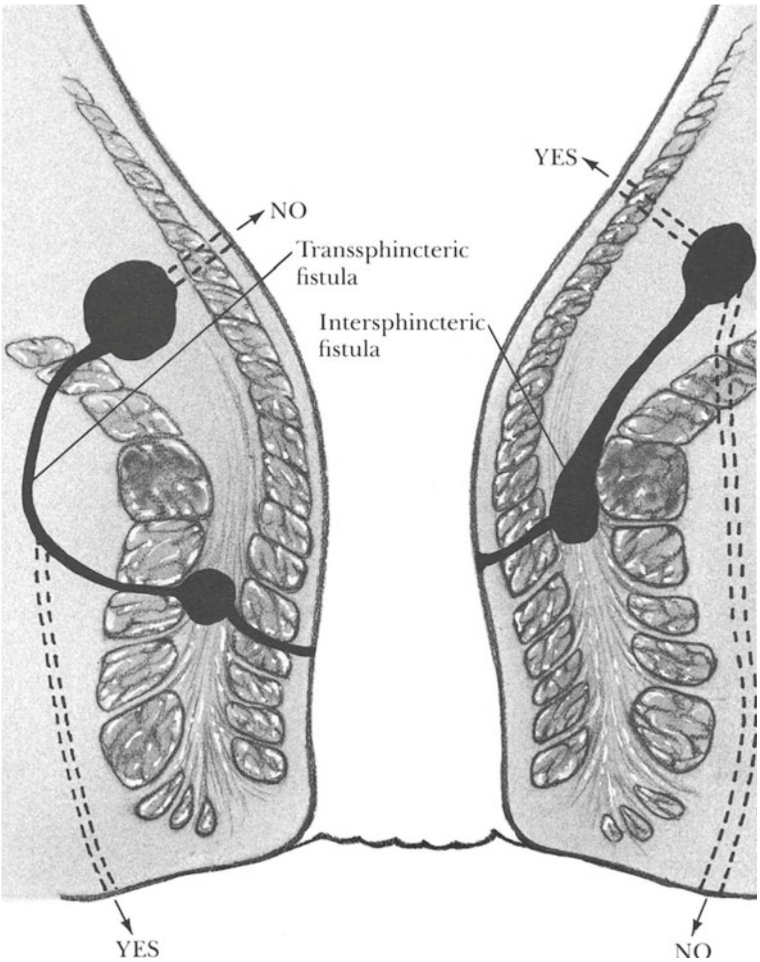

Fig. 71.1

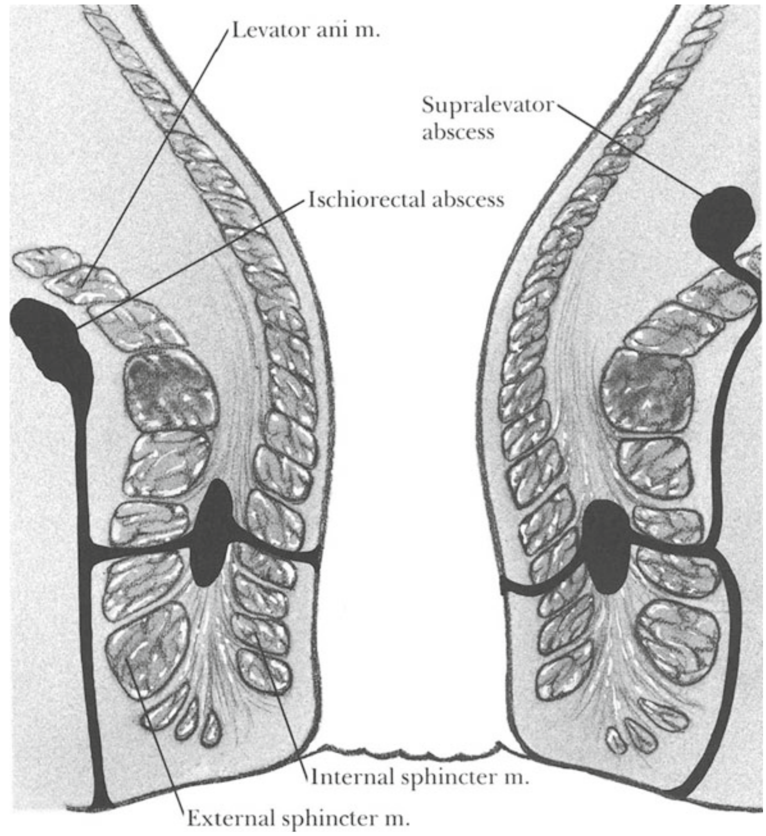

Fig. 71.2 Transsphincteric fistulas (with high blind tracks)

obtained, make an incision in the rectum with electrocautery and drain the abscess through the rectum (Fig. 71.1).

Under no condition should one drain a supralevator abscess through the rectum if the abscess has its origin in an *ischiorectal* space infection (Fig. 71.2), an error that could result in a high extrasphincteric fistula. Similarly, if the supralevator sepsis has arisen from an intersphincteric abscess, draining the supralevator infection through the ischiorectal fossa also leads to a high extrasphincteric fistula, and this error should also be avoided (Fig. 71.3).

Anorectal Fistula

Intersphincteric Fistula

Simple Low Fistula

When dealing with an unselected patient population, simple low fistula occurs in perhaps half of all patients presenting with anorectal fistulas. Here the injected anal gland burrows distally in the intersphincteric space to form either a perianal abscess or a perianal fistula, as illustrated in Fig. 67.2. Performing a fistulotomy here requires only division of the internal sphincter and overlying anoderm up to the internal orifice of the fistula approximately at the dentate line. This divides the distal half of the internal sphincter, rarely producing any permanent disturbance of function.

High Blind Track (Rare)

With a high blind track fistula, the mid-anal infection burrows in a cephalad direction between the circular internal sphincter and the longitudinal muscle fibers of the upper canal and lower rectal wall to form a small *intramural* abscess above the levator diaphragm (Fig. 71.4). This abscess can be palpated by digital examination. The infection will probably heal if the primary focus is drained by excising a 1×1 cm^2 of internal sphincter at the site of the internal orifice of this "fistula." Parks et al. (1976) stated that even if the entire internal sphincter is divided while laying open this high blind track by opening the internal sphincter from the internal orifice of the track to the upper extension of the track, little disturbed continence develops because the edges

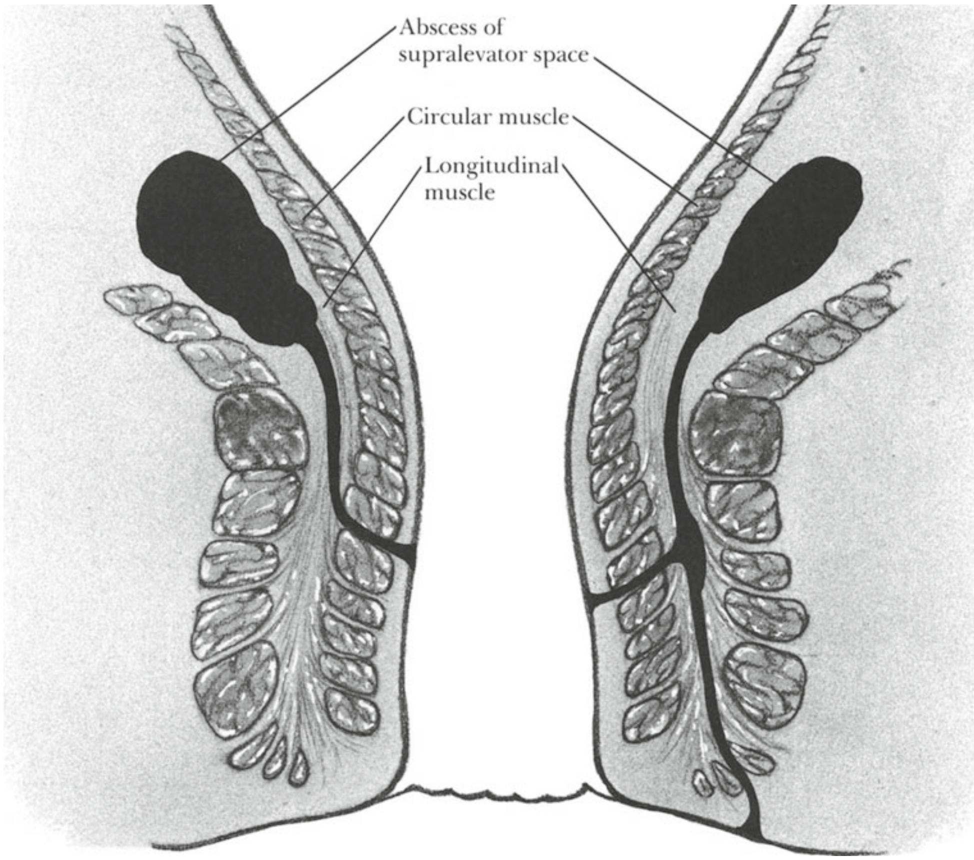

Fig. 71.3 High intersphincteric track fistulas (with supralevator abscesses)

of the sphincter are held together by the fibrosis produced as the track develops.

High Track Opening into Rectum (Rare)

With a high track opening into the rectum, a probe inserted into the internal orifice continues upward between the internal sphincter and the longitudinal muscle of the rectum. The probe opens into the rectum at the upper end of the fistula (Fig. 71.4). If by palpating the probe the surgeon recognizes that this fistula is quite superficial and is located deep only to the circular muscle layer, the tissue overlying the probe can be laid open without risk. On the other hand, if the probe goes deep to the *external* sphincter muscle prior to reentering the rectum (see Fig. 67.5), it constitutes a type of extrasphincteric fistula that is extremely difficult to manage (see below). If there is any doubt about the true nature of this type of fistula, refer the patient to a specialist.

High Track with No Perineal Opening (Rare)

An unusual intersphincteric fistula is the high track fistula with no perineal opening. The infection begins in the mid-anal intersphincteric space and burrows upward in the rectal wall, reentering the lower rectum through a secondary opening above the anorectal ring (Fig. 71.5). There is no downward spread of the infection and no fistula in the perianal skin. To treat this fistula it is necessary to lay the track open from its internal opening in the mid-anal canal up into the lower rectum. Parks and associates emphasized that the lowermost part of the track in the mid-anal canal must be excised because it contains the infected anal gland, which is the primary source of the infection. Leaving it behind may result in a recurrence. If a fistula of this type presents in the acute phase, it resembles a "submucous abscess," but this is an erroneous term because the infection is indeed deep not only to the mucosa but also to the circular muscle layer (Fig. 71.5). This type of abscess is drained by incising the overlying mucosa and circular muscle of the rectum.

High Track with Pelvic Extension (Rare)

With a high track fistula with pelvic extension, the infection spreads upward in the intersphincteric space, breaks through the longitudinal muscle, and enters the pelvis (supralevator) (Fig. 71.3). To treat it, open the fistulous track by incising the internal sphincter together with the overlying mucosa or

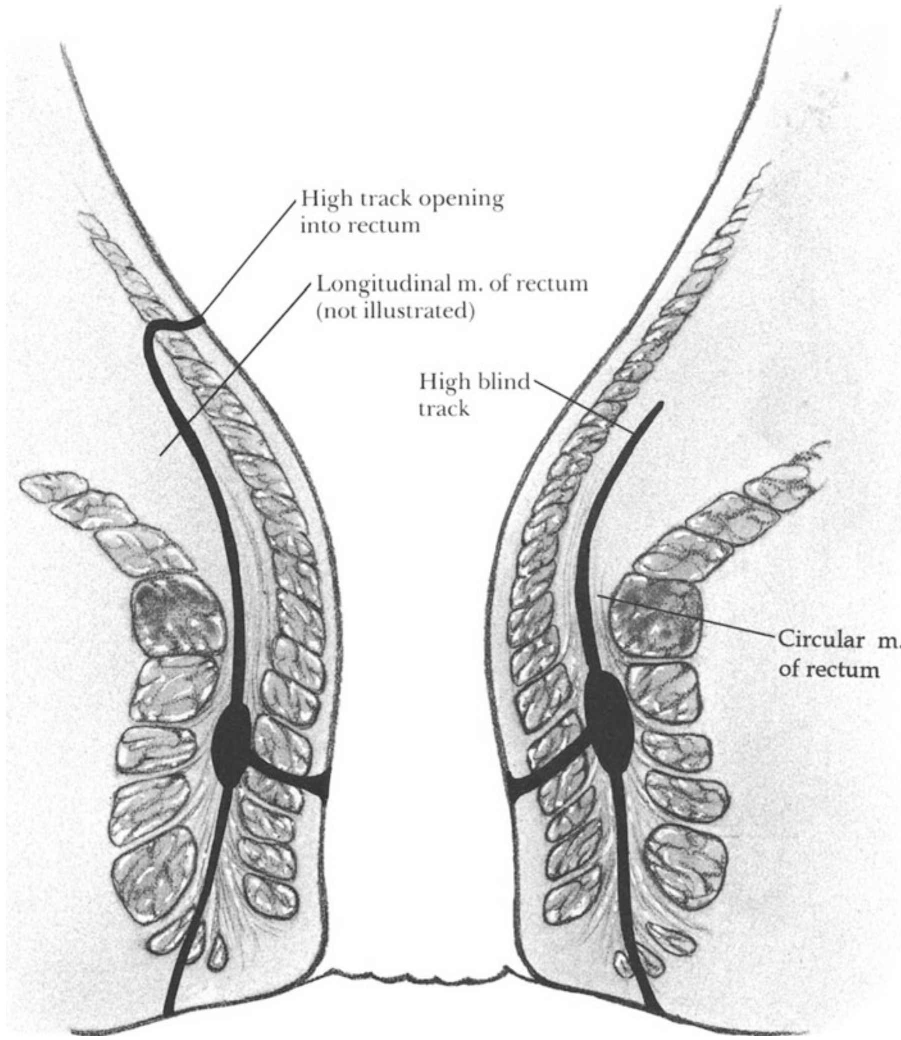

Fig. 71.4 High intersphincteric fistulas

anoderm up into the rectum for 1–3 cm. Drain the pelvic collection through this incision, with the drain exiting into the rectum.

High Track Secondary to Pelvic Disease (Rare)

As mentioned above, the intersphincteric plane "is a natural pathway for infection from the pelvis to follow should it track downward" (Parks et al.). This type of fistula (Fig. 71.6) does not arise from anal disease and does not require perianal surgery. Treatment consists of removing the pelvic infection by abdominal surgery.

Transsphincteric Fistula

Uncomplicated Fistula

As illustrated in Fig. 67.3, the fairly common uncomplicated transsphincteric fistula arises in the intersphincteric space of the mid-anal canal, with the infection then burrowing laterally directly through the external sphincter muscle. There it may form either an abscess or a fistulous track down through the skin overlying the ischiorectal space. If a probe is passed through the fistulous opening in the skin and along the track until it enters the rectum at the internal opening of the fistula, all of the overlying tissue may be divided without serious functional disturbance because only the distal half of the internal sphincter and the distal half of the external sphincter has been transected. Occasionally one of these fistulas crosses the external sphincter closer to the puborectalis muscle than is shown here. In this case, if there is doubt that the entire puborectalis can be left intact, the external sphincter should be divided in two stages. Divide the distal half during the first stage and insert a seton through the remaining fistula, around the remaining muscle bundle. Leave it intact for 2–3 months before dividing the remainder of the sphincter.

High Blind Track

The fistula with high blind track burrows through the external sphincter, generally at the level of the mid-anal canal.

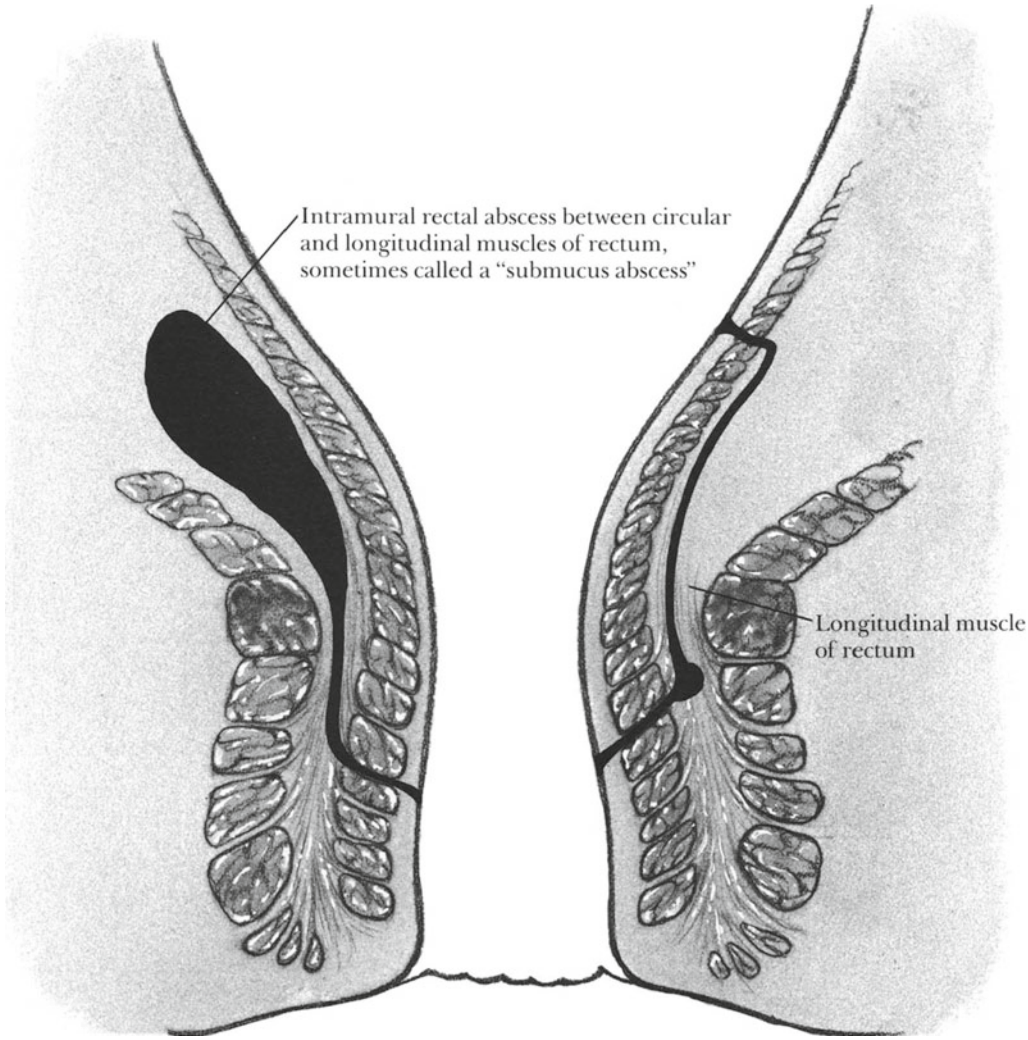

Fig. 71.5 High intersphincteric fistula (or abscess) with no perineal openings

The fistula then not only burrows downward to the skin but also in a cephalad direction to the apex of the ischiorectal fossa (Fig. 71.2).

Occasionally it burrows through the levator ani muscles into the pelvis. Parks et al. pointed out that when a probe is passed into the external opening, it generally goes directly to the upper end of the blind track and that the internal opening in the mid-anal canal may be difficult to delineate by such probing. Occasionally there is localized induration in the mid-anal canal to indicate the site of the infected anal gland that initiated the pathologic process. Probing this area should reveal the internal opening. By inserting the index finger into the anal canal, one can often feel, above the anorectal ring, the induration that is caused by the supralevator extension of the infection. The surgeon can often feel the probe in the fistula with the index finger. The probe may feel close to the rectal wall. Parks emphasized that it is dangerous to penetrate the wall of the rectum with this probe or to try to drain this infection through the upper rectum. If it is done, an extrasphincteric fistula would be created with grave implications for the patient. The proper treatment for this type of fistula, even with a supralevator extension, is to transect the mucosa, internal sphincter, external sphincter, and perianal skin from the mid-anal canal down to the orifice of the track in the skin of the buttock. The upper extension heals with this type of drainage.

Suprasphincteric Fistula (Extremely Rare)

The suprasphincteric fistula originates, as usual, in the mid-anal canal in the intersphincteric space, where its internal opening can generally be found. The fistula extends upward in the intersphincteric plane above the puborectalis muscle into the supralevator space, where it often causes a supralevator abscess. The fistula then penetrates the levator diaphragm and continues downward in the ischiorectal space to its external orifice in the perineal skin (Fig. 67.4). This type of supralevator infection must not be drained through an

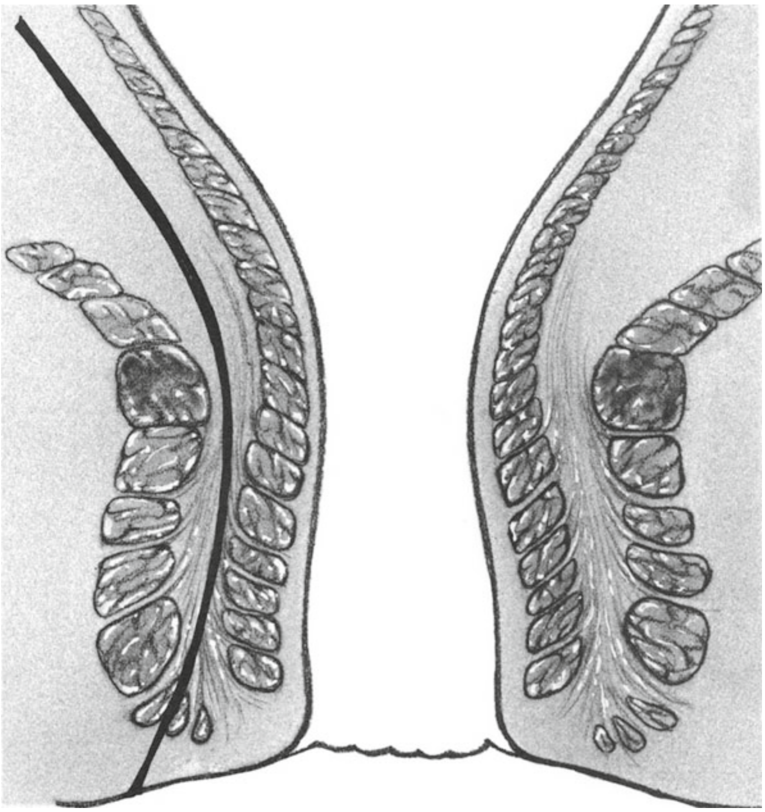

Fig. 71.6 High intersphincteric track fistula (*secondary* to pelvic sepsis)

incision in the rectum. recommended an internal sphincterotomy from the internal opening of the fistula distally and excision of the abscess in the intersphincteric space, if present. They then divide the lower 30–50 % of the external sphincter muscle and continue this incision laterally until the lower portion of the fistulous track has been opened down to its external opening in the skin. This maneuver leaves the upper half of the external and internal sphincter muscles and the puborectalis muscle intact. Insert a seton of heavy braided nylon through the fistula as it surrounds the muscles. Tie the seton with five or six knots but keep the loop in the seton loose enough so it does not constrict the remaining muscles at this time. Insert a drain into the supralevator abscess, preferably in the intersphincteric space between the seton and the remaining internal sphincter muscle. Once adequate drainage has been established, remove this drain, as the heavy seton prevents the lower portion of the wound from closing prematurely. Parks does not remove these setons for at least 3 months. It is often necessary to return the patient to the operating room 10–14 days following the initial operation to examine the situation carefully and to ascertain that no residual pocket of infection has remained undrained. Examination under anesthesia may be necessary on several occasions before complete healing has been achieved. In most cases, after 3 months or more has passed, the supralevator infection has healed completely, and it is not necessary to divide the muscles enclosed in the seton. In these cases simply remove the seton and permit the wound to heal spontaneously. If after 3–4 months there is lingering infection in the upper reaches of the wound, it is possible to divide the muscles contained in the seton because the long-standing fibrosis prevents significant retraction and the muscle generally heals with restoration of fecal continence.

Alternatively, an advancement flap to close the internal opening of the fistula may save these patients multiple operations. It also avoids sphincter division.

Extrasphincteric Fistula (Extremely Rare)

Secondary to Transsphincteric Fistula

In an unusual situation, a transsphincteric fistula, after entering the ischiorectal fossa, travels not only downward to the skin of the buttocks but also in a cephalad direction, penetrating the levator diaphragm into the pelvis and then through the entire wall and mucosa of the rectum (Fig. 67.5). If this fistula were to be completely laid open surgically, the entire internal and entire external sphincter together with part of the levator diaphragm would have to be divided. The result would be total fecal incontinence. The proper treatment here consists of a temporary diverting colostomy combined with simple laying open of the portion of the fistula that extends from the mid-anal canal to the skin. After the defect in the rectum heals, the colostomy can be closed.

The extrasphincteric fistula may also be treated by fashioning an advancement flap. With this procedure it is often unnecessary to create a temporary colostomy.

Secondary to Trauma

A traumatic fistula may be caused by a foreign body penetrating the perineum, the levator ani muscle, and the rectum. A swallowed foreign body such as a fish bone may also perforate the rectum above the anorectal ring and be forced through the levator diaphragm into the ischiorectal fossa. An infection in this space may then drain out through the skin of the perineum to form a complete extrasphincteric fistula. In either case, treatment consists of removing any foreign body, establishing adequate drainage, and sometimes performing a temporary colostomy. It is not necessary to divide any sphincter muscle because the anal canal is not the cause of the patient's pathology.

Secondary to Specific Anorectal Disease

Conditions such as ulcerative colitis, Crohn's disease, and carcinoma may produce unusual and bizarre fistulas in the anorectal area. They are not usually amenable to local surgery. The primary disease must be remedied, often requiring total proctectomy.

Secondary to Pelvic Inflammation

A diverticular abscess of the sigmoid colon, Crohn's disease of the terminal ileum, or perforated pelvic appendicitis may result in perforation of the levator diaphragm, with the infection tracking downward to the perineal skin. To make the proper diagnosis, a radiographic sinogram is performed by injecting an aqueous iodinated contrast medium into the fistula. This procedure may demonstrate a supralevator entrance into the rectum. Therapy for this type of fistula consists of eliminating the pelvic sepsis by abdominal surgery. There is no need to cut any of the anorectal sphincter musculature.

Technical Hints for Performing Fistulotomy

Position

We prefer the prone position, with the patient's hips elevated on a small pillow. The patient should be under regional or local anesthesia with sedation.

Exploration

In accordance with Goodsall's rule, search the suspected area of the anal canal after inserting a Parks bivalve retractor. The internal opening should be located in a crypt near the dentate line, most often in the posterior commissure. If an internal opening has been identified, insert a probe to confirm this fact. Then insert a probe into the external orifice of the fistula. With a simple fistula, in which the probe goes directly into the internal orifice, simply make a scalpel incision dividing all of the tissues superficial to the probe. A grooved directional probe is helpful for this maneuver.

With complex fistulas the probe may not pass through the entire length of the track. In some cases gentle maneuvering with variously sized lacrimal probes may be helpful. If these maneuvers are not successful, Goldberg and associates suggested injecting a dilute (1:10) solution of methylene blue dye into the external orifice of the fistula. Then incise the tissues over a grooved director along that portion of the track the probe enters easily. At this point it is generally easy to identify the probable location of the fistula's internal opening. For fistulas in the posterior half of the anal canal, this opening is located in the posterior commissure at the dentate line. If a patient has multiple fistulas, including a horseshoe fistula, the multiple tracks generally enter into a single posterior track that leads to an internal opening at the usual location in the posterior commissure of the anal canal. In patients with multiple complicated fistulas, fistulograms obtained by radiography or magnetic resonance imaging help delineate the pathology.

Marsupialization

When fistulotomy results in a large gaping wound, Goldberg and associates suggested marsupializing the wound to speed healing: Suture the outer walls of the laid-open fistula to the skin with a continuous absorbable suture. Curet all of the granulation tissue away from the wall of the fistula that has been laid open.

Seton Placement

There are two types of seton: the cutting seton and the drainage seton. Cutting setons are gradually tightened and retied to create progressive fibrosis and, in time, to cut through part of the sphincter, thus obliterating the fistula. The seton produces sufficient fibrosis that the portion of the sphincters which have been divided do not gape open, producing incontinence. Cutting setons, because they must induce fibrosis, are generally fashioned of a heavy silk or braided polyester suture rather than Silastic. In the office the seton is tightened whenever it becomes loose, a tedious procedure for surgeon and patient alike. When sufficient sphincter has been divided by the seton, a minor surgical fistulotomy may be performed to divide the remaining mucosal or skin bridge.

A drainage seton is placed in a situation when fistulotomy is not considered to be an option. These setons are generally fashioned from Silastic vascular loops and secured with several surgical ties. The loop of the seton encircles the fistula loosely. They are replaced when the sutures break or become loose.

To place a seton, insert a flexible probe into the external opening of the fistula and gently guide it to exit through the internal opening by palpation or direct observation using an anoscope. Avoid creating a false tract. Once the probe has completely traversed the fistula, deliver the end of the probe out of the anus and secure the seton to the end of the probe. Then use the probe to pull the seton through the tract. Secure the seton on the outside (Fig. 71.7).

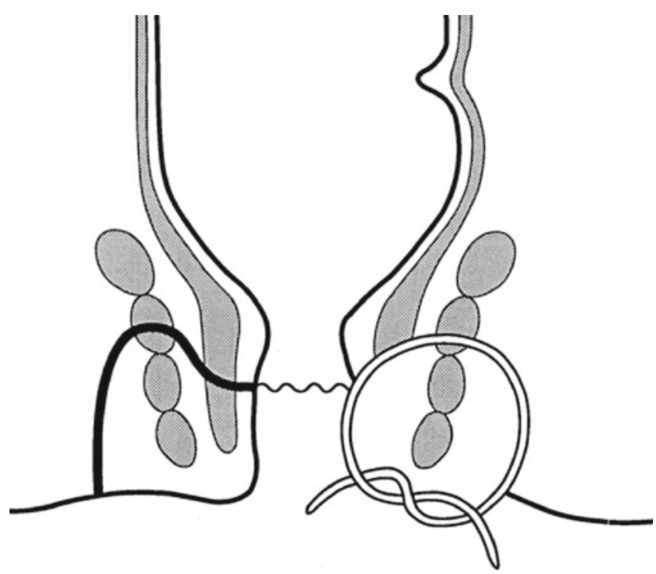

Fig. 71.7 From Wolff BG, Fleshman JW, Beck DE, Pemberton JH, Wexner SD, editors. The ASCRS textbook of colon and rectal surgery. New York: Springer; 2007, with permission

Postoperative Care

Administer a bulk laxative such as Metamucil daily. For the first bowel movement, an additional stimulant, such as Senokot-S (two tablets) may be necessary.

The patient is placed on a regular diet.

For patients who have had operations for fairly simple fistulas, warm sitz baths two or three times daily may be initiated beginning on the first postoperative day, after which no gauze packing may be necessary.

For patients who have complex fistulas, light general anesthesia may be required for removal of the first gauze packing on the second or third postoperative day.

During the early postoperative period, check the wound every day or two to be sure that healing takes place in the depth of the wound before any of the more superficial tissues heal together. Later check the patient once or twice weekly.

When a significant portion of the external sphincter has been divided, warn the patient that for the first week or so there will be some degree of fecal incontinence.

In the case of the rare types of fistula with high extension and a deep wound, Parks and Sitz recommended that the patient be taken to the operating room at intervals for careful examination under anesthesia.

Perform a weekly anal digital examination and dilatation, when necessary, to avoid an anal stenosis secondary to the fibrosis that takes place during the healing of a fistula.

Complications

Urinary retention
Postoperative hemorrhage
Fecal incontinence
Sepsis including cellulitis and recurrent abscess
Recurrent fistula
Thrombosis of external hemorrhoids
Anal stenosis

Further Reading

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Lateral Internal Sphincterotomy for Chronic Anal Fissure

72

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Painful chronic anal fissure not responsive to medical therapy

Preoperative Preparation

Many patients with anal fissure cannot tolerate a preoperative enema because of excessive pain. Consequently, a mild cathartic the night before operation constitutes the only preoperative care necessary.

Pitfalls and Danger Points

Injury to external sphincter
Inducing fecal incontinence by overly extensive sphincterotomy
Bleeding and hematoma

Operative Strategy

Accurate identification of the lower border of the internal sphincter is essential to successful completion of an internal sphincterotomy. Insert a bivalve speculum (e.g., Parks retractor) into the anus and open the speculum for a distance of about two fingerbreadths to place the internal sphincter on stretch. Feel for a distinct groove between the subcutaneous external sphincter and the lower border of the tense internal sphincter. This groove accurately identifies the lower border of the internal sphincter. Optionally, the surgeon may make a radial incision through the mucosa directly over this area to identify visually the lower border of the internal sphincter (we have not found this step necessary).

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Documentation Basics

Coding for anorectal procedures is complex. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (see references at the end). In general, it is important to document:

- Findings
- Extent of sphincterotomy
- Open or closed?
- Excision of hypertrophied papilla or not?

Operative Technique

Anesthesia

A light general or local anesthesia is satisfactory for this procedure.

Closed Sphincterotomy

Place the patient in the lithotomy position. (The prone position is also satisfactory.) Insert a Parks retractor with one blade placed in the anterior aspect and the other in the posterior aspect of the anal canal. Open the retractor about two fingerbreadths. Now, at the right or left lateral margin of the anal canal, palpate the groove between the internal and external sphincters. Once this has been clearly identified, insert a No. 11 scalpel blade into this groove (Fig. 72.1).

†Deceased

C.E.H. Scott-Conner (ed.), *Chassin's Operative Strategy in General Surgery*,
DOI 10.1007/978-1-4614-1393-6_72, © Springer Science+Business Media New York 2014

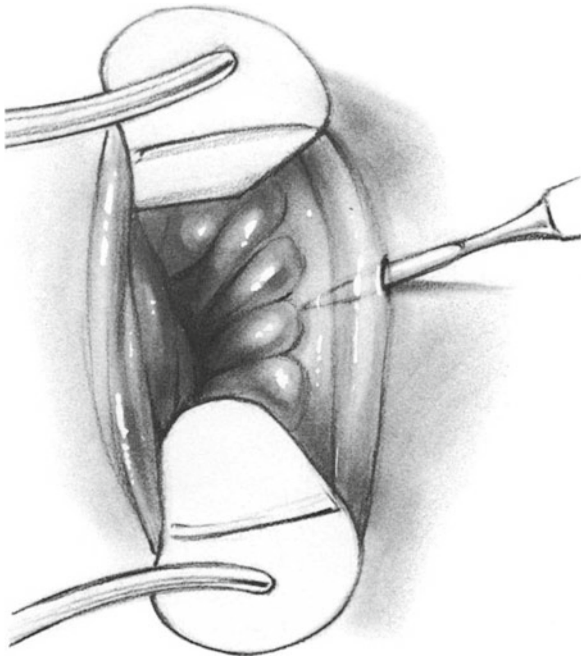

Fig. 72.1

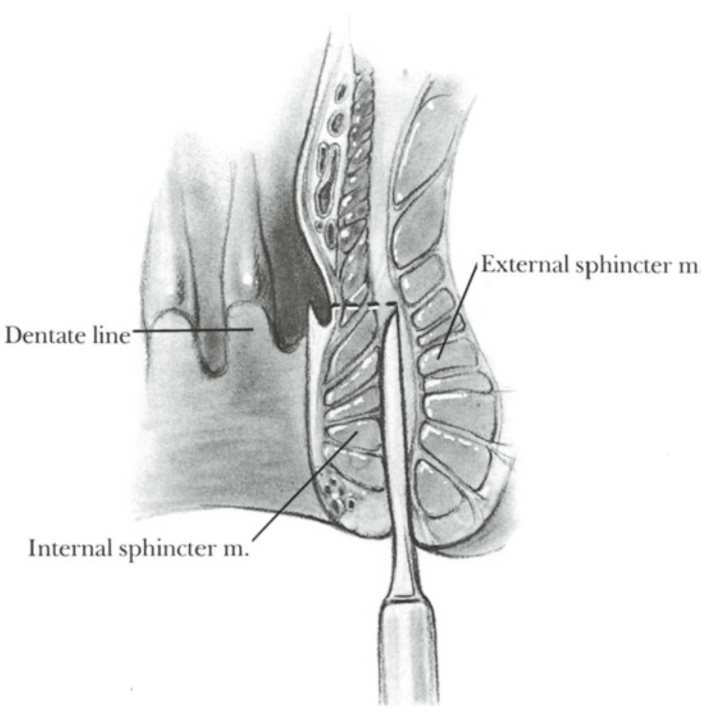

Fig. 72.2

During this insertion keep the flat portion of the blade parallel to the internal sphincter. When the blade has reached the level of the dentate line (about 1.5 cm), rotate the blade 90° so its sharp edge rests against the internal sphincter muscle (Fig. 72.2). Insert the left index finger into the anal canal opposite the scalpel blade. Then, with a gentle sawing motion transect the lower portion of the internal sphincter muscle. There is a gritty sensation while the internal sphincter is being transected, followed by a sudden "give" when the blade has reached the mucosa adjacent to the surgeon's left index finger. Remove the knife and palpate the area of the sphincterotomy with the left index finger. Any remaining muscle fibers are ruptured by lateral pressure exerted by this finger. In the presence of bleeding, apply pressure to this area for at least 5 min. It is rarely necessary to make an incision in the mucosa to identify and coagulate a bleeding point.

An alternative method of performing the subcutaneous sphincterotomy is to insert a No. 11 scalpel blade between the mucosa and the internal sphincter. Then turn the cutting edge of the blade so it faces laterally; cut the sphincter in this fashion. This approach has the disadvantage of possibly lacerating the external sphincter if excessive pressure is applied to the blade. Do not suture the tiny incision in the anoderm.

Open Sphincterotomy

For an open sphincterotomy a radial incision is made in the anoderm just distal to the dentate line and is carried across the lower border of the internal sphincter in the midlateral portion of the anus. Then the lower border of the internal sphincter and intersphincteric groove are identified. The fibers of the internal sphincter have a whitish hue. Divide the lower portion of the internal sphincter up to a point level with the dentate line. Achieve hemostasis with electrocautery, if necessary. Leave the skin wound and apply a dressing.

Removal of the Sentinel Pile

If the patient has a sentinel pile more than a few millimeters in size, simply excise it with a scissors. Leave the skin defect unsutured. Nothing more elaborate need be done.

If in addition to the chronic anal fissure the patient has symptomatic internal hemorrhoids that require surgery, hemorrhoidectomy may be performed simultaneously with the lateral internal sphincterotomy. If the patient has large internal hemorrhoids, and hemorrhoidectomy is not performed simultaneously, the hemorrhoids may prolapse acutely after sphincterotomy, although it is not common.

Postoperative Care

Apply a simple gauze dressing to the anus and remove it the following morning.

Discharge the patient the same day. Generally, there is dramatic relief of the patient's pain promptly after sphincterotomy.

Have the patient continue taking the bulk laxative (e.g., psyllium) that was initiated prior to surgery. Prescribe a mild analgesic in case the patient has some discomfort at the operative site.

Complications

Hematoma or bleeding (rare)

Perianal abscess (rare)

Flatus and fecal soiling

Some patients complain that they have less control over the passage of flatus following sphincterotomy than they had before operation, or they may have some fecal soiling of their underwear; but generally these complaints are temporary, and the problems rarely last more than a few weeks.

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Anoplasty for Anal Stenosis

73

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Symptomatic fibrotic constriction of the anal canal not responsive to simple dilatation

Preoperative Preparation

Preoperative saline enema

Pitfalls and Danger Points

Fecal incontinence
Slough of flap
Inappropriate selection of patients

Operative Strategy

Some patients have a tubular stricture with fibrosis involving mucosa, anal sphincters, and anoderm. This condition, frequently associated with inflammatory bowel disease, is not susceptible to local surgery. In other cases of anal stenosis, elevating the anoderm and mucosa in the proper plane frees these tissues from the underlying muscle and permits formation of sliding pedicle flaps to resurface the denuded anal canal subsequent to dilating the stenosis.

Fecal incontinence is avoided by dilating the anal canal gradually to two or three fingerbreadths and performing, when necessary, a lateral internal sphincterotomy. Patients with mild forms of anal stenosis may respond to a simple internal sphincterotomy if there is no loss of anoderm.

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Documentation Basics

Coding for anorectal procedures is complex. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (see references at the end). In general, it is important to document:

- Findings
- Nature of flap
- Sphincterotomy or not?

Operative Technique

Sliding Mucosal Flap

Incision

With the patient under local or general anesthesia, in the prone position, and with the buttocks retracted laterally by means of adhesive tape, make an incision at 12 o'clock. This incision should extend from the dentate line outward into the anoderm for about 1.5 cm and internally into the rectal mucosa for about 1.5 cm. The linear incision is then about 3 cm in length. Elevate the skin and mucosal flaps for about 1.0–1.5 cm to the right and to the left of the primary incision. Gently dilate the anus (Fig. 73.1).

Internal Sphincterotomy

Insert the bivalved Parks or a Hill-Ferguson retractor into the anal canal after gently dilating the anus. Identify the groove between the external and internal sphincter muscles. If necessary, incise the distal portion of the internal sphincter muscle, no higher than the dentate line (Fig. 73.2). This should permit dilatation of the anus to a width of two or three fingerbreadths.

†Deceased

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DOI 10.1007/978-1-4614-1393-6_73, © Springer Science+Business Media New York 2014

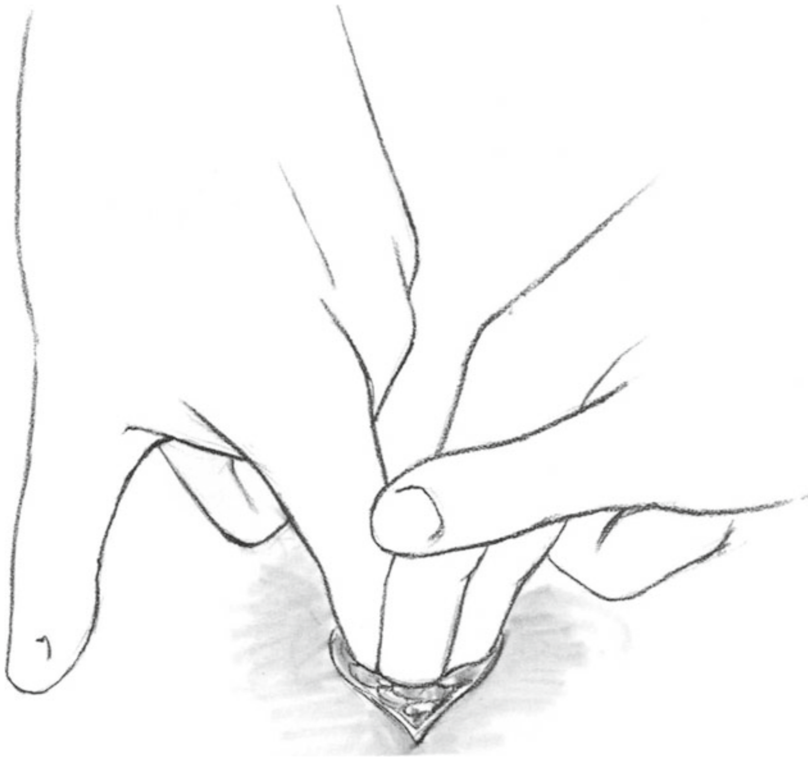

Fig. 73.1

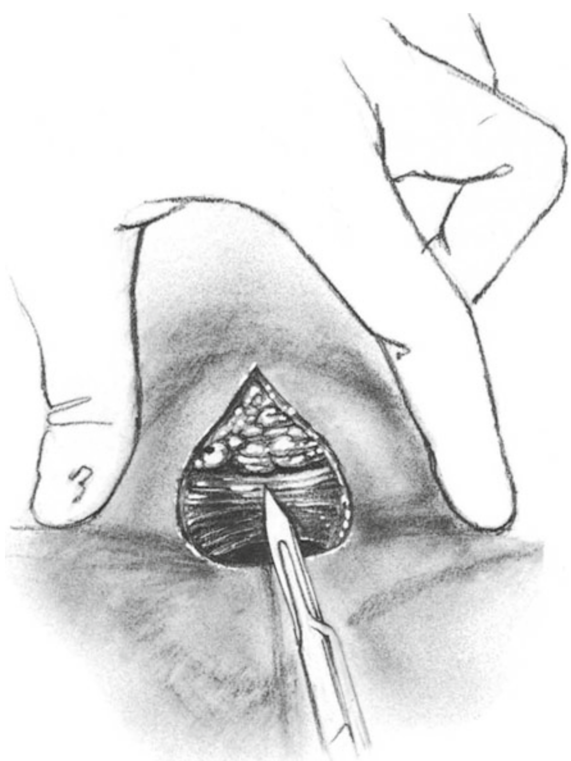

Fig. 73.2

Advancing the Mucosa

Completely elevate the flap of rectal mucosa. Then advance the mucosa so it can be sutured circumferentially to the sphincter muscle (Fig. 73.3). This suture line should fix the rectal mucosa near the normal location of the dentate line. Advancing the mucosa too far results in an ectropion with annoying chronic mucus secretion in the perianal region. Use fine chromic catgut or PG for the suture material. It is not necessary to insert sutures into the perianal skin. In a few cases of severe stenosis, it may be necessary to repeat this process and create a mucosal flap at 6 o'clock (Figs. 73.4 and 73.5).

Hemostasis should be complete following the use of accurate electrocautery and fine ligatures. Insert a small Gelfoam pack into the anal canal.

Sliding Anoderm Flap

Incision

After gently dilating the anus so a small Hill-Ferguson speculum can be inserted into the anal canal, make a vertical incision at the posterior commissure, beginning at the dentate line and extending upward in the rectal mucosa for a distance of about 1.5 cm. Then make a Y extension of this incision on

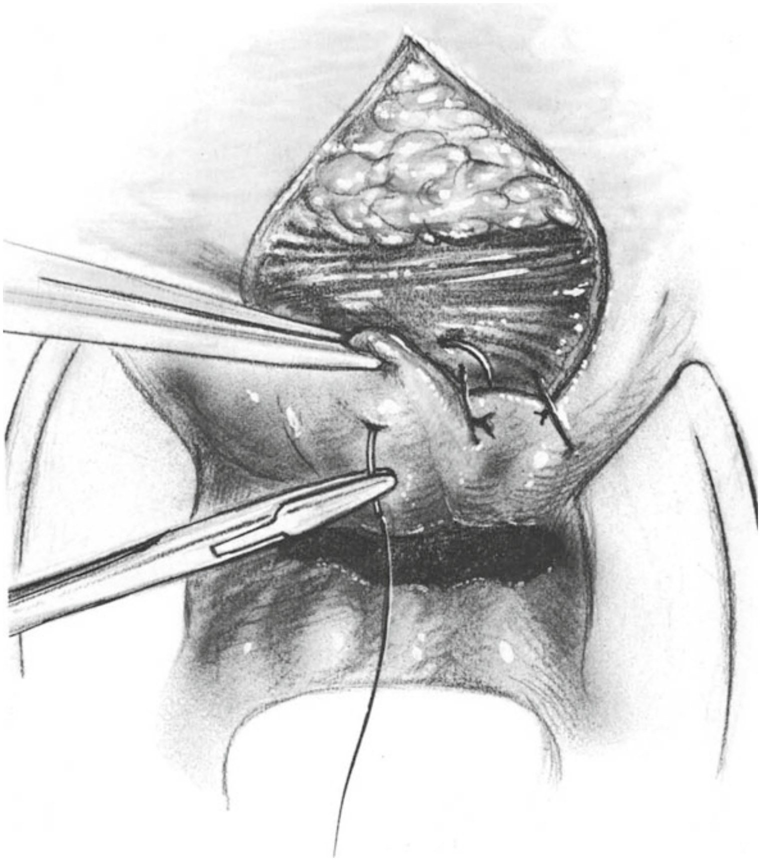

Fig. 73.3

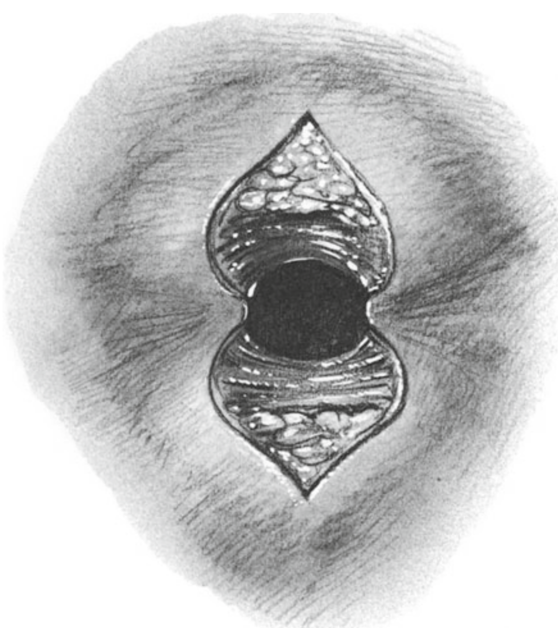

Fig. 73.4

to the anoderm as in Fig. 73.6. Be certain the two limbs of the incision in the anoderm are separated by an angle of at least 90° (angle *A* in Fig. 73.7a). Now by sharp dissection, gently elevate the skin and mucosal flaps for a distance of about 1–2 cm. Take special care not to injure the delicate anoderm during the dissection. When the dissection has been completed, it is possible to advance point *A* on the anoderm to point *B* on the mucosa (Fig. 73.7b) without tension.

Internal Sphincterotomy

In most cases enlarging the anal canal requires division of the distal portion of the internal sphincter muscle. This may be performed through the same incision at the posterior commissure. Insert a sharp scalpel blade in the groove between the internal and external sphincter muscles. Divide the distal 1.0–1.5 cm of the internal sphincter. Then dilate the anal canal to width of two or three fingerbreadths.

Advancing the Anoderm

Using continuous sutures of 5-0 atraumatic Vicryl, advance the flap of anoderm so point *A* meets point *B* (Figs. 73.7b and 73.8) and suture the anoderm to the mucosa with a continuous suture that catches a bit of the underlying sphincter muscle. When the suture line has been completed, the original Y incision in the posterior commissure resembles a V (Figs. 73.7b and 73.9). Insert a small Gelfoam pack into the anal canal.

Postoperative Care

Remove the gauze dressings from the anal wound. It is not necessary to mobilize the Gelfoam because it tends to dissolve in sitz baths, which the patient should start two or three times daily on the day following the operation.

A regular diet is prescribed.

Mineral oil (45 ml) is taken nightly for the first 2–3 days. Thereafter a bulk laxative, such as Metamucil, is prescribed for the remainder of the postoperative period.

Discontinue all intravenous fluids in the recovery room if there has been no postanesthesia complication. This practice reduces the incidence of postoperative urinary retention.

Complications

Urinary retention
Hematoma
Anal ulcer and wound infection (rare)

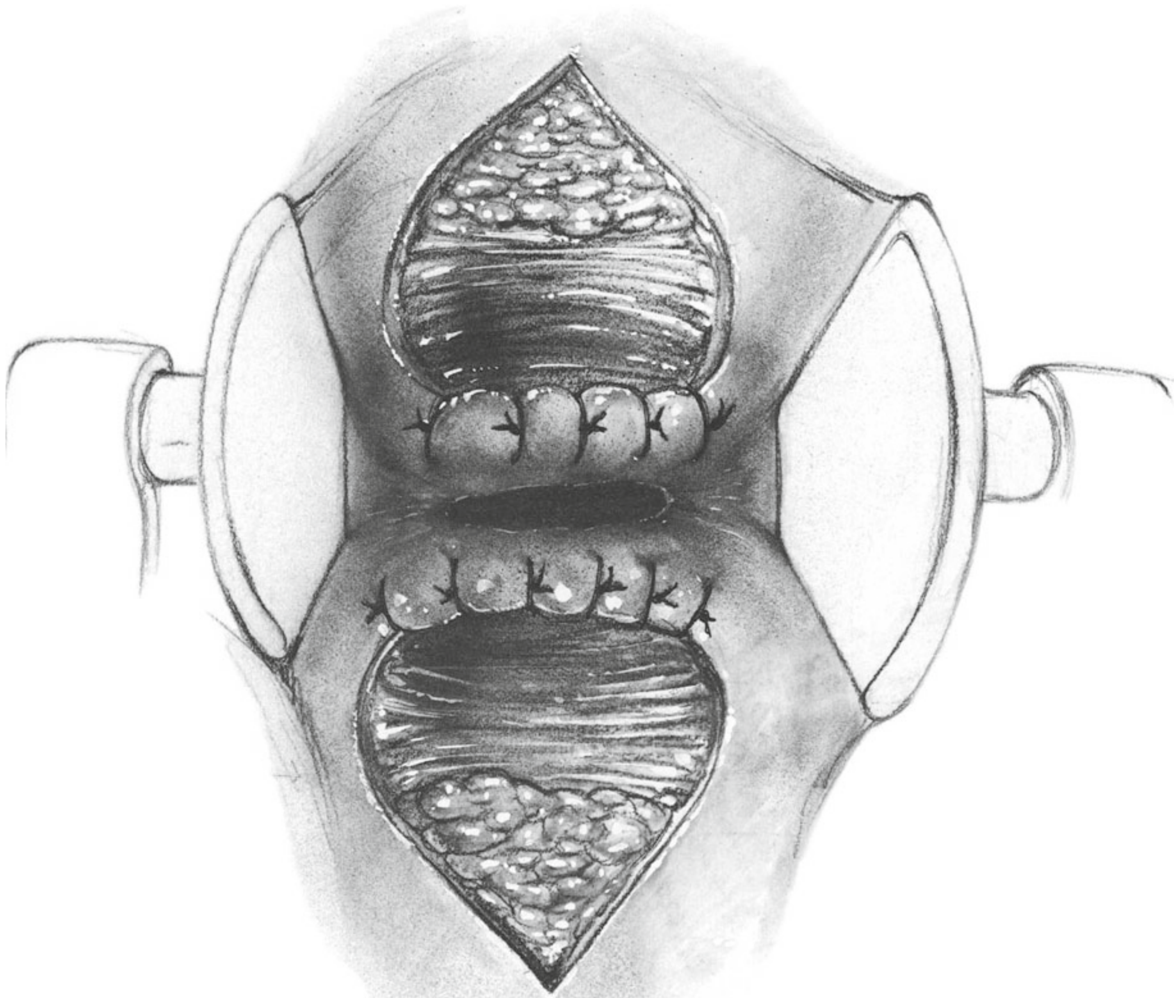

Fig. 73.5

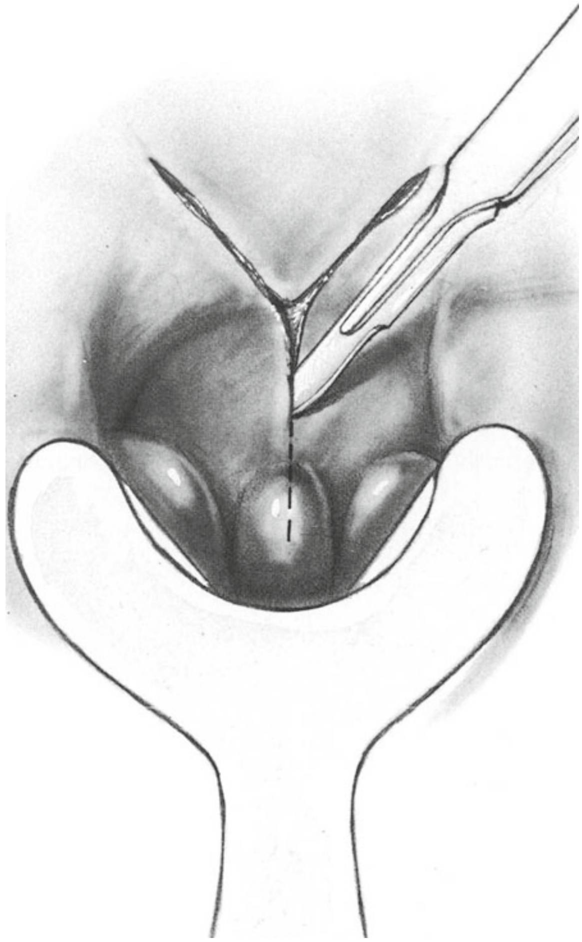

Fig. 73.6

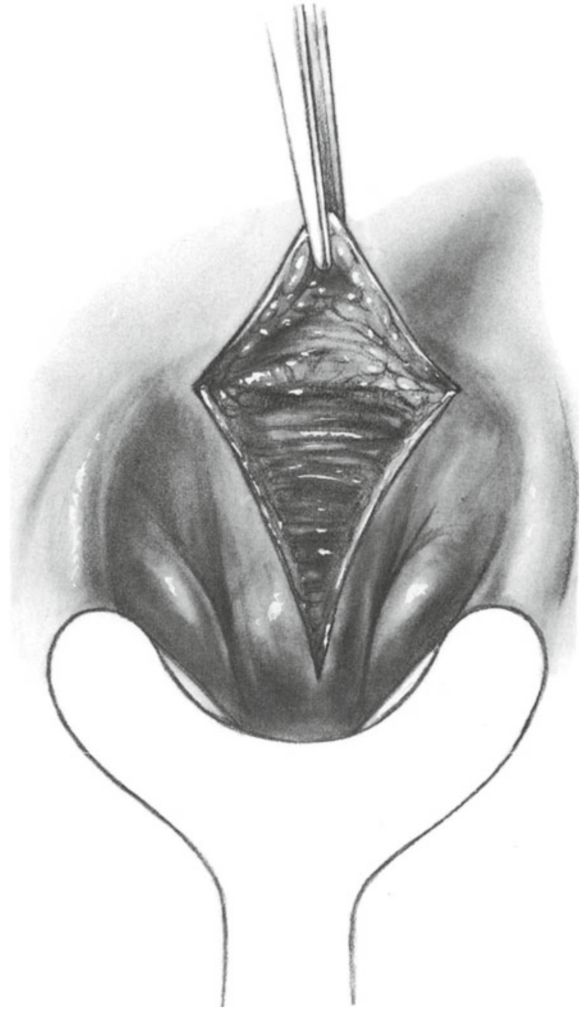

Fig. 73.8

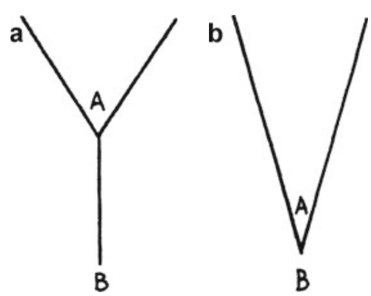

Fig. 73.7

Fig. 73.9

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74 Perineal Operations for Rectal Prolapse

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Perineal procedures are used in patients with full-thickness rectal prolapse. The Altemeier procedure provides an attractive alternative for poor-risk patients who might not tolerate a transabdominal procedure (see Chap. 66). It is also sometimes used in young male patients to avoid the very low (1–2 % in experienced hands) risk of impotence. In women, the perineal approach may be combined with repair of any cystocele or other perineal problem. It is an excellent approach for the irreducible, thrombosed prolapse. Finally, abdominal and perineal procedures complement each other in the sense that failure of one approach (recurrent prolapse) may be most easily corrected by the opposite approach.

The Thiersch operation is indicated in extremely poor-risk patients who have prolapse of the full thickness of rectum (see Chap. 66). Other perineal operations, including the Delorme procedure, are excellent alternatives in poor-risk patients and have largely supplanted this legacy procedure

Contraindications

Severely constipated patients may be better served by an abdominal procedure (resection combined with rectopexy).

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Preoperative Preparation

Basic workup includes colonoscopy with biopsy of any abnormal areas. Rectal ulcers are common and must be differentiated from cancer.

It is crucial that the proper operation be chosen and that the procedure is tailored to the patient (see Further Reading).

Accurately assess and document the degree of preoperative continence by:

- Digital rectal exam to assess resting and squeeze tone.
- Consider anorectal manometry.
- Colon transit times if severe constipation is present.

Because many patients with rectal prolapse suffer from severe constipation, cleanse the colon over a period of a few days with cathartics and enemas.

Bowel preparation as for resection.

Pitfalls and Danger Points

Perineal Proctosigmoidectomy

When surgery is performed for recurrent prolapse (e.g., after failure of an abdominal procedure which includes resection), it is important to consider the blood supply to the bowel so that the anastomosis has a good blood supply.

Injury to vagina or urethra (in male).

Thiersch Procedure

Tying the encircling band too tight so it causes obstruction

Wound infection

Injury to vagina or rectum

Fecal impaction

†Deceased

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Operative Strategy

Perineal Proctosigmoidectomy

The procedure is most easily performed with the patient in the prone jackknife position. Injecting the rectal wall with lidocaine solution containing epinephrine will help minimize bleeding and display the correct dissection plane. Begin with a full-thickness incision in the posterior rectal wall above the dentate line. Extend this incision circumferentially. Place four full-thickness sutures alone the rectal cuff to keep the layers aligned and facilitate later anastomosis. Gradually pull the redundant rectosigmoid out of the anal canal. Secure the mesentery as the bowel is delivered; ensure safety by hugging the rectal wall. Commonly, the peritoneal reflection is first encountered anteriorly as a hernia sac. When no further redundant bowel can be delivered, create a hand-sewn (or EEA) anastomosis to the rectal cuff above the dentate line.

If levatorplasty is desired, perform this before anastomosis by approximating the levators either anterior or posterior to the anal canal. Take care not to tighten the levator sling too much, as most of these patients are prone to constipation.

If only a short prolapse is encountered, a partial thickness (mucosal) resection with plication is an excellent alternative (see Delorme procedure in references at the end).

Thiersch Operation (Surgical Legacy Procedure)

Lomas and Cooperman (1972) recommended that the anal canal be encircled by a four-ply layer of polypropylene mesh. This band is made 1.5 cm in width, so the likelihood it would cut through the tissues is minimized. Labow and associates (1972) used a Dacron-impregnated Silastic sheet (Dow Corning No. 501–7) because it has the advantage of elasticity.

Although some surgeons advocate that the encircling band be adjusted to fit snugly around a Hegar dilator, we have not found this technique satisfactory. Achieve proper tension by inserting an index finger into the anal canal while the assistant adjusts the encircling band so it fits snugly around the finger. If the band is too loose, prolapse is not prevented.

Operative Technique

Perineal Proctosigmoidectomy

Place the patient in the prone jackknife position, with the buttocks distracted by tape. Prep and drape in the usual fashion. Dissection begins 1–2 cm above the dentate line. Inject this region with dilute epinephrine solution to minimize

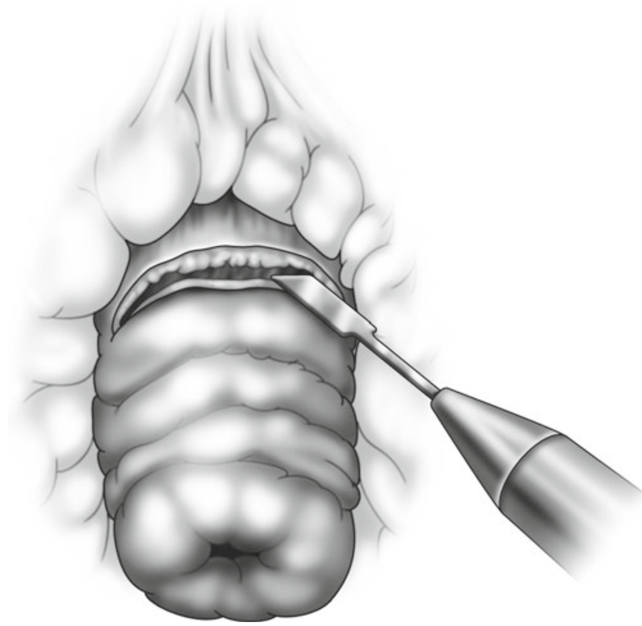

Fig. 74.1

oozing and help develop the plane. Note that dissection will begin with a full-thickness incision through the rectal wall and that thereafter the plane of dissection follows the outer wall of the rectum; thus, the injections should be placed in this area.

Begin with a full-thickness incision 1–2 cm above the dentate line (Fig. 74.1). Place a total of four full-thickness sutures of 2-0 Monocryl equally distributed around the cuff of anorectum, leaving the needles on. These provide traction and exposure. They prevent the layers of the anorectum from separating and thus facilitate subsequent anastomosis. Finally, these four-quadrant sutures will be the first sutures placed to approximate the rectosigmoid to the rectal cuff. Place Allis clamps on the prolapse (Fig. 74.2) and use gentle traction on these to deliver the rectosigmoid into the surgical field. Small bleeders can be secured with electrocautery (Fig. 74.3), but larger mesenteric vessels must be ligated securely as encountered.

When no further redundant bowel can be delivered through the anus, consider whether or not to plicate the levator sling. Palpate the levator sling. Plication may be performed anterior or posterior to the anal canal. Simply retract the prolapsed segment anteriorly or posteriorly and place one or two interrupted 2-0 silk sutures to approximate the levator muscles. Check that the plication has not compromised the lumen too much; the desired result produces some snugness but is not tight.

Resect the redundant segment using the four-quadrant sutures to secure the proximal bowel and avoid retraction (Fig. 74.4) as this resection proceeds. Complete the anastomosis by placing sutures between the four-quadrant sutures (Fig. 74.5).

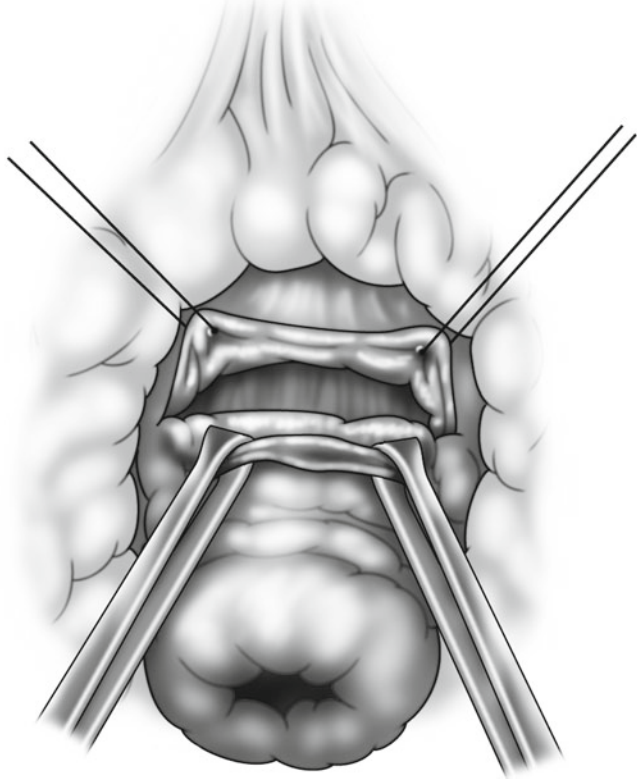

Fig. 74.2

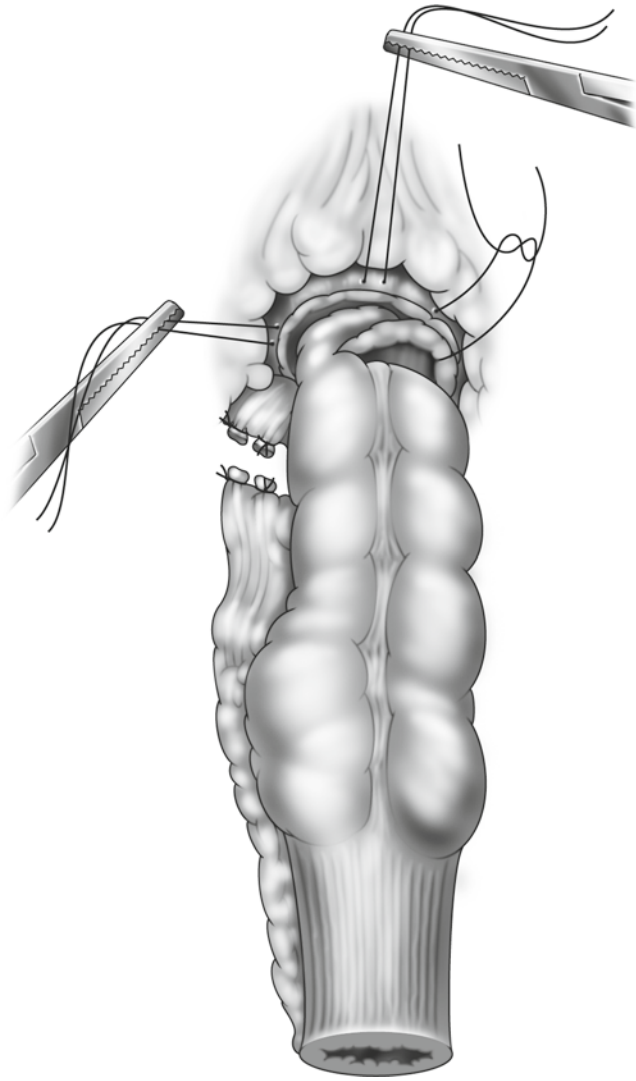

Fig. 74.4

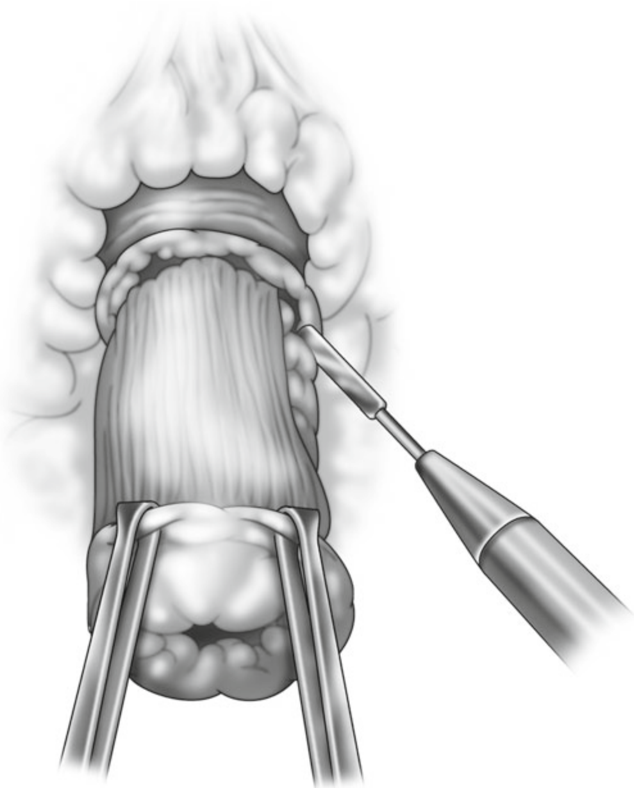

Fig. 74.3

Thiersch Operation (Surgical Legacy Procedure)

Cut a rectangle of Silastic mesh 1.5 × 20.0 cm. Cut the strip so it is elastic along its longitudinal axis and roll it into a cylinder 1.5 cm in width.

This operation may be done with the patient in the prone jackknife or the lithotomy position, under general or regional anesthesia. We prefer the prone position. Make a 2 cm radial incision at 10 o'clock starting at the lateral border of the anal sphincter muscle and continue laterally. Make a similar incision at 4 o'clock. Make each incision about 2.5 cm deep.

Insert a large curved Kelly hemostat or a large right-angle clamp into the incision at 4 o'clock and gently pass the instrument around the external sphincter muscles so it emerges from the incision at 10 o'clock. Insert one end of the mesh strip into the jaws of the hemostat and draw the mesh

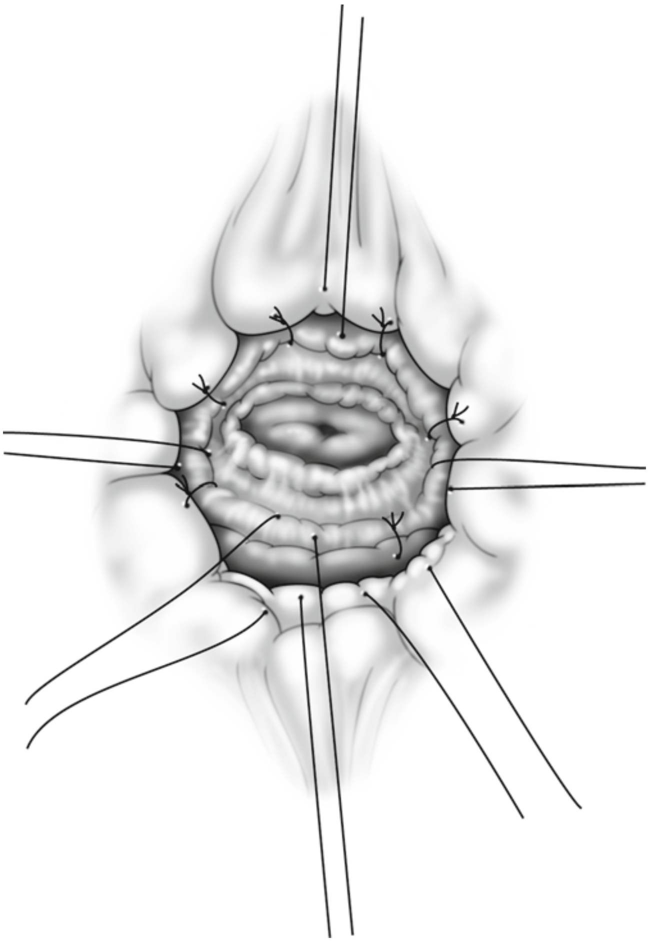

Fig. 74.5

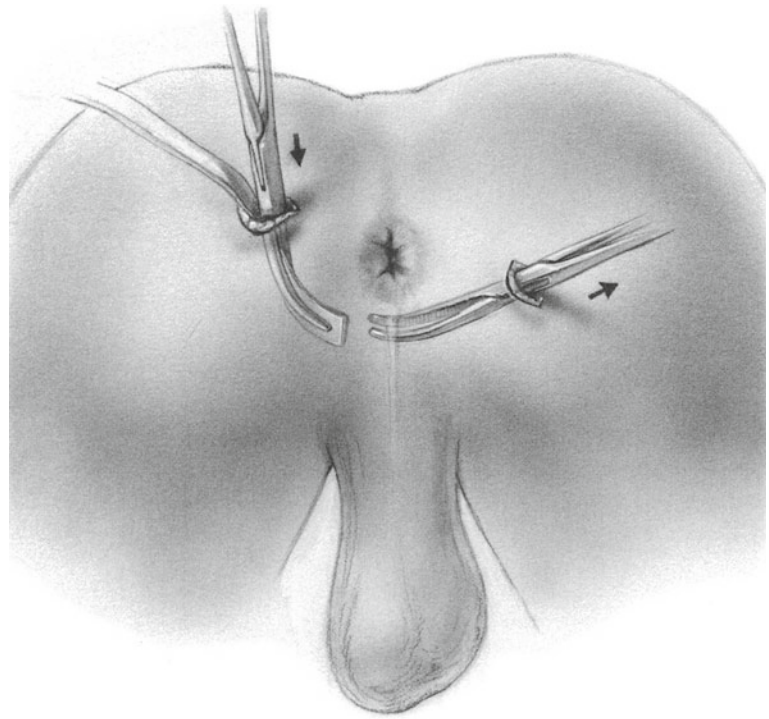

Fig. 74.6

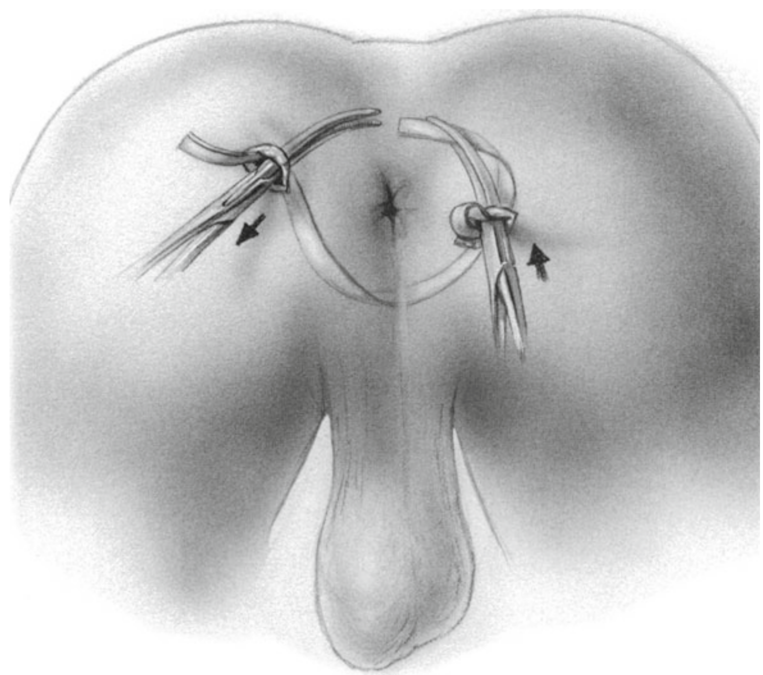

Fig. 74.7

through the upper incision and extract it from the incision at 4 o'clock (Fig. 74.6). Then pass the hemostat through the 10 o'clock incision around the other half of the circumference of the anal canal until it emerges from the 4 o'clock incision. Insert the end of the mesh into the jaws of the hemostat and draw the hemostat back along this path (Fig. 74.7) so it delivers the end of the mesh band into the posterior incision. At this time the entire anal canal has been encircled by the band of mesh, and both ends protrude through the posterior incision. During this manipulation be careful not to penetrate the vagina or the anterior rectal wall. Also, do not permit the mesh to become twisted during its passage around the anal canal. Keep the band flat.

Apply a second sterile glove on top of the previous glove on the left hand. Insert the left index finger into the anal canal. Apply a hemostat to each end of the encircling band. Ask the assistant to increase the tension gradually by overlapping the two ends of mesh. When the band feels snug around the index finger, ask the assistant to insert a 2-0 Prolene suture to maintain this tension. After the suture has been inserted, recheck the tension of the band. Then remove the index finger and remove the contaminated glove. Insert several additional 2-0 Prolene interrupted sutures or a row of 55 mm linear staples to approximate the two ends of the mesh and amputate the excess length of the mesh band. The patient should now have a 1.5 cm wide band of mesh encircling the external sphincter muscles at the midpoint of the

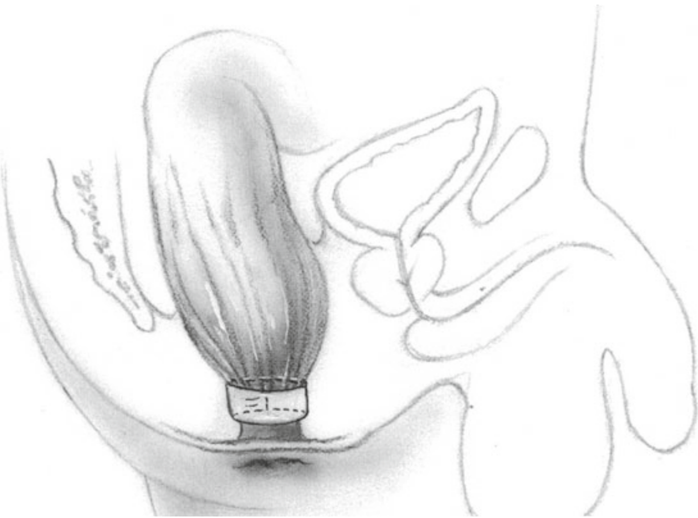

Fig. 74.8

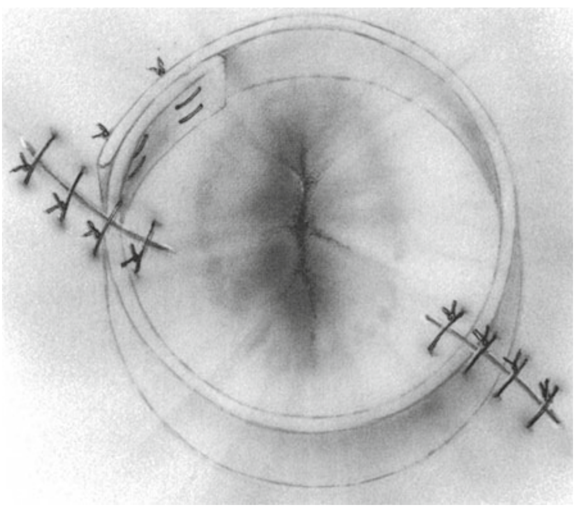

Fig. 74.9

anal canal with sufficient tension to be snug around an index finger in the rectum (Fig. 74.8).

Irrigate both incisions thoroughly with a dilute antibiotic solution. Close the deep perirectal fat with interrupted 4-0 PG interrupted sutures in both incisions. Close the skin with interrupted or continuous subcuticular sutures of the same material (Fig. 74.9). Apply collodion over each incision.

Postoperative Care

Prescribe perioperative antibiotics.

Prescribe a bulk-forming laxative such as Metamucil plus any additional cathartic that may be necessary to prevent fecal impaction. Periodic fleet enemas may be required.

Initiate sitz baths after each bowel movement and two additional times daily for the first 10 days.

Complications

Altemeier Procedure

Anastomotic leaks are relatively common after the Altemeier procedure but rarely require intervention.

Recurrent prolapse may occur and require further intervention.

Thiersch Band

If the patient develops a *wound infection*, it may not be necessary to remove the band. First, open the incision to obtain adequate drainage and treat the patient with antibiotics. If the infection heals, it is not necessary to remove the foreign body.

Some patients experience *perineal pain* following surgery, but it usually diminishes in time. If the pain is severe and unrelenting, the mesh must be removed. If removal can be postponed for 4–6 months, there may be enough residual perirectal fibrosis to prevent recurrence of the prolapse.

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Operations for Pilonidal Disease

75

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Recurrent symptoms of pain, swelling, and purulent drainage

Pitfalls and Danger Points

Unnecessarily radical excision

Operative Strategy

Acute Pilonidal Abscess

If an adequate incision can be made and all of the granulation tissue and hair are removed from the cavity, a cure is accomplished in a number of patients with acute abscesses by simple incision, drainage, and curettage.

Marsupialization

During marsupialization a narrow elliptical incision is used to unroof the length of the pilonidal cavity. Do not excise a significant width of the overlying skin—only enough to remove the sinus pits. If this is accomplished, one can approximate the lateral margin of the pilonidal cyst wall to the subcuticular layer of the skin with interrupted sutures. At the conclusion of the procedure, no subcutaneous fat is visible in the wound. Healing of exposed subcutaneous fat tends to be slow. On the other hand, the fibrous tissue lining the pilonidal cyst contracts fairly rapidly, producing approximation of the marsupialized edges of skin over a period of only several weeks. There is no need to excise a width of skin more than 0.8–1.0 cm. Conservative skin excision is followed by more rapid healing. Of course, all granulation tissue and hair must be curetted away from the fibrous lining of the pilonidal cyst.

Excision with Primary Suture

Allow several months to pass after an episode of acute infection to minimize the bacterial content of the pilonidal complex. Successful accomplishment of primary healing requires that the pilonidal cyst be encompassed by excision of a narrow strip of skin that includes the sinus pits and a patch of subcutaneous fat not much more than 1 cm in width. If this can be achieved without entering the cyst, closing the relatively shallow, narrow wound is not difficult. Perform the dissection with electrocautery. Hemostasis must be perfect to ensure complete excision of the cyst and any sinus tracts without unnecessary contamination of the wound. If this technique has been successful, postoperative convalescence is quite short.

It is not necessary to carry the dissection down to the sacrococcygeal ligaments to ensure successful elimination of the pilonidal disease. In essence, the surgeon is simply excising a chronic granulomas surrounded by a fibrous capsule and covered by a strip of skin containing the pits that constituted the original portal of entry of infection and hair into the abscess.

Primary healing requires good wound architecture. If a large segment of subcutaneous fat is excised, simply approximating the skin over a large dead space may result in temporary healing, but eventually the wound is likely to separate. Unless the surgeon is willing to construct extensive sliding skin flaps or a Z-plasty, excision with primary closure should

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be restricted to patients in whom wide excision is not necessary.

Flap techniques are described in the references at the end of the chapter.

Documentation Basics

Coding for anorectal procedures is complex, and the complexity is multiplied when flap closure is elected. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (see references at the end). In general, it is important to document:

- Findings
- Primary closure or marsupialization?
- Flaps? Which type? Measured length?

Operative Technique

Although it is possible to excise the midline sinus pits and to evacuate the pus and hair through this incision under local anesthesia, often the abscess points in an area away from the gluteal cleft and complete extraction of the hair prove to be too painful to the patient. Consequently, in most cases simply evacuate the pus during the initial drainage procedure, and postpone a definitive operation until the infection has subsided.

Infiltrate the skin overlying the abscess with 1 % lidocaine containing 1:200,000 epinephrine. Make a scalpel incision of sufficient size to evacuate the pus and necrotic material. Whenever possible, avoid making the incision in the midline. If it is possible to extract the loose hair in the abscess, do so; otherwise, simply insert loose gauze packing.

Marsupialization

First described by Buie in 1944, marsupialization begins by inserting a probe or grooved director into the sinus. Then incise the skin overlying the probe with a scalpel. Do not carry the incision beyond the confines of the pilonidal cyst. If the patient has a tract leading in a lateral direction, insert the probe into the lateral sinus and incise the skin over it. Now excise no more than 1–3 cm of the skin edges on each side to include the epithelium of all of the sinus pits along the edge of the skin wound (Fig. 75.1). This maneuver exposes a narrow band of subcutaneous fat between the lateral margins of the pilonidal cyst and the epithelium of the skin. Achieve complete hemostasis by carefully electrocauterizing each bleeding point.

After unroofing the pilonidal cyst, remove all granulation tissue and hair, if present, using dry gauze, the back of a scalpel handle, or a large curet to wipe clean the posterior wall of the cyst (Fig. 75.2). Then approximate the subcuticular level of the skin to the lateral margin of the pilonidal cyst with interrupted sutures of 3-0 or 4-0 PG (Fig. 75.3).

Fig. 75.1

Ideally, at the conclusion of this procedure, there is a fairly flat wound consisting of skin attached to the fibrous posterior wall of the pilonidal cyst, with no subcutaneous fat visible. In the rare situation where the pilonidal cyst wall is covered by squamous epithelium, the marsupialization operation is just as effective as in most cases where the wall consists only of fibrous tissue. We usually perform this operation with the patient in the prone position with the buttocks retracted laterally by adhesive straps under local anesthesia, as Abramson advocated for his modification of the marsupialization operation.

Pilonidal Excision with Primary Suture

For pilonidal excision with primary suture, use regional, general, or local field block anesthesia. Place the patient in the prone position with a pillow under the hips and the legs slightly flexed.

Apply adhesive strapping to each buttock and retract each in a lateral direction by attaching the adhesive tape to the operating table. Before scrubbing, in preparation for the surgery, insert a sterile probe into the pilonidal sinus, and gently explore the dimensions of the underlying cavity to confirm that it is not too large for excision and primary suture.

Fig. 75.2

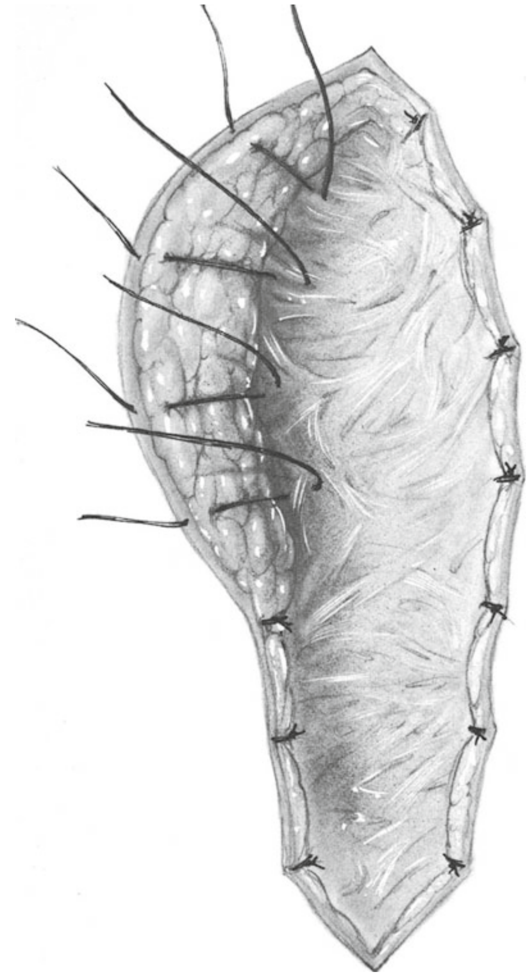

Fig. 75.3

After shaving, cleansing, and preparing the area with an iodophor solution, make an elliptical incision only of sufficient length and width to encompass the underlying pilonidal sinus and the sinus pits in the gluteal cleft (Fig. 75.1). In properly selected patients, this requires excising a strip of skin no more than 1.0–1.5 cm in width. Deepen the incision on each side of the pilonidal sinus (Fig. 75.4). Use electrocautery for this dissection to achieve complete hemostasis. Otherwise, the presence of blood prevents the accurate visualization necessary to avoid entering one of the potentially infected pilonidal tracts. Dissect the specimen away from the underlying fat without exposing the sacrococcygeal periosteum or ligaments. Remove the specimen and check for complete hemostasis. The specimen should not measure more than 5.0 × 1.5 × 1.5 cm. It should be possible to approximate the subcutaneous fat with interrupted 3-0 or 4-0 PG sutures without tension (Fig. 75.5). Insert interrupted subcuticular sutures of 4-0 PG (Fig. 75.6) or close the skin with interrupted nylon vertical mattress sutures. Avoid leaving any dead space in the incision. If at some point during the operation the pilonidal cyst has been opened inadvertently, irrigate the wound with a dilute antibiotic solution and complete the operation as planned unless frank pus has filled the wound. In the latter case, simply leave the wound open and insert gauze packing without any sutures. The patient must remain inactive to encourage primary healing.

Excision of Sinus Pits with Lateral Drainage

For Bascom's (1980) modification of Lord and Millar's (1965) operation, only the sinus pits (Fig. 75.7) are excised in the mid-gluteal cleft. This may be accomplished with a pointed No. 11 scalpel blade (Fig. 75.8a) or with the dermatologist's round skin biopsy punches. The latter, available in diameters as large as 5 mm, are simply cork borers whose ends have been sharpened to a cutting edge. Most of the pits are simply epithelial tubes going down toward the pilonidal cyst for a distance of a few millimeters. Leave unsutured the resulting wounds from the pit excisions.

Insert a probe into the underlying pilonidal cavity to determine its dimensions. Then make a vertical incision parallel to the long axis of the pilonidal cavity. Make this incision about 1.5 cm lateral to the mid-gluteal cleft (Fig. 75.8b). Open the pilonidal cyst through this incision. Curet out all of the granulation tissue and hair. Achieve complete hemostasis with the electrocoagulator. A peanut gauze dissector is also useful for this step. Bascom did not insert drains or packing. Occasionally three or more enlarged follicles (pits) are so

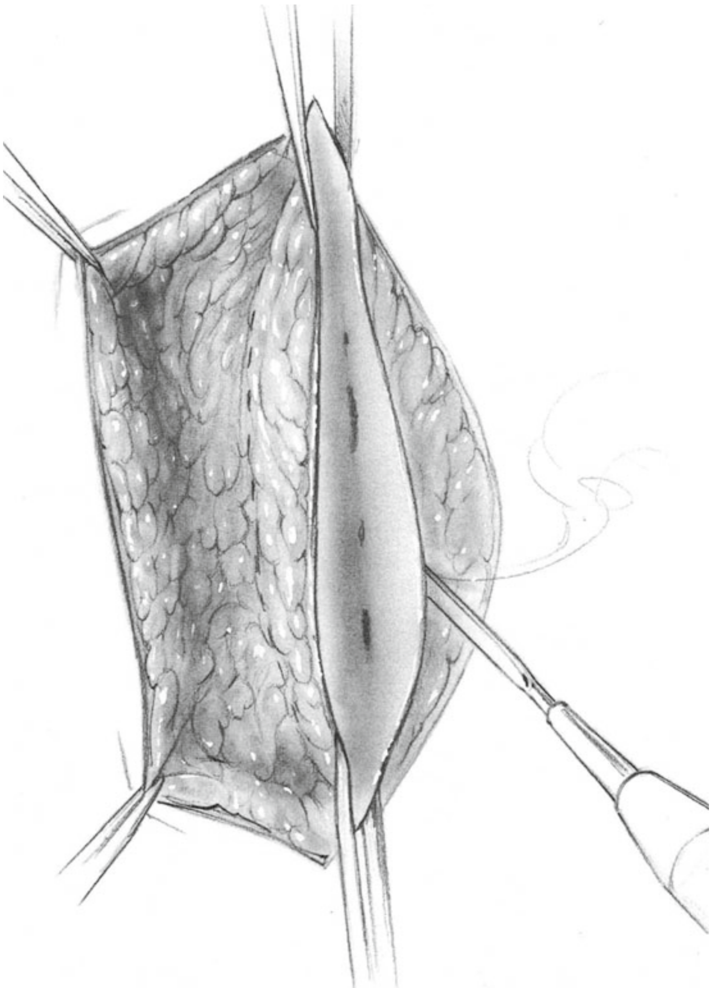

Fig. 75.4

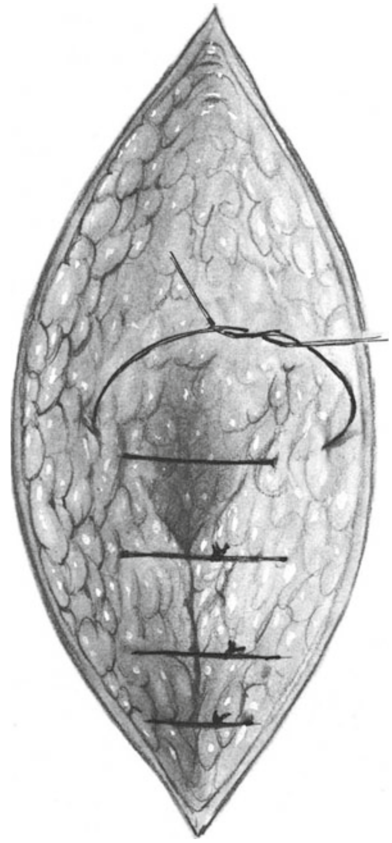

Fig. 75.5

close together in the mid-gluteal cleft that individual excision of each follicle is impossible. In this case Bascom simply excised a narrow strip of skin encompassing all of the pits. If the skin defect in the cleft exceeded 7 mm, he sutured it closed. The lateral incision is always left open. In patients who have lateral extensions of their pilonidal disease, each lateral sinus pit is excised. Bascom found that occasionally there was an ingrowth of dermal epithelium into the subcutaneous fat, forming an epithelial tube resembling a thyroglossal duct remnant. These structures resemble pieces of macaroni, and Bascom advised excising these epithelial tubes through the lateral incision.

Postoperative Care

Following drainage of an *acute pilonidal abscess*, remove the gauze packing the next day and have the patient shower daily to keep the gluteal cleft clean and free of any loose hair. Shave the skin for a distance of about 5 cm around the mid-gluteal cleft weekly. In some cases it is possible to use a depilatory cream to achieve the same result. Otherwise, hair finds its way into the pilonidal cavity and acts as a foreign body, initiating a recurrent infection.

Following *excision and primary suture*, remove the gauze dressing on the second day and leave the wound exposed. Initiate daily showering especially after each bowel movement. Observe the patient closely two or three times a week in the office. If evidence of a localized wound infection appears, open this area of the wound and administer appropriate antibiotics, treating the condition the same way you would treat an infection in an abdominal incision. If the infection is extensive, it is then necessary to lay open the entire incision. With good wound architecture, infection is uncommon. Also shave or apply a depilatory cream to the area of the mid-gluteal cleft for the first two to three postoperative weeks or until the wound is completely healed.

If the patient has undergone *pit excision and lateral drainage*, postoperative care is limited to daily showers and weekly observation by the surgeon to remove any hairs that may have invaded the wound. Bascom applied Monsel's solution to granulation tissue. All of his patients have been operated in the ambulatory outpatient setting. No matter what the operative procedure, patients with pilonidal disease require instruction always to avoid accumulation of loose

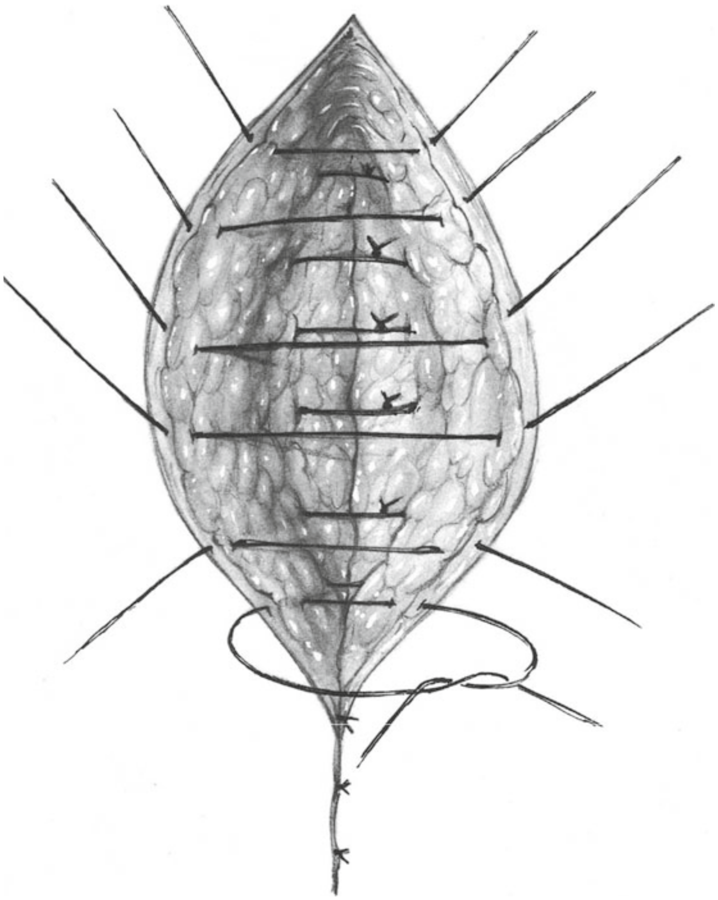

Fig. 75.6

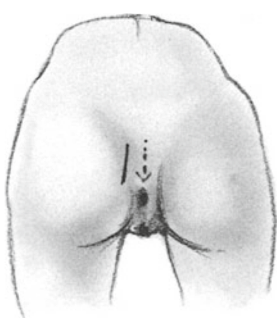

Fig. 75.7

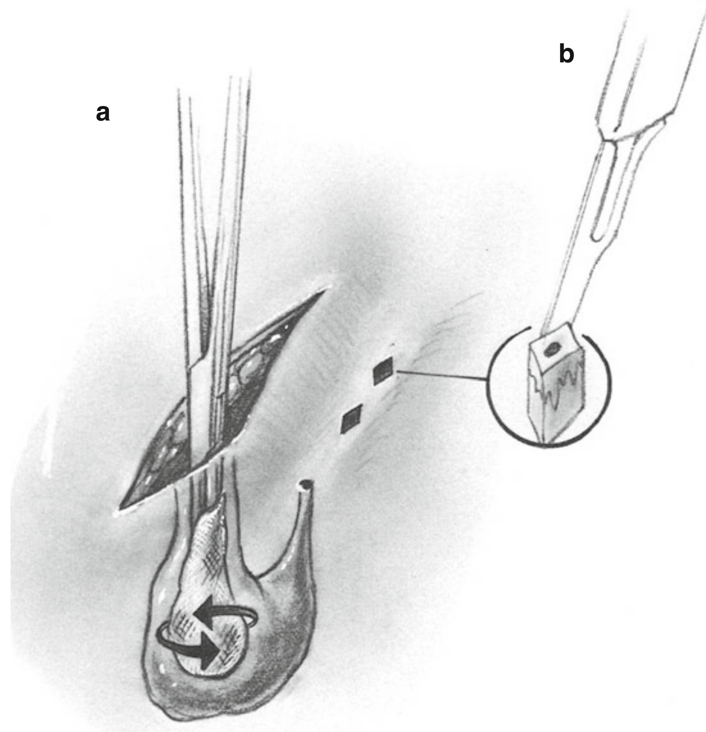

Fig. 75.8

hair in the mid-gluteal cleft. Daily showering with special attention to cleaning this area should prevent recurrence.

Complications

Infection may follow the primary suture operation.

Hemorrhage is easily preventable by meticulous electrocoagulation of each bleeding point in the operating room. It is rare following primary suture or marsupialization operations.

Among patients followed for a number of years, pilonidal disease *recurs* in 15 % whether treated by primary suture, excision and packing, or marsupialization. Even the radical excision operation does not seem to prevent recurrence. Consequently, it appears that in most cases recurrence is caused by poor hygiene, permitting hair to drill its way into the skin of the mid-gluteal cleft, rather than by inadequate surgery. Most recurrences are in the midline.

There may be a *failure to heal*. Some patients, especially those who have had a radical excision of pilonidal disease that leaves a large midline defect bounded by sacrococcygeal periosteum in its depths and subcutaneous fat around its perimeter, endure healing failure for a period as long as 2 years (Bascom). In some cases it is due to inadequate postoperative care in which the bridging of unhealed cavities has taken place or in which loose hair has found its way into the cavity and produced reinfection. Occasionally, even when postoperative care is conscientious in these patients, there is protracted healing of the residual wound.

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Part VII

Hepatobiliary Tract

76 Concepts in Hepatobiliary Surgery

Umut Sarpel and H. Leon Pachter

The hepatobiliary system is a core component of general surgery. This chapter introduces the most common disorders of the biliary tract and liver and provides the concepts necessary for safe surgery in this region.

Biliary Surgery

Bile and associated products produced in the liver drain through the biliary tree into the duodenum, with the gallbladder serving as a storage area off the main trunk. Disorders along this system are extremely common and can usually be handled uneventfully. However, advanced management of the biliary system requires a clear understanding of the anatomy and physiology involved in order to have a successful outcome.

Biliary Colic and Cholecystitis

Cholelithiasis is extremely common, is most frequently asymptomatic, and is not in itself an indication for surgery (Muhrbeck and Ahlberg 1995). However, once patients develop symptoms of biliary colic or cholecystitis, they should be evaluated for cholecystectomy since recurrent episodes tend to occur.

In biliary colic, gallstones intermittently obstruct the cystic duct, causing pain that lasts 4–6 h and is usually self-limited. Nausea is often present, and vomiting may occur, but this is not the dominant symptom. It is important to note that, while obstruction of the cystic duct is present, infection is not. Therefore true abdominal tenderness should be absent. Bowel rest, intravenous fluids, and pain control are the treatment; cholecystectomy should be performed to prevent future symptoms.

In cholecystitis, the offending gallstone is lodged in the cystic duct, and stasis of bile within the gallbladder allows for bacterial proliferation and infection. These patients will present with complaints similar to biliary colic; however the pain of cholecystitis is persistent and lasts 1–2 days if untreated. On physical examination, tenderness will be present due to the infection and inflammation of the gallbladder. A classic Murphy's sign describes the focal gallbladder tenderness that is elicited when, upon taking a deep breath, the patient abruptly halts inspiration due to the sudden pain that occurs when the descending gallbladder hits the examiner's hand, which is pressed into the right subcostal margin. Fever and mild leukocytosis are typically present, consistent with infection. Importantly, liver function tests should be entirely normal, except for in rare cases of Mirizzi syndrome where a large stone impacted in the gallbladder infundibulum can compresses the adjacent common bile duct (CBD). The treatment of cholecystitis consists of antibiotics, bowel rest with intravenous hydration, pain control, and cholecystectomy.

In the past, delayed cholecystectomy was advocated as safer than cholecystectomy performed during the acute inflammatory phase. However, a meta-analysis of 12 prospective, randomized trials showed that prompt cholecystectomy does not result in higher rates of CBD injury and actually results in significantly lower length of stay and decreased hospital costs (Johansson et al. 2003; Papi et al. 2004). Therefore, unless there are medical contraindications, early cholecystectomy should be performed.

In evaluating a patient for biliary disorders, ultrasound is the method of choice for visualizing stones in the gallbladder. A hepatobiliary scintigraphy scan is the most specific test for cholecystitis, and a patent cystic duct on this

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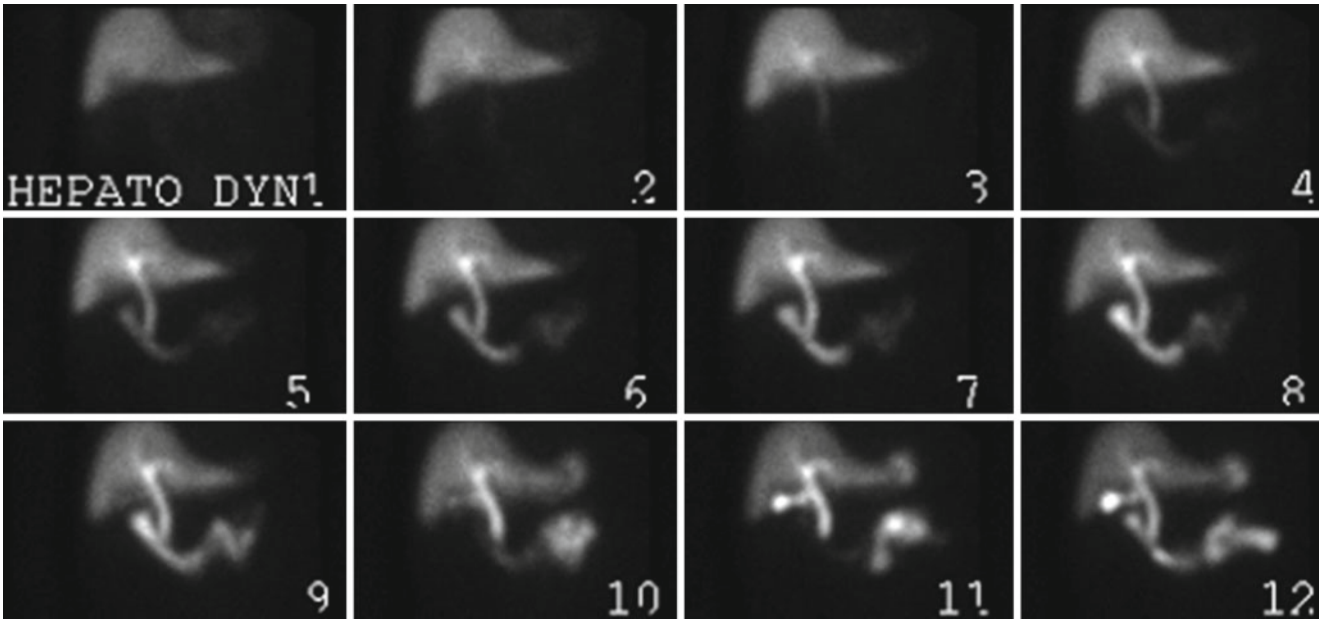

Fig. 76.1 Normal hepatobiliary scintigraphy showing prompt filling of the CBD, gallbladder, and small bowel

study virtually rules out acute cholecystitis (Fig. 76.1) (Velasco et al. 1982). Although CT scans are widely performed, they are not optimal for evaluating the gallbladder for two reasons. First, approximately one-third of gallstones are not radiopaque and will be missed on CT scans; therefore the absence of stones on a CT cannot be used to rule out their presence (Barakos et al. 1987). Second, CT scans are often too sensitive for nonspecific findings such as gallbladder wall thickening or pericholecystic fluid, which are not necessarily indicative of acute cholecystitis.

Cholecystitis During Pregnancy

Cholecystitis is common during pregnancy and is the second most frequent non-gynecologic abdominal complaint after appendicitis (Date et al. 2008). The natural hesitancy of clinicians to image and treat a pregnant patient can lead to a delay in diagnosis and intervention. This delay can be more harmful to the mother and fetus than the cholecystitis itself.

If possible, patients should be treated with bowel rest and intravenous antibiotics so that the pregnancy can be brought to term. However if cholecystectomy is necessary during pregnancy, it is ideally performed during the second trimester since surgery during the first trimester risks fetal loss, and surgery during the third trimester may cause preterm labor (Date et al. 2008).

Cholecystitis in the Hospitalized Patient

The surgeon is often asked to consult on the possibility of cholecystitis as the source of infection in hospitalized patients with a fever of unknown origin. This suspicion may be prompted by an investigatory CT scan showing mild gallbladder wall thickening. Many times this finding is nonspecific and no cholecystitis is present, as previously noted. If feasible, biliary scintigraphy can be used to definitively rule out the gallbladder as the source of infection; however the unwieldy nature of this test makes it difficult to perform in severely ill patients. In a septic patient with multiple comorbidities when the gallbladder cannot be definitively ruled out as a source of infection, ultrasound-guided percutaneous placement of cholecystostomy tube is often the safest temporizing treatment (Byrne et al. 2003). This both relieves cholecystitis if present, and spares the patient the physiologic insult of surgery if the source of infection lies elsewhere.

The exception to this is acalculous cholecystitis, a condition typically seen in severely ill patients on vasopressor support. This condition is thought to develop from hypotension and ischemic end-organ injury and can result in necrosis of the gallbladder (Warren 1992). Once tissue necrosis has set in, simple cholecystostomy tube placement will not ameliorate the condition; cholecystectomy is needed to debride the necrotic infected tissue (Fagan et al. 2003).

Cholecystectomy

The vast majority of cholecystectomies can be performed laparoscopically. As surgeons have become more facile at managing difficult cholecystectomies laparoscopically, the only absolute indications that remain for conversion to open cholecystectomy are brisk hemorrhage and an inability to clarify biliary anatomy. In these cases, prompt conversion to open cholecystectomy should not be considered a technical failure, but a demonstration of sound clinical judgment. Any surgeon operating on the biliary tract must be confident with the technique for open cholecystectomy, as described in subsequent chapters.

Intraoperative Cholangiography

The purpose of cholangiography is twofold: first to confirm the biliary anatomy and second to identify unsuspected stones in the CBD. During cholecystectomy some surgeons use intraoperative cholangiography on a selective basis and others advocate for its routine use.

Selective users perform cholangiography based on certain criteria. Preoperative indications for cholangiography include jaundice or hyperbilirubinemia, gallstone pancreatitis, or the presence of biliary dilatation. If these indications are not present, and the intraoperative anatomy is straightforward, no cholangiogram is performed.

However, proponents of routine cholangiography state that approximately 6 % of asymptomatic patients are found to have incidental CBD stones (Majeed et al. 1999) which should be removed due to the potentially severe consequences of gallstone pancreatitis or cholangitis. Routine cholangiography adds only 10 min to the procedure in experienced hands and also provides a permanent record of the state of the common bile duct at the time of surgery.

Advocates of selective cholangiography respond that incidentally discovered stones are typically small and would pass spontaneously. Furthermore, cholangiography is not entirely without risk, including false-positives caused by the inadvertent introduction of air bubbles within the CBD that are subsequently mistaken for stones.

Regardless of personal preference, there is universal agreement that any confusion about the biliary anatomy or concern for an iatrogenic bile duct injury mandates an immediate intraoperative cholangiogram for evaluation.

Use of Drains

The routine use of closed suction drains is not indicated after cholecystectomy. However, it is wise to leave a drain when bile leakage is considered possible, such as in cases when closure of the cystic duct stump is tenuous due to severe inflammation. The use of a drain allows for a controlled biliary-cutaneous fistula if a bile leak should develop. This is well-tolerated and provides the luxury of time, since most bile leaks are from the cystic duct stump and will resolve spontaneously or with ERCP-guided sphincterotomy (Massoumi et al. 2007). In contrast, an undrained bile collection is both very irritating to the peritoneal cavity and can become infected, requiring emergent imaging-guided percutaneous drainage.

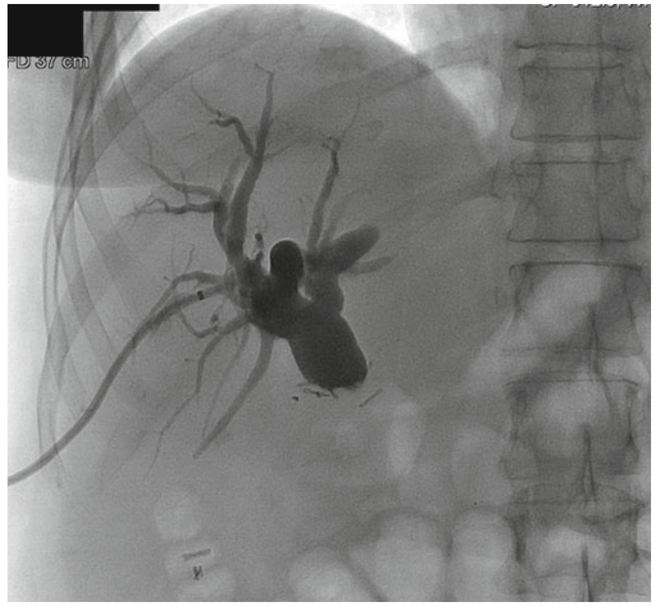

Fig. 76.2 Percutaneous cholangiogram demonstrating iatrogenic ligation of the common bile duct during laparoscopic cholecystectomy. Note the mulitple surgical clips present at the stump of the CBD

Iatrogenic Biliary Injury

The most feared complication of cholecystectomy is that of iatrogenic injury to the common bile duct (Fig. 76.2). A detailed classification of biliary injuries by Strasberg et al. (1995) and Bismuth (1982) outlines the varieties of biliary tree injuries that can occur during cholecystectomy. The surgeon must always be on the alert for potential CBD injury even during apparently straightforward cases. In fact, it is often anecdotally said that CBD injury happens on the easy cases, when attention tends to wane. As a matter of practice, no structure should be divided until its identity is certain.

The classic mechanism of injury is failure to recognize that the structure being dissected is not the cystic duct, but is in fact the common bile duct. This tends to occur when the cystic duct has not been thoroughly dissected out or when excessive traction straightens out the cystic duct/common bile duct junction, as discussed in the following chapters. Often a dual injury can occur, and surgeons must be aware of this pattern: the common bile duct is mistaken for the cystic duct, and – as a part of the illusion – the right hepatic artery is mistaken for the cystic artery. Both structures are unknowingly clipped and divided. Therefore, in all cases of iatrogenic bile duct injury, it is important to also investigate the patency of the right hepatic artery (Strasberg et al. 1995; Davidoff et al. 1992).

If a common bile duct injury is recognized at the time of surgery, it is wise to recruit the assistance of a hepatobiliary surgeon to aid in the reconstruction. Even if the original operating surgeon is skilled in biliary repair, the emotional toll of having caused an iatrogenic injury clouds judgment, and therefore assistance should be sought. A limited, nonthermal, sharp injury to the common bile duct detected at the time of surgery may be repaired over a T-tube; however most laparoscopic bile duct injuries result in complete discontinuity of the biliary tree and will require a Roux-en-Y hepaticojejunostomy. Cautery and crush injuries should *absolutely not* be repaired primarily since the area of tissue damage always extends beyond what is immediately apparent.

Most instances of injury to the biliary tree are not recognized at time of surgery (Lillemoe et al. 1997). Postoperative manifestations may be that of a bile leak, biliary obstruction, or both – depending on the nature of the injury. *Any patient who develops abdominal pain, fever, or jaundice following cholecystectomy has a biliary injury until proven otherwise.* The most important initial steps in managing these patients are to determine the exact anatomy of the injury and to ascertain whether any bile leak is controlled or not. Imaging is the first step in the evaluation of these patients. A CT scan of the abdomen may reveal the presence of intrahepatic biliary dilatation and/or a fluid collection in the liver bed. If a biloma is detected, it should be drained percutaneously by interventional radiology, and a closed suction drain should be left at the site. If the bilious output fails to resolve promptly, this should be investigated by endoscopic cholangiography.

If a CBD injury is ultimately diagnosed, reconstruction with a Roux-en-Y hepaticojejunostomy is necessary to restore biliary-enteric continuity. Over 90 % of these patients will do well, but some may suffer from anastomotic stricture and bouts of cholangitis over their lifetime (Lillemoe et al. 2000). The timing of repair is an important consideration. If the leak or obstruction is diagnosed expeditiously and the patient is stable, it is best to proceed with Roux-en-Y hepaticojejunostomy promptly. However, if the diagnosis has been delayed and a prolonged or uncontrolled bile leak has been present, the patient may be quite ill. Bile peritonitis creates a hostile abdomen which can cause bowel edema and complicate Roux-en-Y hepaticojejunostomy. In these cases it may be optimal to temporize the patient with a stent and drain(s) to allow the inflammation to resolve before proceeding with definitive repair. In cases of iatrogenic ligation of the CBD, without a leak, some surgeons advocate delayed repair to allow the CBD remnant to dilate, which allows for a larger anastomosis. However, this approach obligates the presence of a transhepatic biliary drainage catheter for weeks and is not ideal.

The development of a biliary stricture following cholecystectomy is usually the result of iatrogenic injury to the common bile duct. This may be the result of direct compression of the bile duct by a surgical clip that was placed too close to the CBD. Another common mechanism of injury results from overly aggressive dissection near the junction of the cystic duct with the CBD; this skeletonization of the duct can lead to a delayed ischemic stricture which presents as progressive jaundice weeks after cholecystectomy. Similarly, the use of cautery too close to the CBD can result in a thermal injury with delayed structuring. ERCP with balloon dilation and stenting can be attempted for strictures of the common bile duct; however the stricture may recur over time. Elective Roux-en-Y hepaticojejunostomy may ultimately be necessary for long-term relief.

Choledocholithiasis and Cholangitis

Choledocholithiasis refers to the presence of stones in the common bile duct. In the majority of cases, these stones originate from the gallbladder. Most small stones will pass uneventfully through the ampulla of Vater into the duodenum; however they can also cause serious illness such as gallstone pancreatitis or cholangitis. These can be life-threatening, and in order to prevent them, even asymptomatic incidentally discovered CBD stones should be removed.

Cholangitis occurs when a stone becomes lodged at the ampulla and the obstructed column of bile becomes infected. The presentation of cholangitis is described by *Charcot's Triad*: fever, jaundice, and right upper quadrant pain. Because the liver is a highly vascular organ, infection of the biliary tree rapidly leads to bacteremia. *Reynaud's Pentad* – the addition of hypotension and mental status changes – heralds the onset of sepsis.

Laboratory values will demonstrate leukocytosis and a direct hyperbilirubinemia, often accompanied by mildly elevated transaminases. Ultrasonography will typically reveal intrahepatic biliary dilatation due to downstream obstruction. However, it is important to point out that it can take 24–48 h for appreciable biliary dilatation to develop. Therefore, the absence of biliary dilatation on initial imaging studies does not rule out obstructive cholangitis. If uncertainty exists, an MRI/MRCP can identify the presence and location of stones. However, *if the clinical suspicion for cholangitis is high, it is best to proceed directly to ERCP, which can both diagnose and treat the condition.*

Ductal Drainage Procedures

Antibiotic administration for cholangitis is necessary but not sufficient for its treatment. It is critical to underscore that the urgently needed treatment for cholangitis is decompression (Kinney 2007). This is especially true once suppurative cholangitis has developed, where the mortality is 100 % if the CBD is not drained. Similar to lancing an abscess, drainage is absolutely necessary – antibiotics alone are insufficient to treat the infection.

Drainage of the common bile duct can be accomplished by one of four approaches: (1) endoscopic, (2) transhepatic, (3) laparoscopic, and (4) open CBD exploration. In general, the endoscopic approach is the first choice since it is the least invasive. However, if a qualified gastroenterologist is not promptly available, there should be no hesitation to pursue percutaneous transhepatic drainage. Similarly, if interventional radiology is not available, then the surgeon must pursue operative options without delay. This approach is described in subsequent chapters.

T-Tube Management

Following CBD exploration, a T-tube should be placed to allow access to and provide drainage of the common bile duct. Even though the obstructing stone was removed at CBD exploration, operative instrumentation of the ampulla results in edema that can cause transient obstruction and increased pressure in the biliary system. A T-tube allows the surgeon to decompress the system, thus preventing the bile leak that might have occurred if the duct had been closed primarily.

Initially a T-tube should be placed to straight drainage to allow for decompression. However, once the period of acute inflammation has passed, the T-tube should be capped, which frees the patient of the biliary drainage bag and allows for the return of normal bile-aided absorption of GI contents. Bilirubin levels should be checked 24 h after capping to ensure that bile flow out the ampulla is not obstructed.

Prior to removal of a T-tube, it is advisable to obtain a cholangiogram. This confirms that the biliary system is patent and intact, and that there are no remaining stones present. If necessary, interventional radiologists can use the T-tube to access the common bile duct to remove any residual stones. When a catheter that is 14 French in size is used, stones up to 5 mm can be removed via the T-tube (Blumgart 2006).

In general, T-tubes should not be removed prior to about 6 weeks. This is due to the fact that removal of the tube leaves behind an open hole in the CBD. The only reason that this does not lead to bile peritonitis is that a fibrous tract has developed around the path of the T-tube, excluding it from the peritoneal cavity. Removing the tube before this tract has had a chance to become established increases the risk of a free bile leak.

Even when removed at the appropriate time, some patients will nonetheless develop sudden, severe abdominal pain, indicating a bile leak. These patients should be admitted, made NPO with intravenous fluids, and provided pain medication. Thankfully, most of these leaks are mild and self-limited, with resolution of pain within hours. Persistent pain should be treated the same as de novo bile leaks, with prompt IR drainage and ERCP with stent placement.

Gallbladder Carcinoma

The discovery of early stage gallbladder carcinomas has become increasingly common due to the rise in the number of cholecystectomies performed in the era of laparoscopic surgery. Patients with incidentally discovered gallbladder cancer typically have T1 or T2 disease and may have a favorable long-term prognosis. However, patients who present with symptomatic gallbladder cancer almost always have advanced disease with nodal metastases.

Patients with the finding of T1 disease following cholecystectomy are typically observed without further intervention. Although the data are mixed, most surgeons feel that patients with T2 disease should undergo extended cholecystectomy, which includes a complete hepatoduodenal lymphadenectomy, resection of the liver bed, and excision of at least the trochar site where the gallbladder specimen was extracted. Patients with T3 disease will require major hepatectomy in addition to the node dissection and port site excision (Miller and Jarnagin 2008). Patients whose preoperative imaging demonstrates distant metastases or malignant adenopathy outside the region of lymphadenectomy are not helped by surgical intervention.

Cholangiocarcinoma

Malignancy of the extrahepatic bile ducts typically presents with jaundice. Subsequent imaging reveals the presence of biliary dilatation up to the point of malignant involvement. Unfortunately, most patients will already have metastatic liver satellites or distant lymphadenopathy on presentation. However, a small percentage of patients can be cured with surgical resection. The common bile duct is resected in conjunction with either a liver resection or a pancreaticoduodenectomy, depending on whether the tumor is located proximally or distally in the biliary tree. Extensive neurovascular spread is the norm for cholangiocarcinoma and therefore isolated CBD resections are usually too limited to accomplish tumor clearance. A complete portal lymphadenectomy is also performed as part of the procedure.

In advanced stages, palliative biliary drainage should be performed to relieve the symptoms of obstruction. Although ERCP can be attempted, in most patients with advanced cholangiocarcinoma, the right and left biliary systems become isolated from each other due to tumor infiltration of the bifurcation, making the endoscopic approach in effective. Ultimately, these patients often require bilateral transhepatic drains for relief.

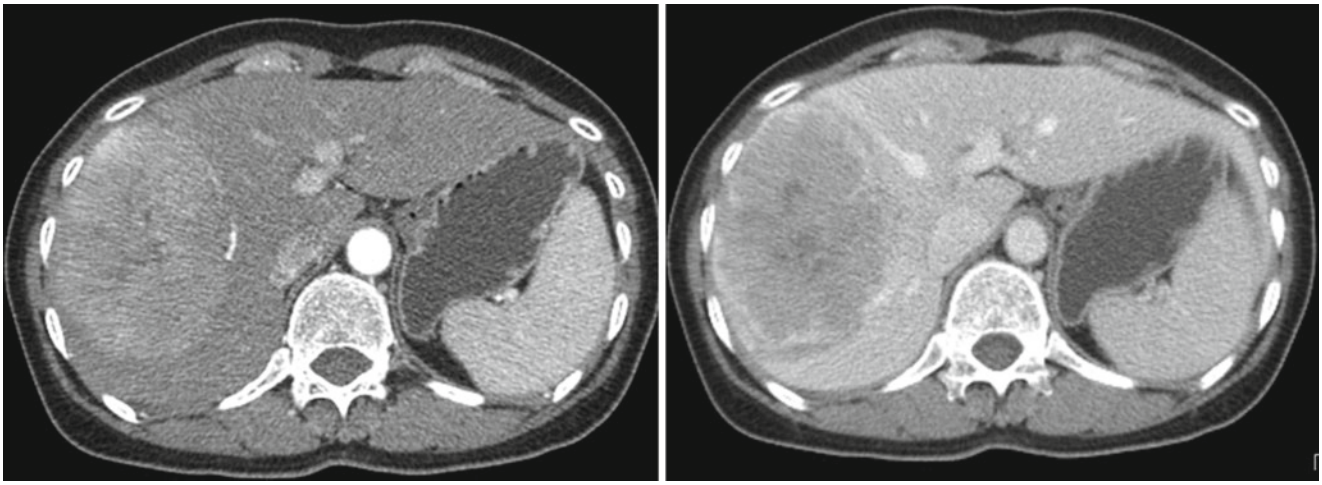

Fig. 76.3 Hepatocellular carcinoma, note the classic pattern of arterial enhancement and venous washout

Hepatic Surgery

Liver resection has become increasingly common due to the rising incidence of hepatocellular carcinoma as well the improvements in survival achieved with hepatic metastasectomy of colorectal tumors. These new indications, coupled with the improved safety of hepatic surgery, have expanded the pool of patients undergoing liver resection.

Hepatocellular Carcinoma

Hepatocellular carcinoma (HCC) is the fifth most common cancer in the world and is one of the few cancers in the United States whose incidence continues to rise (Jemal et al. 2005; El Serag et al. 2001). HCC usually occurs due to the presence of an underlying liver disease – although advanced age may be a risk factor in itself. Cirrhosis due to alcohol abuse, viral infection, or diabetes represents the most common etiology for HCC in the United States and Europe. Notably, chronic hepatitis B infection can cause HCC even in the absence of cirrhosis, and this virus is the most common cause of HCC development in Asia and in sub-Saharan Africa. No biopsy is indicated in the evaluation of HCC since the diagnosis can be definitively made by the radiologic criteria of arterial enhancement and venous washout (Fig. 76.3) (Bruix and Sherman 2011).

The best curative therapies for HCC are hepatic resection or liver transplantation and should therefore be the first choice. In general, transplantation is preferred for patients with multifocal disease or underlying cirrhosis. Resection is preferred in patients with a single-lesion and well-preserved liver function, since it avoids the morbidity of transplantation and the need for lifelong immunosuppression (Bruix and Sherman 2010).

Ablative procedures can also be curative for small lesions (<3 cm in size) but is highly operator dependent and should be reserved for centers with experience. Chemoembolization and oral tyrosine kinase inhibitors are modalities that can slow the progression of the tumor, but are not curative (Bruix and Sherman 2010).

In patients with HCC secondary to underlying hepatitis B infection, it is important to measure the viral load and initiate antiviral treatment as indicated. Not only has this been proven to reduce recurrence of HCC following resection (Kubo et al. 2007), but studies demonstrate that regeneration of the liver remnant is improved if the viral load is kept low in the postoperative period (Li et al. 2010).

Colorectal Liver Metastases

Resection of hepatic metastases has become increasingly accepted as newer chemotherapeutic regimens have allowed for improved long-term survival of patients with colorectal cancer. Liver metastases usually appear as simple, round, nonenhancing lesions, although long-standing or treated lesions can show areas of necrosis or calcification (Fig. 76.4).

The key to successful metastasectomy is proper patient selection. The patients who will benefit the most from hepatic resection are those with metachronous disease, a node-negative primary tumor, a single metastatic lesion, and low carcinoembryonic antigen levels, which are surrogate markers of indolent tumor biology (Fong et al. 1999).

When a patient presents with resectable liver metastases, a limited course of neoadjuvant chemotherapy prior to surgery may be considered. This approach serves two purposes. First, it allows a period of time for the tumor to declare its biology; if the lesion continues to grow on treatment, or other lesions develop, this suggests that the patient would not

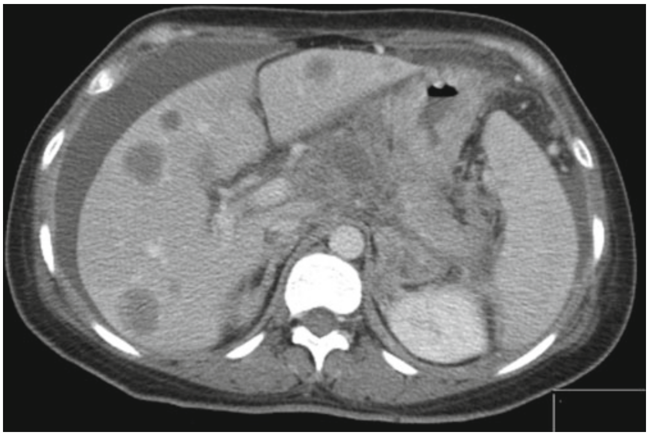

Fig. 76.4 Characteristic CT appearance of liver metastases from colorectal carcinoma

Fig. 76.5 Major hepatic laceration of the right lobe caused by blunt abdominal trauma

benefit from metastasectomy and should remain on systemic treatment. Second, in cases where there is a postoperative complication of hepatectomy, providing chemotherapy upfront ensures that the patient has seen some systemic treatment.

The parenchymal transection itself tends to be more straightforward for colorectal metastases, since – unlike HCC – patients with metastases tend to have noncirrhotic livers. Ablative procedures can also be used as an alternative or to supplement resection. Following metastasectomy, patients should be closely followed with imaging surveillance. If recurrences develop, repeat interventions can be considered.

Hepatic Trauma

The liver is the largest intra-abdominal organ and the most frequently injured by trauma. Fortunately the liver is also very resilient, and as a result most hepatic trauma can be managed nonoperatively provided that the patient is hemodynamically stable. Minor bile leaks after nonoperative management are not unusual, but these can be effectively managed by percutaneous drainage as described above.

The focused assessment by ultrasound for trauma (FAST) is frequently the first diagnostic tool used in the emergency room. However, the presence of free fluid on FAST is not in itself an indication for laparotomy, since as mentioned, minor injuries are self-limited. Stable patients should proceed to CT imaging with intravenous contrast, which is the best modality to visualize the extent of liver injury.

Diagnostic peritoneal lavage (DPL) is another method of detecting blood in the abdomen and can be performed rapidly in an unstable multi-trauma patient if there is uncertainty as to the source of hypotension. The classic example of this situation is the tachycardic patient with blunt abdominal trauma and pelvic fractures. If DPL is negative, the patient can go directly to interventional radiology for embolization of pelvic vessels, thus avoiding a negative laparotomy.

For more serious hepatic injuries (Fig. 76.5), the decision to operate is guided by the clinical picture. Tachycardic or hypotensive patients, or those with clear peritonitis mandate prompt exploration. Patients with a transient response to fluid boluses or those needing repeated blood transfusions to maintain hematocrit levels should also be explored.

At laparotomy, most hemorrhages can be controlled by perihepatic packing (Pachter and Feliciano 1996). To provide sufficient compression, this maneuver requires the placement of laparotomy pads lateral, anterior, and superior to the liver. If hemorrhage continues after packing, the Pringle maneuver can be applied by placement of an atraumatic vascular clamp across the porta hepatis. This provides the surgeon the ability to visualize and repair the site of injury. Liver resection is only indicated in patients with shattered or devascularized hepatic lobes.

Retrohepatic injuries to the inferior vena cava are frequently fatal even with prompt exploration since the mobilization of the liver required to access this portion of the cava is time consuming. Attempts to mobilize the liver may exacerbate bleeding by decompressing the pericaval space that was serving to partially tamponade the bleeding. For this reason, these injuries are often best controlled by packing and resuscitation. The abdomen can be closed with laparotomy pads in place using a temporary vacuum dressing allowing for stabilization in an intensive care unit.

Concepts in Liver Resection

The choice of an anatomic resection versus a non-anatomic (or wedge) resection depends on both the tumor type and the patient's underlying liver reserve. In general, it is wise to preserve liver parenchyma when feasible – particularly in patients with borderline liver function. However, some data suggest that for primary liver cancer, an anatomic resection of the functional liver unit provides improved survival (Wakai et al. 2007). This concept does appear not hold for metastatic colorectal lesions which arrived by hematogenous dissemination and are not based within a functional hepatic unit (Sarpel et al. 2009).

Determining Resectability

In determining resectability, strict rules as to the number and location of hepatic lesions have not proven to be useful in guiding decision making. In certain cases, the resection of massive or multifocal tumors is easily accomplished, while in other settings even small tumors can prove to be unresectable.

In general, the determination of whether a liver lesion is resectable can be guided by ascertaining "inflow, outflow, and parenchyma." In other words, if the proposed hepatectomy were to be performed, the surgeon should consider whether there will remain blood *inflow* to the remnant liver, venous *outflow* from the remnant, and sufficient hepatic *parenchyma* to support liver function. Inflow may be the concern when, for example, a cholangiocarcinoma encases the bifurcation of the hepatic artery or portal vein. Occasionally outflow makes a tumor unresectable, as in the case of a large hepatocellular carcinoma that involves the confluence of the hepatic veins and the vena cava. Most frequently, however, the limiting factor is the parenchyma.

In a noncirrhotic patient with normal liver function, approximately 80 % of the liver can be resected without concern for liver failure. A hepatic trisegmentectomy for multifocal colorectal liver metastases is an example of this type of massive resection of parenchyma that can be performed with low morbidity and mortality in experienced hands. However, this amount of tissue loss would not be tolerated in a cirrhotic patient where even a limited wedge resection can lead to fatal postoperative liver failure.

The determination of precisely how much parenchymal loss will be tolerated is a matter of experience. The Child-Turcotte-Pugh score is a useful starting point, since liver resection is uniformly fatal in Child C cirrhotics, and only the most limited resections are tolerated in select Child B patients. However, the Child A designation is a large umbrella term and contains too wide of a group of patients to be sufficiently sensitive to guide resection (Poon and Fan 2005).

In these patients, certain laboratory values can be used as surrogate markers of the presence of cirrhosis and can help guide decision making. A validated rule of thumb is that patients with a platelet count of $<100\times10^9$/L will not tolerate liver resection (Poon et al. 2004). Significant hepatic fibrosis leads to portal hypertension; the back pressure into the splanchnic circulation leads to splenomegaly, which in turn causes platelet sequestration. Through this mechanism, thrombocytopenia serves as a surrogate marker for hepatic fibrosis. The presence of esophageal varices is an alternate marker of portal hypertension resulting from the same pathophysiologic process.

More sophisticated methods of quantifying the function of the future liver remnant have been investigated, but none have proven consistently useful or superior. These methods include direct measurement of portal pressures, the use of indocyanine green clearance, and the calculation of liver remnant volume by imaging (Schulick 2006). Certain patients with borderline liver function can be optimized by portal vein embolization to induce hypertrophy of the future liver remnant (Abulkhir et al. 2008).

Hemostasis

Mortality following liver resection should be rare, with rates of 1–3 % at high-volume centers (Torzilli et al. 1999). The major intraoperative risk of hepatectomy is that of massive hemorrhage. Intimate knowledge of the intrahepatic vasculature – specifically the hepatic veins – is necessary to plan lines of transection and to prevent inadvertent injury. Control of hepatic inflow by clamping the hepatoduodenal ligament, known as the Pringle maneuver, is useful to limit bleeding during transection. The Pringle maneuver can be applied safely for 15 min in cirrhotics and indefinitely in noncirrhotics with intermittent reperfusion (Sakamoto et al. 1999).

In addition, hepatic resection should be performed under low central venous pressure (e.g., CVP of 1–5 mmHg). While this may at first seem counterintuitive, maintenance of low intravascular volume leads to lower blood loss during hepatic transection (Wang et al. 2006). This is due to the fact that although the surgeon can control hepatic inflow using the Pringle maneuver, back bleeding of the inferior vena cava through the hepatic venous branches still occurs. This bleeding is exacerbated when aggressive infusion of intravenous fluids leads to a full vena cava. Maintenance of low intravascular volume requires good communication between the surgical and anesthesia teams; objective measurement of central venous pressure with a central line is not mandatory but may be useful.

There are several acceptable techniques for performing transection of the liver parenchyma, based on surgeon preference. Following transection, localized bleeding from transected vessels should be ligated with gentle figure-of-eight sutures. Generalized oozing from the cut surface of the liver is usually self-limited and responds to pressure and patience. Argon beam cautery and thrombin-soaked foam sponges can be useful adjuncts, but cannot be relied upon to remedy surgical bleeding.

Use of Drains

The use of drains following liver resection is at the discretion of the operating surgeon. Although published reports in the literature have not demonstrated a benefit to routine drainage (Gurusamy et al. 2007), bile leaks from the cut surface are not uncommon following major liver resection, and many hepatic surgeons advocate the routine use of contained self-suction drains to prevent biloma formation. In addition, patients with borderline liver function often develop ascites in the postoperative period. The use of a drain in these patients allows for controlled release of ascitic fluid and prevents the weeping of the ascites through the wound, which can lead to skin maceration, wound infection, and dehiscence.

Postoperative Management

The major complication of hepatectomy in the postoperative period is liver failure. All patients will demonstrate a transaminitis following hepatectomy, but the levels of these enzymes should begin to normalize promptly. Patients with borderline liver function may experience transient liver failure, as evidenced by elevated total bilirubin and coagulation parameters, and the presence of new ascites. These signs typically occur starting on postoperative day three but usually resolve with supportive care.

In borderline patients, the postoperative maintenance of low intravascular volume is once again a key point. Overburdening the remnant liver with high volumes is thought to exacerbate liver failure. Therefore, especially in cirrhotics, many hepatic surgeons allow relatively low urine output and advocate the use of colloids for resuscitation. Ominous signs of irreversible liver failure include worsening jaundice, coagulopathy, and encephalopathy. At this point, little can be done to mitigate fatal liver failure.

Following hepatic resection, the liver will regenerate to completely replace the resected volume. This process begins within the first week after resection, as evidenced by the welcomed drop in serum phosphate levels on postoperative labs, and is usually complete by 6 weeks.

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77 Cholecystectomy

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Symptomatic cholelithiasis, when laparoscopic cholecystectomy is not feasible
Acute cholecystitis, both calculous and acalculous
Chronic acalculous cholecystosis and cholesterosis, when accompanied by symptoms of gallbladder colic
Carcinoma of gallbladder
Trauma
Incidental removal during laparotomy for another indication, either for technical reasons or gallstones
Failed laparoscopic cholecystectomy ("conversion")

Preoperative Preparation

Diagnostic confirmation of gallbladder disease
Perioperative antibiotics
Nasogastric tube for patients with acute cholecystitis or choledocholithiasis

Pitfalls and Danger Points

Injury to bile ducts
Injury to hepatic artery or portal vein
Hemorrhage from cystic or hepatic artery or from liver bed
Injury to duodenum or colon

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Operative Strategy

Anomalies of the Extrahepatic Bile Ducts

Anomalies, major and minor, of the extrahepatic bile ducts are quite common. A surgeon who is not aware of the variational anatomy of these ducts is much more prone to injure them during biliary surgery. The most common anomaly is a right segmental hepatic duct that drains the dorsal caudal segment of the right lobe. This segmental duct may drain into the right hepatic duct, the common hepatic duct (Fig. 77.1a), the cystic duct (Fig. 77.1b), or the common bile duct (CBD) (Fig. 77.1c). Division of this segmental duct may result in a postoperative bile fistula that drains as much as 500 ml of bile per day. Ligation, rather than preservation, is the appropriate management if a small segmental duct is injured.

Important cystic duct anomalies (Fig. 77.2) include the entrance of the cystic duct into the right hepatic duct (Fig. 77.2e), a low entrance of the cystic duct that occasionally joins the CBD rather close to the ampulla (Fig. 77.2c), and a cystic duct that enters the left side of the CBD (Fig. 77.2f).

Another extremely important anomaly of which the surgeon should be aware is the apparent entrance of the right main hepatic duct into the cystic duct. The latter duct, in turn, joins the left hepatic duct to form the CBD, as illustrated in Fig. 77.3. In this case, dividing and ligating the cystic duct at its apparent point of origin early in the operation results in occluding the right hepatic duct. If the technique described in the next section is carefully followed, this accident can be avoided.

Avoiding Injury to the Bile Ducts

Most serious injuries of the bile ducts are not caused by congenital anomalies or unusually severe pathologic

†Deceased

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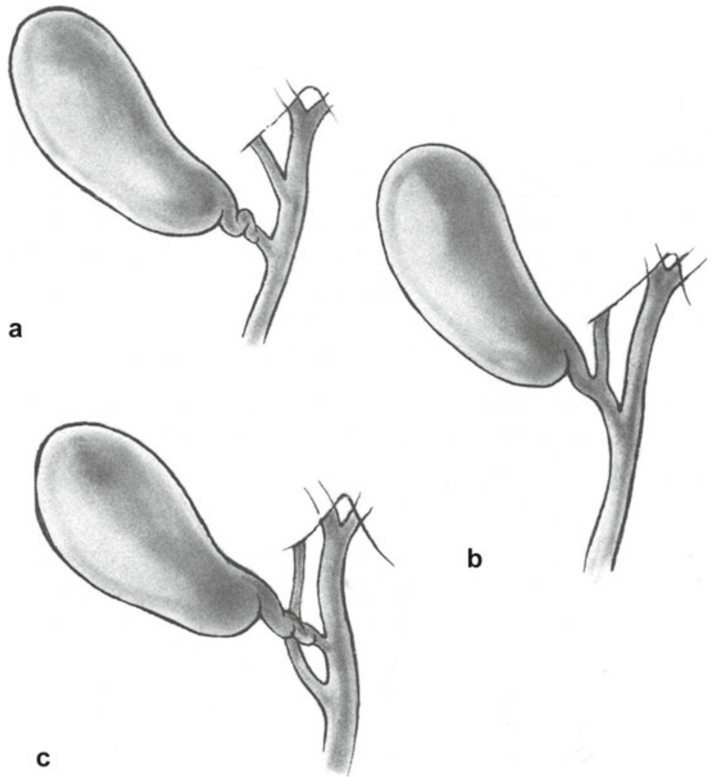

Fig. 77.1 Anomalous segmental right hepatic ducts

changes. In most cases, iatrogenic trauma results because the surgeon who mistakenly ligates and divides the CBD thinks it is the cystic duct. It is important to remember that the diameter of the normal CBD may vary from 2 to 15 mm. It is easy to clamp, divide, and ligate a small CBD as the first step in cholecystectomy under the erroneous impression that it is the cystic duct. The surgeon who makes this mistake must also divide the common hepatic duct before the gallbladder is freed from all its attachments. This leaves a 2- to 4-cm segment of common and hepatic duct attached to the specimen (Fig. 77.4). Because this is the most common cause of serious duct injury, *we never permit the cystic duct to be clamped or divided until the entire gallbladder has been dissected free down to its junction with the cystic duct*. Division of the cystic duct is always the last step in the cholecystectomy. When the back wall of the gallbladder is being dissected away from the liver, it is important carefully to dissect out each structure that may enter the gallbladder from the liver. Generally, there are only a few minor blood vessels that may be divided by sharp dissection and then occluded by electrocoagulation. Any structure that resembles a bile duct must be carefully delineated by sharp dissection. In no case should the surgeon apply a hemostat to a large wad of tissue running from the liver to the gallbladder, as it may contain the common hepatic duct.

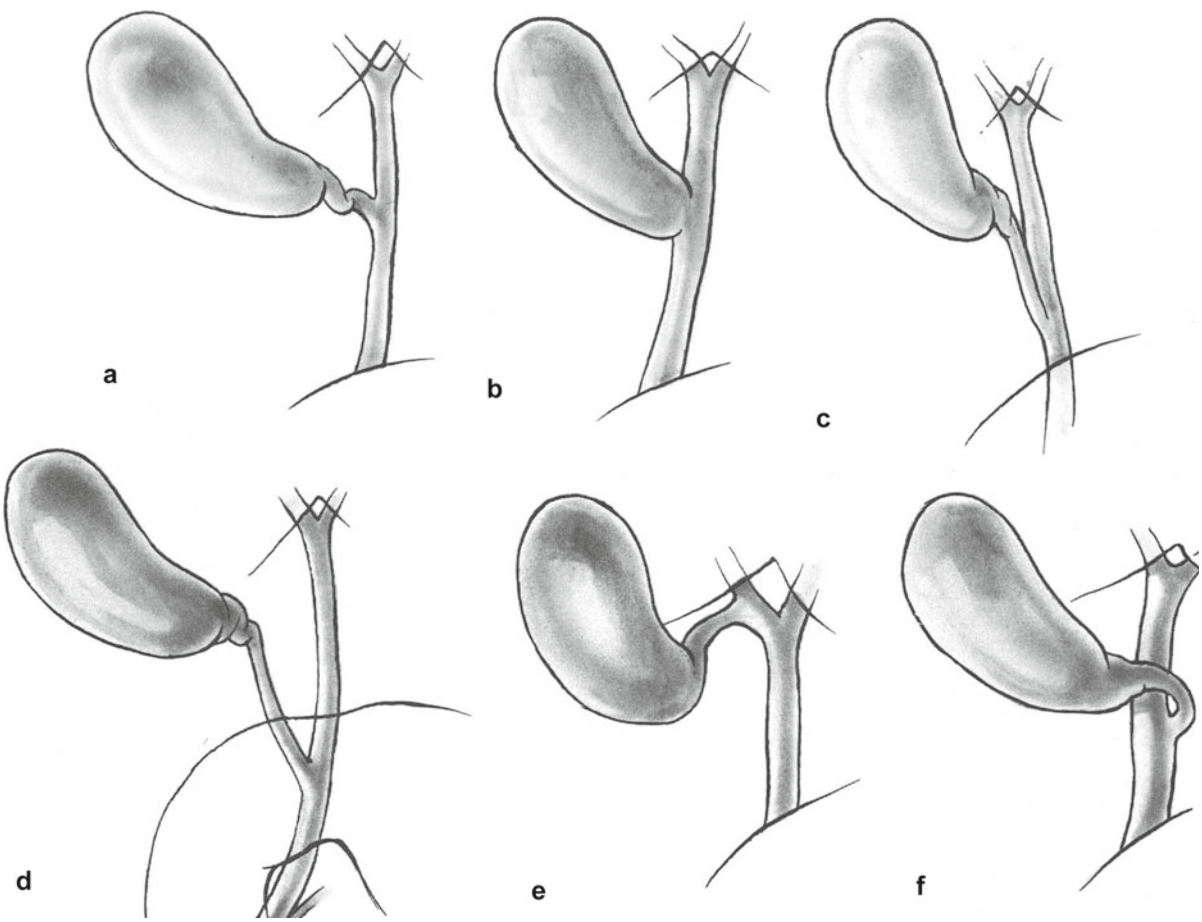

Fig. 77.2 Variations in entry of the cystic duct into the common bile duct

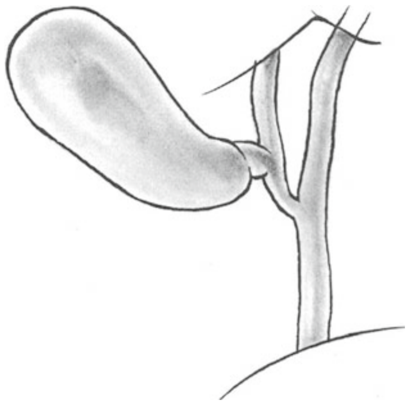

Fig. 77.3 Anomalous entry of the right hepatic duct into the cystic duct

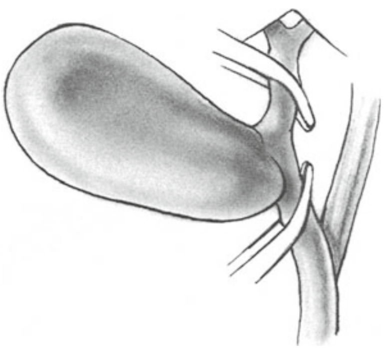

Fig. 77.4

Rarely, an anomalous bile duct enters the gallbladder directly from the liver bed. Such ducts should be suture ligated or clipped to avoid postoperative bile drainage.

Ligating the Hepatic Artery Inadvertently

Careful dissection prevents injury or inadvertent ligature of one of the hepatic arteries. However, if one of these vessels should be ligated accidentally, this complication is not ordinarily fatal because hepatic viability can usually be maintained by the remaining portal venous flow and by arterial collaterals, such as those from the undersurface of the diaphragm. This is true only if the patient has normal hepatic function and there has been no jaundice, hemorrhage, shock, trauma, or sepsis. Generally, based on findings from experimental work on animals, antibiotics are administered in cases of this type, although the need for antibiotic therapy has not been firmly established in humans.

Although hepatic artery ligation generally has a low mortality rate, it is not zero. Consequently, if a major lobar hepatic artery or the common hepatic artery has been inadvertently divided or ligated, end-to-end arterial reconstruction may be performed if local factors are favorable. For other branches of the hepatic artery, arterial reconstruction is not necessary. Variations in the anatomy of the hepatic arteries are shown in Fig. 77.5.

Avoiding Hemorrhage

In most cases, hemorrhage during the course of cholecystectomy is due to inadvertent laceration of the cystic artery. Often the stump of the bleeding vessel retracts into the fat in the vicinity of the hepatic duct, making accurate clamping difficult. If the bleeding artery is not distinctly visible, do not apply any hemostats. Rather, grasp the hepatoduodenal ligament between the index finger and thumb of the left hand and compress the common hepatic artery. This measure temporarily stops the bleeding. Now check whether the exposure is adequate and if the anesthesiologist has provided good muscle relaxation. If necessary, have the first assistant enlarge the incision appropriately. After adequate exposure has been achieved, it is generally possible to identify the bleeding vessel, which is then clamped and ligated. Occasionally the cystic artery is torn off flush with the right hepatic artery. If so, the defect in the right hepatic artery must be closed with a continuous vascular suture such as 6-0 Prolene. On rare occasions it is helpful to occlude the hepatoduodenal ligament by applying an atraumatic vascular clamp. It is safe to perform this maneuver for as long as 15–20 min.

The second major cause of bleeding during the course of a cholecystectomy is hemorrhage from the gallbladder bed in the liver. Bleeding occurs when the plane of dissection is too deep. This complication may be prevented if the plane is kept between the submucosa and the "serosa" of the gallbladder. If this layer of fibrous tissue is left behind on the liver, there is no problem controlling bleeding. With this plane intact, it is easy to see the individual bleeding points and to control them by electrocoagulation. Occasionally, a small artery requires a suture ligature or a hemoclip for hemostasis. With proper exposure, hemostasis should be perfect. On the other hand, when this fibrous plane has been removed with the gallbladder and liver parenchyma is exposed, the surface is irregular and the blood vessels retract into the liver substance, making electrocoagulation less effective. Blood may ooze from a large area. In this case, apply a layer of topical hemostatic agent to the bleeding surface and cover it with a dry gauze pad; use a retractor to apply pressure to the gauze pad. After 15 min, carefully remove the gauze pad. The topical hemostatic agent may then be carefully removed or left in place.

Cystic Duct Cholangiography

Cystic duct cholangiography is useful for detecting CBD stones and delineating biliary anatomy. The use of fluoroscopy considerably facilitates the procedure. When cholangiography is used routinely, it requires only 5–10 min of

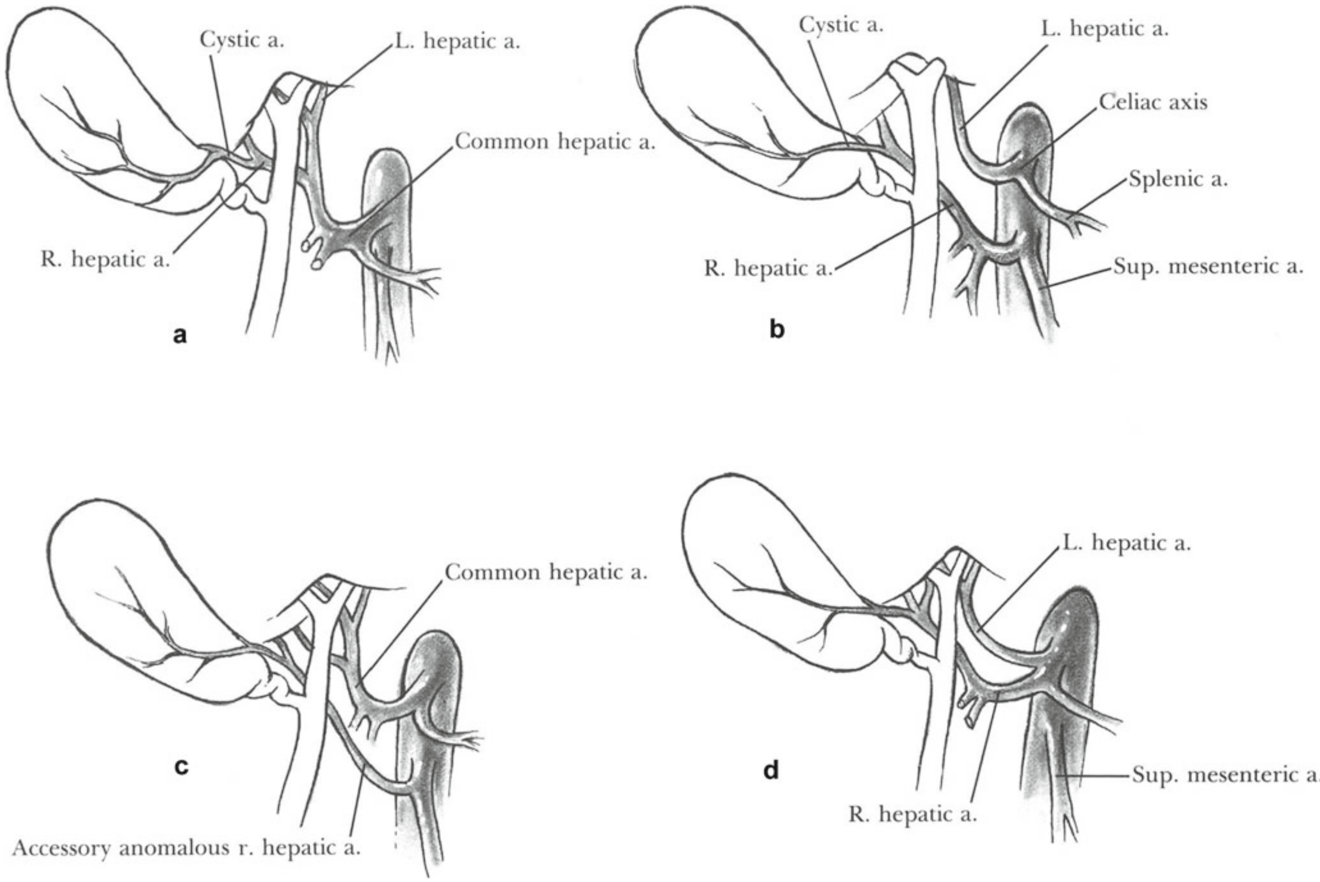

Fig. 77.5 Variations in the anatomy of the hepatic arteries

additional operating time; over time the surgical and radiology teams gain expertise with the technique, making the results more accurate.

Modifications in Operative Strategy Due to Acute Cholecystitis

Decompressing the Gallbladder

Tense enlargement of the gallbladder due to cystic duct obstruction interferes with exposure of adjacent vital structures. Insert a trocar or an 18-gauge needle attached to suction and aspirate bile or pus from the gallbladder, allowing the organ to collapse. After the trocar has been removed, close the puncture site with a purse-string suture or a large hemostat.

Sequence of Dissection

Although there is sometimes so much edema and fibrosis around the cystic and common ducts that the gallbladder must be dissected from the fundus down, in most patients an incision in the peritoneum overlying the cystic duct near its junction with the CBD reveals that these two structures are not intimately involved in the acute inflammatory process. When this is the case, identify and encircle (but do not ligate) the cystic duct with 4-0 silk sutures and dissect out the cystic artery.

If the cystic artery is not readily seen, make a window in the peritoneum overlying Calot's triangle just cephalad to the cystic duct. Next, insert the tip of a Mixter right-angle clamp into this window and elevate the tissue between the window and the liver on the tip of this clamp. This maneuver improves exposure of this area. By carefully dissecting out the contents of this tissue, one can generally identify the cystic artery. Ligate it with 2-0 silk and divide the artery. When this can be done early in the operation, there is less bleeding during liberation of the fundus of the gallbladder.

Dissecting the Gallbladder Away from the Liver

Use a scalpel incision on the back wall of the gallbladder and carry it down to the mucosal layer of the gallbladder. If part of the mucosa is necrotic, dissect around the necrotic area so as not to lose the proper plane. If it has not been possible to delineate the proper plane and the dissection inadvertently is between the outer layer of the gallbladder and the hepatic parenchyma, complete the dissection quickly and apply a topical hemostatic agent to the oozing liver bed. Then apply a moist gauze pad and use a retractor over the gauze pad to maintain exposure while the dissection is being completed. If the cystic artery has not been ligated in the previous step, it is identifiable as it crosses from the region of the common hepatic duct toward the back wall of the gallbladder.

Management of the Cystic Duct

Cholangiography

Cholangiography is performed in patients with acute obstructive cholecystitis to exclude the presence of common duct stones and to delineate anatomy. If the cystic duct is not patent, perform cholangiography through a small scalp vein needle inserted directly into the CBD.

Occasionally, the cystic duct is so inflamed it is easily avulsed from its junction with the CBD. If this accident occurs, suture the resulting defect in the CBD with a 5-0 Vicryl suture. If the cystic duct has been avulsed and its orifice in the CBD cannot be located, simply insert a sump or closed suction catheter to a point deep to the CBD in the right renal fossa after obtaining a cholangiogram.

When to Abandon Cholecystectomy and Perform Cholecystostomy

If at any time during the course of dissecting the gallbladder such an advanced state of fibrosis or inflammation is encountered that continued dissection may endanger the bile ducts or other vital structures, all plans for completing the cholecystectomy should be abandoned. Convert the operation to a cholecystostomy (see Chap. 79). If a portion of the gallbladder has already been mobilized or removed, it is possible to perform a partial cholecystectomy and to insert a catheter into the gallbladder remnant. Then sew the remaining gallbladder wall around the catheter. Place additional drains in the renal fossa. Remove the gallbladder remnant at a later date, after the inflammation has subsided. Meanwhile, the pus has been drained out of the gallbladder.

The need to abandon cholecystectomy for a lesser procedure occurs in no more than 1 % of all cases of acute cholecystitis if the surgeon has experience with this type of surgery. Less experienced surgeons should not hesitate to perform a cholecystostomy when they believe that removing the gallbladder may damage a vital structure.

Documentation Basics

- Findings
- Cholangiogram or not? Findings?

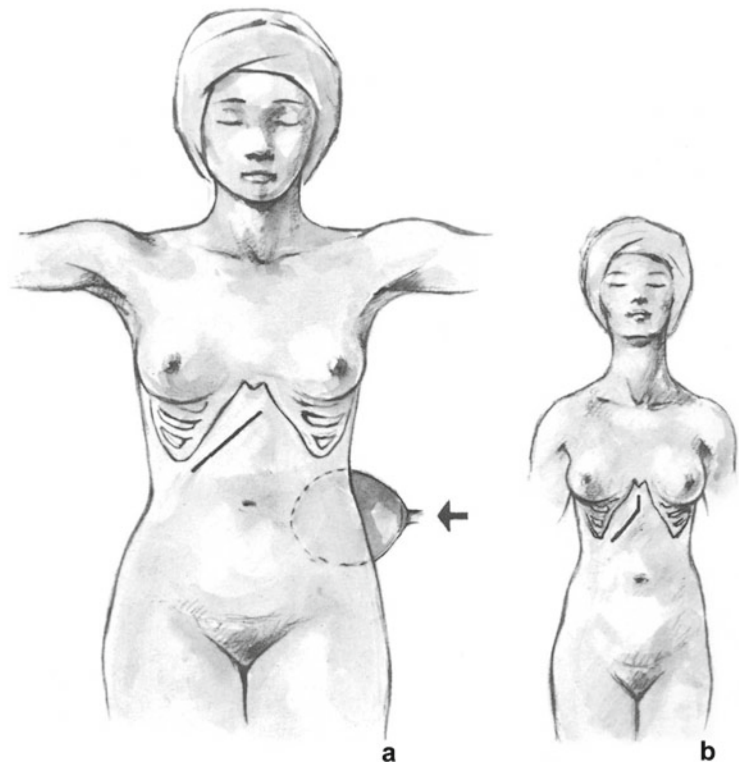

Fig. 77.6

Operative Technique

Incision

We prefer to make a subcostal incision for almost all cholecystectomies because of the excellent exposure afforded in the region of the gallbladder bed and cystic duct. It is important to start the incision at least 1 cm to the left of the linea alba. Then incise in a lateral direction roughly parallel to and 4 cm below the costal margin (Fig. 77.6a). Continue for a variable distance depending on the patient's body build. This incision divides the ninth intercostal nerve, which emerges just lateral to the border of the rectus muscle. Cutting one intercostal nerve produces a small area of hypoesthesia of the skin but no muscle weakness. If more than one intercostal nerve is divided, the abdominal musculature sometimes bulges.

In a thin patient with a narrow costal arch, a Kehr hockey-stick modification is useful (Fig. 77.6b). This incision starts at the tip of the xiphoid, proceeds down the midline for 3–4 cm, and then curves laterally in a direction parallel to the costal margin until the width of the right belly of the rectus muscle has been encompassed. If a midline incision is utilized, excellent exposure often requires that the incision be continued 3–6 cm below the umbilicus.

When the liver and gallbladder are high under the costal arch and this anatomic configuration interferes with

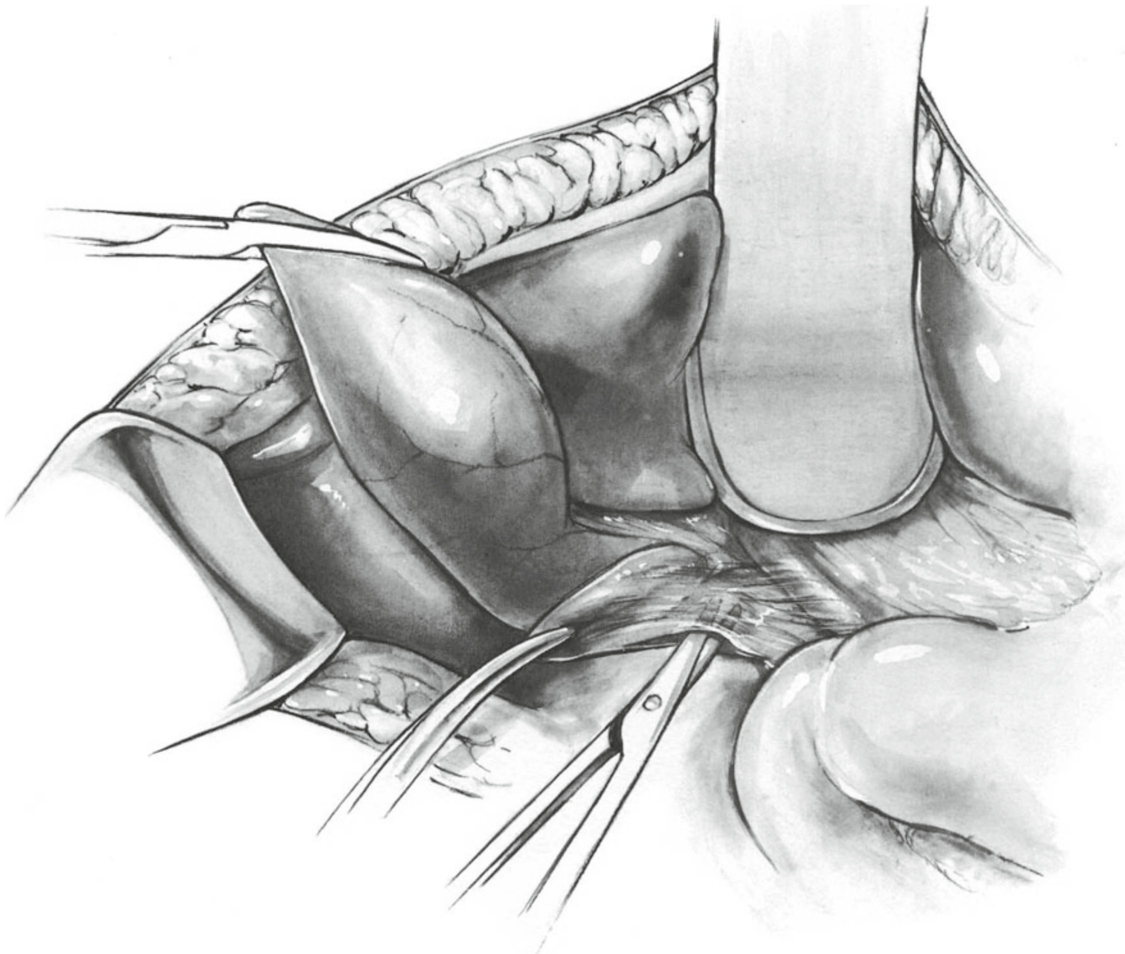

Fig. 77.7

exposure, or when necessary in obese patients, add a Kehr extension (up the midline to the xiphoid) to a long subcostal incision and divide the falciform ligament. This vertical extension of the incision often markedly improves exposure. Also, apply an upper hand or Thompson retractor to the costal arch and draw it upward.

After the incision has been made, the entire abdomen is thoroughly explored. Then direct attention to the gallbladder, confirming the presence of stones by palpation. Check the pancreas for pancreatitis or carcinoma and palpate the descending duodenum for a possible ampullary cancer.

Dissecting the Cystic Duct

Expose the gallbladder field by applying a Foss retractor to the inferior surface of the liver just medial to the gallbladder and a Richardson or a Balfour self-retaining retractor to the costal margin. Alternatively, affix a Thompson retractor to the operating table; then attach a blade to the Thompson retractor and use it to elevate and pull the right costal margin in a cephalad direction. Apply a gauze pad over the hepatic flexure and another over the duodenum. Occasionally, adhesions between omentum, colon, or duodenum and the gallbladder must be divided prior to placing the gauze pads. Have the first assistant retract the duodenum away from the gallbladder with the left hand. This move places the CBD on stretch.

Place a Kelly hemostat on the fundus of the gallbladder. With traction on the gallbladder, slide Metzenbaum scissors underneath the peritoneum that covers the area between the wall of the gallbladder and the CBD (Fig. 77.7). Expose the cystic duct by alternately sliding Metzenbaum scissors underneath the peritoneum to define the plane and then cutting along the gallbladder wall. If the inferior surface of the gallbladder is dissected free and elevated, this plane of dissection must lead to the cystic duct, provided the plane hugs the surface of the gallbladder. The cystic duct can be easily delineated by inserting a right-angle Mixter clamp behind the gallbladder. Apply a temporary ligature of 4-0 silk to the cystic duct with a single throw to avoid inadvertently milking calculi from the gallbladder into the CBD. Do not injure the cystic duct by strangulating it with this ligature because this structure, on occasion, proves to be a small CBD, not the cystic duct. If you do not elect to obtain a cholangiogram, proceed to ligating and dividing the cystic artery. Otherwise, at this point in the operation, perform cystic duct cholangiography.

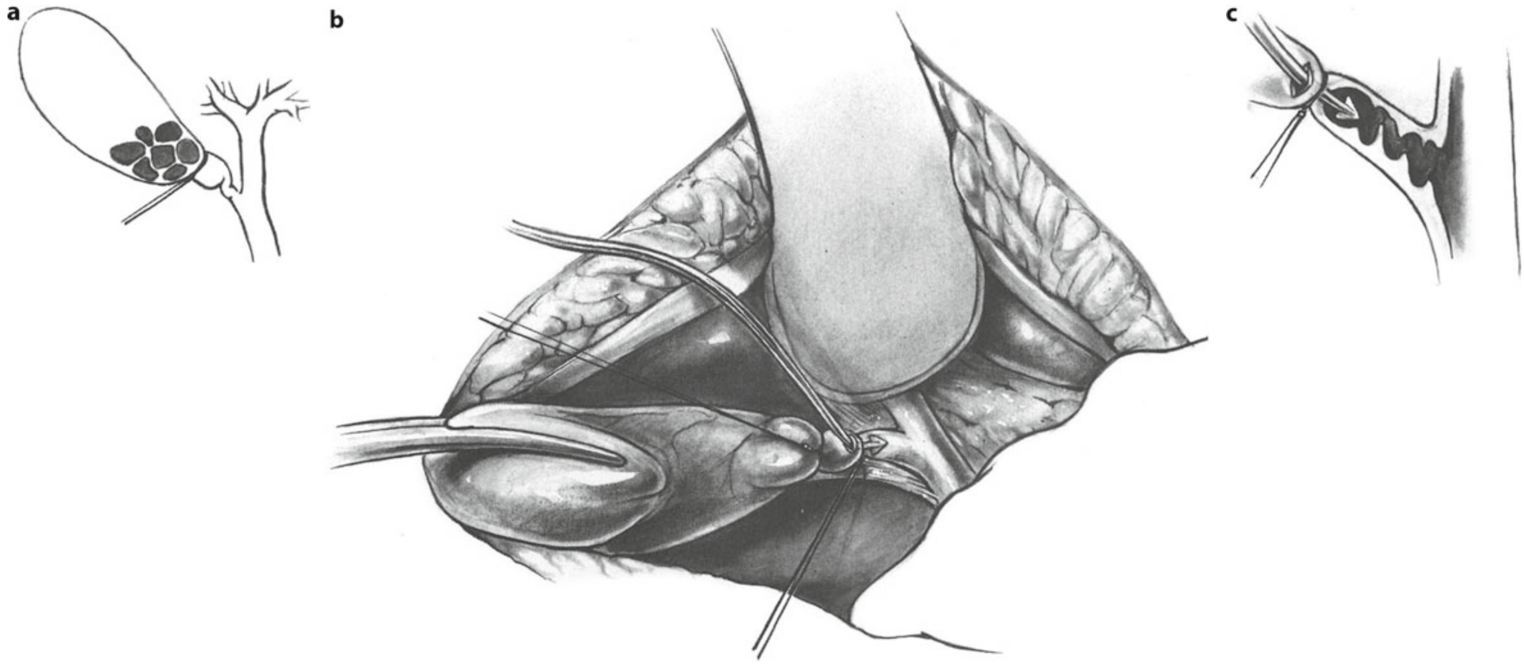

Fig. 77.8

Cystic Duct Cholangiography

We routinely perform cholangiography during cholecystectomy. There are two major impediments to catheterizing the cystic duct: (1) the internal diameter may be too small for the catheter and (2) the valves of Heister frequently prevent passage of the catheter or needle even for the 4–5 mm necessary to properly secure the catheter tip with a ligature. Although the valves may be disrupted by insertion of a malleable probe or a pointed hemostat, this maneuver sometimes results in shredding the cystic duct. A method that facilitates intubating the cystic duct is isolation of the proximal portion of the duct, including its junction with the gallbladder. Here the duct is large enough to permit introduction of the catheter at a point *proximal* to the valves of Heister, simplifying the entire task.

After the cystic duct has been isolated, continue the dissection proximally until the infundibulum of the gallbladder has been freed. The diameter at this point should be 4–5 mm. Then milk any stones up out of the cystic duct into the gallbladder and ligate the gallbladder with a 2-0 silk ligature (Fig. 77.8a). Pass another 2-0 ligature loosely around the cystic duct. Make a small transverse scalpel incision in the ampulla of the gallbladder near the entrance of the cystic duct.

At this point attach a 2-m length of plastic tubing to a 50-ml syringe that has been filled with a 1:1 solution of Conray/saline. Then check to see that the entire system—the syringe, 2 m of plastic tubing, and cholangiogram catheter—is *absolutely free of air bubbles*. Pass the catheter into the incision and then into the cystic duct for a distance of 5 mm (Fig. 77.8b). Tie the previously placed 2-0 ligature just above the bead at the termination of the cholangiogram catheter (Fig. 77.8c). Under no condition, attempt to aspirate bile into the system, as this maneuver often results in aspirating air bubbles into the tubing. Some surgeons prefer a ureteral or intravenous catheter over the Taut cholangiogram catheter to intubate the cystic duct.

Elevate the left side of the patient about 10 cm above the horizontal table to prevent the image of the CBD from being superimposed on the vertebral column with its confusing shadows. This is done by having the anesthesiologist inflate a previously positioned rubber balloon under the left hip and flank (Fig. 77.6a); alternatively, two folded sheets may be placed underneath the patient's left hip and flank.

Now stand behind a portable lead shield covered with a sterile sheet. If a C-arm fluoroscopy unit is available, make the injection under fluoroscopic control. If not, follow the procedure described here and record two exposures in sequence. After the film and x-ray tube have been positioned, slowly inject no more than 4 ml of contrast medium for the first exposure. X-ray film is then put into position and a second exposure recorded after an additional injection of 4–6 ml. When radiographing a hugely dilated bile duct, as much as 30–40 ml may be required in *fractional* doses. On rare occasions, spasm in the region of the ampulla of Vater does not permit passage of contrast medium into the duodenum unless a small dose of nitroglycerin is administered intravenously. We have found nitroglycerin to be superior to intravenous glucagon (1 mg) for relieving sphincter spasm. If the duodenum is still not visualized, choledochotomy and exploration are indicated.

While waiting for the films to be developed, continue with the next step in the operation, ligating and dividing the cystic artery, without removing the cannula from the cystic duct. Ensure objectivity by *requesting the radiologist to provide immediate interpretation of the cholangiographic films*. Inspect the films yourself as well.

When cystic duct cholangiography is performed prior to instrumentation of the CBD and ampulla, dye almost always enters the duodenum if there is no CBD or ampullary pathology. When T-tube cholangiography is performed after completing the bile duct exploration, spasm often prevents visualization of the terminal CBD and ampulla. This problem can be averted by routine cholangiography prior to choledochotomy, even if you have already decided to explore the CBD.

Common Errors of Operative Cholangiography

Injecting too much contrast material. When a large dose of contrast material is injected into the ductal system, the duodenum is frequently flooded with dye, which may obscure stones in the distal CBD.

Dye too concentrated. Especially when the CBD is somewhat enlarged, the injection of concentrated contrast material can mask the presence of small radiolucent calculi. Consequently, dilute the contrast material 1:2 with normal saline solution when the CBD is large.

Air bubbles. Compulsive attention is necessary to eliminate air bubbles from the syringe and the plastic tubing leading to the cystic duct. Also, never try to aspirate bile into this tubing, as the ligature fixing the cystic duct around the cholangiography cannula may not be airtight and air may be sucked into the system and later injected into the CBD. It may then be impossible to differentiate between an air bubble and a calculus.

Poor technical quality. If the radiograph is not of excellent quality, there is a greater chance of a false-negative interpretation. It is useless to try to interpret a film that is not technically satisfactory. One technical error is easily avoided by elevating the left flank of the patient about 8–10 cm so the image of the bile ducts is not superimposed on the patient's vertebral column (Fig. 77.6a). Especially in obese patients, it is important to be sure that all the exposure factors are correct by using a scout film prior to starting the operation. Using an image-enhancing film holder with a proper grid also improves technical quality. If the *hepatic ducts* have not been filled with contrast material, repeat the radiography after injecting another dose into the cystic duct. Otherwise hepatic duct stones are not visualized. It is sometimes helpful to administer morphine sulfate, which induces sphincter spasm. Dye injected into the cystic duct then fills the hepatic ducts.

Performing cystic duct cholangiography routinely serves to familiarize the technicians and the surgical team with all of the details necessary to provide superior films. It also shortens the time required for this step to 5–10 min.

Sphincter spasm. Spasm of the sphincter of Oddi sometimes prevents passage of contrast medium into the duodenum. Although this outcome is far more frequent after CBD exploration with instrumentation of the ampulla, it does occur on rare occasions during cystic duct cholangiography. We have found that giving nitroglycerin intravenously seems to be more effective than using intravenous glucagon to relax the sphincter. Simultaneous with sphincter relaxation, there is generally a mild drop in the patient's blood pressure. At this time inject the contrast medium into the CBD. Nitroglycerin is also useful when performing completion cholangiography when the CBD exploration has been completed.

Failing to consult with the radiologist. It is not reasonable for the operating surgeon to be the only physician responsible for interpreting the cholangiographic films. The surgeon tends to be overoptimistic, tends to accept poor technical quality, and is responsible for an excessive number of false-negative interpretations. Always have a consultation with a radiologist familiar with this procedure before forming a final conclusion concerning the cholangiogram.

Ligating the Cystic Artery

Gentle dissection in the triangle of Calot reveals the cystic artery, which may cross over or under the common or right hepatic duct on its way to the gallbladder. It frequently divides into two branches, one anterior and one posterior. Confirmation of the identity of this structure is obtained by tracing the artery up along the gallbladder wall and demonstrating the lack of any sizable branch going to the liver. Often the anterior branch of the cystic artery can be seen running up the medial surface of the gallbladder. Tracing this branch from above down to its point of origin leads to the cystic artery. Ligate this artery in continuity after passing a 2-0 silk ligature around it with a Mixter right-angle hemostat (Fig. 77.9). Apply a hemoclip to the gallbladder side of the vessel and transect the cystic artery, preferably leaving a 1-cm stump of artery distal to the ligature (Fig. 77.10). If there is fibrosis in Calot's triangle and the artery is not evident, pass a Mixter clamp underneath these fibrotic structures. While the first assistant exposes the structures by elevating the Mixter clamp, the surgeon can more easily dissect out the artery from the surrounding scar tissue. If the cystic artery is torn and hemorrhage results, control it by inserting the left index finger into the foramen of Winslow and compressing the hepatic artery between the thumb and forefinger until the exact source of bleeding is secured by a clamp or a suture.

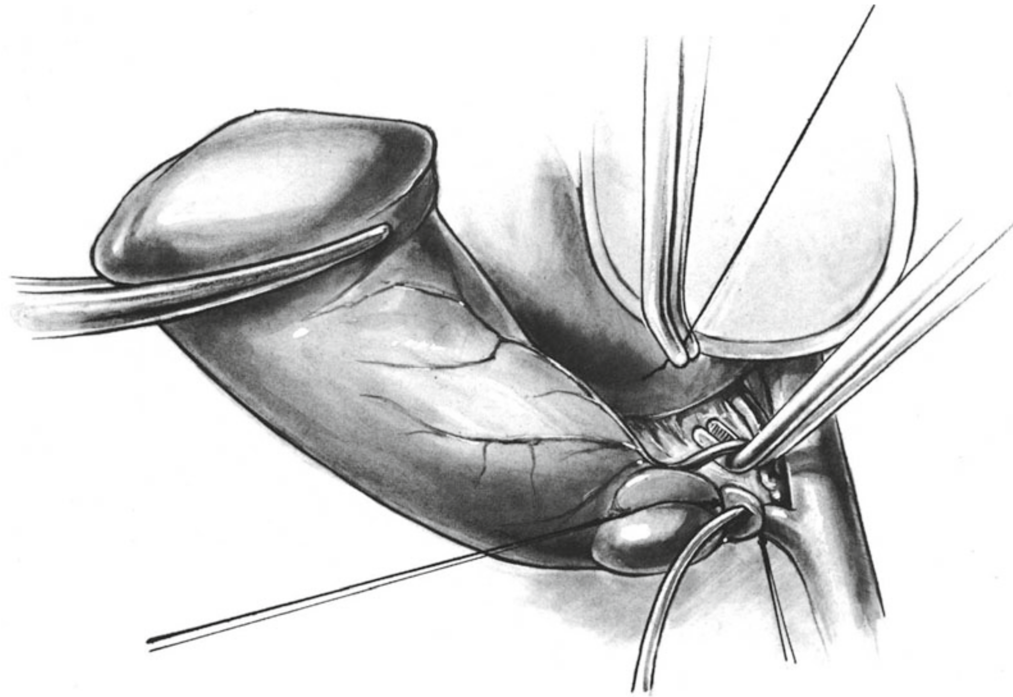

Fig. 77.9

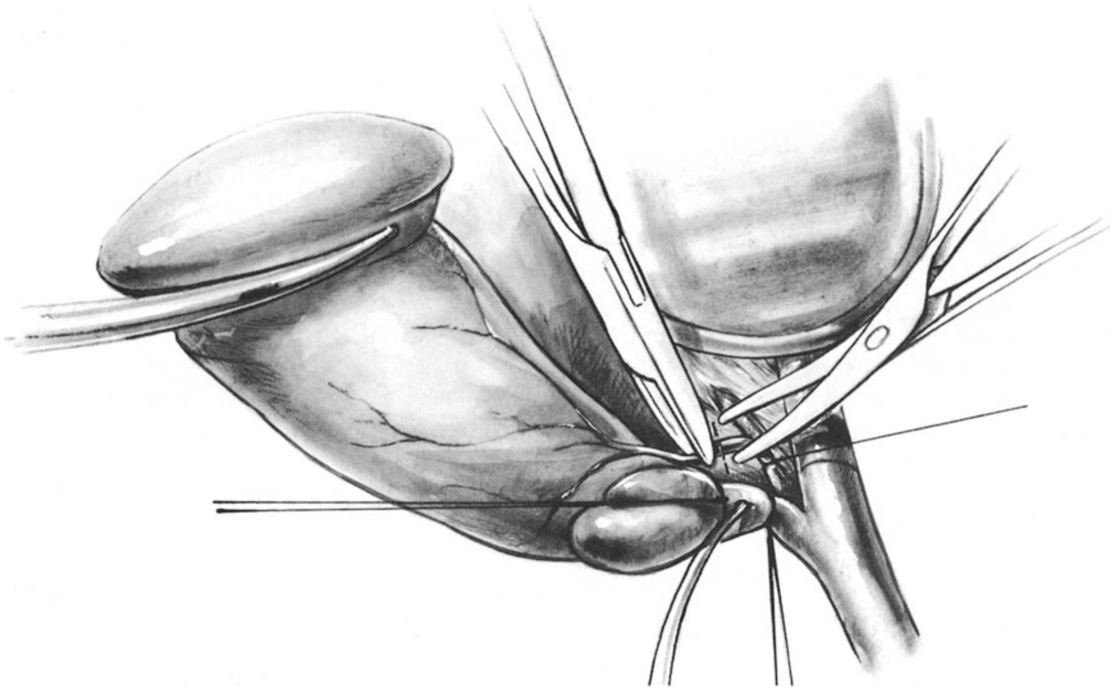

Fig. 77.10

Dissecting the Gallbladder Bed

In no case during cholecystectomy is the cystic duct transected or clamped prior to complete mobilization of the gallbladder. Mobilization may be done by taking advantage of the incision in the peritoneum overlying Calot's triangle as described above and simply continuing this peritoneal dissection from below upward along the medial border of the gallbladder. Insert a Mixter clamp underneath the peritoneum while the first assistant makes an incision using electrocautery (Fig. 77.11). Alternatively, make a scalpel incision in the superficial layer of the gallbladder wall across its fundus. Use

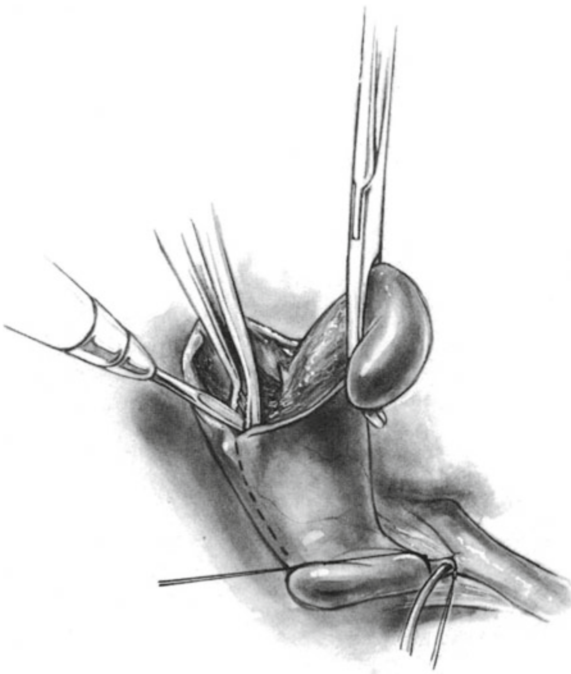

Fig. 77.11

electrocautery to dissect the mucosal layer of the gallbladder away from the serosal layer, *leaving as much tissue as possible on the liver side*. This leaves a shiny layer of submucosa on the gallbladder. Tiny vessels coming from the liver to the gallbladder can be identified and individually controlled with electrocautery. When the plane of dissection is deep to the serosa, raw liver parenchyma presents itself. Oozing from raw liver is difficult to control with electrocoagulation. In this case, either prolonged pressure with moist gauze or application of a small sheet of Surgicel to the raw liver surface can provide excellent hemostasis after 10–15 min of local compression.

As the dissection proceeds down along the liver, do not apply any hemostats, as the vessels in this plane are small. Near the termination of this dissection along the posterior wall of the gallbladder, a bridge of tissue is found connecting the gallbladder ampulla with the liver bed. Instruct the assistant to pass a Mixter clamp through the opening in Calot's triangle that had been made when the cystic artery was ligated (Fig. 77.12). This clamp elevates the bridge of tissue, and the surgeon dissects out its contents by carefully nibbling away at it with Metzenbaum scissors to rule out the possibility that it contains the common hepatic duct. In cases

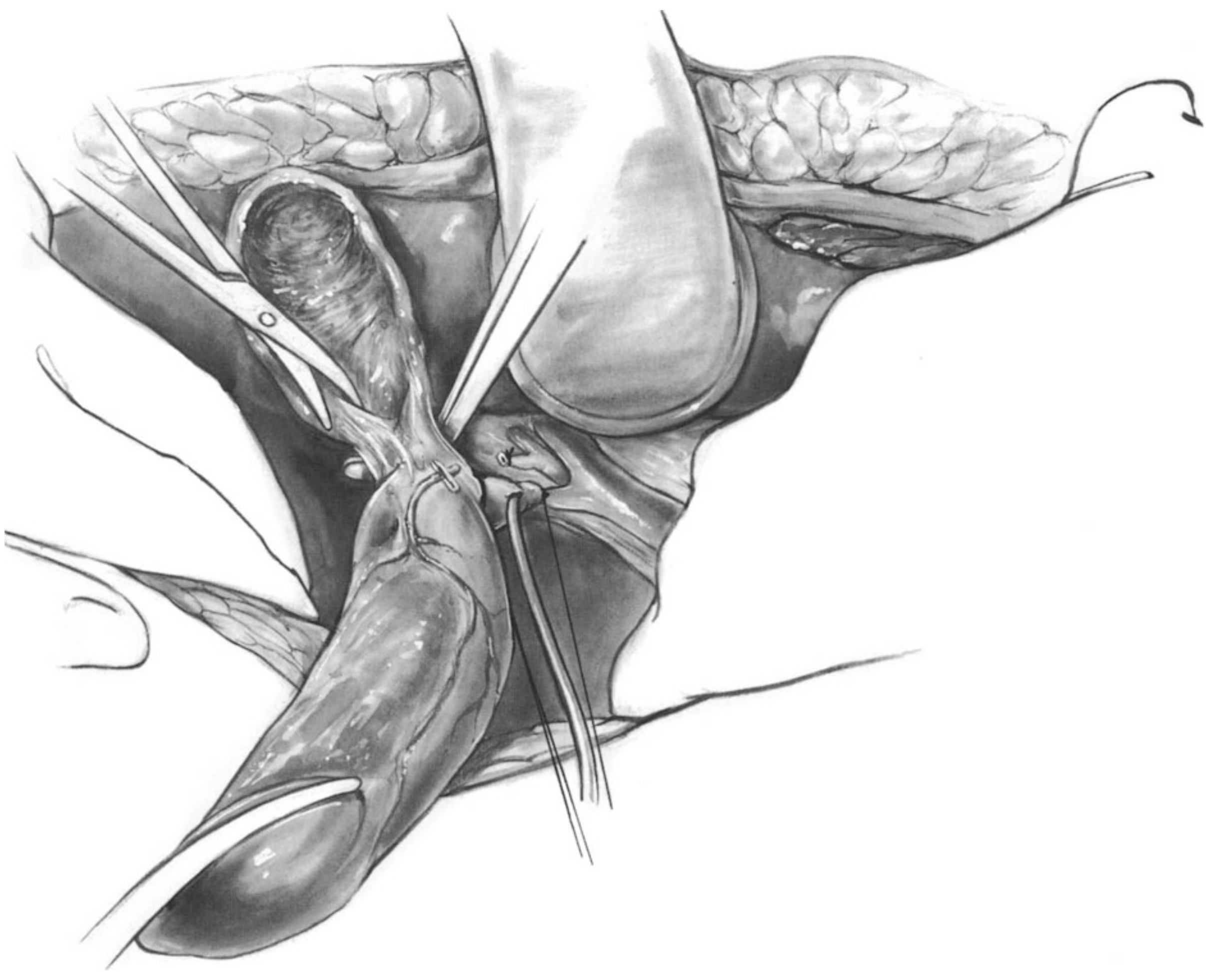

Fig. 77.12

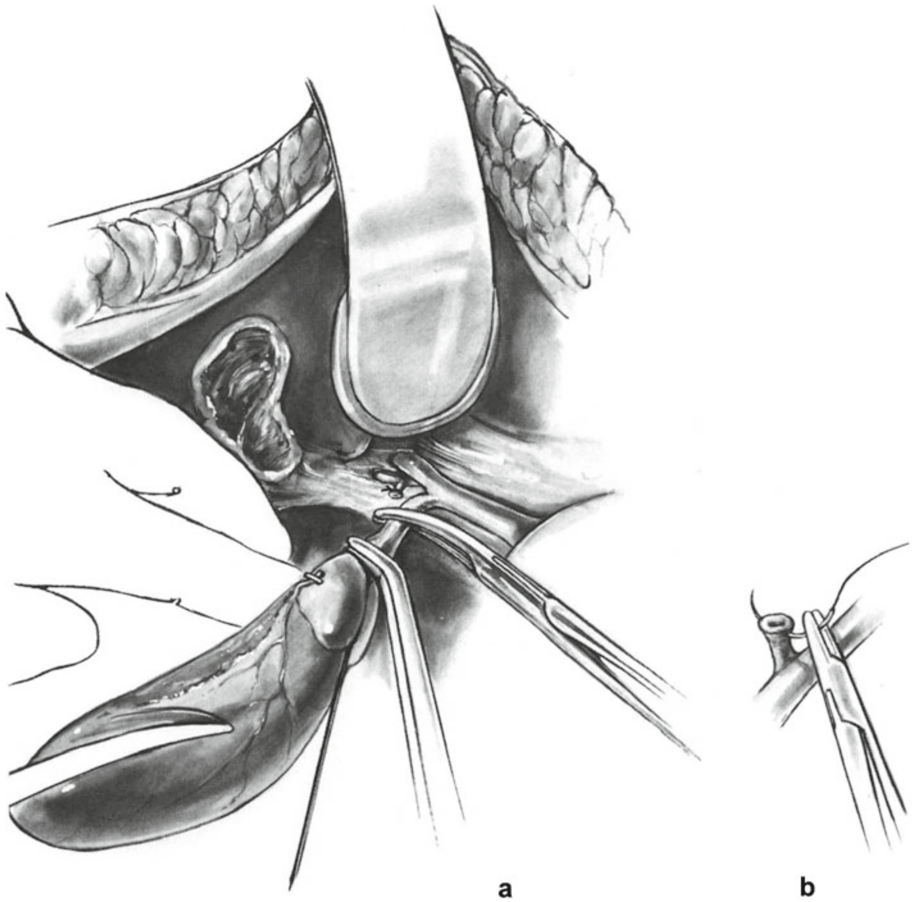

Fig. 77.13

where excessive fibrosis has prevented identification and ligature of the cystic artery, there is generally, at this stage of the dissection, no great problem identifying this vessel coming from the area near the hilus of the liver toward the back wall of the gallbladder.

With the gallbladder hanging suspended only by the cystic duct, dissect the duct down to its junction with the common hepatic duct. Exact determination of the junction between the cystic and hepatic ducts is usually not difficult after electrocoagulating one or two tiny vessels that cross over the acute angle between the two ducts. Rarely, a lengthy cystic duct continues distally toward the duodenum for several centimeters.

The cystic duct may even enter the CBD on its *medial* aspect near the ampulla of Vater. In these cases it is hazardous to dissect the cystic duct down into the groove between the duodenum and pancreas; it is preferable to leave a few centimeters of duct behind. The anatomy may be confirmed by cholangiography. In general, clamp and divide the cystic duct at a point about 1 cm from its termination (Fig. 77.13a). Transfix the cystic duct stump with a 3-0 PG suture ligature (Fig. 77.13b). *Never clamp or divide the cystic duct except as the last step during a cholecystectomy*.

Achieve complete hemostasis of the liver bed with electrocautery (Fig. 77.14). If necessary, use suture ligatures.

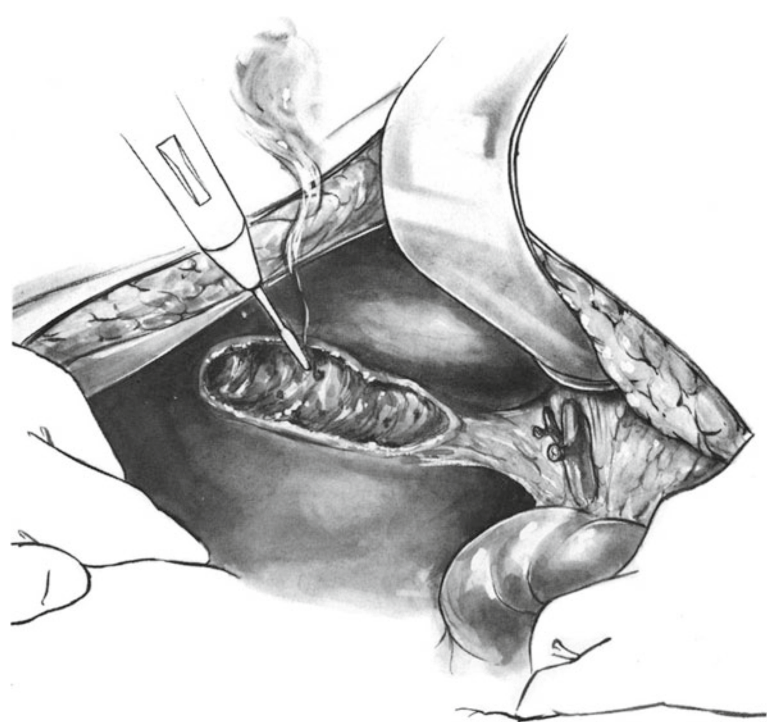

Fig. 77.14

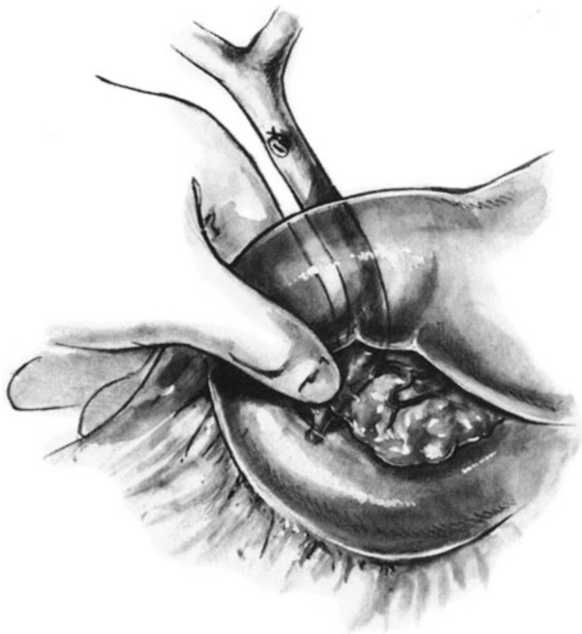

Fig. 77.15

In unusual cases, leave a sheet of topical hemostatic agent in the liver bed to control venous oozing.

Palpating the CBD

Prior to terminating the operation, especially if cholangiography has not been performed, it is essential to palpate the CBD properly to reduce the possibility of overlooked calculi. This is done by inserting the index finger into the foramen of Winslow and palpating the entire duct between the left index finger and thumb. Because a portion of the distal CBD is situated between the posterior wall of the duodenum and the pancreas, *it is necessary to insert the index finger into the potential space posterior to the pancreas and behind the second portion of the duodenum*. It is not necessary to perform a complete Kocher maneuver. Gently insinuate the left index finger behind the CBD and continue in a caudal direction behind the pancreas and the duodenum. In this fashion, with the index finger behind the second portion of the duodenum and the thumb on its anterior wall, carcinomas of the ampulla and calculi in the distal CBD can be detected (Fig. 77.15). Do not use force if the index finger does not pass easily; rather, proceed to a formal Kocher maneuver.

Drainage and Closure

We insert a flat Silastic Jackson-Pratt closed suction catheter following cholecystectomy only in cases of acute cholecystitis. Bring the catheter out from the renal fossa through a puncture wound just lateral to the right termination of the subcostal incision (Fig. 77.16). There is abundant evidence that a patient who has undergone a technically precise and uncomplicated simple cholecystectomy does not require insertion of any type of drain.

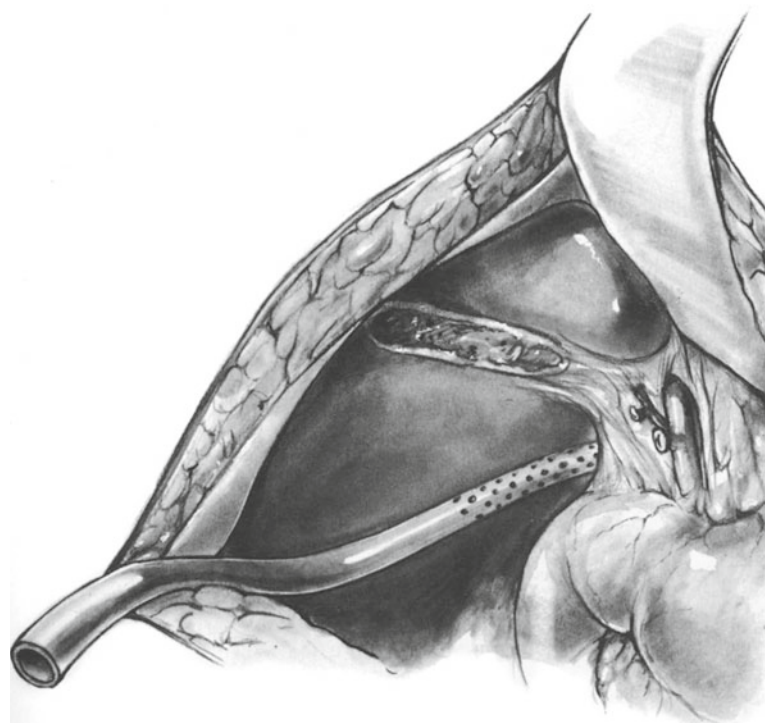

Fig. 77.16

Do not reperitonealize the liver bed, as this step serves no useful purpose. Close the abdominal wall in routine fashion (see Chap. 3). We use No. 1 PDS suture material for this step.

Postoperative Care

After an uncomplicated cholecystectomy, nasogastric suction is not necessary. In patients with acute cholecystitis, paralytic ileus is not uncommon, so nasogastric suction may be necessary for 1–3 days.

After uncomplicated cholecystectomy, antibiotics are not required except in the older age group (>70 years). Elderly patients have a high incidence of bacteria in the gallbladder bile and so should be given perioperative antibiotics prior to and for two or three doses after operation. Following cholecystectomy for acute cholecystitis, administer antibiotics for 4–5 days, depending on the Gram stain of the gallbladder bile sampled in the operating room. Unless there is a significant amount of bilious drainage, remove the drain on approximately the fourth postoperative day.

Complications

Bile leak. Minor drainage of bile may follow interruption of some small branches of the bile ducts in the liver bed. This does not occur if the outer layer of the gallbladder serosa is left behind on the liver bed. On rare occasions a duct of significant size may enter the gallbladder, but we have never encountered such an instance. Bile drainage of 100–200 ml occurs if the surgeon has inadvertently transected an anomalous duct draining the dorsal caudal segment of the right lobe. If this complication is diagnosed by a sinogram radiograph, expectant therapy may result in gradual diminution of drainage as the tract becomes stenotic. Endoscopic retrograde cholangiopancreatography (ERCP) and papillotomy or nasobiliary drainage may hasten resolution.

If there is any infection in the area drained by the duct, recurrent cholangitis or liver abscess may occur. In this case, permanent relief may eventually necessitate resecting the segment of the liver drained by the transected duct. If the volume of bile drainage exceeds 400 ml/day, suspect transection of the hepatic or the common bile duct.

Jaundice. Postcholecystectomy jaundice is usually due to ligature of the CBD or an overlooked CBD stone. If other causes are ruled out, ERCP is indicated to identify the obstruction.

Hemorrhage. If the cystic artery has been accurately ligated, postoperative bleeding is rare. Occasionally, oozing from the liver bed continues postoperatively and may require relaparotomy for control.

Subhepatic and hepatic abscesses. Following cholecystectomy these two complications are seen primarily in cases of acute cholecystitis. Postoperative abscesses are rare in patients whose surgery was for chronic cholecystitis unless a bile leak occurs. Treatment by percutaneous computed tomography-guided catheter drainage is usually successful.

Further Reading

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78 Laparoscopic Cholecystectomy

Carol E.H. Scott-Conner

Indications

Confirmed diagnosis of symptomatic gallstones
Acute or chronic cholecystitis

Contraindications

Prior major surgery of the upper abdomen
Cirrhosis and bleeding disorders (relative contraindications)

Preoperative Preparation

Ultrasonography demonstrating the presence of gallbladder calculi
Perioperative antibiotics initiated prior to the induction of anesthesia
Insertion of an orogastric tube for gastric decompression during surgery
Insertion of a Foley catheter (optional)

The management of patients with suspected common bile duct (CBD) calculi will vary depending upon local expertise and the degree of suspicion. As discussed in Chap. 76, patients who present with acute cholangitis require urgent decompression of the bile duct, best obtained by ERCP and endoscopic papillotomy with stone removal followed, in most cases, by laparoscopic cholecystectomy several days later. Patients who have a dilated CBD on ultrasound, or those with suspicious liver chemistry abnormalities, may be candidates for intraoperative cholangiography. If the team is skilled at laparoscopic choledocholithotomy, stones may be removed if identified.

Operative Strategy

Avoiding Bleeding

Meticulous hemostasis is essential for laparoscopic cholecystectomy, not only to avoid blood loss but because bleeding impairs the visibility necessary to perform this operation safely and with precision. Careful use of electrocautery can accomplish this end.

Great care must be exercised with any source of energy, especially in the triangle of Calot, as there have been reports of lengthy strictures of the common and hepatic ducts presumably due to careless application of the laser or electrocautery in this area. When employing cautery near the bile ducts, use a hook cautery and elevate the tissues above any underlying structures in Calot's triangle before applying energy. This practice minimizes damage to the bile ducts.

Preventing Bile Duct Damage

As discussed under Complications at the conclusion of this chapter, the most serious bile duct injuries result from the surgeon's mistaking the CBD for the cystic duct, resulting in transection of the CBD and occasionally excision of the CBD and most of the common hepatic duct. During laparoscopic cholecystectomy, cephalad retraction of the gallbladder fundus results in abnormal displacement of the usual pathway of the common and hepatic ducts. Normally the CBD and common hepatic duct are aligned essentially in a straight line ascending from the duodenum to the liver. However, with forceful cephalad retraction of the gallbladder fundus, the CBD appears to run in a straight line with the cystic duct directly into the gallbladder, as illustrated in Fig. 78.1. In this situation, the common hepatic duct appears

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to join this straight line at a right angle. It is dangerous to initiate the dissection in the region of the bile ducts, as it may lead to the mistake of assuming that the CBD is indeed the cystic duct. A dissection proceeding in an ascending direction toward the gallbladder may very well transect the common hepatic duct.

Two precautions must be taken to avoid this error. First, always initiate the dissection on the gallbladder and remove all areolar tissue in a downward direction so the dissection continuously proceeds from the gallbladder ampulla downward toward the cystic duct. Second, after the gallbladder ampulla and infundibulum have been cleared of areolar tissue and fat, retract these structures laterally toward the patient's right, as seen in Fig. 78.2a. This helps restore the normal anatomy of the common and hepatic ducts and serves to open up the triangle of Calot and the space between the cystic and common hepatic ducts.

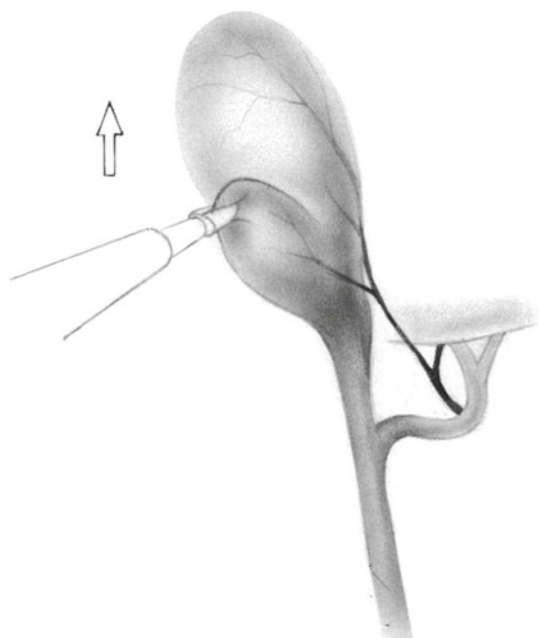

Fig. 78.1

The final essential component of a technique that avoids damaging the common bile duct is *creating a window behind the gallbladder near the termination on the cystic duct* by dissecting the gallbladder away from the liver. Then, having exposed the posterior surface of the gallbladder, continue to clear the posterior walls of the infundibulum and the cystic duct until there is a 3- to 4-cm window of empty space behind the cystic duct, infundibulum, and gallbladder ampulla (Fig. 78.2b). If the continuum between gallbladder, infundibulum, and cystic duct is clearly identified after elevating the structures, one can then be assured of the identity of the cystic duct. If by mistake one had initiated the dissection by freeing up the CBD caudal to its junction with the cystic duct, as the dissection proceeded cephalad toward the gallbladder, the common hepatic duct would be encountered joining the cystic duct on its medial aspect (Fig. 78.1). This approach puts the hepatic and common ducts at risk of major injury.

Ensuring Good Exposure

Because excellent visibility is essential to prevent unnecessary damage, do not hesitate to install an additional cannula and use a retractor to depress the transverse colon or to elevate the liver when necessary.

Intraoperative Cholangiography

Many experienced laparoscopic surgeons believe that an intraoperative cholangiogram, obtained as soon as the cystic

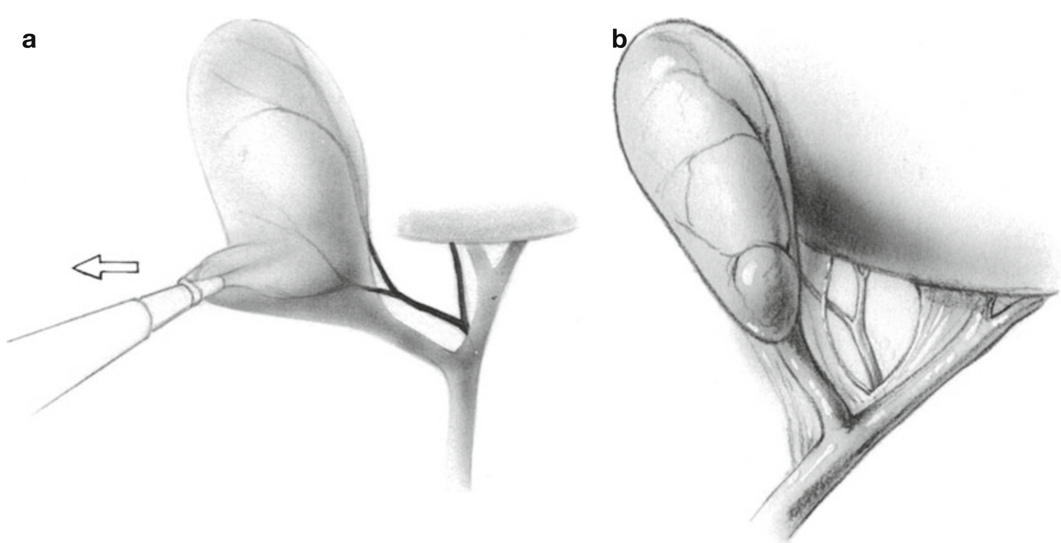

Fig. 78.2

duct is identified, is an excellent means for ascertaining the exact anatomy of the biliary tree. This confirms identification of the cystic duct and detects an anomalous hepatic duct in time to avoid operative trauma.

Conversion to Open Cholecystectomy

Whenever there is any doubt about the safety of a laparoscopic cholecystectomy, whether because of inflammation, scarring, poor visibility, equipment deficiencies, or any other reason, *do not hesitate to convert* the operation to an open cholecystectomy. Every patient's preoperative consent form should acknowledge the possibility that an open cholecystectomy may be necessary for the patient's safety. *Conversion to open cholecystectomy is not an admission of failure but an expression of sound judgment by a surgeon who gives first priority to the safe conduct of the operation. Because conversion is generally required only in difficult cases, it is essential that the laparoscopic surgeon be familiar with the material in* Chap. 77 *on the open cholecystectomy even though most cholecystectomies are performed laparoscopically*.

Pitfalls and Danger Points

Be aware that some patients have a *short cystic duct*, which increases the risk of bile duct damage by misidentification. Again, if the dissection is initiated to free the posterior wall of the gallbladder and its infundibulum, expose the common hepatic duct behind the gallbladder early during the dissection (Fig. 78.3). This should prevent misidentification of the anatomy. If one suspects the presence of a short cystic duct but is not certain, perform intraoperative cholecystocholangiography by injecting contrast material into the gallbladder with a long needle.

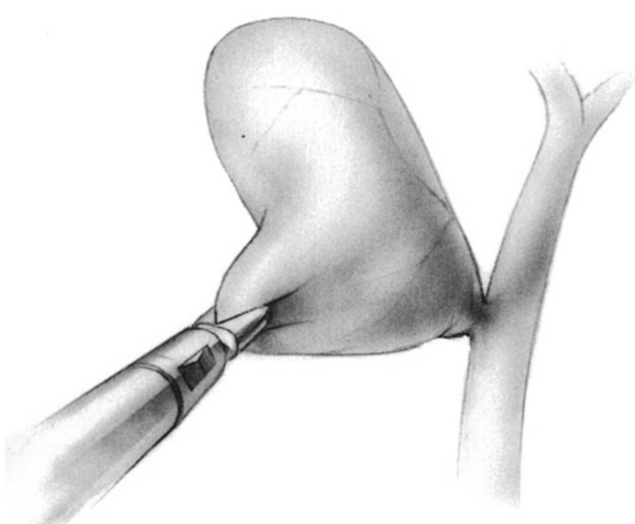

Fig. 78.3

There may be *damage to aorta*, *vena cava*, *iliac vessels*, *or bowel during trocar insertion* (see Chap. 9). There may also be *damage to the common or hepatic duct* due to misidentification.

Bleeding may be due to avulsion of the posterior branch of the cystic artery that has not been properly identified.

Documentation Basics

- Findings
- Cholangiogram or not?
- Document identification of key structures and steps to avoid injury

Operative Technique

This chapter describes the basic, four-trocar technique of laparoscopic cholecystectomy. Variations involving smaller numbers of trocars, including natural orifice and single-site approaches, are described in the references at the end. The room setup, entry into the peritoneal cavity, and first steps for any laparoscopic procedure are described in Chap. 9.

Initial Inspection of the Peritoneal Cavity

Plan the initial trocar site either just above or below the umbilicus in a natural skin crease. Gain access to the abdomen via a closed (Veress needle) or open (Hassan cannula) technique. Some surgeons prefer a 30° angled laparoscope for biliary surgery, but the operation can comfortably be performed with a straight (0°) laparoscope.

Insert the laparoscope into the cannula. Inspect the organs of the pelvis and posterior abdominal wall. Look for unexpected pathology and evidence of trauma that might have been inflicted during needle insertion to the vascular structures or the bowel. If no evidence of trauma is seen, aim the telescope at the right upper quadrant and make a preliminary observation of the upper abdominal organs and gallbladder.

Insertion of Secondary Trocar Cannulas

A second 10- to 11-mm cannula is inserted in the epigastrium at a point about one-third the distance between the xiphoid process and the umbilicus. It generally is placed just to the right of the midline to avoid the falciform ligament. With a finger, depress the abdominal wall in this general area and observe with the telescope to define the exact location at which to insert the trocar. Make a 1-cm transverse skin incision at this point and insert the trocar cannula under direct vision by aiming the telescope-camera at the entry point of the trocar. Apply even pressure with no sudden motions.

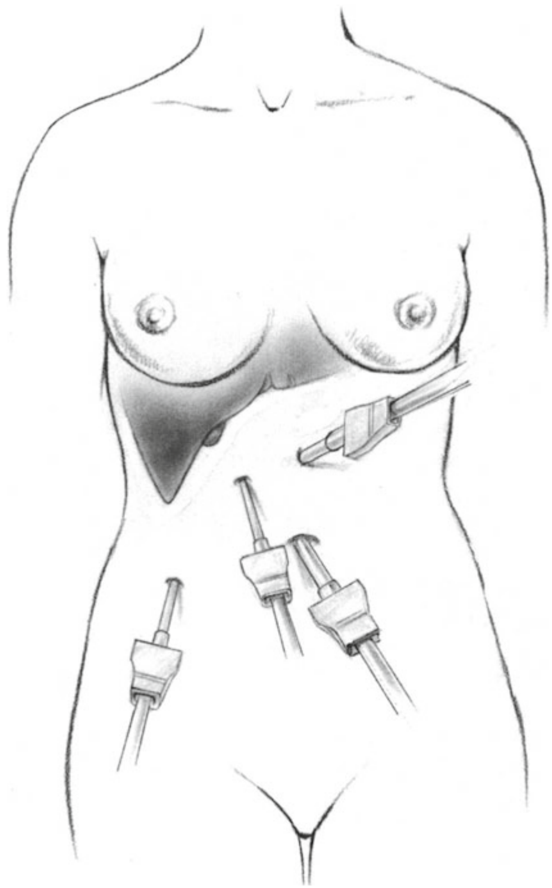

Fig. 78.4

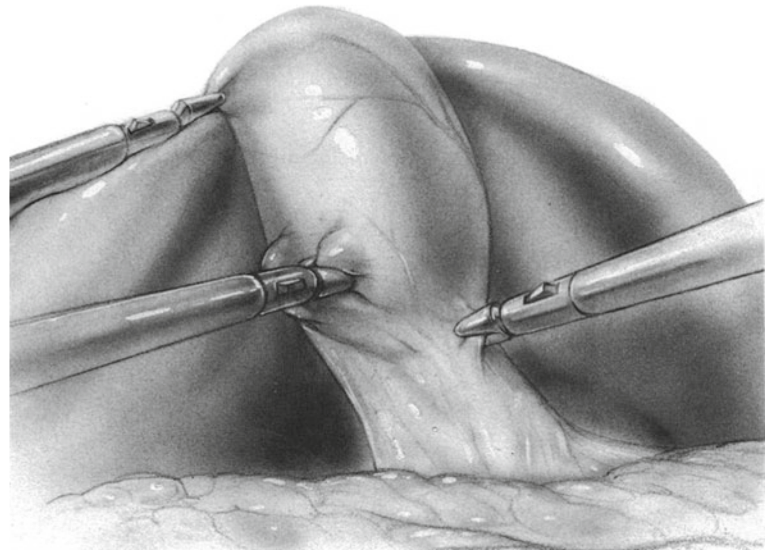

Fig. 78.5

Serious injuries of the liver and other organs have been reported following vigorous insertions of the trocar. As soon as the cannula has entered the abdominal cavity, remove the trocar; this site constitutes the main operating port.

Establish two secondary ports, one in the midclavicular line about 2–3 cm below the costal margin and the other in the anterior axillary line at a point about level with the umbilicus. These two 5-mm ports are mainly used for grasping and retraction.

Insert a trocar in each of these ports after making a 5-mm skin incision. Observe and control the entry of these trocars carefully by watching the television monitor. The objective is to position the ports so the surgeon can manipulate the dissecting instruments at a point in front of and roughly at right angles to the telescope. Figure 78.4 illustrates a typical arrangement of cannulas.

Dissecting the Gallbladder to Expose the Cystic Duct

To expose the gallbladder, elevate the head of the table to a 30° reverse Trendelenburg position. Apply suction to the nasogastric tube as necessary to deflate the stomach. Sometimes moderate upward rotation of the right side of the operating table is also helpful for improving exposure. Insert a grasping forceps through the right lateral port and grasp the upper edge of the gallbladder. Push the gallbladder in a cephalad direction anterior to the liver. Utilizing the midclavicular port, have the assistant insert a second grasping forceps to grasp the gallbladder fundus and apply countertraction while the surgeon uses an appropriate dissecting forceps inserted through the upper midline port.

The first objective is to expose the gallbladder fundus by dissecting away any adherent omentum and other structures. Then grasp the areolar tissue and fat overlying the fundus with a grasping forceps (Fig. 78.5), apply a burst of coagulating current, and pull the tissue in a caudad direction. While this is being done, the assistant's grasping forceps draws the ampulla of the gallbladder gently toward the patient's right, as illustrated in Fig. 78.2. Hook electrocautery or electrified scissors can also be used to divide the peritoneal layers that cover the infundibulum of the gallbladder and cystic duct. Use the hook dissector to liberate the lower portion of the gallbladder from its attachment to the liver, both laterally and medially. *Create a large window of space behind the gallbladder*, *the infundibulum*, *and the cystic duct* (Fig. 78.2). The dissection should continuously be directed from the gallbladder downward toward the cystic duct. Always consider that the CBD and hepatic ducts may be closer to the gallbladder than you think, especially in patients who have a short cystic duct (Fig. 78.3). Concentrating on the lower portion of the gallbladder and infundibulum is much safer than initiating the dissection behind what you *think* is the cystic duct but that may indeed be the CBD.

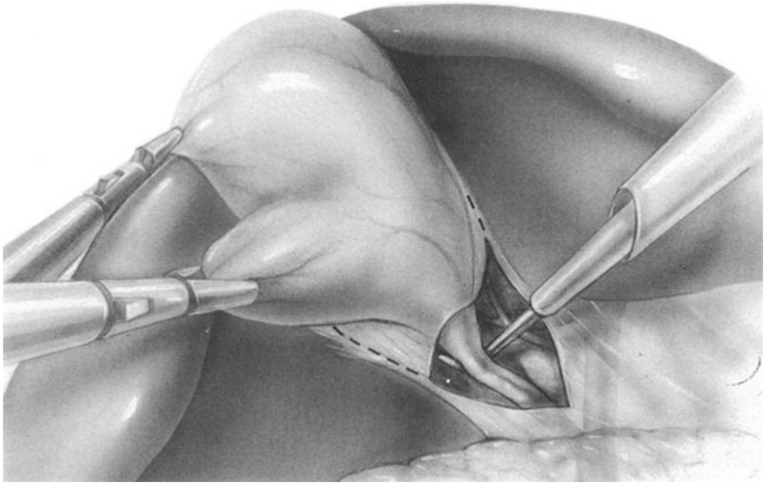

Fig. 78.6

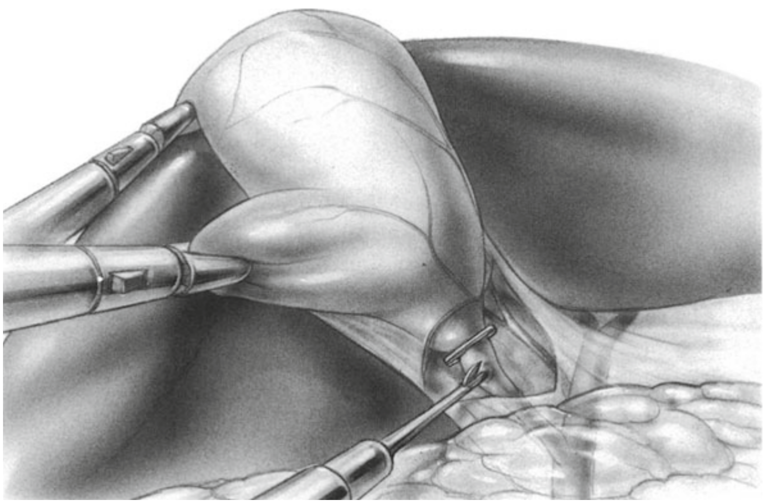

Fig. 78.7

After dissecting on both sides of the cystic duct by manipulating the ampulla from right to left, pass a right-angled Maryland dissector or a hook behind the cystic duct and free up several centimeters so there is *complete exposure of the continuum of the posterior cystic duct going up to the infundibulum and the lower portion of the gallbladder* (Fig. 78.6).

Cystic Duct Cholangiogram

When certain that the cystic duct has been identified, apply an endoscopic clip to the area of the infundibulum of the gallbladder and use scissors to make an incision in the cystic duct just below the clip (Fig. 78.7). For cholangiography, we prefer a balloon-tipped catheter of the type made by the Arrow Company. Test the balloon and insert the catheter into the upper midline or midclavicular port. Adjust the curvature of the catheter tip by pushing or withdrawing the catheter through its curved plastic catheter holder. Thread the catheter into the cystic duct incision for no more than 1 cm (Fig. 78.8), a point marked by two black lines on the catheter body. Inflate the balloon and tentatively inject some contrast material to determine that leakage does not take place. Do not insert the catheter too far into the cystic duct; otherwise, it enters the CBD, and the balloon occludes the CBD at the point of injection, resulting in an image of the distal CBD only from the catheter tip to the ampulla of Vater. This image cannot prove that the common hepatic duct is intact. In this case, back out the catheter for a short distance and repeat the cholangiogram. Use C-arm fluoroscopy to monitor the injection. If fluoroscopy is not available, obtain two plain radiographs. Inject 4 ml of contrast material for the first film and an additional 8 ml for the second. *If the proximal ducts do not fill, assume a CBD injury and convert to open laparostomy*.

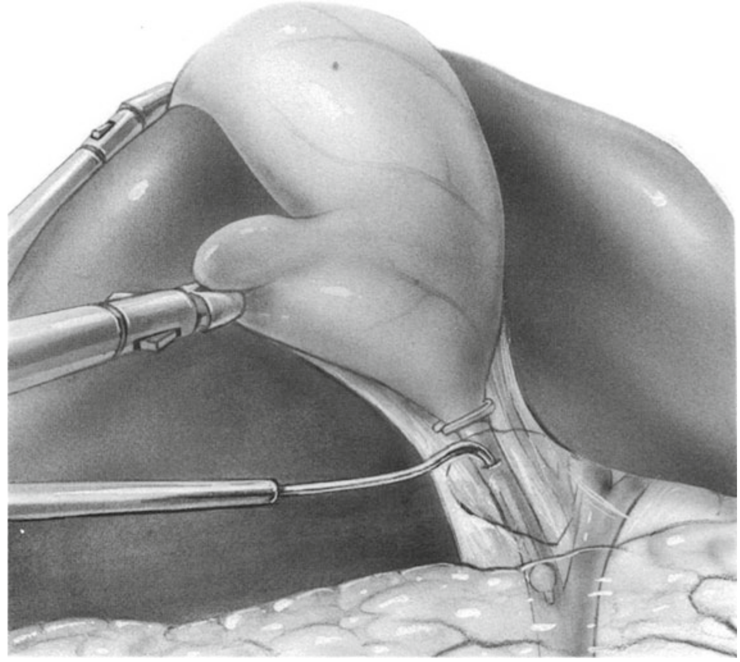

Fig. 78.8

If the cholangiogram demonstrates satisfactory filling of the hepatic duct and CBD as well as the duodenum, remove the catheter and continue to the next step, which is dividing the cystic duct as described below. If the cholangiogram demonstrates a calculus in the CBD, perform a laparoscopic CBD exploration if the technology and skill are available (see References). Otherwise, one has the choice of performing an open cholecystectomy and choledocholithotomy or scheduling the patient for a postoperative endoscopic papillotomy for stone extraction. If the stone is exceedingly large (approaching 2 cm), an open choledocholithotomy is preferable. This is also the case if the patient has a large number of

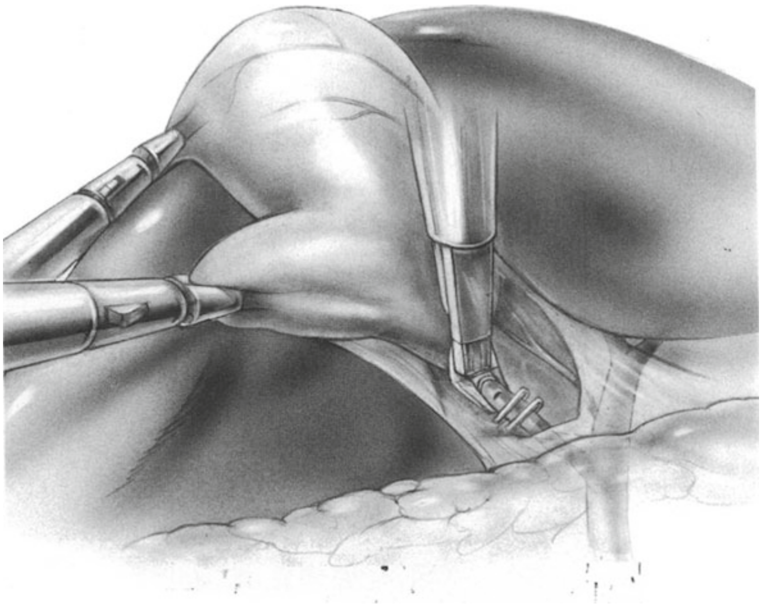

Fig. 78.9

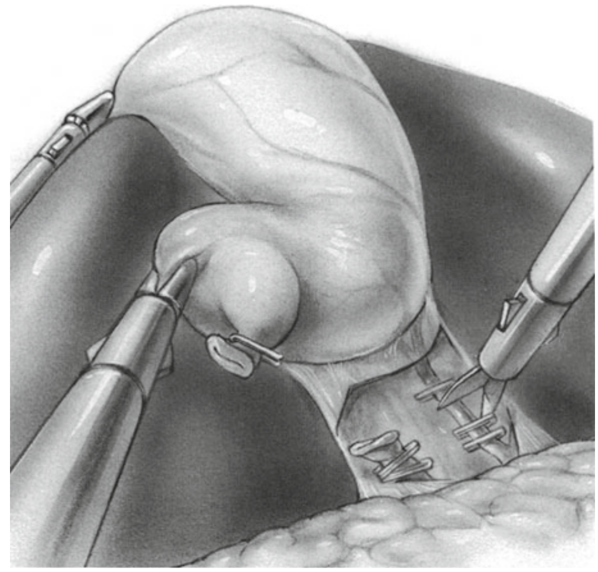

Fig. 78.10

stones or has had a previous Billroth II gastrectomy, making endoscopic papillotomy an unlikely choice.

There need be no hesitation on the part of the surgeon to proceed to open cholecystectomy and choledocholithotomy. This is a safe operation that generally accomplishes complete clearing of the CBD in one procedure. Such clearance may take the endoscopist several attempts to accomplish by endoscopic papillotomy. Remember also that endoscopic papillotomy for CBD extraction is associated with 1 % mortality. One advantage of the open choledocholithotomy in patients who have 10–20 calculi is the ability to incorporate into the operation a biliary-enteric bypass, such as choledochoduodenostomy. Because endoscopic papillotomy is feasible in only about 90 % of patients owing to anatomic variability or periampullary diverticula, it may be helpful to insert a guidewire through the opening in the cystic duct and pass it down the CBD into the duodenum. Duodenal placement can be confirmed by an abdominal radiograph. In the presence of this guidewire, endoscopic papillotomy can be performed in almost 100 % of patients.

In cases where passage of the cholangiogram catheter is obstructed by the valves of Heister, the obstruction may be corrected by inserting the tip of the scissors into the cystic duct. Keep the scissors closed upon entering the duct and then open them with mild force to dilate the valves.

Removing the Gallbladder

Remove the cholangiogram catheter and apply another endoscopic clip on the gallbladder side of the incision (Fig. 78.9). Then apply two clips on the distal portion of the cystic duct. Divide the cystic duct with scissors.

During dissection of the cystic duct, the cystic artery is generally identified slightly cephalad to the cystic duct. Whenever this structure has been clearly identified, elevate it with either a Maryland dissector or a hook so at least 1 cm is dissected completely from surrounding structures. Then apply one endoscopic clip above and two clips below, and divide the artery with scissors (Fig. 78.10). Note that the point at which the cystic artery divides into its anterior and posterior branches can be somewhat variable. When you think you have divided the main cystic artery, you may have divided only the anterior branch. Be alert during the latter part of the dissection for a posterior branch that must often be clipped and divided when the infundibulum of the gallbladder is freed. If this branch is small enough, it may be handled by electrocautery instead of clipping.

Now continue to dissect the gallbladder away from the liver. This can be done with electrocautery using either a hook or a spatula dissection. Divide the peritoneum between the gallbladder and the liver on each side of the gallbladder. Then continue the dissection on the posterior wall of the gallbladder. The first assistant maneuvers the two grasping forceps to expose various aspects of the gallbladder and applies countertraction for the surgeon. Some surgeons utilize a two-handed technique: dissection with the right hand and manipulating the medial grasping forceps with the left hand.

Before the gallbladder is totally free of its attachment to the liver, carefully inspect the liver bed for bleeding points. Irrigate the area. If there are any bleeding points in the liver bed, they can be occluded by applying a suction electrocoagulator.

Finally, elevate and divide the gallbladder from its final attachment to the liver (Fig. 78.11). Leave the gallbladder in position over the dome of the liver being held in the lateral port grasper.

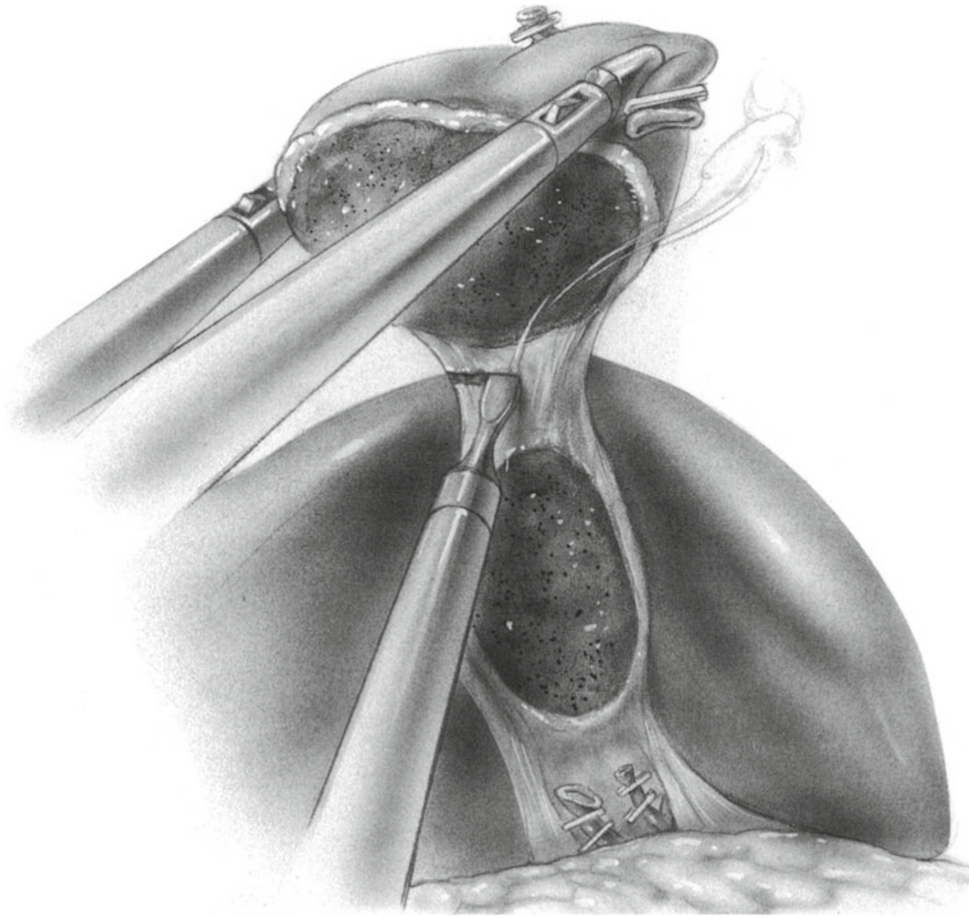

Fig. 78.11

Remove the laparoscope from the umbilical cannula and place it through the upper midline sheath. Insert a large claw grasper through the umbilical cannula. Pass the claw along the anterior abdominal wall to reach the gallbladder over the dome of the liver. Follow the action with the camera. The claw grasps the gallbladder at its neck. Then pull the gallbladder into the umbilical cannula as far as it will go. Now remove the cannula together with the gallbladder. As soon as the neck of the gallbladder is seen outside the umbilicus (Fig. 78.12), make an incision in the gallbladder (Fig. 78.13) and insert a suction device to aspirate bile (Fig. 78.14). Apply a Kelly hemostat to the neck of the gallbladder and gradually extract it from the abdomen while observing the action on the video monitor (Fig. 78.15). If the gallbladder is too large to pass through the umbilical incision, the incision can be enlarged somewhat by inserting a large hemostat and stretching the width of the incision. Alternatively, the incision may be lengthened by several millimeters in both directions using the scalpel until the gallbladder can be removed. Sometimes an endoscopic retrieval bag is useful, particularly if the gallbladder is inflamed.

In the patient with a small gallbladder, do not move the telescope from the umbilical port. Rather, pass the claw

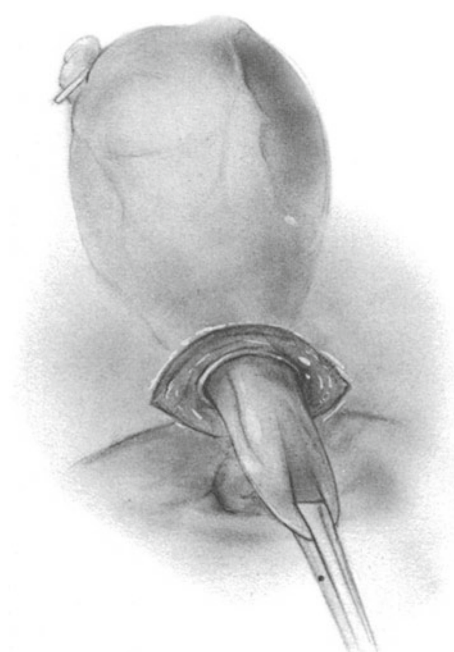

Fig. 78.12

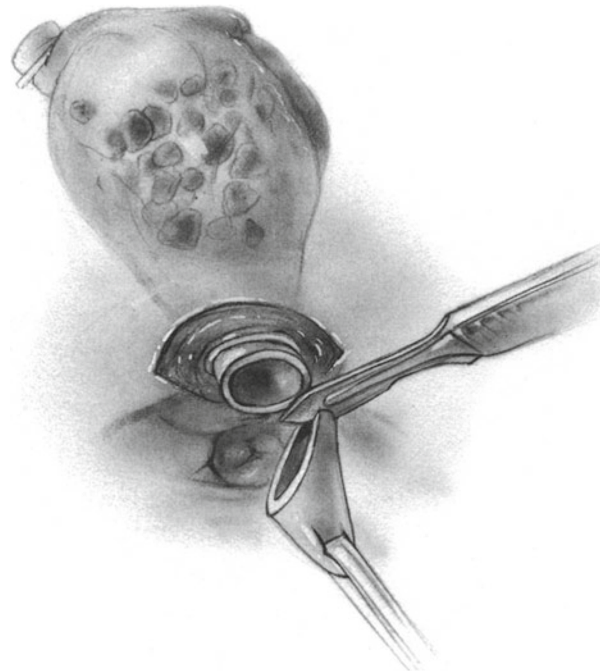

Fig. 78.13

Fig. 78.14

grasper through the epigastric port and draw the gallbladder through the epigastric incision.

If the laparoscope has been transferred to the epigastric port, return it to the umbilical cannula and make a last inspection of the abdominal viscera, pelvis, and gallbladder bed. If there are any signs of retroperitoneal

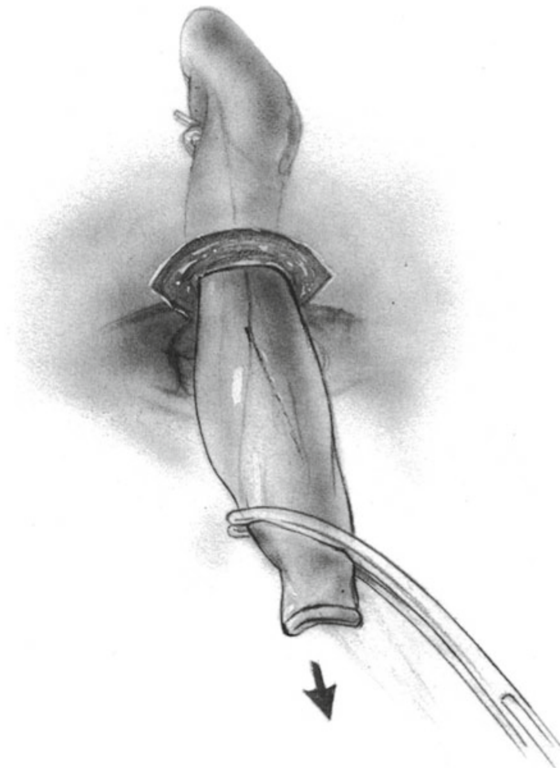

Fig. 78.15

hematomas in the region of the aorta, vena cava, or iliac vessels, assume that there has been major injury to these vessels and perform a laparotomy if necessary to rule out this possibility. Remember, even with disposable trocars that have plastic shields, forceful collision of the shielded trocar with the vena cava may result in perforation of this vessel. Bleeding from the great vessels constitutes the main cause of the rare fatality that follows laparoscopic cholecystectomy. Carefully observe the withdrawal of each cannula to ascertain the absence of bleeding in each case. Finally, permit the escape of carbon dioxide from the abdominal cavity and remove the final cannula. Insert sutures of heavy Vicryl in the two 10-mm incisions in the midline of the abdomen. The 5-mm incisions do not require closure. Close the skin with sterile adhesive tape or subcuticular sutures.

Postoperative Care

Remove the nasogastric or orogastric tube and urinary catheter (if placed) before the patient leaves the recovery room. Mild pain medication may be necessary. Ambulate the patient as soon as he or she awakens. A regular diet may be ordered unless the patient is nauseated.

Discharge patients a day or two following surgery. They may resume full activity by the end of 1 week.

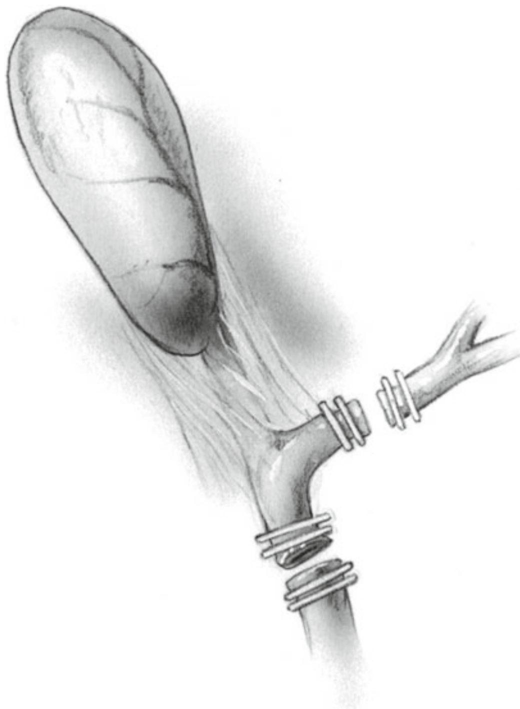

Fig. 78.16

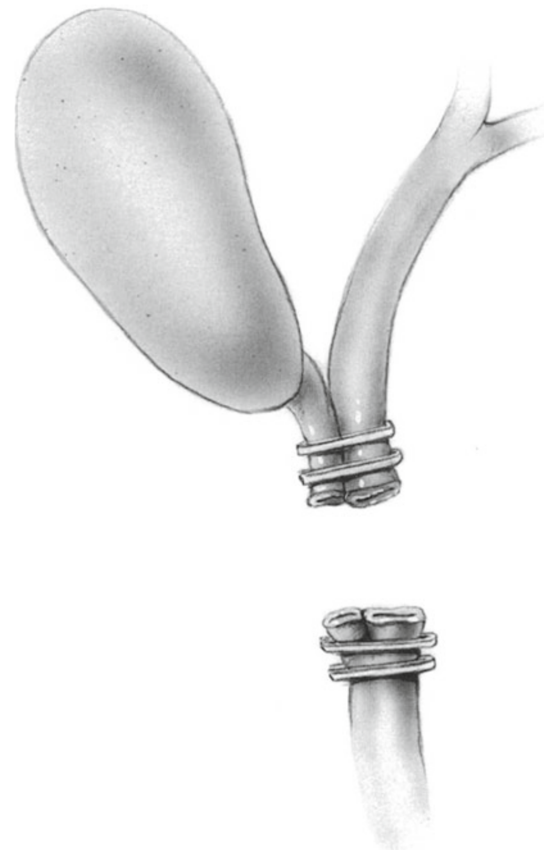

Fig. 78.17

Complications

Needle or Trocar Damage

Retroperitoneal bleeding from damage to one of the great vessels during insertion of the initial trocar can be fatal. A retroperitoneal hematoma noted during laparoscopy requires open exploration for great vessel injury.

Bowel injury can result from introducing the Veress needle or a trocar, especially if the trocar is passed through adherent bowel. Careful inspection of the abdomen by laparoscopy after inserting the initial trocar and again before terminating the operation is essential if these injuries are to be detected early and then repaired.

Insufflation-Related Complications

See Chap. 9.

Bile Duct Damage: Excision of Common and Hepatic Ducts

The classic laparoscopic biliary injury includes resection of large sections of the CBD and the common hepatic duct together with the cystic duct and the gallbladder (Fig. 78.16). Injury results from mistaking the CBD for the cystic duct and applying clips to the CBD. The CBD is then dissected in a cephalad direction as though it were the cystic duct with transection of the proximal hepatic ductal system with or without clip ligation.

Significant leakage of bile into the operative field is a danger sign that should not be ignored. Inadequate visualization of the surgical field often contributes to these errors and to significant bleeding.

If, in fact, a surgeon divides the common bile duct by mistake, there is certainly no excuse for failing to detect this error when the dissection encounters the common hepatic duct. As seen in Fig. 78.16 (modified from Davidoff et al. (1992)), if one dissects the proximal divided end of the CBD in a cephalad direction, it is not possible to remove the gallbladder without transecting the common hepatic duct. With proper surgical dissection, it should be obvious that the presence of this duct indicates that the operative strategy is wrong and requires an immediate course correction.

One factor contributing to injury is fibrosis or scarring in Calot's triangle, as shown in Fig. 78.17. The cystic duct is densely adherent to the common hepatic duct for several centimeters above the junction of the cystic and common ducts. This injury does not occur if the dissection is initiated at the distal gallbladder and if the posterior portion of the

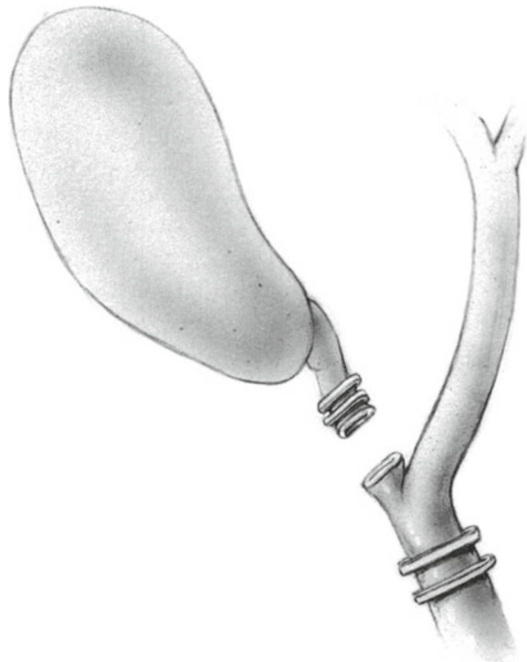

Fig. 78.18

gallbladder infundibulum is dissected away from the liver before dissecting the cystic duct. Dissection should always progress from the gallbladder toward the cystic duct, completely freeing the entire circumference of the fundus, the infundibulum of the gallbladder, and the cystic duct.

Another common pattern of CBD injury is illustrated in Fig. 78.18. Here, clips were applied to the CBD just below its junction with the cystic duct, but the transection took place across the distal portion of the cystic duct. In this case the patient will have a total biliary fistula into the peritoneal cavity.

The CBD may also be injured when the clip applied to the proximal portion of the cystic duct also encompasses the right hepatic duct. Fibrosis in Calot's triangle may contribute to this injury by placing the right hepatic duct in close proximity to the cystic duct. This injury may be avoided if the surgeon properly dissects the gallbladder infundibulum and cystic duct from above down prior to applying the clips.

Finally, late strictures (presumably due to thermal damage) have been reported.

In summary, prevention of damage to the bile ducts requires good visibility (sometimes facilitated by use of a 30° angled laparoscope), lateral traction on the fundus and infundibulum of the gallbladder to separate the cystic duct from the common hepatic duct, directing the dissection from the distal gallbladder downward toward the cystic duct rather than the reverse, using electrocautery with caution, applying routine cholangiography early in the operation, and converting to open cholecystectomy whenever there is any doubt concerning the safety of the laparoscopic cholecystectomy. A satisfactory intraoperative cholangiogram must show intact bile ducts from the right and left hepatic ducts down to the duodenum. When there is doubt concerning which duct to use for the cholangiogram, a cholecystocholangiogram may be obtained by injecting 30–40 ml of contrast material directly into the gallbladder.

Bile Leak

Leakage of bile into the right upper quadrant following laparoscopic cholecystectomy does not necessarily indicate an injury to the bile duct. It may simply mean that the occluding clips have slipped off the cystic duct or that a minor accessory bile duct is leaking. Symptoms generally develop a few days after laparoscopic cholecystectomy and consist of generalized abdominal discomfort, anorexia, fatigue, and sometimes jaundice. Sonography can reveal the presence of fluid in the subhepatic space. A HIDA scan demonstrates the presence of bile outside the biliary tree, and ERCP demonstrates the point of leakage. In the absence of obstruction in the CBD, these leaks generally heal spontaneously. Healing may be expedited by percutaneous insertion of a drainage catheter into the right upper quadrant and insertion of a stent into the CBD following endoscopic papillotomy. Of course, major ductal injury requires surgical reconstruction, generally by the hepaticojejunostomy Roux-en-Y procedure.

Intraoperative Hemorrhage from Cystic Artery

Occasionally brisk bleeding results when the cystic artery is cut or torn. It is generally a minor complication during open cholecystectomy because grasping the hepatic artery between two fingers in the foramen of Winslow (Pringle maneuver) ensures prompt if temporary control of bleeding. With laparoscopic cholecystectomy, however, losing 30–40 ml of blood may be serious because the blood obscures visibility through the laparoscope.

Frequently it is possible to control cystic artery bleeding by grasping the gallbladder ampulla near the bleeding vessel and pushing the ampulla firmly against the liver (Fig. 78.19). If this maneuver successfully controls the bleeding, insert one or more additional cannulas for suction and retraction and attempt to localize and clip the bleeding vessel. It is not worth spending much time on occluding this bleeder laparoscopically because making a subcostal incision affords an opportunity to localize and control the bleeder quickly with no risk.

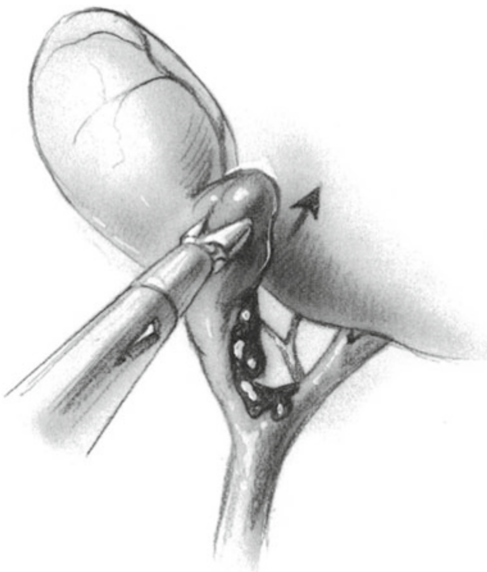

Fig. 78.19

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Cholecystostomy: Surgical Legacy Technique

79

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Cholecystostomy may be performed in patients suffering from acute cholecystitis when cholecystectomy may be hazardous for technical reasons or when cholecystectomy has been attempted and is too technically difficult. Computed tomography (CT)-guided percutaneous catheter drainage may be the most pragmatic method for managing acute cholecystitis in poor-risk patients. Rarely, it is not possible for technical reasons, and open or laparoscopic (see references) cholecystostomy is an option in these cases.

Contraindication

Patients with acute cholangitis owing to common bile duct (CBD) obstruction

Preoperative Preparation

Appropriate antibiotics

Pitfalls and Danger Points

Overlooking acute purulent cholangitis
Overlooking gangrene of the gallbladder
Postoperative bile leak

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Operative Strategy

When Is Cholecystostomy Inadequate?

Cholecystostomy does not provide adequate drainage for an infected bile duct. In most cases it is not difficult to differentiate acute cholecystitis from acute cholangitis. When a patient with acute cholangitis does not respond immediately to antibiotic treatment, prompt drainage of the CBD is lifesaving. Undrained acute purulent cholangitis is often rapidly fatal. When performing cholecystostomy, one must be alert not to overlook this disease of the bile duct.

Gangrene of the gallbladder is another complication of acute cholecystitis, for which cholecystostomy is an inadequate operation. The gangrene may occur in the deep portion of the gallbladder fundus, where it may be hidden by adherent omentum or bowel. It is easy to overlook a patch of necrosis when operating through a small incision under local anesthesia. When a necrotic area is found in the gallbladder, it is preferable to perform a complete cholecystectomy; if this operation is impossible for technical reasons, a partial cholecystectomy around a catheter with removal of the gangrenous patch can be done (Fig. 79.1).

Choice of Anesthesia

Because of the danger of overlooking disease of the CBD and gangrene or perforation of the gallbladder, it is preferable to perform the cholecystostomy through an adequate incision under general anesthesia. With modern anesthesia and monitoring techniques, it is safe for most poor-risk patients to undergo a biliary operation under general anesthesia. Otherwise, perform percutaneous catheter drainage of the gallbladder.

†Deceased

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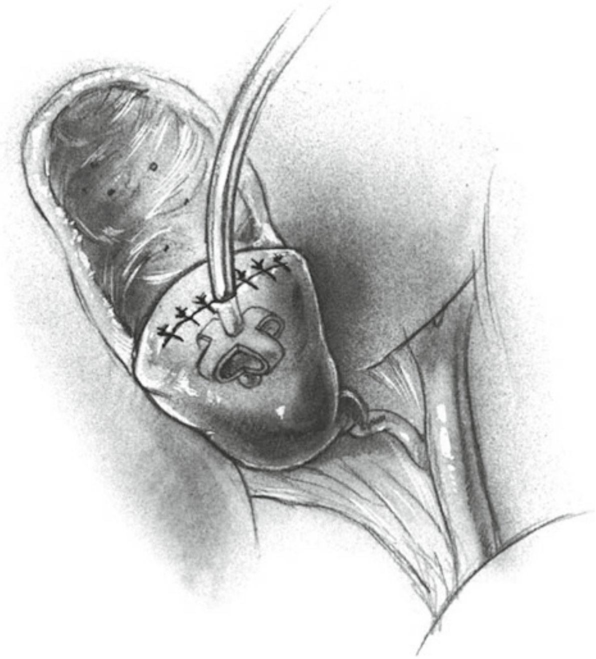

Fig. 79.1

Preventing Bile Leaks

One distressing complication that occasionally follows cholecystostomy is leakage of bile around the catheter into the free peritoneal cavity, resulting in bile peritonitis. This complication can generally be avoided by using a large catheter and suturing the gallbladder around the catheter (Fig. 79.2). It is important also to suture the fundus of the gallbladder to the peritoneum around the exit wound of the drainage catheter (Fig. 79.3). Adequate drainage is also necessary in the vicinity of the gallbladder.

Documentation Basics

- Findings and reason for procedure (rather than cholecystectomy)
- Type and size of catheter

Operative Technique

Incision

Under general anesthesia, make a subcostal incision at least 10–12 cm in length. Find the plane between the adherent omentum and the inflamed gallbladder. Once this plane is entered, the omentum can generally be freed from the gallbladder wall by gentle blunt dissection. Continuing in this plane, inspect the gallbladder and its ampulla.

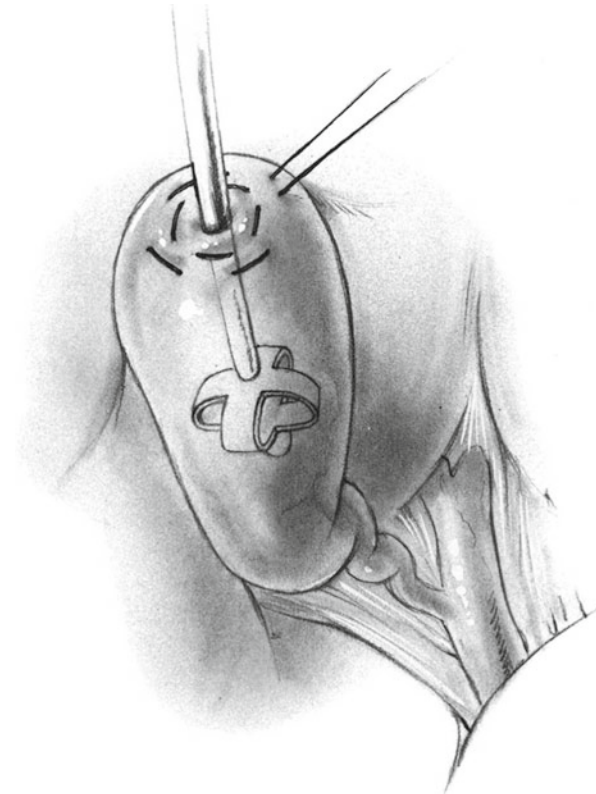

Fig. 79.2

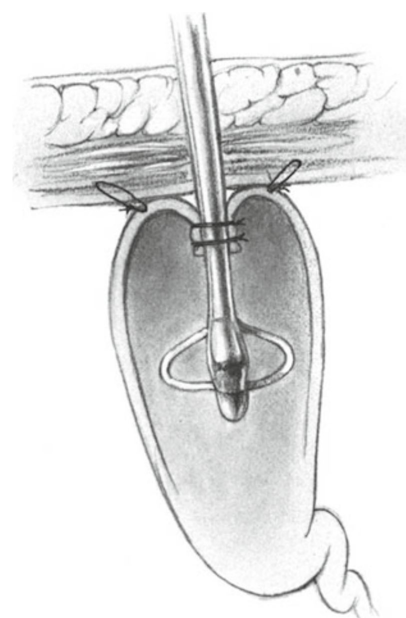

Fig. 79.3

Emptying the Gallbladder

After ascertaining that there is no perforation of the gallbladder or any patch of gangrene, empty the gallbladder with a 16-gauge needle or a suction trocar inserted into the tip of the gallbladder. Perform an immediate Gram stain. Enlarge the stab wound in the gallbladder. Attempt to remove the gallbladder calculi with pituitary scoops and Randall stone forceps. It may be necessary to compress the gallbladder ampulla manually to milk stones up toward the fundus. After flushing the gallbladder with saline, insert a 20 F straight or Pezzar catheter 3–4 cm into the gallbladder. Close the defect in the gallbladder wall with two inverting purse-string sutures of 2-0 PG suture material (Fig. 79.2). If the gallbladder wall is unusually thick, it may be necessary to close the gallbladder around the catheter with interrupted Lembert sutures.

If the patient is in satisfactory condition, attempt cholangiography through the gallbladder catheter. It is not always possible to extract a stone that is impacted in the cystic duct. This circumstance eliminates the possibility of obtaining a cholangiogram by this route.

Now make a stab wound through the abdominal wall close to the fundus of the gallbladder. Draw the catheter through the abdominal wall and suture the fundus of the gallbladder to the peritoneum alongside the stab wound (Fig. 79.3). Make a stab wound and insert two closed suction catheters: one in the vicinity of the cholecystostomy and one in the right renal fossa.

Close the abdominal incision in routine fashion as described in Chap. 3. We use No. 1 PDS sutures for this closure.

Postoperative Care

Connect the cholecystostomy catheter to a sterile plastic collecting bag for gravity drainage.

Continue antibiotic treatment for the next 7–10 days. Until bacterial culture and sensitivity studies have been reported on the gallbladder bile, use antibiotics that are effective against gram-negative bacteria, enterococci, and anaerobes.

Employ nasogastric suction if necessary.

Measure the daily output of bile and replace with an appropriate dose of sodium.

Do not remove the gallbladder drainage catheter for 12–14 days. Obtain a cholangiogram before removing the catheter.

Complications

Bile peritonitis

Subhepatic, subphrenic, or intrahepatic abscess

Septicemia

Patients with acute cholecystitis generally respond promptly to adequate drainage of the infection. If the patient shows persistent signs of sepsis and bacteremia, it is likely that this complication stems from an undrained focus of infection. It may be an obstructed CBD with cholangitis or a subhepatic, *intrahepatic*, or subphrenic abscess. Endoscopic retrograde cholangiopancreatography (ERCP) and CT scanning may be helpful for detecting these complications.

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80 Common Bile Duct Exploration: Surgical Legacy Technique

Carol E.H. Scott-Conner

Indications

Multiple alternatives have largely superseded open common bile duct (CBD) exploration. Endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy provides access to the common duct for extraction of stones and biliary decompression. Laparoscopic transcystic common duct exploration or laparoscopic choledochotomy are alternatives when common duct stones are found at laparoscopic cholecystectomy. Open CBD exploration is still occasionally needed when these methods are not available or fail. The principles of access to the CBD described here are used during the performance of advanced biliary tract surgery and must be thoroughly understood.

Chills, fever, and jaundice prior to operation (in more than 90 % of cases CBD exploration reveals calculi)

Palpation of a calculus in the CBD

Acute suppurative cholangitis

Positive finding of a calculus on routine cystic duct cholangiography, preoperative ERCP, or percutaneous transhepatic cholangiogram

Access to the CBD is sometimes required during the course of other procedures in this region (e.g., to delineate the course of the CBD during a difficult ulcer operation). The principles delineated here apply in those situations as well. Adequate cholangiography can prove or disprove the presence of stones in many situations that formerly were listed as relative indications for CBD exploration.

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Preoperative Preparation

Computed tomography (CT) or sonography is used. Generally ERCP is performed as the next diagnostic maneuver when dilated ducts are seen, and intervention (papillotomy and stone extraction) may obviate the need for open CBD exploration.

Correct abnormalities of the serum prothrombin preoperatively with injections of vitamin K.

When CBD exploration is planned, the patient should receive perioperative intravenous antibiotics beginning 1 h prior to operation. To ensure an adequate antibacterial blood level, repeat the dose in 3 h, during the operation. We use either a third- or fourth-generation cephalosporin or a penicillin-aminoglycoside combination.

Pitfalls and Danger Points

Injuring the bile ducts

Creating a false passage into the duodenum when probing the CBD, damaging the ampulla or pancreas, inducing postoperative pancreatitis

Perforating a periampullary duodenal diverticulum

Sepsis

Failing to remove all of the biliary calculi

Operative Strategy

Avoiding Postoperative Pancreatitis

Postoperative acute pancreatitis can be lethal. Use routine cholangiography to minimize the number of unnecessary CBD explorations. Explore the distal duct with delicacy and meticulous care to avoid trauma to the ampulla or pancreas, which may induce pancreatitis.

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CBD Perforations

Another *serious and often fatal error* is to perforate the distal CBD and penetrate the pancreas with an instrument such as the metal Bakes dilator. When the surgeon experiences any difficulty negotiating the ampulla with an instrument, duodenotomy and direct exposure of the ampulla are preferable to repeated blunt trauma from above. Using a 10 F Coude or whistle-tipped rubber catheter, rather than a metal dilator, lessens the risk of ampullary trauma and postoperative acute pancreatitis. Never forcefully dilate the sphincter of Oddi; this procedure serves no useful purpose, and the trauma to the ampulla not only increases the risk of postoperative acute pancreatitis it produces lacerations and hematomas of the ampulla.

If an instrument has perforated the distal CBD and the head of the pancreas, it may be detected when the CBD is irrigated with saline by noting saline leakage from the posterior surface of the pancreas. The perforation may also be detected by cholangiography. This type of trauma, which leads to bile flow directly into the head of the pancreas, often causes fatal pancreatitis. For this reason, when this complication is identified, divide the CBD just above its entry into the pancreaticoduodenal sulcus; transfix the distal end of the duct with a suture and anastomose the proximal cut end of the CBD to a Roux-en-Y segment of jejunum. When this procedure is carried out, diverting the bile from the traumatized pancreas may prove lifesaving. Also insert a closed-suction drain behind the pancreatic head to remove any leaking pancreatic secretions.

If the CBD has been perforated at an accessible point proximal to the head of the pancreas, suture the laceration with 5-0 PG or PDS. If the laceration is not accessible, simply insert a large-caliber T-tube into the CBD for decompression proximal to the laceration. Then place a closed-suction catheter drain down to the region of the laceration.

Locating and Removing Biliary Calculi

To avoid overlooking biliary calculi, obtain a cystic duct cholangiogram before exploring the CBD. Be sure that the radiograph clearly shows the hepatic ducts and the distal CBD. If the hepatic ducts cannot be seen because the dye runs into the duodenum, administer morphine to induce spasm of the ampulla; alternatively, open the CBD, insert an 8 F Foley catheter into the proximal CBD, and use this device to obtain a radiograph of the intrahepatic radicles. This cholangiogram can provide an estimate of size, number, and location of calculi.

Always perform a Kocher maneuver before exploring the CBD. It permits the surgeon to place the fingers of the left hand behind the ampullary region with the thumb on top of the anterior wall of the duodenum. This allows the instrument to be directed more accurately while palpating its distal tip.

Once the CBD has been opened, the safest, most effective device for extracting stones is the pituitary scoop with a malleable handle. Available with various size cups, this device can be bent to the exact curvature required to pass through the CBD down to the ampulla. By delicate maneuvering, the surgeon can remove most stones with the scoop. Also, it is often easy to palpate a stone against this metallic instrument.

Other methods that are helpful for retrieving stones are the Randall stone forceps, the Fogarty balloon, and thorough saline irrigation. On rare occasions a Dormia basket can retrieve a stone that is otherwise inaccessible. Choledochoscopy, discussed below, is another excellent means for helping to identify residual biliary calculi in the operating room.

When the ampullary region contains an impacted stone that cannot be removed with minimal trauma by the usual methods, *do not hesitate to perform a sphincteroplasty for the purpose of extracting the stone* under direct vision. Otherwise, excessive trauma to the ampullary region may cause serious postoperative acute pancreatitis.

A completion cholangiogram through the T-tube after the exploration has been concluded is the final maneuver required to minimize the number of stones overlooked at operation. It is important to use a T-tube that is 16 F or larger following choledocholithotomy. Otherwise, the track remaining when the T-tube is removed may not be large enough to admit the instruments required to remove residual stones by Burhenne's method. Even small ducts admit a 16 F T-tube if the tube is trimmed by the technique described below in the section Insertion of the T-Tube.

Documentation Basics

- Cholecystectomy performed?
- Details of cholangiogram and findings
- Findings at exploration
- Size and type of T-tube placed, other drains

Operative Technique

Cholangiography

If for some reason the cystic duct is not a suitable route for cholangiography, insert a 21-gauge scalp vein needle into the CBD. Aspirate bile to confirm that the needle is in the duct lumen. Use a structure to fix the needle to the CBD. Attach a 2-m length of sterile plastic tubing filled with the proper contrast medium. The remaining details of cholangiography are the same as those described in Chap. 77.

Kocher Maneuver

After the gallbladder has been removed and it is determined that CBD exploration is indicated, perform a Kocher maneuver (see Figs. 14.14, 14.15, and 14.16) by incising the lateral peritoneal attachments along the descending duodenum. Then incise the layer of avascular fibrous tissue that attaches the posterior duodenum to Gerota's fascia and to the foramen of Winslow. Elevate the duodenum and head of the pancreas by sharp and blunt dissection in the areolar plane until the inferior vena cava is seen. With the left index and middle fingers situated behind the pancreas and duodenum and the thumb applied to the anterior wall of the duodenum, palpate the distal CBD and the ampulla. Pay special attention to the ampullary region so as not to overlook a small ampullary carcinoma, which is often felt as a hard protrusion into the lumen from the back wall of the duodenum. An adequate Kocher maneuver allows the surgeon to palpate the distal duct and head of pancreas and makes it possible to straighten the distal duct by gentle downward traction.

Choledochotomy Incision

Incise the peritoneum overlying in CBD to identify the duct's anterior wall. Select an area for the choledochotomy preferably distal to the entrance of the cystic duct. Insert two guy sutures of 4-0 PG or PDS, one opposite the other on the anterior wall of the duct. If there are any obvious blood vessels located in this area, transfix them with 5-0 PG or PDS suture-ligatures or apply careful electrocautery. Use a No. 15 scalpel blade to make a short incision in the anterior wall of the CBD while the assistant holds up the guy sutures. Then use Potts angled scissors to enlarge the incision in both directions. Pay attention to the possibility that the cystic duct may share a wall with the CBD for a distance of 2 cm or more. If the incision is made in the vicinity of this common wall, it is possible to open the cystic duct instead of the CBD, which would cause considerable confusion. It is even possible to make an incision along the common wall and not encounter the lumen of either the cystic duct or the CBD and to expose the portal vein. If the anteromedial aspect of the CBD is used for the choledochotomy incision, this problem is avoided.

Exploring the CBD

As soon as the CBD has been opened, take a sample of the bile for bacteriologic culture and Gram stain. During passage

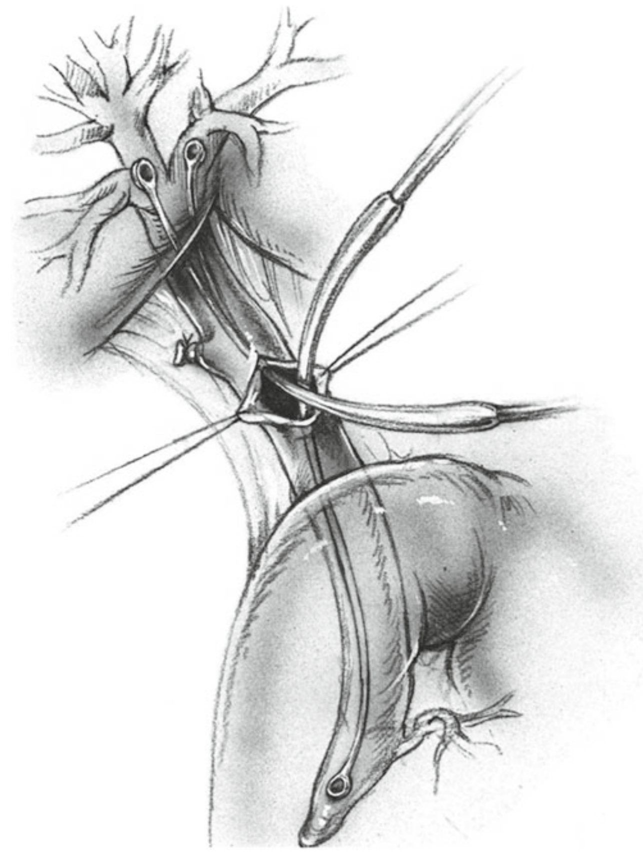

Fig. 80.1

of the instruments, maintain the left hand behind the duodenum and head of pancreas. Gentle downward traction can be used to straighten the distal duct, and the sense of touch facilitates passing the instruments through the ampulla.

Using the left thumb and index finger, milk down any possible stones from the common hepatic duct into the choledochotomy incision. Perform the same maneuver on the distal CBD. This maneuver often delivers several calculi into the choledochotomy. Take care not to push stones up into the intrahepatic biliary tree where subsequent extraction may be difficult.

Pass a pituitary scoop of the appropriate size up into the right and left main hepatic ducts to remove any possible calculi (Fig. 80.1). Then, with the left index finger placed behind the ampulla, use the right hand to pass a pituitary scoop down to the region of the ampulla and remove any calculi encountered with this maneuver. It is helpful simultaneously to palpate with the left index finger behind the distal CBD while the scoop is being passed. Avoid excessive trauma to the ampulla. A Randall stone forceps (Fig. 80.2) may be inserted into the CBD for the purpose of removing stones, but we have not found this instrument to be particularly valuable compared to the pituitary scoop. Following these maneuvers, use a small, straight catheter to irrigate

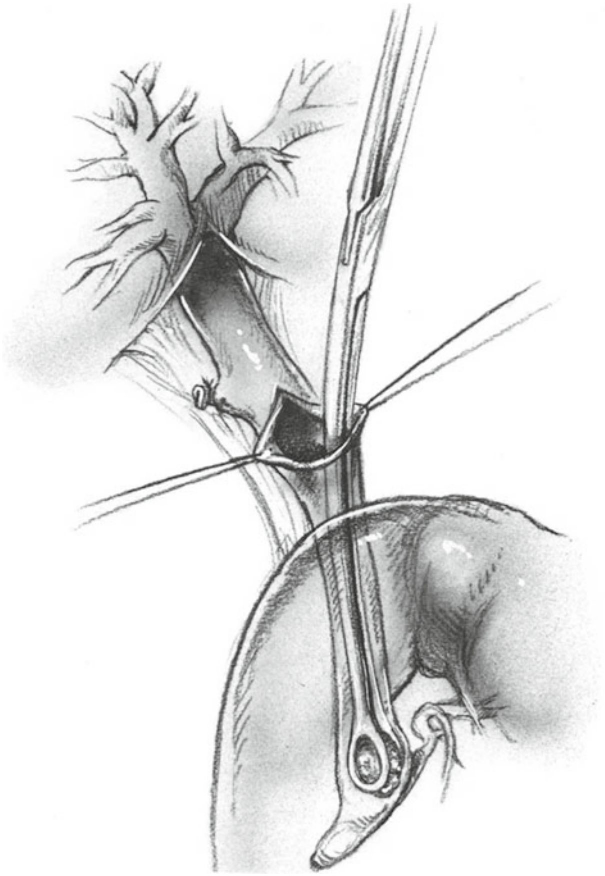

Fig. 80.2

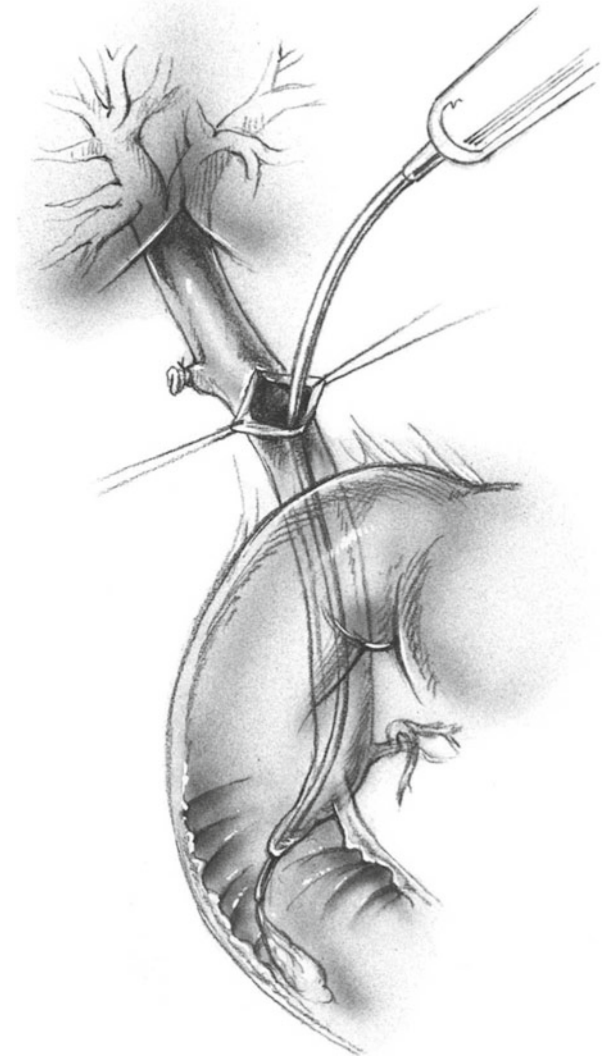

Fig. 80.3

both the hepatic ducts and the distal CBD with normal saline solution (Fig. 80.3).

Now try to pass a 10 F Coude tipped catheter through the ampulla. Inject saline through the catheter. The saline is seen to flow back out through the choledochotomy so long as the catheter is in the duct. When the catheter passes into the duodenum, the flow of saline ceases. If metal Bakes dilators are used instead to determine the patency of the ampulla, perform this maneuver with great delicacy as it is easy to perforate the distal CBD and to make a false passage through the head of the pancreas. It is not necessary to pass any instrument larger than a No. 3 Bakes dilator through the ampulla.

If there appears to be a calculus in the distal end of the CBD and it is not easily removed by means of the scoop, insert a biliary Fogarty catheter down the CBD into the duodenum. Blow up the balloon, which helps identify the ampulla by affording a sense of resistance as the catheter is pulled back. Gradually deflate the balloon as the catheter is withdrawn until it traverses the ampulla. As soon as the balloon is inside the CBD, reinflate and withdraw it. This occasionally removes a stone that has been overlooked. Repeat the same maneuver in the right and left hepatic ducts. It is for retrieval of hepatic duct stones that the Fogarty catheter has its greatest usefulness.

Another maneuver that occasionally removes a stone is use of a 16 F rubber catheter. Cut most of the flared proximal end of the catheter off and insert this end down the CBD to make contact with the stone. Amputate the tip of the catheter and attach a syringe to the catheter's distal tip; apply suction while simultaneously withdrawing the catheter. The suction sometimes traps the calculus in the end of the catheter, after which it is easily removed.

If an impacted stone in the distal CBD cannot be removed in a nontraumatic fashion by these various maneuvers, do not hesitate to perform a sphincteroplasty (see Chap. 82). This choice is safer than traumatizing the ampulla.

Choledochoscopy

We believe that choledochoscopy is an integral part of the CBD exploration. This procedure can detect and retrieve stones or detect and biopsy ductal tumors, in some cases when all other methods have failed. Both rigid and flexible fiberoptic choledochoscopes are available. The rigid right-angle choledochoscope (Storz Endoscopy), which contains a Hopkins rod-lens system that is illuminated by a fiberoptic channel, gives the best image quality. It is simpler to operate and less expensive than the flexible fiberoptic endoscopes. If this scope is not available, a rigid nephroscope may be used instead.

Both rigid and flexible choledochoscopes must be sterilized by ethylene oxide gas, precluding repeated utilization of the same scope on the same day. Although flexible instruments have a higher initial cost, more expensive upkeep, shorter life span, much greater susceptibility to damage, and somewhat inferior optical properties, they have one important advantage over the rigid scopes: The flexible scope can be passed for greater distances up along the hepatic radicles for extraction of an otherwise inaccessible stone in this location. Similarly, the flexible scope can be passed right down to the ampulla and in about one-third of cases into the duodenum to rule out the presence of stones in the distal ampulla. Even if the scope does not enter the duodenum, when it is passed down to the ampullary orifice and the flow of saline enters the duodenum without refluxing back up into the CBD it constitutes good evidence that the distal duct is free of calculi. The rigid scopes are not generally of sufficient length to accomplish this mission. Another area in which the flexible scope is occasionally useful is extraction of retained calculi via the T-tube track subsequent to CBD exploration.

Because of their lower cost and greater durability, the rigid scopes have been adopted more widely than have the flexible scopes despite the handicap mentioned above. The horizontal arm of the Storz choledochoscope comes in two lengths: 40 and 60 mm. The vertical limbs of the two models are identical. The cross section of the horizontal limb, which must pass into the bile duct is 5 × 3 mm, approximately the diameter of a No. 5 Bakes dilator. If the CBD does not admit a No. 5 dilator, choledochoscopy by this technique is contraindicated.

Rigid and flexible choledochoscopes operate in a liquid medium, which requires that a continuous stream of sterile saline under pressure be injected into the sidearm of the scope. The saline then flows into the bile ducts. By crossing the two guy sutures over the choledochotomy incision, the CBD can be maintained in a state of distension by the flow of saline, providing optimal visualization. If the CBD is large enough, a metal instrument channel can be attached to the choledochoscope. Through this channel can be passed a flexible biopsy punch, a flexible forceps (7 F size), a Dormia stone basket, or a Fogarty biliary catheter (5 F caliber).

To use the choledochoscope, stand on the left side of the patient. Make the choledochotomy incision as far distal in the CBD as possible, and insert the choledochoscope toward the hepatic duct (Fig. 80.4). Initiate the flow of saline, and cross over the two guy sutures to reduce the loss of saline from the choledochotomy incision. Enclose the 1-l bag of sterile saline in a pressure pump (Fenwall) and use sterile intravenous tubing to connect the bag of saline to three-way stopcock. Insert the stopcock into the saline channel on the side of the choledochoscope.

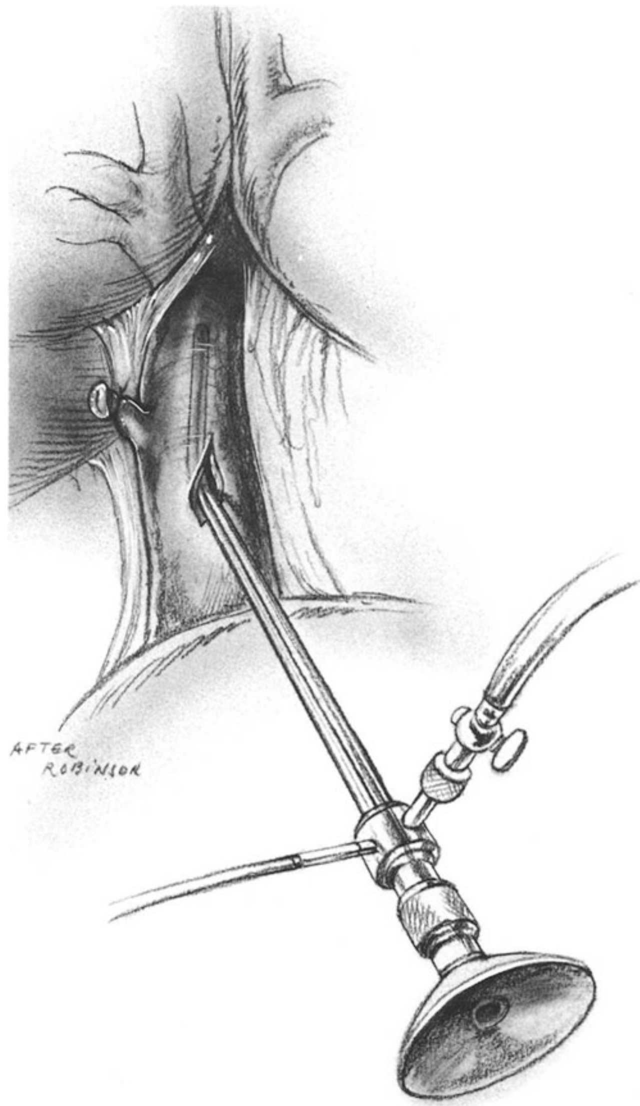

Fig. 80.4

Pass the horizontal limb of the scope up the common hepatic duct; the bifurcation of the right and left ducts is soon seen. Occasionally the first branch of the right main duct opens into the bifurcation so it resembles a trifurcation. Generally the left duct appears to be somewhat larger and easier to enter than the right. By properly directing the scope, it is possible to see into the orifices of many of the secondary and tertiary ducts. Withdraw the scope until the bifurcation is again seen and then pass the instrument into the right main duct using the same technique.

Before passing the scope down into the distal CBD, be sure the duodenum has been completely Kocherized. By placing slight traction with the left hand on the region of the ampulla, the surgeon helps elongate and straighten the course of the CBD. This step is important because the scope then visualizes the duct with clear focus to infinity. What the surgeon really wants to learn from the choledochoscopy is whether there are residual calculi between the scope and the ampulla. It requires exact knowledge of the appearance of the ampulla, which has been described as an inverted cone with a small orifice that opens and closes intermittently to permit the passage of saline. However, we have found that using these landmarks as the only criterion for identifying the ampulla may lead to error. Occasionally, this type of error permits a stone in the distal CBD to go undetected. Consequently, we believe there are only two positive methods for identifying the distal termination of the CBD. One is passage of the 60 mm choledochoscope through a patulous ampulla (rarely possible). When it is possible and if the duodenum is inflated with saline, one can see quite clearly the duodenal mucosa, which is markedly different from the smooth epithelium of the CBD. If the duodenum is not filled with saline, the mucosa is not seen. If the scope does not pass into the duodenum spontaneously, make no attempt to pass it forcibly. A second method for positively identifying the termination of the CBD is to pass a Fogarty balloon catheter alongside the choledochoscope into the duodenum. Inflate the balloon and draw back on the catheter. By following the catheter with a choledochoscope down to the region of the balloon one can be more certain that the entire CBD has been visualized and that there are no residual calculi.

Occasionally, the view of the distal CBD is impeded by what appear to be shreds of fibrin or ductal mucosa, which may hang as a partially obscuring curtain across the lumen of the duct. Despite some of these difficulties while interpreting choledochoscopic observations, this procedure does indeed detect stones that were missed by all other methods. In the hands of an experienced observer, choledochoscopy is probably the most accurate single method for detecting CBD stones. Calculi are easily identified. It may at first be confusing to find that a calculus 3 mm in diameter looks as big as a chunk of coal through the magnifying lens system. It is important to note that the Storz-type choledochoscope achieves a clear focus at distances of about 5 mm to infinity and that any object within 0–5 mm of the tip of the scope is not in focus.

If stones are seen, remove the choledochoscope and extract the stones by the usual means. If this is not possible, reinsert the choledochoscope and use a flexible alligator forceps, a Fogarty catheter, or the Dormia stone basket, *all under direct visual control of the choledochoscope*.

If a suspicious mucosal lesion is identified, insert a flexible biopsy punch and obtain a sample. Sometimes an ampullary or distal bile duct carcinoma is diagnosed in this manner. Bile duct cancers can be multicentric, and a second lesion may be found in the common duct or the hepatic duct. Under direct visual control, accurate biopsy is not difficult through the choledochoscope.

Routine CBD exploration and removal of calculi is accompanied by a 3 % incidence of retained stones. Choledochoscopy decreases the incidence of residual stones to 0–2 %. Using choledochoscopy routinely during CBD exploration adds no more than 10 min to the procedure and, in our experience, occasionally detects a stone that has been missed by all other modalities. Because it appears to be devoid of dangerous complications, we have adopted choledochoscopy as a part of routine CBD exploration. We have experienced one complication that was possibly related to the saline flush under pressure during choledochoscopy, namely, a mild case of postoperative pancreatitis. However, we have no data to indicate that the incidence of postoperative pancreatitis is increased by the use of choledochoscopy.

Sphincterotomy for Impacted Stones

Perform a complete Kocher maneuver down to the third part of the duodenum and insert a folded gauze pad behind the duodenum and the head of the pancreas. Pass a stiff catheter or a No. 4 Bakes dilator into the choledochotomy incision and down to the distal CBD. Do not pass it into the duodenum. By palpating the tip of the catheter or the Bakes instrument through the anterior wall of the duodenum, ascertain the location of the ampulla. Make a 4 cm incision in the lateral wall of the duodenum opposite the ampulla. Insert small Richardson retractors to expose the ampulla. Often the impacted stone is not in the lumen of the CBD but partially buried in the duct wall. This permits the Bakes dilator to pass beyond the stone and distend the ampulla. If this is the case, make a 10 mm incision with a scalpel through the anterior wall of the ampulla down to the metal instrument at 11 o'clock, a location far away from the entrance of the pancreatic duct. A 10 mm incision allows the dilator to enter the duodenum. Remove the Bakes dilator through the choledochotomy incision and explore the distal CBD through the sphincterotomy incision. Use the smallest size pituitary scoop. Often the stone can be easily removed in this fashion. If the papillotomy incision must be extended a significant distance to provide adequate exposure, a complete sphincteroplasty should be undertaken, which is described in Chap. 82. If the sphincterotomy is less than 10 mm in length, it is generally not necessary to suture the mucosa of the CBD to that of the duodenum. Rather, if there is no bleeding, leave the papillotomy undisturbed after the impacted stone has been removed. Repair the duodenotomy by the same technique as described following

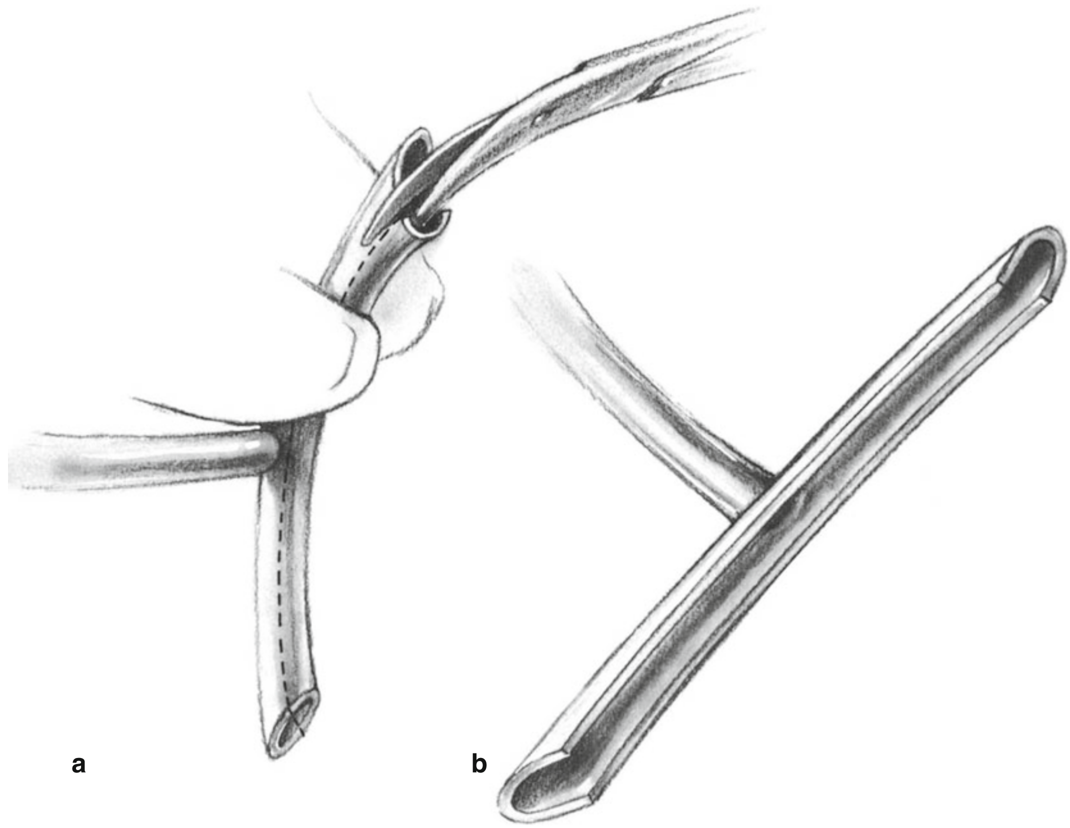

Fig. 80.5

sphincteroplasty (see Chap. 82). Then insert the T-tube into the CBD incision.

Checking for Ampullary Stenosis

Before completing the CBD exploration, the diameter of the ampulla of Vater may be calibrated by passing a catheter or a Bakes dilator. If a 10 F rubber catheter passes through the ampulla, no further calibration is necessary. If this device is too soft, try a Coude tipped catheter. If the catheters fail to pass, insert the left hand behind the region of the ampulla and pass a No. 3 Bakes dilator gently through the ampulla. Failure to pass through the ampulla with ease is more often due to pushing the instrument in the wrong direction than to an ampullary stenosis. In the absence of malignancy, we have found it rare to be unable to pass a catheter or dilator through the ampulla using gentle manipulation. If the pre-exploration cystic duct cholangiogram showed dye passing through the duodenum, failing to pass a 3 mm instrument through the ampulla is not by itself an indication for sphincteroplasty or biliary-intestinal bypass.

In any case, never use excessive force when passing these instruments. Penetration of the intrapancreatic portion of the CBD may produce fatal complications, especially if the damage is not recognized during the operation.

Insertion of the T-Tube

Although it is possible in some cases to avoid draining the CBD following stone removal, we believe that a T-tube should be inserted routinely to decompress the CBD and to facilitate cholangiography 7–8 days following surgery. Do not use a silicone T-tube, as this substance is nonreactive. Consequently, there may be no well-organized tract from the CBD to the outside, and bile peritonitis may occur when the silicone tube is removed. Use a 16 F rubber tube to facilitate extraction of any residual stones postoperatively through the T-tube track. If the duct is small, excise half the circumference from the horizontal limb of the 16 F tube as illustrated in Fig. 80.5a, b. After inserting the T-tube, close the choledochotomy incision with a continuous 4-0 atraumatic PG or PDS suture (Fig. 80.6). Make this closure snug around the T-tube to avoid leakage during cholangiography and subsequent leakage of bile.

Completion Cholangiogram

Eliminate the air in the long limb of the T-tube by inserting the long cholangiogram catheter that was used for the cystic duct cholangiogram down into the vertical limb of the T-tube for its full distance. Then gradually inject the contrast

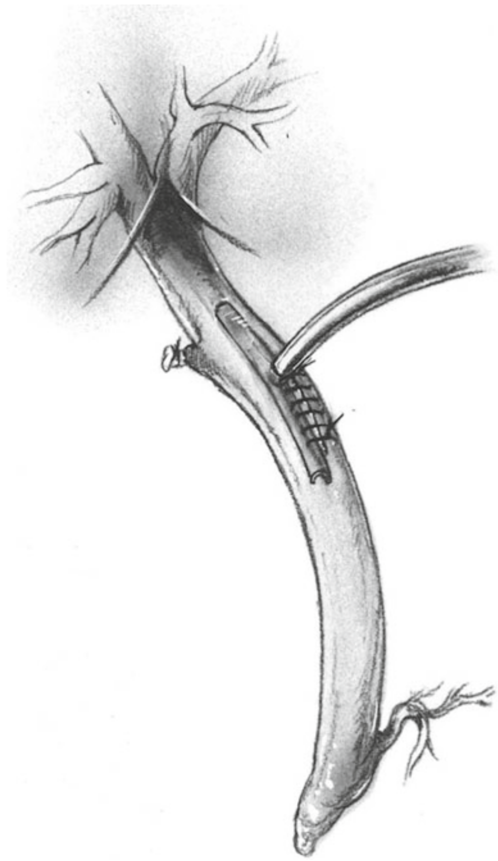

Fig. 80.6

medium into this limb while simultaneously removing the plastic catheter. This maneuver fills the vertical limb with contrast material and displaces the air. Then attach the T-tube directly to a long plastic connecting tube, which in turn is attached to a 30 ml syringe.

Elevate the left flank about 10 cm above the horizontal operating table. Stand behind a lead screen covered with sterile sheets and obtain the cholangiogram by injecting 4 ml of diluted contrast medium for the first radiograph and an equal amount for the second and third pictures. Fluoroscopy with a C-arm (if available) allows the surgeon to watch the flow of contrast and facilitates the procedure. We use a mixture of one part water-soluble contrast and one or two parts saline. The larger the duct, the more dilute is the solution to avoid obscuring small stones within a dense column of dye.

If the contrast material has not entered the duodenum, repeat the sequence after giving nitroglycerin intravenously. If the contrast material still does not enter the duodenum but the radiograph is otherwise negative, discontinue the study. Severe sphincter spasm often follows ampullary instrumentation and cannot be overcome during completion cholangiography.

Drainage and Closure

Bring the T-tube out through a stab wound near the anterior axillary line. Place a closed-suction drain through a separate stab wound and bring it down near the CBD. Place omentum over the CBD and under the incision. Suture the T-tube to the skin, leaving enough slack between the CBD and the abdominal wall to allow for some abdominal distension. Close the abdominal wall in the usual fashion.

Postoperative Care

Attach the T-tube to a sterile plastic bag. Permit it to drain freely by gravity until cholangiography is performed through the T-tube in the radiology department on postoperative day 5. Do not permit contrast material to be injected into the T-tube under pressure, as it may produce pancreatitis or bacteremia. Injection by gravity flow is preferable. If the cholangiogram is negative and shows free flow into the duodenum, clamp the T-tube. Unclamp it if the patient experiences any abdominal pain, nausea, vomiting, shoulder pain, or leakage of bile around the T-tube. Remove the T-tube on postoperative day 21.

Following choledocholithotomy, continue antibiotics for at least 3 days, depending on the results of the Gram stain, the bacteriologic studies, and the patient's clinical response. Continue nasogastric suction for 1–3 days. Remove the closed-suction drain 4–7 days following surgery unless there has been significant bilious drainage.

Observe the patient carefully for possible development of postoperative acute pancreatitis by determining the serum amylase levels every 3 days. If there is significant elevation, continue nasogastric suction and intravenous fluids. Some patients with postoperative acute pancreatitis do not have pain or significantly elevated serum amylase, but they do have intolerance for food, with frequent vomiting after nasogastric suction has been discontinued. In these cases a sonogram or CT scan showing an enlarged pancreas is enough to confirm the diagnosis. In general, do not feed the patient following biliary tract surgery if the serum amylase level is significantly elevated or if there is any other strong suspicion of acute pancreatitis, as this complication may be serious.

Complications

Bile Leak and Bile Peritonitis

T-Tube Displacement. The T-tube is fixed at two points: (1) the CBD and (2) the point on the skin where the T-tube is sutured in position. Enough slack must be left in the long limb of the T-tube between the CBD and the skin so an increase in abdominal distension does not result in the tube being drawn out of the CBD. Occasionally, the T-tube is inadvertently partially withdrawn from the CBD even before the abdominal incision is closed. When bile leaks around the choledochotomy incision, bilious drainage from the drain track alongside the T-tube is noted. If this leak occurs during the first few days following the operation, upper abdominal pain and tenderness may appear, indicating bile peritonitis. A localized bile leak is fairly well tolerated in the postoperative patient who has adequate drainage, whereas when bile spreads diffusely over a large part of the abdominal cavity it may produce generalized bile peritonitis if the bile is infected. Diffuse abdominal tenderness generally demands either immediate laparotomy for replacement of the T-tube or insertion of an ERCP stent into the CBD.

Ductal Injury. When a completion cholangiogram through the T-tube is obtained in the operating room, a *major* ductal injury is apparent on the film, whereas an injury to an *accessory* duct may not be. If the latter manifests by continuous drainage of small to moderate amounts of bile along the drain tract and the cholangiogram is persistently normal, remove the T-tube and insert a small Foley catheter into the drain tract. Two weeks after surgery, perform cholangiography through this catheter after the balloon has been inflated. The most frequently injured anomalous bile duct is that which drains the dorsal caudal segment of the right lobe.

Postoperative Acute Pancreatitis

Acute pancreatitis following choledocholithotomy accounts for about half the postoperative fatalities. It is often caused by instrumental trauma to the ampullary region owing to excessive zeal when dilating the ampulla or when extracting an impacted stone. In the latter case, if the impacted stone cannot be removed with ease through the choledochotomy incision, approach it via a duodenotomy and papillotomy. Treatment of acute pancreatitis calls for prolonged nasogastric suction, fluid replacement, and respiratory support when indicated. Antibiotics are probably also indicated.

Frequent determinations of the serum amylase level in patients following choledocholithotomy are necessary because some patients with postoperative pancreatitis do not complain of an unusual degree of pain. Their only symptom may be abdominal distension and vomiting unless shock and hypoxia supervene. The mortality rate following postoperative acute pancreatitis is reported to be quite high, approaching 30–50 %. Total parenteral nutrition is indicated because many of these patients require 3–6 weeks of nasogastric suction before the amylase returns to normal, at which time food may be given by mouth. Premature feeding in these cases may cause a severe, even fatal exacerbation.

Increasing Jaundice

After choledocholithotomy in the jaundiced patient, it is common for the serum bilirubin concentration to increase by 4–6 mg/dl during the first postoperative week. This does not mean that the patient necessarily has a CBD obstruction. Rather, imposition of major surgery and anesthesia on the liver already damaged by a period of ductal obstruction temporarily aggravates the hepatic dysfunction. By postoperative days 10–12, the bilirubin level has peaked and has started on its way down toward normal, unless there is another cause for the postoperative jaundice, possibly a blood clot or an overlooked carcinoma in the main hepatic duct. Obstruction of the distal CBD by a retained stone does not produce postoperative jaundice if the T-tube is functioning properly. Obtain a routine cholangiogram through the T-tube by postoperative day 7. It can clarify the cause of the persistent jaundice.

Hemorrhage

Intraabdominal Hemorrhage. Intraabdominal hemorrhage often manifests as red blood coming through the drainage track. If it is not accompanied by systemic symptoms or abdominal signs, one may suspect that the bleeding arises from a blood vessel in the skin or the abdominal wound. Bleeding of sufficient magnitude to require one or more blood transfusions invariably originates from the operative area. The cause may be a defective ligature on the cystic artery or oozing from the liver or some intraabdominal blood vessel. These patients require prompt reexploration through the same incision, complete evacuation of the blood clots, and identification of the bleeding point.

Hemobilia. Bleeding through the T-tube indicates hemobilia. It may arise from intrahepatic trauma during attempts to extract an intrahepatic calculus. Generally, expectant therapy is sufficient in any vitamin K deficiency has been corrected preoperatively. In case of persistent hemobilia, perform hepatic arteriography, as iatrogenic trauma to a specific branch of the hepatic artery during the hepatic duct exploration may be the source of bleeding. This is a rare complication, with a reported incidence of less than .1 %. Treatment consists of transcatheter embolization in the angiography suite. If open exploration is required, a T-tube cholangiogram plus the hepatic arteriogram may help the surgeon identify the appropriate vessel to ligate.

Residual CBD Stone

Early Postoperative Treatment. Most often a residual CBD stone is detected when postoperative T-tube cholangiography is performed. When this study is read as positive for calculi by the radiologist, carefully review the films. Request a repeat study to rule out the possibility that the shadow is due to an air bubble. Shadows that are odd in shape may not be calculi but may be due to residual blood clot or debris. There is no need for early operative intervention aimed at removing a residual CBD stone so long as the T-tube is draining well. This is true because the nonoperative methods of extracting calculi are extremely effective and have a low complication rate. Also, some of the radiographic shadows, interpreted as calculi, may indeed be artifacts that disappear without treatment.

If the radiographic evidence is convincing and a stone less than 1 cm in diameter is seen in the lower portion of the CBD, a saline flush with or without heparin solution may be indicated if tolerated by the patient. This should not be performed before the 12th postoperative day. Infuse 1,000 ml of normal saline with 5,000 units of heparin through the T-tube over a 24-h period, provided it does not produce excessive pain. If the calculus completely blocks the distal CBD, this technique is contraindicated. Repeat this therapy every day for 4–5 days if tolerated. Then repeat the cholangiogram. If the radiographic appearance of the stone shows a reduction in size, repeat the series of saline flushes the following week. Otherwise, send the patient home with the T-tube in place. If the stone is not obstructing and the patient tolerates clamping of the T-tube, keep the tube clamped. Prescribe a choleretic such as Decholin to dilute the bile. Otherwise, have the patient inject 30–60 ml of sterile saline into the T-tube daily. Ask the patient to return to the hospital about 6 weeks following operation.

Subsequent Postoperative Treatment. When the patient returns for examination 6 weeks after the operation, repeat the T-tube cholangiography to confirm the persistence of the residual stone because in a number of cases the calculus spontaneously passes into the duodenum. The simplest, safest method for extracting residual calculi is that described by Burhenne. With this method it is necessary that the long arm of the T-tube be at least the size of a 14–16 F catheter. After cholangiography is completed and confirms the presence of stones, remove the T-tube and insert a flexible catheter that can be manipulated, such as the one available from Medi-Tech. With a continuous flow of contrast medium through the catheter, insert the device down the T-tube track until the CBD has been entered. Then, directing the tip of the catheter toward the calculus, insert a Dormia stone basket device through the Medi-Tech catheter. Under fluoroscopic control, trap the stone in the stone basket and withdraw the basket, the stone, and the catheter through the T-tube track. Experienced radiologists such as Burhenne have reported a success rate better than 90 % with this technique. If the stone is quite large, it may not fit into the T-tube track. Large stones are not commonly left behind by competent surgeons, so almost all residual stones can be removed by this technique. It is even possible to cannulate the right and the left hepatic ducts to remove stones. Another method for accomplishing the same end is to pass a flexible fiberoptic choledochoscope into the CBD via the T-tube track.

If these methods have failed, endoscopic papillotomy by ERCP should be tried *if an expert is available*. Experience endoscopists have reported performing ERCP-papillotomy and extraction of retained stones with 1–2 % mortality. If expertise with this technique is not available, a stone blocking the flow of bile to the CBD requires relaparotomy and choledochotomy for removal. A CBD stone that is not symptomatic when the T-tube is clamped presents a more difficult problem. Some surgeons elect to remove the T-tube, continue to observe the patient, and reserve reoperation for patients who later become symptomatic. Alternatively, it may well be argued that it is safer to perform an elective operation to remove the stone than an urgent procedure in the presence of cholangitis. In most cases elective choledocholithotomy is indicated (see Chap. 81).

Further Reading

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Secondary Choledocholithotomy: Surgical Legacy Technique

81

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Retained or recurrent common bile duct (CBD) stones subsequent to previous cholecystectomy that cannot be removed by endoscopic retrograde cholangiopancreatography (ERCP).

This approach is also used when reconstructive biliary tract surgery is required. In such cases, it must be adapted to the known anatomy and previous procedure performed (see Chap. 80).

Preoperative Preparation

Generally, ultrasonography has demonstrated ductal dilatation and may show CBD stones.

Most retained stones are currently extracted endoscopically. It is only the failed cases that come to surgery. If ERCP was performed, these films can help guide the surgical approach.

Computed tomography (CT) of the abdomen is often performed to exclude other causes of jaundice, such as pancreatic cancer.

Obtain a copy of the operative report and any cholangiograms, as for any reoperative surgery.

Give vitamin K if necessary to restore the prothrombin time to normal.

Perform routine measures to prepare a patient for major surgery.

Perioperative antibiotics are indicated.

Pitfalls and Danger Points

Trauma to adherent duodenum, colon, or liver

Trauma to CBD hepatic artery or the portal vein

Operative Strategy

If the patient's first operation was not followed by any significant collection of bile, blood, or pus in the right upper quadrant, secondary choledocholithotomy is not generally a difficult dissection. On the other hand, occasionally the right upper quadrant is obliterated by dense adhesions requiring a carefully planned sequential dissection. First, dissect the peritoneum of the anterior abdominal wall completely free from underlying adhesions. Carry this dissection to the right as far as the posterior axillary line, which exposes the lateral portion of the right lobe of the liver and the hepatic flexure of the colon.

The strategy now is to free the inferior surface of the liver from adherent colon and duodenum. Approach this from the lateral edge of the liver and proceed medially. After 3–6 cm of the undersurface of the lateral portion of the liver has been exposed, start to dissect the omentum and colon away from the anterior border of the undersurface of the liver. The dissection now goes from lateral to medial and from anterior to posterior. If this dissection becomes difficult and there is a risk of perforating the duodenum or colon, enter the right paracolic gutter and incise the paracolic peritoneum at the hepatic flexure. Placing the left hand behind the colon gives the surgeon entry into a virgin portion of the abdomen, which aids in freeing the colon from the liver. The maneuver uncovers the descending portion of duodenum, also in virgin territory. Perform a Kocher maneuver and bring the left hand behind the duodenum, which helps guide the dissection toward the CBD. If the foramen of Winslow is accessible at this point, inserting the finger into this foramen permits palpation of the hepatic artery with the thumb against the forefinger. The CBD can be found to the right of the pulsation of the hepatic artery.

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Now, resume the lateral to medial and anterior to posterior dissection until the undersurface of the liver has been cleared down to the CBD and the hepatic artery. It is not necessary to free the undersurface of the liver for a large area medial to the CBD for adequate exposure.

Documentation Basics

- Findings
- Cholangiogram

Operative Technique

Incision

Use a subcostal incision (see Chap. 77) if the previous operation was performed laparoscopically. If the patient has had a previous open subcostal incision, we prefer a long vertical midline incision. If the patient has previously been operated on through a vertical incision, a long subcostal incision, about two fingerbreadths below the costal margin, is preferred. Placing the incision at a site away from the previous operative field makes it easier for the surgeon to enter the abdominal cavity expeditiously. Once the peritoneum and falciform ligament have been identified, free the abdominal wall from all underlying adhesions over the entire right side of the upper abdomen.

Freeing Subhepatic Adhesions

In the usual case, initiate the dissection on the right lateral edge of the liver, clearing its undersurface from right to left. If this dissection goes easily, it may be a simple matter to use Metzenbaum scissors to divide filmy adhesions by the techniques described in Chap. 44. When it is difficult to differentiate colon or duodenum from scar tissue, identify the ascending colon in the right gutter. Incise the parabolic peritoneum and slide the left hand behind the ascending colon. Liberate the hepatic flexure up to the undersurface of the liver, and then free the colon from the liver.

If similar difficulties are encountered when identifying or dissecting the duodenum, perform a Kocher maneuver and slide the left hand behind the duodenum, dissecting this organ away from the renal fascia, vena cava, and aorta. Now start dissecting the omentum, colon, and duodenum from the undersurface of the liver, going from anterior to posterior until the hepatoduodenal ligament has been reached. Confirm the identity of the hepatoduodenal ligament by inserting the left index finger into the foramen of Winslow and palpating the hepatic artery, which should be just to the left of the CBD. Confirm the position of the CBD, if necessary, by aspirating bile with a 25-gauge needle and syringe.

Exploring the CBD

After the CBD has been identified, a cholangiogram may be obtained by inserting a 21-gauge scalp vein needle into the duct and starting cholangiography. The technique for CBD exploration is no different from that described in Chap. 80. Choledochoscopy and postexploratory cholangiography should be included in the operative procedure.

Draining the CBD

Insert a 16 F T-tube trimmed as in Fig. 80.5a, b, and close the choledochotomy with 5-0 Vicryl sutures, continuous or interrupted. The indications for sphincteroplasty or biliary-intestinal bypass are discussed in Chap. 82. That the common duct is thick walled or dilated does not itself constitute an indication for additional surgery other than choledocholithotomy. The abdomen is drained and closed as in Chap. 80. Postoperative care and complications are similar to those discussed in Chap. 80.

Sphincteroplasty: Surgical Legacy Technique

82

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Failed previous surgery for common bile duct (CBD) stasis with sludge, primary, or recurrent stones
Doubt that all CBD stones have been removed; hepatic duct stones that cannot be removed
Ampullary or pancreatic duct orifice stenosis with recurrent pain or pancreatitis (rare)

Preoperative Preparation

Perioperative antibiotics
Vitamin K in the jaundiced patient
Endoscopic retrograde cholangiopancreatography (ERCP) to identify CBD calculi or ampullary stenosis and to visualize the pancreatic duct

Pitfalls and Danger Points

Trauma to the pancreatic duct or pancreas resulting in postoperative pancreatitis
Postoperative duodenal fistula secondary to a leak from sphincteroplasty or duodenotomy suture line
Postoperative hemorrhage

Operative Strategy

Protecting the Pancreatic Duct

Make the incision in the ampulla on its superior wall at about 10 or 11 o'clock. After making the initial incision about 5–6 mm in length, locate the orifice of the pancreatic duct. In 80 % of cases, it can be identified at about 5 o'clock where it enters the ampulla just proximal to the ampulla's termination. Wearing telescopic lenses with a magnification of about 2.5× for this operation helps a great deal. If the orifice of the pancreatic duct cannot be identified, inject secretion to stimulate flow of the watery pancreatic secretion and facilitate identification of the ductal orifice. Insert a lacrimal probe or a No. 2 Bakes dilator into the orifice to confirm that it is indeed the pancreatic duct. Some surgeons prefer to insert a 6 F or 8 F pediatric feeding tube into the duct to protect it while suturing the sphincteroplasty. We agree with Jones that keeping a tube in the duct is not necessary if one keeps the ductal orifice in view during the suturing process.

When the indication for sphincteroplasty is ampullary stenosis, abdominal pain, or recurrent pancreatitis, it is essential to add a "ductoplasty" of the pancreatic ductal orifice by incising the septum that forms the common wall between the distal pancreatic duct and the ampulla of Vater. After the pancreatic duct's orifice has been enlarged, it should freely admit a No. 3 Bakes dilator.

Preventing Hemorrhage

The long sphincterotomy incision used for sphincteroplasty cuts across the anterior wall of the distal CBD and the back wall of the duodenum for a distance of 1.5–2.0 cm. This "blind" incision may lacerate an anomalous retroduodenal or an anomalous right hepatic artery arising from the superior mesenteric artery and crossing in this region. It is important

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to *palpate the area behind the ampulla to detect pulsation of an anomalous artery*. If such a vessel is behind the ampulla, sphincteroplasty by the usual technique may be contraindicated. We are aware, by anecdote, of two patients who died subsequent to a classic sphincteroplasty by the Jones technique owing to massive postoperative hemorrhage despite reexploration. In one case, autopsy demonstrated laceration of an anomalous right hepatic artery. The laceration had apparently been temporarily controlled by the 5-0 interrupted silk sutures that had been used to fashion the sphincteroplasty.

Using Jones's technique, initially small straight hemostats grasp 3–4 mm of tissue on either side of the contemplated ampullary incision. The tissue between the hemostats is then divided. Next, a 5-0 silk suture is inserted behind each of the two hemostats, and two additional hemostats are inserted. The sphincterotomy incision is lengthened, and silk sutures again are placed behind each hemostat. In this way it is possible to divide a large anomalous vessel partially and achieve temporary control, first by the hemostat and then by the 5-0 silk suture. During the postoperative period, the artery may escape from the 5-0 stitch, and serious hemorrhage may follow. Although hemorrhage is a rare complication, it appears prudent to omit this prior application of hemostats. By first making a 3- to 4-mm incision with Potts scissors, one should become immediately aware of any laceration of a major vessel at a time when proper reparative measures can be effectively undertaken. Otherwise, inflammation that occurs 5–6 days after the operation may make accurate identification of the anatomy difficult during any relaparotomy for hemorrhage. For this reason, we recommend making the incision first for a short distance, next inserting sutures, then lengthening the incision, and inserting additional sutures sequentially until the proper size sphincteroplasty has been achieved.

Avoiding Duodenal Fistula

Leakage from the duodenum can occur from the apex of the sphincteroplasty because at this point the CBD and duodenum no longer share a wall. Here accurate suturing is necessary to reapproximate the incised CBD to the back wall of the duodenum.

A second potential source of leakage is the suture line closing the duodenotomy. A longitudinal duodenotomy is preferred because it may be extended in either direction if the situation requires more exposure. Close this longitudinal incision in the same direction in which the incision was originally made. Otherwise, distortion of the duodenum takes place, and linear tension on the suture line may impair successful healing. Precise insertion of sutures, one layer in the mucosa and another in the seromuscular layer, can be accomplished without narrowing the duodenum. Leaks from incisions in the second portion of the duodenum cause serious if not lethal consequences; therefore, take special care when resuturing the duodenotomy incision.

Documentation Basics

- Findings
- Identification of pancreatic duct
- Procedure on pancreatic duct?

Operative Technique

Incision and Exploration

Make a long right subcostal or midline incision, free any adhesions, and perform a routine abdominal exploration. If satisfactory preoperative ERCP has not been accomplished, perform cholangiography.

Kocher Maneuver

Perform a complete Kocher maneuver and gently elevate the duodenum up almost to the level of the anterior abdominal wall, facilitating exposure of the ampulla (see Figs. 89.2 and 89.3). Place the left hand behind the head of the pancreas and elevate it from the flimsy attachments to the vena cava and posterior abdominal wall. Place a gauze pack behind the pancreatic head.

CBD Exploration

Make an incision in the anterior wall of the CBD as close to the duodenum as possible because, if for some reason sphincteroplasty is not feasible, it may prove desirable to perform a choledochoduodenostomy. For the latter operation, an incision in the distal portion of the CBD allows the surgeon to make an anastomosis to the duodenum under less tension than an incision made at a higher level. If CBD exploration for calculi is indicated, follow the procedure described in Chap. 80. Then pass a No. 4 Bakes dilator into the CBD down to, but not through, the ampulla of Vater. Palpating the tip of the dilator through the anterior duodenal wall facilitates placement of the duodenal incision accurately with reference to the location of the ampulla.

Duodenotomy and Sphincterotomy

Make a 4-cm scalpel incision along the antimesenteric border of the duodenum (Fig. 82.1). Center this incision

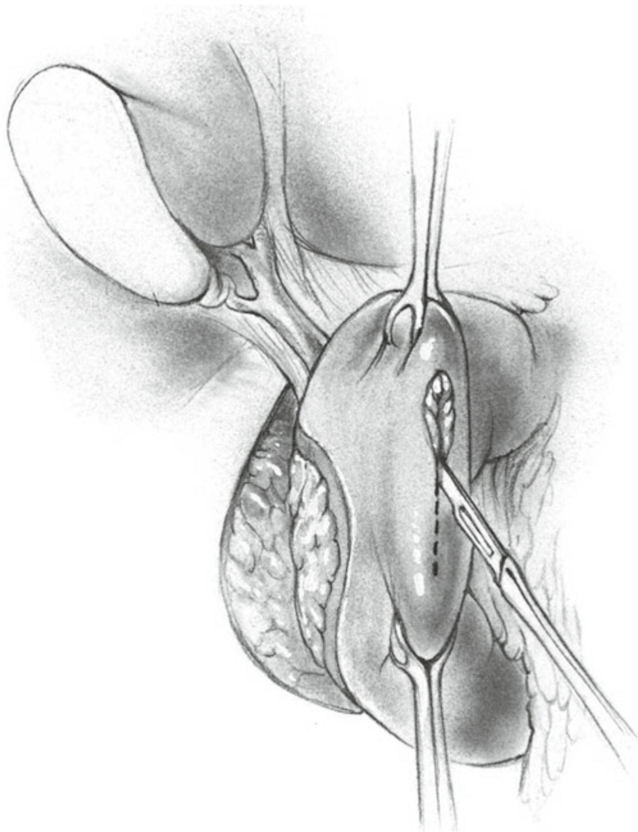

Fig. 82.1

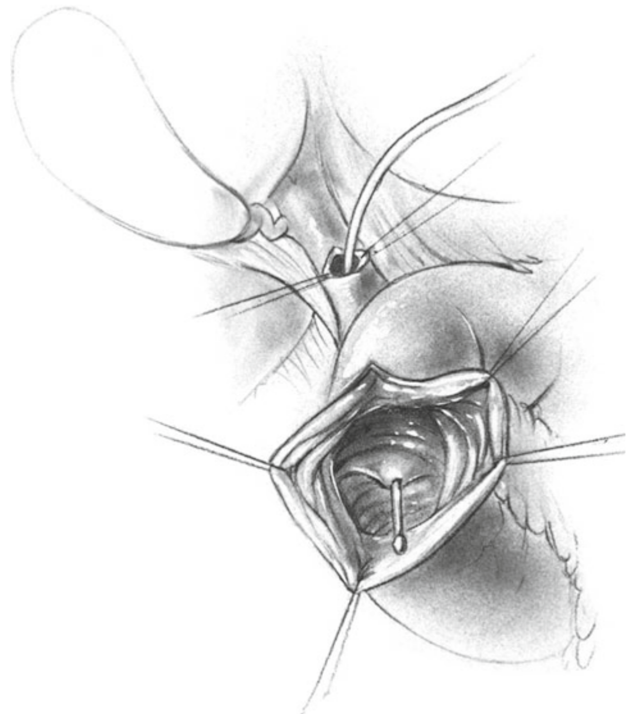

Fig. 82.2

at the estimated location of the ampulla, as judged by palpating the tip of the Bakes dilator (Fig. 82.2). Control bleeding points by careful electrocoagulation and an occasional 5-0 PG suture. Achieve exposure of the ampulla by inserting appropriately sized Richardson retractors at the proximal and distal extremities of the duodenal incision.

Make a 5-mm incision at 10 or 11 o'clock along the anterior wall of the ampulla using a scalpel blade against the large Bakes dilator impacted in the ampulla or Potts scissors with one blade inside the ampulla (Fig. 82.3). Insert one or two 5-0 Vicryl sutures on each side of the partially incised ampulla (Fig. 82.4). Place small hemostats on the tails of the tied sutures and use them to apply gentle traction.

Identify the orifice of the pancreatic duct, which enters the back wall of the ampulla at about 5 o'clock near its termination. If the exposure of this portion of the ampulla is inadequate, extend the sphincterotomy by another 3–4 mm and insert an additional suture on each side. If the ductal orifice still has not been located, inject secretin (1 unit/kg body weight) intravenously to stimulate the flow of pancreatic juice into the duodenum. Verify the location of the ductal orifice by inserting either a lacrimal probe or a No. 2 Bakes dilator. Then make a mental note to avoid traumatizing this

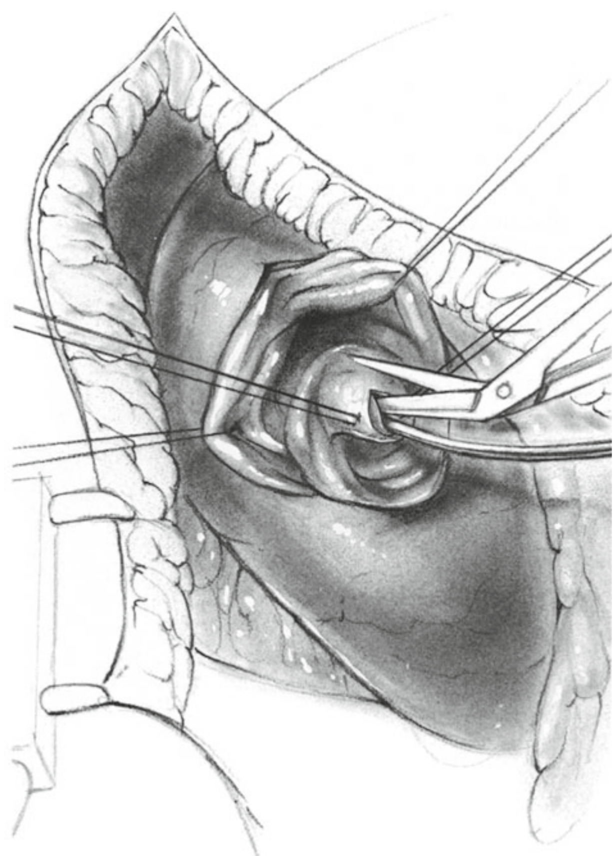

Fig. 82.3

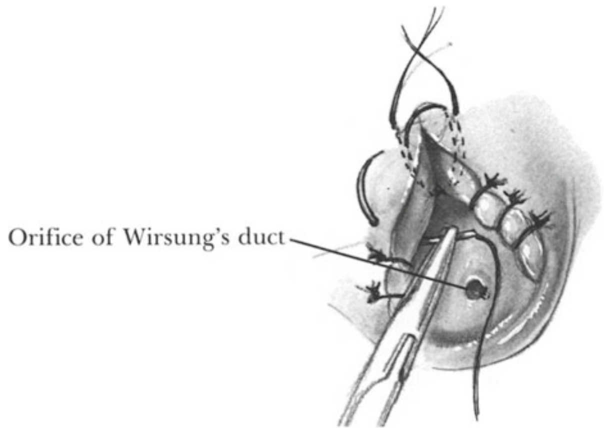

Fig. 82.4

area by inaccurate dissecting or suturing. Continue the sequence of incising the ampulla for about 3 mm at a time and inserting interrupted sutures (Fig. 82.5). To incise the entire sphincter of Oddi, the sphincterotomy must be almost 2 cm in length. Additionally, if residual calculi are possible and the CBD is large, the length of the sphincterotomy incision should at least equal the diameter of the CBD. Biopsy any area suspicious for cancer and obtain a frozen section evaluation.

It is important to insert a figure-of-eight suture at the apex of the sphincterotomy to minimize the possibility of leakage. Carefully inspect the sutures at the conclusion of this step. They should be close together, and bleeding should be completely controlled.

When the indication for sphincteroplasty is recurrent pancreatitis or recurrent abdominal pain, pancreatography is a vital part of the operation unless this step has been done preoperatively by means of ERCP. Insert a suitable plastic tube such as an angiocath or a ureteral or small whistle-tip rubber catheter into the pancreatic duct. Use only 2–3 ml of diluted Conray or Hypaque and make the injection without pressure. Most patients with chronic recurrent pancreatitis have multiple areas of narrowing and dilatation of the pancreatic duct, making sphincteroplasty a useless therapeutic procedure. If the pancreatic duct is dilated and the ductal orifice is narrowed so it does not admit a No. 3 Bakes dilator, enlarging this orifice by ductoplasty may prove beneficial, although this combination of conditions occurs only rarely.

Ductoplasty for Stenosis of the Pancreatic Duct Orifice

Magnify the orifice of the pancreatic duct by wearing telescopic lenses. Insert Potts scissors into the pancreatic duct orifice and incise the septum, which constitutes the common wall between the anterior surface of the pancreatic duct and the posterior wall of the ampulla. Sometimes the orifice is too narrow to admit the blade of the Potts scissors. In that case, insert a metal probe into the ductal orifice and cut the anterior wall of the duct by incising for 3–4 mm using a scalpel against the metal of the probe. Then complete the incision with Potts scissors. Generally, an 8- to 10-mm incision permits easy passage of a No. 3 Bakes dilator into the pancreatic duct.

Insert several 3-0 PG sutures to maintain the approximation of the pancreatic duct to the mucosa of the ampulla (Fig. 82.5). We do not insert any type of stent through the pancreatic ductoplasty.

Closing the Duodenotomy

Close the duodenal incision longitudinally in two layers by the usual method of inverting the mucosa with a continuous Connell, Cushing, or seromucosal suture. Close the seromuscular layer by carefully inserting interrupted 4-0 silk Lembert sutures.

When the diameter of the duodenum appears narrower than usual, include only the protruding mucosa in the first layer; make no attempt to invert the serosa with this suture line. For the second layer, insert interrupted Lembert sutures that take small, accurate bites of the seromuscular coat, including submucosa. If this is done with precision, closing the longitudinal incision does not narrow the duodenum. Cover the duodenotomy with omentum.

Cholecystectomy

If the gallbladder has not been removed at a previous operation, a sphincteroplasty produces increased stasis of gallbladder bile, which may lead to stone formation. Consequently, perform a cholecystectomy.

Abdominal Closure and Drainage

After irrigating the operative site and the incision with a dilute antibiotic solution, drain the area of the sphincteroplasty with a closed-suction plastic catheter (4–5 mm diameter) brought out through a puncture wound in the upper abdomen. Be careful to avoid contact between the catheter and the duodenal suture lines. Suture the tip of the catheter in the proper location with fine catgut.

Place an indwelling 14 F T-tube into the CBD for drainage and close the CBD around the T-tube using a 5-0 PG suture. Then close the abdominal wall in the usual fashion.

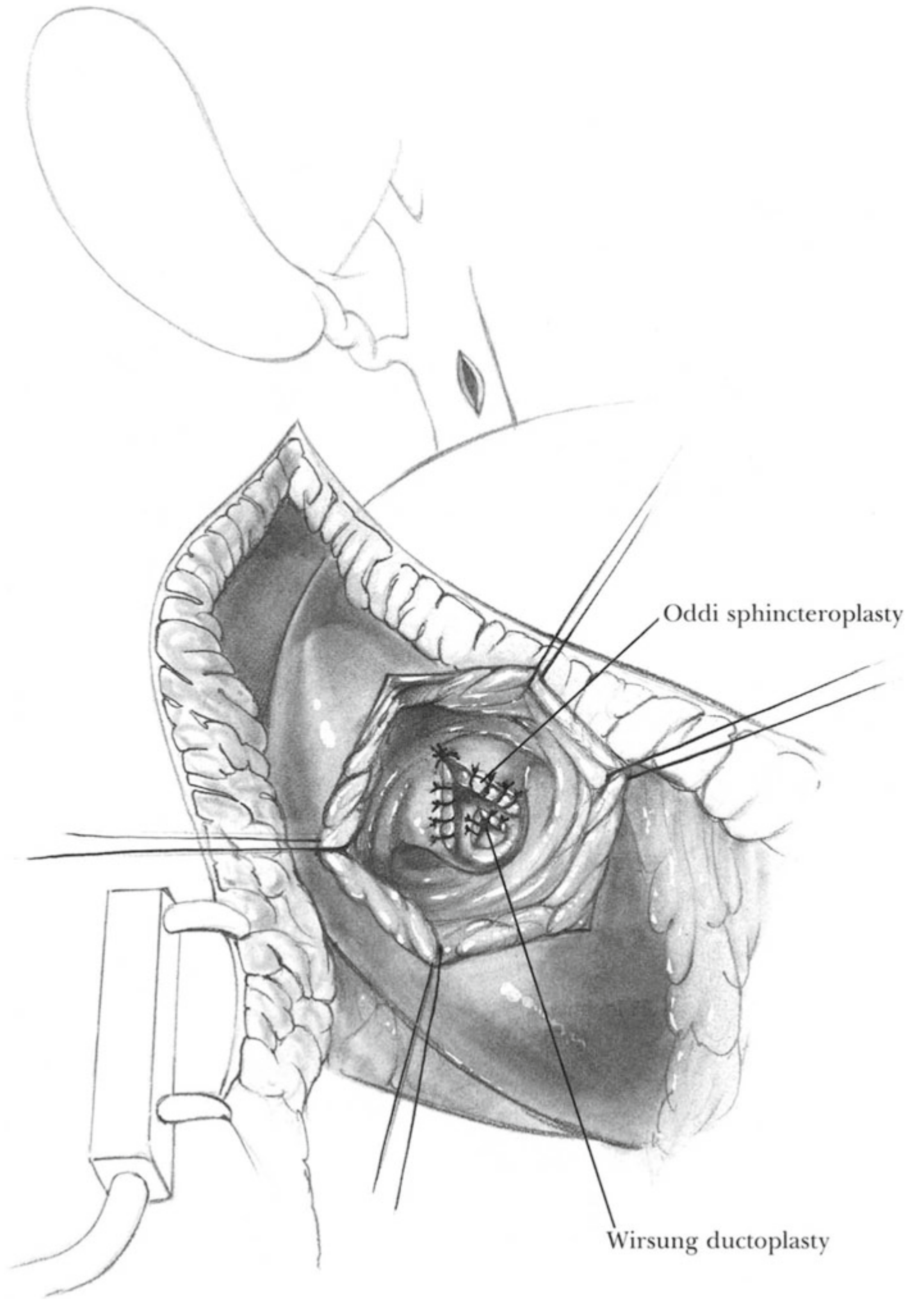

Fig. 82.5

Postoperative Care

Continue nasogastric suction for a few days or until evidence of peristalsis is present with the passage of flatus.

Monitor the serum amylase level every 2 days.

Continue perioperative antibiotics for 24 h. If the bile is infected, continue the antibiotics for 7 days.

Perform cholangiography on the 7th postoperative day and remove the T-tube on the 14th postoperative day if the radiograph shows satisfactory flow into the duodenum without leakage.

Remove the closed-suction drain by the 7th postoperative day unless there is bilious or duodenal drainage.

Complications

Duodenal Fistula. A suspected duodenal fistula can often be confirmed by giving the patient methylene blue dye by mouth and looking for the blue dye in the closed-suction catheter or by performing T-tube cholangiography. For minor duodenal fistulas where there is neither significant systemic toxicity nor abdominal tenderness, it is possible that a small leak will heal when managed by continuing the closed-suction drainage supplemented by systemic antibiotics and intravenous alimentation.

A major *leak* from the duodenum is a life-threatening complication. If systemic toxicity is not controlled by conservative management, relaparotomy is indicated. Resuturing the duodenum generally fails because of the local inflammation. In this situation, insert a sump-suction catheter into the duodenal fistula. Isolate the fistula by performing a Billroth II gastrectomy with vagotomy. Divert the bile from the duodenum by dividing the CBD and anastomosing the proximal cut end of the duct to a Roux-en-Y segment of jejunum so bile drains into the efferent limb of the jejunum distal to the gastrojejunostomy.

Further Reading

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83 Choledochoduodenostomy: Surgical Legacy Technique

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Common bile duct (CBD) stasis with sludge or primary or recurrent stones (only if the bile duct is more than 1.5 cm in diameter)

Doubt that all CBD stones have been removed (only if CBD is >1.5 cm in diameter)

Constriction of distal CBD because of chronic pancreatitis as an alternative to stenting or to Roux-en-Y bypass (see Chap. 84)

Contraindications

CBD diameter <1.5 cm

Acute inflammation or excessive fibrosis in duodenal wall

Carcinoma of the pancreatic head when stenting is not successful (hepaticojejunostomy Roux-en-Y is our preferred bypass procedure for pancreatic carcinoma obstructing the CBD. It is a safer operation, and the anastomosis is not obstructed by the advancing growth of the malignancy.)

Preoperative Preparation

Perioperative antibiotics

Vitamin K in jaundiced patients

Nasogastric tube

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Pitfalls and Danger Points

Anastomotic stoma too small, resulting in postoperative recurrent cholangitis

Diameter of CBD too small

Anastomotic leak, duodenal fistula

Postoperative "sump" syndrome in which debris accumulates in the distal common duct

Operative Strategy

Size of Anastomotic Stoma

As the anastomotic stoma after choledochoduodenostomy permits passage of food from the duodenum into the CBD, it is important that the anastomosis be large enough to permit the food to pass back freely into the duodenum. Otherwise, food particles partially obstruct the anastomotic stoma and produce recurrent cholangitis. If the surgeon constructs an anastomosis with a stoma 2.5 cm or more in diameter, postoperative cholangitis is rare. The size of the stoma may be estimated postoperatively by an upper gastrointestinal barium radiographic study.

Obviously, if the diameter of the CBD is small, a large anastomotic stoma is difficult to achieve. Transduodenal sphincteroplasty (see Chap. 82) is a surgical better option for the patient with a small CBD.

Location of the Anastomosis

There are several alternative locations for incisions in the CBD and duodenum. If postoperative anastomotic leakage is to be prevented, it is vitally important that these incisions be made in tissues of satisfactory quality and that there be no tension on the anastomosis.

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A problem occurs when the surgeon has made one incision in the CBD in the vicinity of the cystic duct for the CBD exploration and a second (duodenal) incision opposite the ampulla for an impacted ampullary calculus. Under these conditions, even with an extensive Kocher maneuver, it may not be possible to approximate these two incisions by suturing because there is too much tension on the anastomosis. In this situation a Roux-en-Y choledochojejunostomy or a sphincteroplasty is preferable. When the possibility of a choledochoduodenostomy is anticipated prior to the CBD exploration, make the incision in the CBD near the point where it enters the sulcus between the pancreas and the duodenum. This facilitates constructing the anastomosis described in this chapter.

When the incision in the CBD has been made in a more proximal location, test the mobility of the duodenum after performing a Kocher maneuver. If the duodenum is easily elevated to the region of the CBD incision, a choledochoduodenostomy by the method illustrated below in Alternative Method of Anastomosis, is acceptable. There must be no tension on the anastomosis.

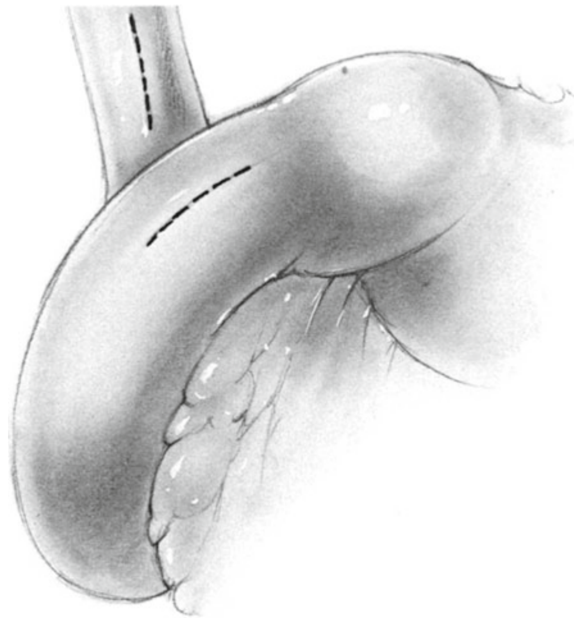

Fig. 83.1

Preventing the Sump Syndrome

Sporadic reports have appeared describing the accumulation of food debris or calculi in the terminal portion of the CBD following choledochoduodenostomy. Such an accumulation produces intermittent cholangitis and has been called the "sump syndrome." Several techniques have been advocated to prevent it. All are more complex than the technique described here.

In the simplest variation, the CBD is divided and the distal portion oversewn. The proximal portion is anastomosed to the duodenum to create an end-to-side, rather than a side-to-side, choledochoduodenostomy. Alternatively, the proximal CBD may be anastomosed to a Roux-en-Y limb of jejunum. This construction completely prevents food from entering the CBD and provides the lowest incidence of sump syndrome.

Documentation Basics

- Findings
- End-to-side versus side-to-side anastomosis

Operative Technique

Incision

A right subcostal or a midline incision from the xiphoid to a point 5 cm below the umbilicus is suitable for this operation. Divide any adhesions and explore the abdomen. Perform a complete Kocher maneuver. If the diameter of the CBD is less than 1.5 cm, do *not* perform a choledochoduodenostomy.

Choledochoduodenal Anastomosis

Free the peritoneum over the distal CBD. Make an incision on the anterior wall of the CBD for a distance of at least 2.5 cm. This incision should terminate close to the point where the duodenum crosses the distal CBD. Make another incision of equal size along the long axis of the duodenum at a point close to the CBD (Fig. 83.1). Insert the index finger into the duodenum and palpate the ampulla of Vater to be certain a carcinoma of the ampulla has not been overlooked.

Place guy sutures at the midpoints of the lateral and medial margins of the CBD incision. Apply traction to these guy sutures in opposite directions to open up the choledochotomy incision (Fig. 83.2). One layer of interrupted 4-0 Vicryl sutures is used for this anastomosis. Insert the first stitch of the posterior layer approximating the midpoint of the duodenal incision to the distal margin of the choledochotomy. Tie the stitch with the knot inside the lumen. Insert additional stitches that go through the full thickness of the duodenum and the CBD (Fig. 83.3) until the entire posterior layer has been completed. Cut all of the sutures except the most lateral and most medial stitches. Approximate the proximal margin of the choledochotomy with the same suture material to the midpoint of the anterior layer of the duodenum and tie this stitch so it inverts

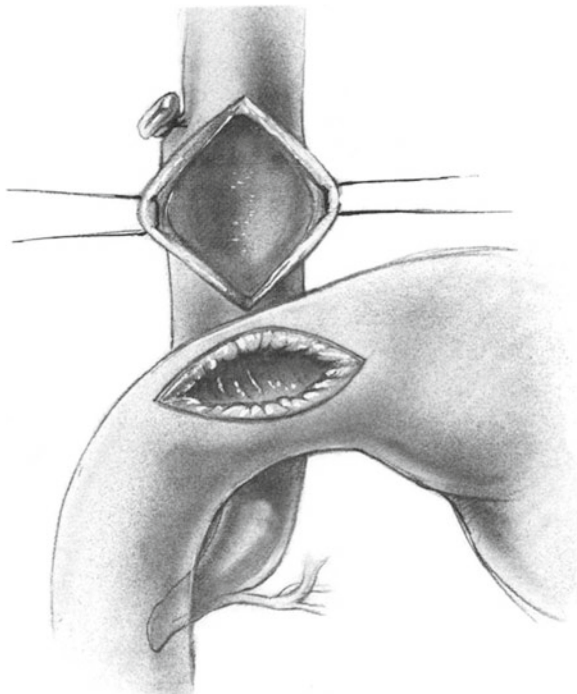

Fig. 83.2

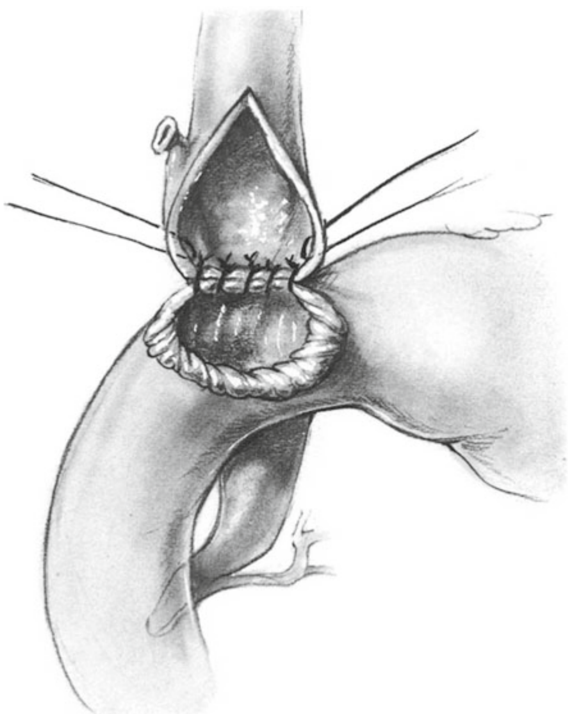

Fig. 83.3

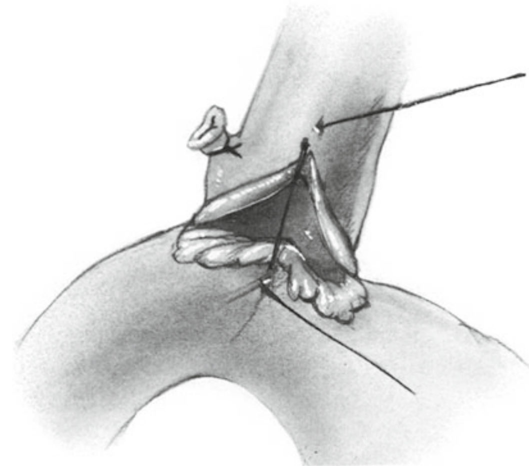

Fig. 83.4

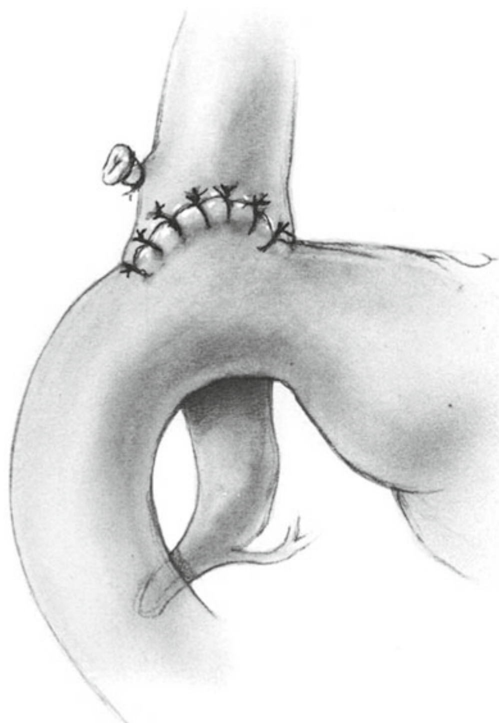

Fig. 83.5

the mucosa of the duodenum (Fig. 83.4). Continue to insert interrupted through-and-through sutures until the anterior layer has been completed (Fig. 83.5). This anastomosis should be completed without tension.

Alternative Method of Anastomosis

In some cases, the surgeon elects to perform a choledochoduodenal anastomosis after making a choledochotomy incision in a location too far proximal on the CBD to accomplish the anastomosis by the above technique. In this case, enlarge the choledochotomy so it measures at least 2.5 cm in length.

Next, perform a thorough Kocher maneuver to increase the mobility of the duodenum. Then move the duodenum toward the choledochotomy incision and determine which

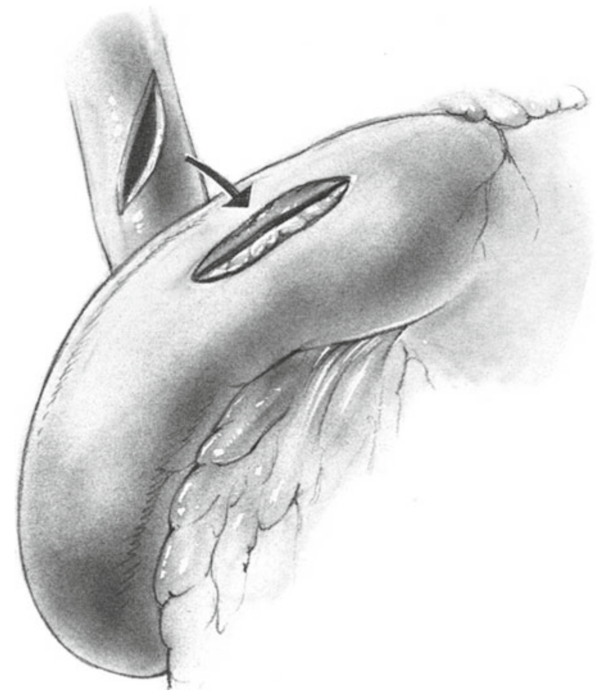

Fig. 83.6

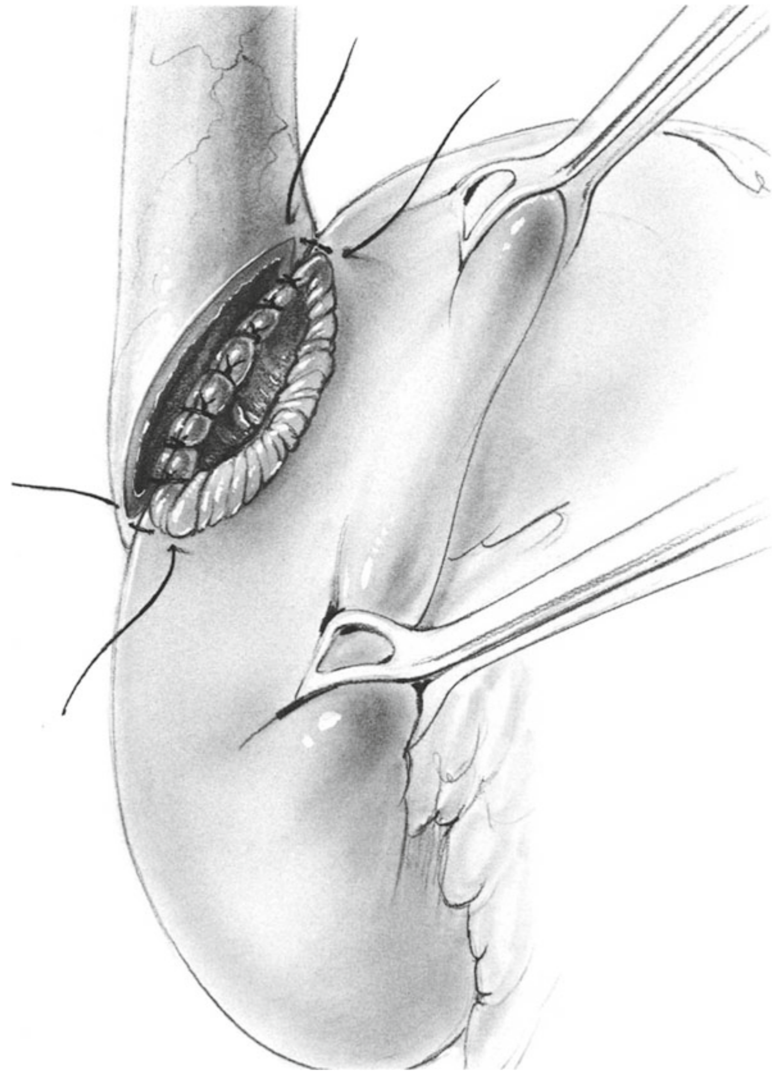

Fig. 83.7

portion of the duodenum is most suitable for a side-to-side anastomosis *without tension*. If tension cannot be avoided, perform a Roux-en-Y anastomosis.

Make an incision in the duodenum parallel to the choledochotomy and approximately equal in length (Fig. 83.6). Approximate the posterior layer with interrupted sutures and tie them (Fig. 83.7), with the knots inside the lumen. Leave the tails of the most cephalad and most distal sutures long, but cut all other sutures. Bisect the anterior layer of the anastomosis and insert a 4-0 PG Lembert suture to approximate the midpoint of the CBD incision to the midpoint of the duodenal incision. Tie this suture so the duodenal mucosa is inverted. Insert additional sutures of the same type to complete the approximation. The knots are on the outside surface of the anastomosis for the anterior layer. Because the CBD is quite large in these cases and the duodenal wall is free of pathology, no T-tube or other stent is necessary.

Drainage and Closure

As bile has an extremely low surface tension, there is a tendency for a small amount of this substance to leak out along the suture holes during the first day or two following a biliary tract anastomosis. For this reason, insert a closed-suction drainage catheter through a puncture wound in the right upper quadrant and bring the catheter to the general vicinity of the anastomosis.

Postoperative Care

Continue nasogastric suction if necessary.
Leave the closed-suction drain in place for 5–7 days.

Complications

Duodenal fistula (see Chap. 82)
Subhepatic abscess
Late development of cholangitis owing to the anastomotic stoma being too small
Late development of “sump” syndrome

Further Reading

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Roux-en-Y Biliary-Enteric Bypass

84

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Biliary reconstruction after major ductal injury
Common bile duct obstruction due to nonresectable tumor, chronic pancreatitis, or surgical trauma

Preoperative Preparation

Perioperative antibiotics
Vitamin K in jaundiced patients

Pitfalls and Danger Points

Devascularizing the jejunal segment by inaccurate division of the mesentery
Anastomotic leak or stricture

Operative Strategy

Choice of Bypass

An isoperistaltic Roux-en-Y segment of jejunum provides a safe way to drain the extrahepatic biliary tract. There are several ways to construct the anastomosis to the bile duct. Side-to-end or side-to-side choledochojejunostomy are equivalent and has the advantage of simplicity. Circumferential dissection of the common bile duct (CBD) is not required, and an anastomosis is rapidly constructed between the side of the CBD and the Roux limb of jejunum. Either the end of the Roux limb (please see section below on Side-to-end Choledochojejunostomy or Hepaticojejunostomy) or the side may be used. Because the mesentery of the jejunum tethers the Roux loop, the loop tends to curl in such a manner that the antimesenteric border lies comfortably in opposition to the CBD. This type of anastomosis is commonly performed for palliation of carcinoma of the pancreas, when endoscopic stenting fails or is not technically feasible.

End-to-side or end-to-end choledochojejunostomy eliminates the blind segment of distal CBD and the potential for debris, food, and calculi to accumulate, causing the sump syndrome. It requires circumferential dissection of the CBD. The anastomosis is commonly performed for operative strictures or injuries.

Preserving Vascular Supply to the Jejunal Loop

Creating a Roux-en-Y loop requires precise division of the jejunal mesentery to preserve the blood supply to both segments of jejunum. In most cases, the marginal artery of the jejunum is divided immediately distal to the artery supplying the second arcade. By dividing only one or two additional arcade vessels, sufficient jejunum can be mobilized to reach the hepatic duct without tension. The jejunum is passed through an incision in the avascular portion of the transverse mesocolon, generally to the right of the middle colic artery. This dissection must be done carefully and is facilitated by transilluminating the jejunal mesentery by means of a spotlight or a sterilized fiberoptic illuminator.

Create the Roux limb early, as soon as it is decided to proceed with this bypass. Then wrap both ends in a moist laparotomy pad and return them to the abdomen. This allows time for any ischemic regions to manifest. If the end of either segment turns dusky, resect the darkened portion back to pink, bleeding intestine.

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When a Roux-en-Y biliary-intestinal bypass is performed for carcinoma of the pancreas, carefully evaluate the root of the small bowel mesentery before dividing it. Some pancreatic tumors extend deeply into this mesentery, making it impossible to separate the jejunal blood supply for the Roux-en-Y segment. This operation is contraindicated in these few cases, and some other type of bypass must be considered. Under these conditions, anastomosing the gallbladder to the side of a loop of jejunum may prove adequate palliation for the short life expectancy of these patients. Many of these patients are better managed by endoscopic biliary stents rather than operative bypass.

Documentation Basics

- Findings
- Level of anastomosis (common duct versus hepatic ducts)
- Nature of anastomosis

Operative Technique

Incision and Biopsy

If there has been a previous operation on the biliary tract that utilized a subcostal incision, make a long midline incision. If the previous incision was vertical, make a long subcostal incision and enter the abdomen. In secondary cases, the first effort is to free the peritoneum of the anterior abdominal wall from all its underlying adhesions as far lateral as the midaxillary line. Then continue to free the structures as described in Chap. 81.

With primary operations for carcinoma of the pancreas, make a long midline incision from the xiphoid to a point 6–7 cm below the umbilicus. This incision is good for a bypass or for partial or total pancreatectomy. Conduct the usual exploration to arrive at an accurate diagnosis. In patients with inoperable pancreatic carcinoma, take biopsy specimens from areas of obvious carcinoma with a scalpel or biopsy a metastatic lymph node. When these steps are not possible, we have generally been successful in confirming the diagnosis of carcinoma by inserting a syringe with a 22-gauge needle into the hardest part of the pancreas. As soon as the needle enters the suspicious area, apply suction and plunge the needle for 1 cm distances in two directions. Then release the plunger of the syringe so no further suction is being applied. Remove the syringe and the needle. Pass it promptly to the cytopathologist, as *immediate* fixation is necessary for an accurate cytologic diagnosis. This method has provided us with a higher percentage of positive diagnoses of carcinoma of the pancreas than the tissue techniques. The cytologist's report should not take more than 10–15 min.

Which Type of Bypass?

For carcinoma of the pancreas, evaluate the local extent of disease and its probable future encroachment on the common duct, cystic duct, and root of the jejunal mesentery. If extensive disease limits access to the common duct or involves the root of the mesentery, a dilated Courvoisier gallbladder may be simply anastomosed to an omega loop of jejunum. Ascertain that the cystic duct-common duct juncture is high enough above the tumor that this bypass remains patent.

If access to the common duct is good, a choledochojejunostomy or hepaticojejunostomy is preferred. Remove the gallbladder, if present. This accomplishes two things: It significantly improves access to the CBD, and it prevents subsequent cholecystitis due to bile stasis and bacterial contamination. A cholangiogram, obtained through the cystic duct, may help operative planning and is easy to obtain. With operations performed for stricture, the site of the stricture determines the level of the anastomosis.

Creating the Roux-en-Y Jejunal Limb

Once it is decided to proceed with a Roux-en-Y bypass, divide the jejunum and its mesentery. Inspect the proximal jejunal mesentery and look for the first two branches from the superior mesenteric artery to the jejunum just beyond the ligament of Treitz. Identify the marginal artery at a point 2 cm beyond its junction with the second jejunal branch, which is generally about 15 cm from the ligament of Treitz. Make a light scalpel incision over the jejunal mesentery from the jejunum across the marginal artery and into the avascular area of the mesentery. Divide the mesentery in a distal direction until the third vessel is encountered. Divide and ligate this vessel and continue the incision in the mesentery down to the fourth vessel. This most often does not require division (Fig. 84.1).

Clean the mesenteric margin of the jejunum and divide between Allen clamps or with a cutting linear gastrointestinal stapler. Tentatively pass the liberated limb of jejunum up toward the hepatic duct to determine whether sufficient mesentery has been dissected. If this is so, expose the right portion of the transverse mesocolon. Find an avascular area, generally to the right of the middle colic vessels and make a 2- to 3-cm incision through the mesocolon. Pass the liberated limb of jejunum through the incision in the mesocolon. It may be necessary to free some of the omentum from the area of the hepatic flexure to permit free passage of the jejunum up to the hepatic duct. The end of the jejunum should reach the proximal portion of the common hepatic duct with no tension whatever.

Place both ends of the jejunum in a moist laparotomy pad and return them to the abdomen. Reassess the color and

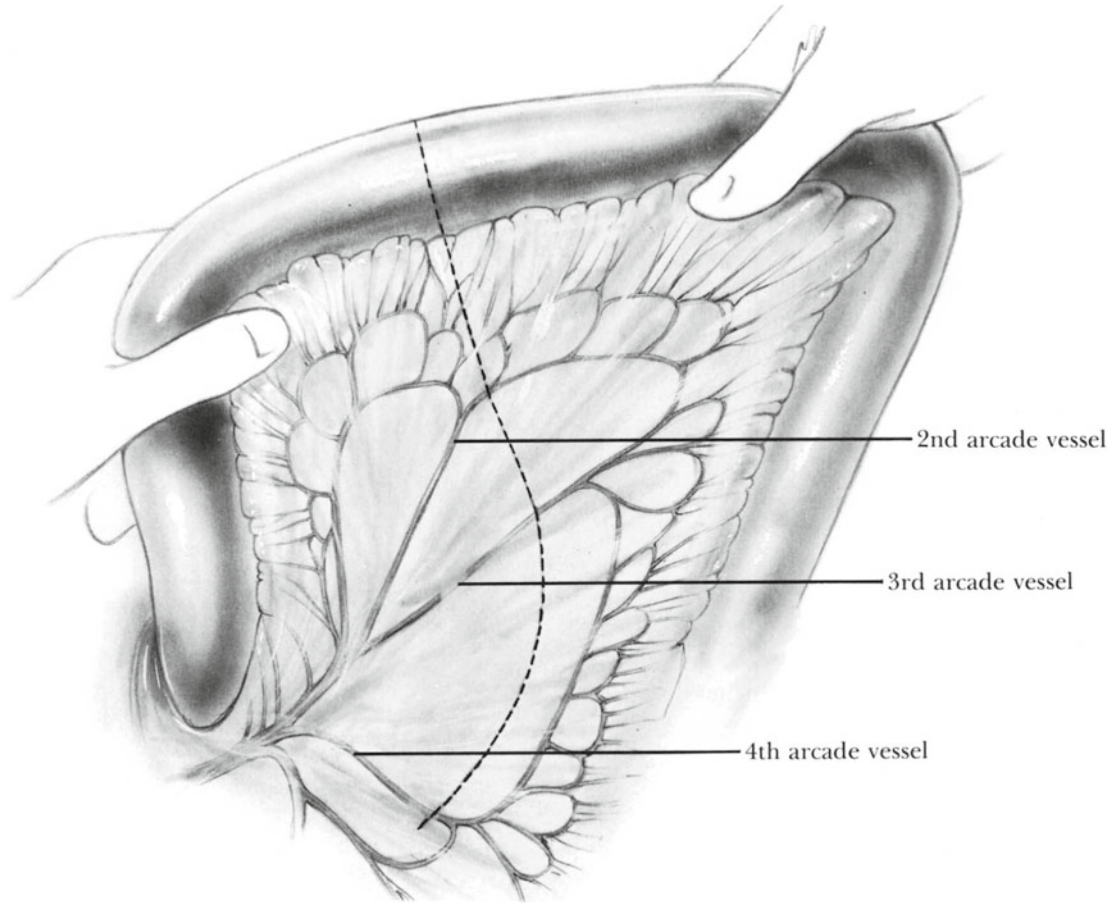

Fig. 84.1

blood supply before making the anastomosis. Do not hesitate to resect a dusky portion at either end.

Side-to-End Choledochojejunostomy or Hepaticojejunostomy

Remove the Allen clamp or staple line by incising adjacent jejunum with electrocautery. If the jejunal mucosa protrudes more than 2 mm beyond the incised seromuscular layer, amputate it flush with the seromuscular incision or use a continuous suture of 5-0 PG in an over-and-over fashion to approximate the mucosa to the cut end of the seromuscular layer. This step is advisable because the hepaticojejunal anastomosis is performed with one layer of sutures. Clean the mesenteric border of the jejunum for a distance of about 5 mm from its cut end.

In cases of carcinoma, expose the proximal portion of the hepatic duct (Fig. 84.2) to place the anastomosis as far from the tumor as possible because pancreatic and CBD malignancies grow upward along the wall of the CBD. Placing the anastomosis at a distance generally avoids occlusion of the anastomosis by further growth of the malignancy. In the case of benign disease, the anastomosis may be made at any convenient location along the dilated hepatic or CBD. Incise the layer of peritoneum overlying the duct. Then make a 2.5- to 3.5-cm longitudinal incision in the anterior wall of the hepatic duct and evacuate the bile.

Only one layer of seromucosal sutures is necessary for this anastomosis (Fig. 84.3). Each bite of the suture material should encompass 4 mm of the jejunum and the full thickness of the hepatic duct. Place the sutures about 4 mm apart. Initiate the anastomosis by inserting the first 5-0 PG or PDS suture at the caudal end of the anastomosis, which corresponds with the mesenteric border of the jejunum. Tie the suture and tag it with a hemostat. Then insert the most cephalad stitch and tag it with a hemostat. Complete the right side of the anastomosis with interrupted 5-0 sutures by the technique of successive bisection (see also Figs. 4.19 and 4.20). Do not tie any of these sutures but tag each with a hemostat. After all the sutures have been placed, tie them and complete the right-hand side of the anastomosis (Fig. 84.4). All of the mucosa should have been inverted. If there is any difficulty inverting this mucosa, it is permissible to use an accurate Lembert-type stitch on the jejunum and a through-and-through stitch on the CBD. Cut all the

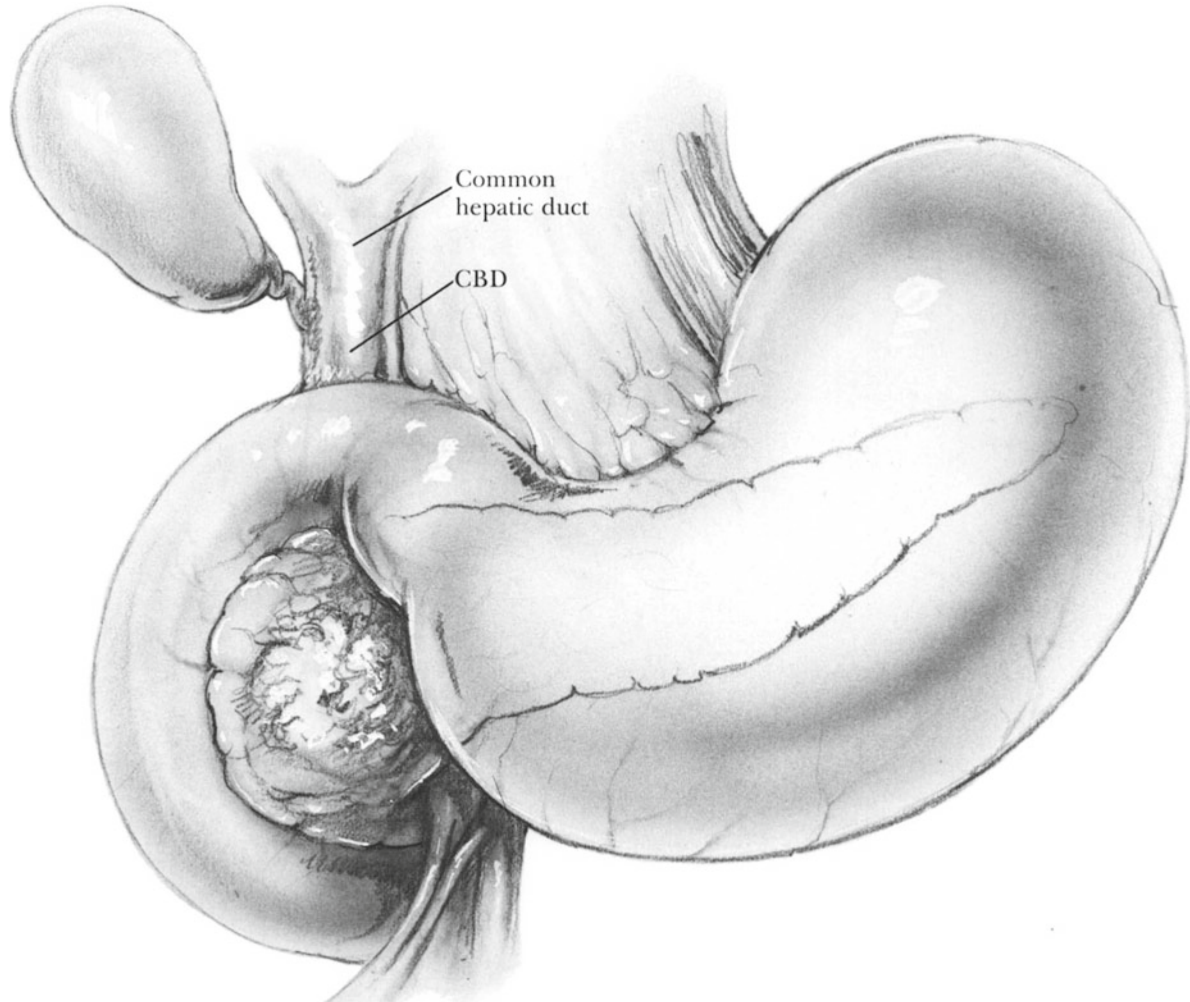

Fig. 84.2

tails of the sutures except the most proximal and distal stitches, which are retained as guy sutures. Then retract the jejunum somewhat toward the patient's right. Now initiate the left half of the anastomosis by bisecting the area between the proximal and distal stitches. Insert the first stitch at this point (Fig. 84.5). If the hepatic duct is large, it is permissible to tie these sutures as they are inserted. If the duct is small enough to cause concern that you may catch the opposite wall of the bile duct while inserting stitches, do not tie any of them until all of the sutures have been inserted. The bile duct can then be easily inspected prior to tying the stitches. Constructing this anastomosis with continuous sutures is also acceptable.

After all the sutures are tied, it is evident that a large end-to-side anastomosis has been accomplished with little difficulty. All the knots are tied outside the lumen of the anastomosis in this case, although the use of synthetic absorbable suture material makes it of no importance whether the knots are inside or outside the lumen. We see no indication at this time for the use of nonabsorbable sutures in the bile ducts. We have not used a stent, catheter, or T-tube in any of the Roux-en-Y biliary-jejunal anastomoses unless they were done for posttraumatic or iatrogenic bile duct strictures.

To perform a side-to-side choledochojejunostomy or hepaticojejunostomy, close the end of the jejunum by applying a 55/3.5 mm linear stapler. Cut the excess jejunum off flush with the stapler. If the jejunum was divided with the linear cutting stapler and the end has retained its viability, it may be possible simply to use this staple line. Lightly cauterize the mucosa. It is not necessary to invert the staple line with sutures. Using 5-0 PG or PDS suture material, insert through-and-through sutures on the posterior layer and tie the knots inside the lumen. On the anterior layer of this anastomosis, the knots are tied outside the lumen with mucosa being inverted. Again, a Lembert suture may be used if necessary because there is little danger of inverting too much jejunum when only one layer of sutures is used and the duct is large.

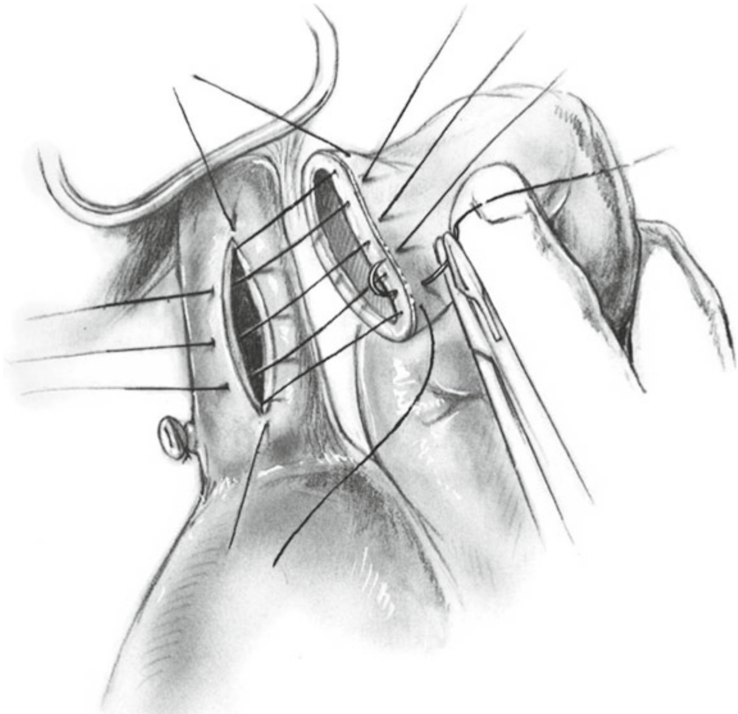

Fig. 84.3

Fig. 84.4

If an anastomosis is contemplated between the divided cut end of the hepatic duct and the side of the jejunum, accomplish oblique division of the hepatic duct. This converts the anastomosis from a circular to an elliptical shape and has the effect of enlarging the diameter of the anastomotic stoma.

In cases of bile duct strictures, it is imperative to dissect out and remove the portion of the bile duct that consists largely of scar tissue and has no mucosa, so the anastomosis is constructed with normal, unscarred duct. Make an incision on the antimesenteric side of the jejunum. This incision should be a millimeter or two larger than the diameter of the transected hepatic duct. Use 5-0 PG or PDS to place interrupted sutures and create the posterior suture line first.

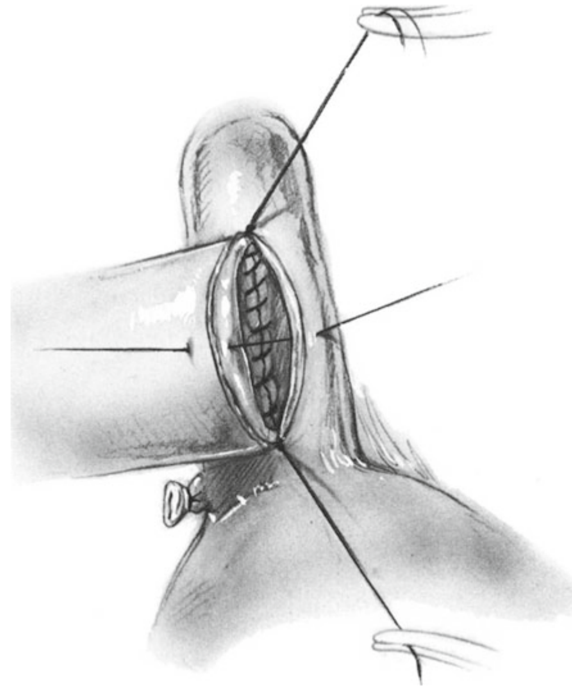

Fig. 84.5

Excise any redundant protruding jejunal mucosa to facilitate a one-layer anastomosis. Take a bite of hepatic duct and then of jejunum, encompassing only 2–3 mm of tissue with each bite, but penetrate the entire wall of the bile duct and the jejunum. Tie the knots on the inside of the lumen for the posterior half of the anastomosis. For the anterior half of the anastomosis, insert the sutures so the knots are tied outside the lumen, spaced 3–4 mm apart. After the anastomosis has been completed, inspect the backside and the anterior wall for possible imperfections. To avoid linear tension on the anastomosis by gravity, insert a few seromuscular sutures into the jejunum and attach the jejunum to the undersurface of the liver or to adjacent peritoneum.

Gastrojejunostomy

Because patients with pancreatic carcinoma may develop duodenal obstruction before succumbing to their malignancy, we generally invest a few additional minutes to perform a stapled side-to-side gastrojejunostomy. This anastomosis is created 60 cm distal to the hepaticojejunostomy.

Pass the jejunal limb antecolic and lay it in a comfortable position adjacent to the greater curvature of the gastric antrum. Divide and ligate the branches of the gastroepiploic arcade along the greater curvature of the antrum so a 5- to 7-cm area is free.

Use electrocautery to make a stab wound on the greater curvature aspect of the stomach and on the antimesenteric

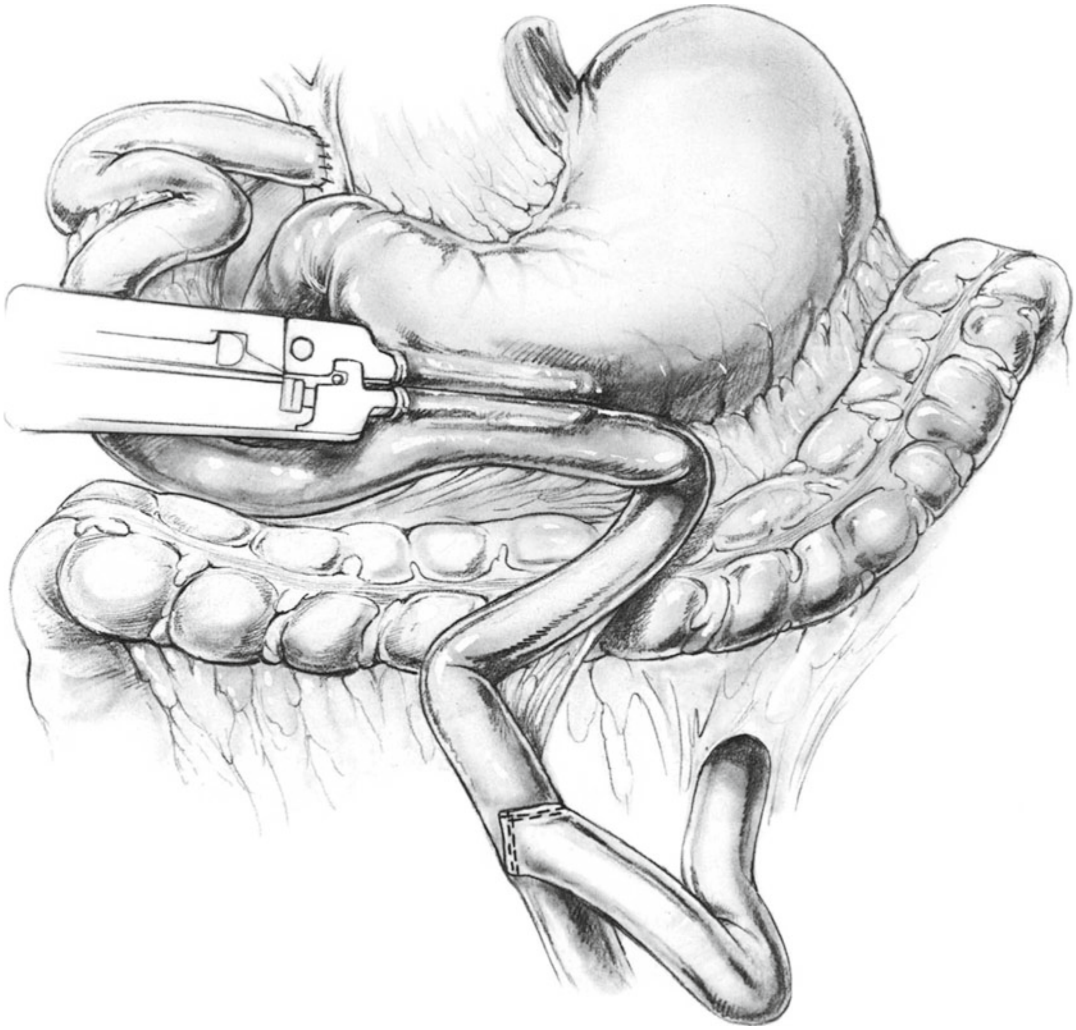

Fig. 84.6

side of the jejunum. Insert the linear cutting stapling device in a position where it does not transect any blood vessels. Lock the device (Fig. 84.6). Fire the stapler and remove it. Inspect the suture line for bleeding, which should be controlled with cautious electrocoagulation or 3-0 PG suture ligatures. Then grasp the two ends of the staple line with Allis clamps and apply additional Allis clamps to the gap between stomach and jejunum. Then close this gap with a single application of a 55/4.8 mm linear stapler. With Mayo scissors amputate the redundant tissue and lightly electrocoagulate the mucosa. Remove the stapling device and inspect the anastomosis for any possible defects or bleeding (see Figs. 32.5 and 32.6).

Stapling the Roux-en-Y Jejunojejunostomy

At a point 10–15 cm distal to the gastrojejunostomy, align the proximal cut end of the jejunum with the descending limb of jejunum, as depicted in Fig. 84.7. It is important to have the cut end of the proximal jejunum facing in a cephalad direction, thereby facilitating construction of the stapled anastomosis. Make a 1.5 cm longitudinal incision with electrocautery on the antimesenteric border of the descending limb of jejunum 10–15 cm distal to the gastrojejunostomy. Remove the Allen clamp from the proximal end of the jejunum and insert the cutting linear stapling device, one limb into the stab wound and the other limb into the open end of jejunum (Fig. 84.7). Lock the stapler, fire it, and remove it. Inspect the staple line for bleeding.

Place a guy suture at the midpoint of the remaining defect approximating the descending limb of jejunum with the proximal open end of jejunum as in Fig. 84.8. Apply Allis clamps to the anterior and posterior terminations of the staple line (Fig. 84.9). Close the remaining defects with additional Allis clamps and close the defect by triangulation in the usual manner (Figs. 84.10 and 84.11).

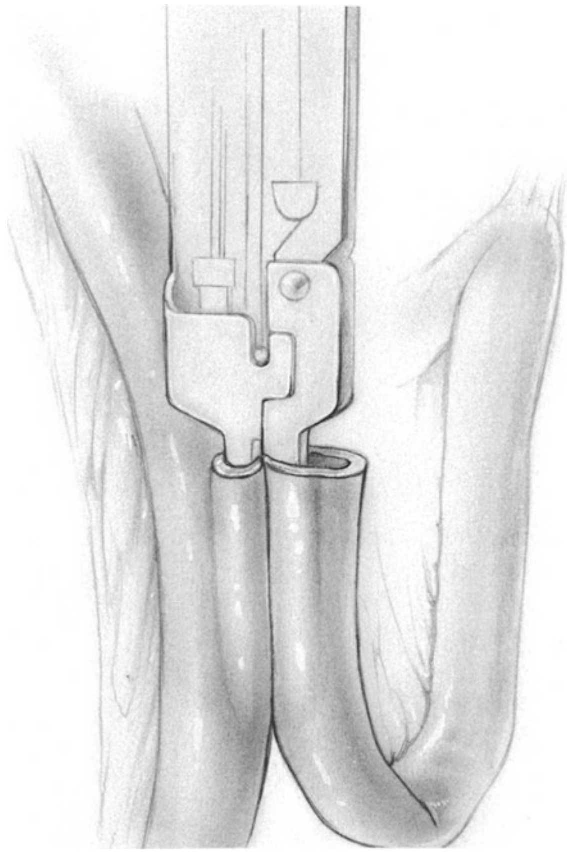

Fig. 84.7

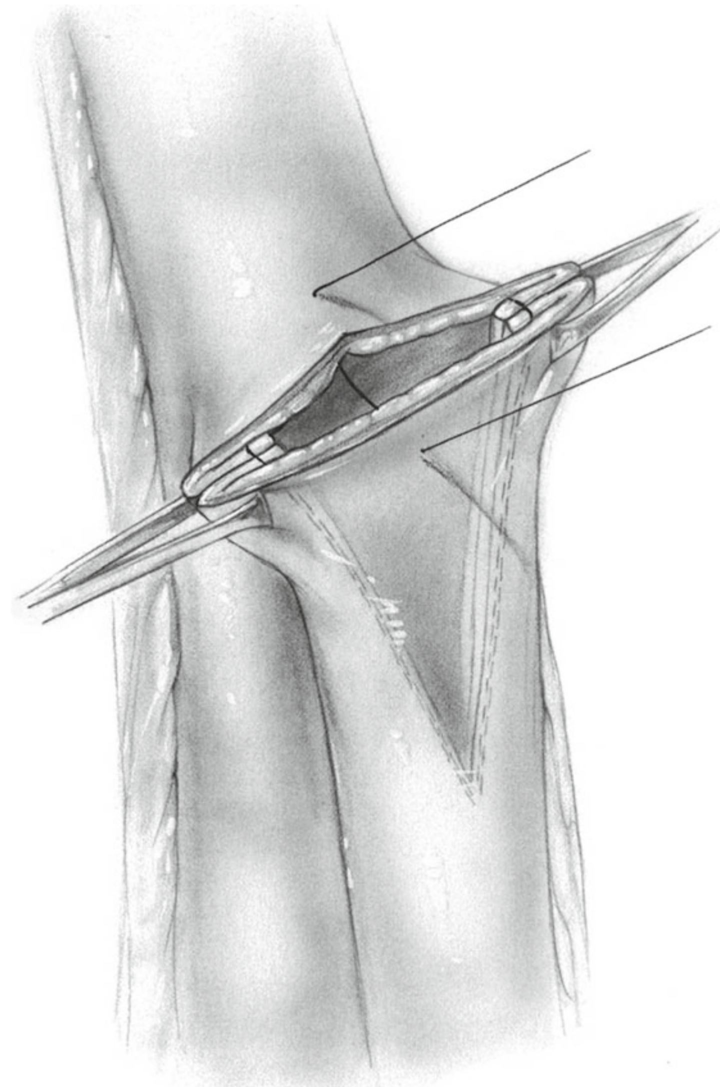

Fig. 84.9

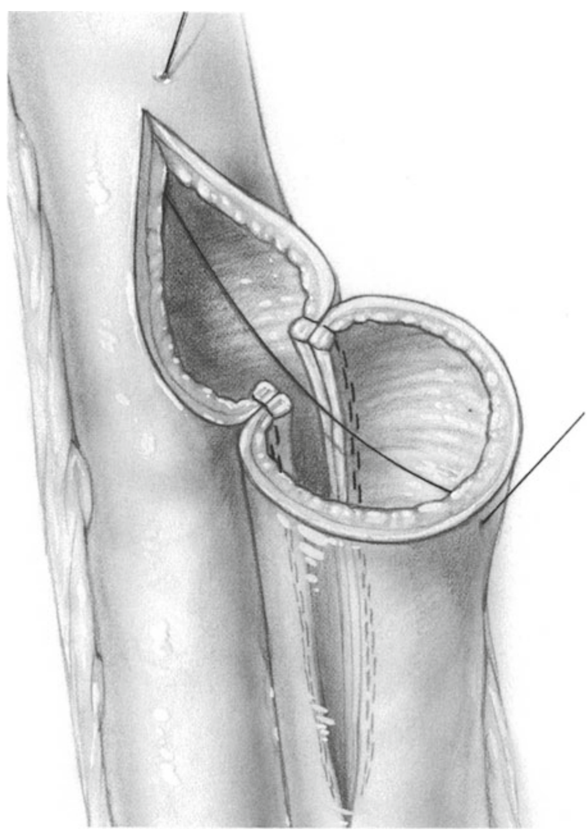

Fig. 84.8

Closure of Mesenteric Gaps

Using 4-0 PG or other suture material, place interrupted sutures to attach the transverse mesocolon to the limb of jejunum, which has been brought up to the incision in the mesocolon. This maneuver eliminates any gaps through which small bowel might herniate. Use the same technique to close the gaps in the mesentery of the jejunum in which the Roux-en-Y jejunojejunostomy has been constructed.

Abdominal Closure and Drainage

Close the abdomen in routine fashion. Because bile has extremely low surface tension, a small amount of bile may escape from the anastomosis during the first couple of days

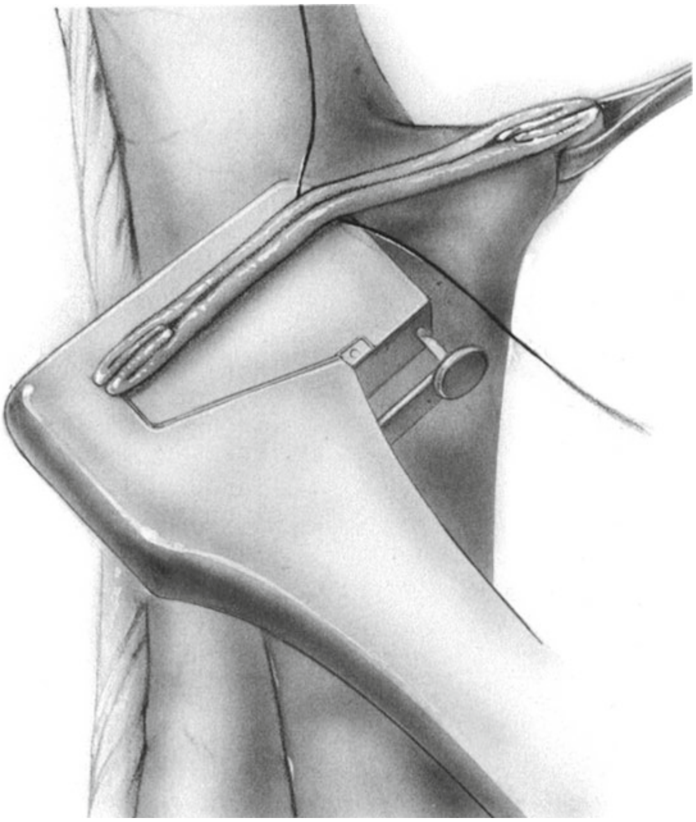

Fig. 84.10

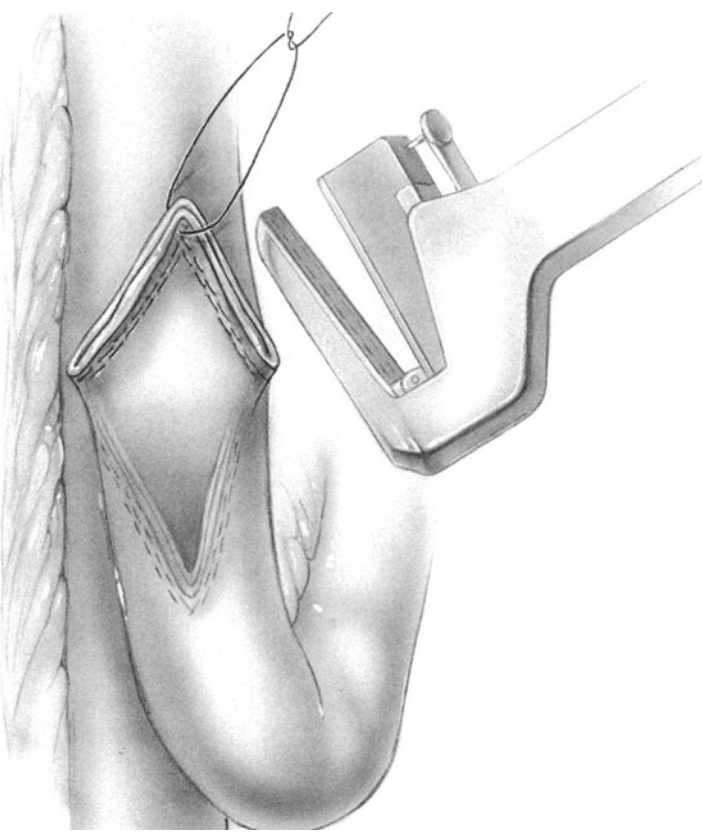

Fig. 84.11

following the operation. For this reason, insert a closed-suction drainage catheter through a puncture wound in the lateral abdominal wall. Bring the catheter up to the region of the hepaticojejunostomy.

Postoperative Care

Continue nasogastric suction for 1–2 days.

Acid-reducing therapy with H_2-blocking agents or proton pump inhibitors is prudent.

Remove the closed-suction drain after drainage has essentially ceased.

Complications

Bile Leak. Although occasionally bile drainage persists for as long as 5–7 days, it invariably ceases in our experience and has never constituted a significant problem following the Roux-en-Y anastomosis.

Stenosis of the Anastomosis. Late stenosis of the anastomosis, signaled by cholangitis or jaundice, may occur. Patients should be followed with periodic checks of liver chemistry tests (bilirubin, alkaline phosphatase, γ-glutamyl transferase) to detect this complication early. Sometimes endoscopic or transhepatic dilatation is feasible.

Cholangitis. Cholangitis is rare following a Roux-en-Y hepaticojejunostomy unless the anastomosis becomes stenotic. In patients who have had multiple hepatic duct calculi, there may be transient cholangitis while a calculus is in transit from the hepatic duct down to the hepaticojejunostomy.

Postoperative Duodenal Ulcer. Patients with chronic pancreatitis already have minimal flow of alkaline pancreatic juice into the duodenum; thus, with all the bile diverted into the Roux-en-Y hepaticojejunostomy, there may be an increased tendency for duodenal ulcer formation. These patients should be warned to return for prompt medical attention if they develop symptoms of peptic ulceration. Alternatively, hepaticojejunoduodenostomy (Fig. 84.12) may be performed in patients known to have an ulcer diathesis, although it is rarely needed with the current methods of treating duodenal ulcer disease.

Delayed Gastric Emptying. Following choledochojejunostomy with or without concomitant gastrojejunostomy, 10–20 % of patients develop delayed gastric emptying. All of our patients with this problem responded to a period of nasogastric suction, sometimes with the assistance of bethanechol or metoclopramide.

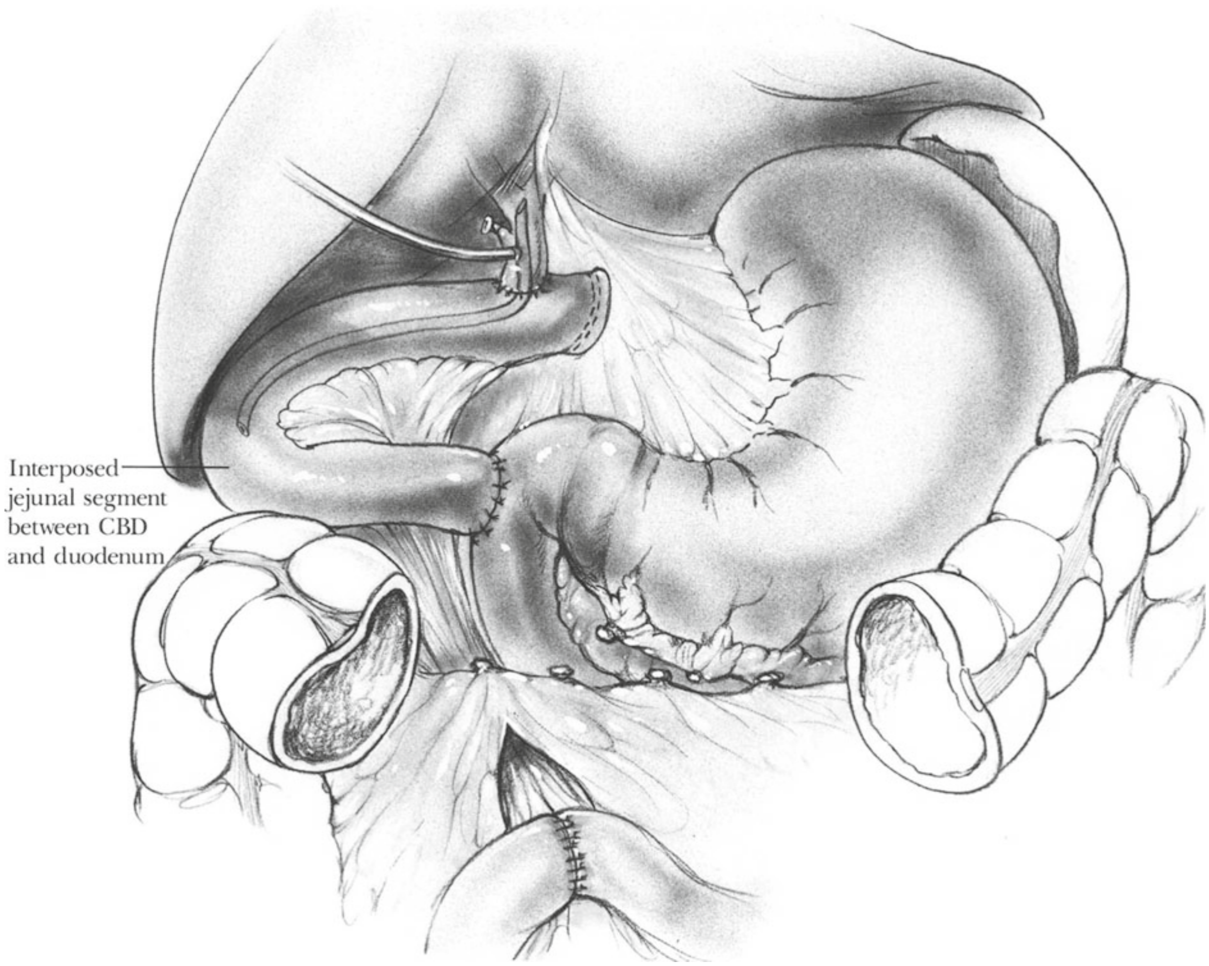

Fig. 84.12

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85 Transduodenal Diverticulectomy

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Perforation
Hemorrhage

Preoperative Preparation

Perioperative antibiotics

Pitfalls and Danger Points

Injury to pancreas, resulting in postoperative acute pancreatitis
Injury to distal common bile duct (CBD)

Operative Strategy

The strategy of managing patients operated on for perforation depends on the degree of surrounding inflammation. If the neck of the diverticulum is free of inflammation, it may be possible to accomplish primary closure of the neck of the sac with interrupted sutures. More often, leakage of duodenal content through a perforated periampullary diverticulum produces a violent inflammatory reaction. One cannot expect primary suture of the duodenal wall to be secure under these conditions. Consequently, as a lifesaving measure, it may be necessary to divert both bile and gastric contents and to insert multiple suction drains to the area of perforation.

In elective cases *where the diverticulum is free of inflammation*, the technique of transduodenal diverticulectomy described here works well. The sac of the diverticulum is inverted through an incision in the second portion of the duodenum. The diverticulum is excised, and the defect in the duodenal wall is closed from inside the lumen.

An alternative technique involves dissecting the duodenal diverticulum from surrounding pancreas and duodenal wall down to its neck near the ampulla. The terminal CBD must be identified as it enters the posterior wall of the duodenum. Place a catheter in the CBD. Then transect the diverticulum at its neck and repair the defect in the duodenal wall. This technique may be facilitated by inflating the duodenal diverticulum with air injected through a nasogastric tube. It requires meticulous dissection of the pancreas away from its attachments to the posterior duodenal wall. As the pancreas is dissected away from the duodenum, the terminal portion of the CBD and the diverticulum may be exposed. This dissection is tedious and sometimes difficult. It carried a greater risk of causing postoperative acute pancreatitis than does the transduodenal approach.

Documentation Basics

- Findings
- Preservation of ampullary structures (how assured)

Operative Technique

Incision

Make a midline incision from the xiphoid to a point about 5 cm below the umbilicus or, alternatively, a long subcostal incision.

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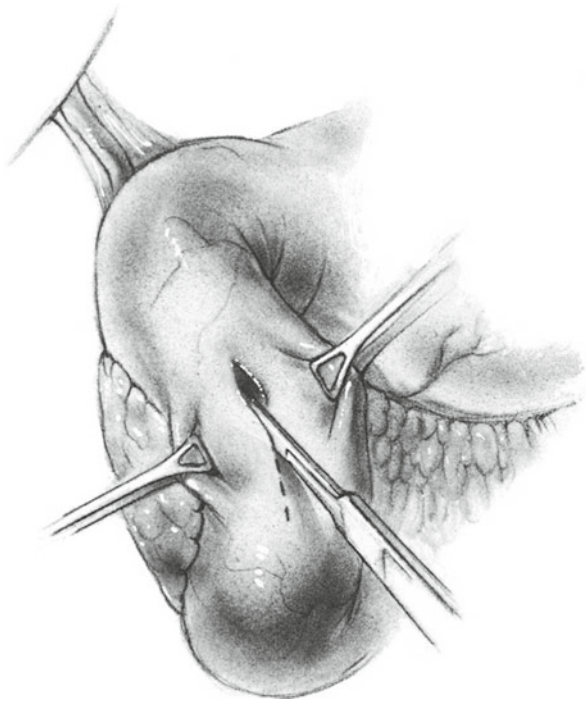

Fig. 85.1

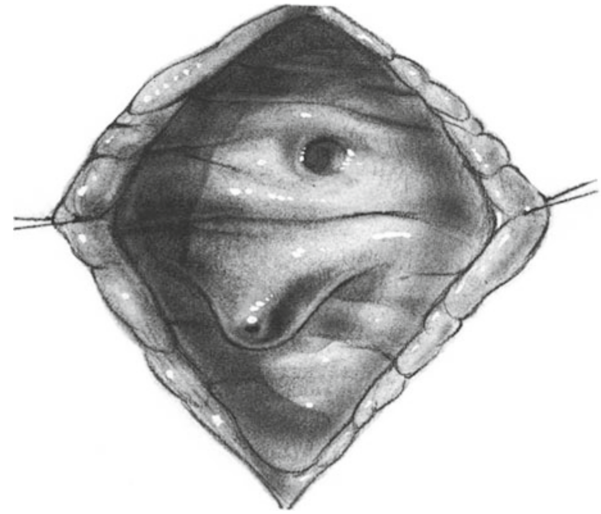

Fig. 85.2

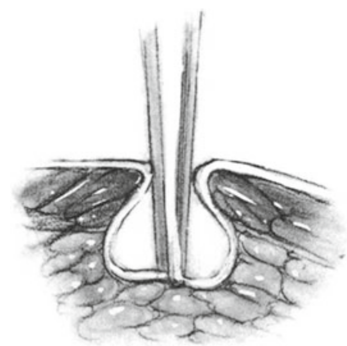

Fig. 85.3

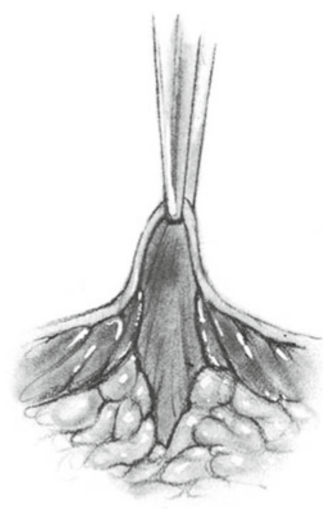

Fig. 85.4

Kocher Maneuver

Incise the lateral peritoneal attachments of the descending duodenum and mobilize the duodenum and the head of the pancreas as shown in Figs. 14.14, 14.15, and 14.16. Place a gauze pad behind the head of the pancreas to elevate the duodenum.

Duodenotomy and Diverticulectomy

Make a 4- to 5-cm longitudinal incision near the antimesenteric border of the descending duodenum (Fig. 85.1). Identify the ampulla by palpation or visualization (Fig. 85.2). If there is any difficulty identifying the ampulla in this fashion, do not hesitate to make an incision in the CBD and pass a Coude catheter gently down to the ampulla through the CBD incision. Identify the orifice of the periampullary diverticulum and insert forceps into the diverticulum. Grasp the mucosal wall of the diverticulum (Fig. 85.3) and gently draw the mucosa into the lumen of the duodenum until the entire diverticulum has been inverted into the lumen of the duodenum (Figs. 85.4 and 85.5). Transect the neck of the diverticulum about 2–3 mm from its junction with the duodenal wall.

Inspect the bed of the diverticulum through the orifice in the duodenum to check for bleeding. Then close the duodenal wall by suturing the seromuscular layer with interrupted 4-0 PG and invert this layer into the lumen of the duodenum. Close the defect in the mucosa with inverting sutures of interrupted 5-0 PG (Fig. 85.6). This provides a two-layered closure of the diverticulum, performed from inside the duodenum.

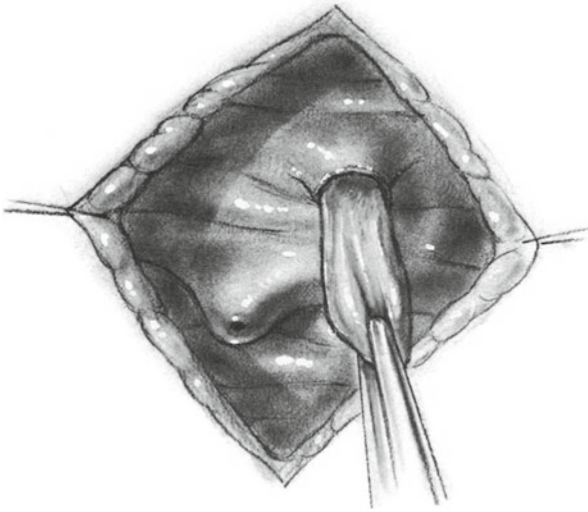

Fig. 85.5

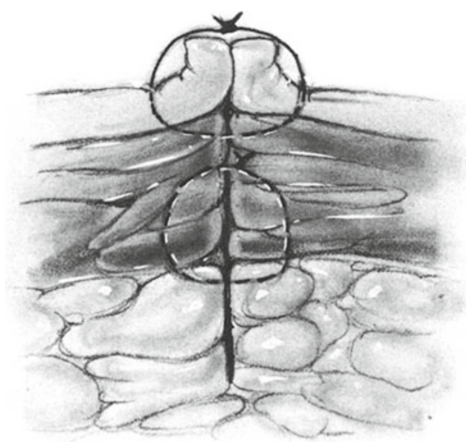

Fig. 85.6

Close the duodenotomy incision in two layers. Use interrupted or continuous inverting sutures of 5-0 PG for the mucosal layer and interrupted 4-0 atraumatic silk Lembert sutures for the seromuscular coat.

Closure and Drainage

Bring a closed-suction drain out from the region of the head of the pancreas through a puncture wound in the right upper quadrant of the abdomen. Close the abdominal wall in routine fashion.

Postoperative Care

Continue nasogastric suction for 3–5 days.
Give the patient perioperative antibiotics.
Check postoperative levels of serum amylase to detect postoperative pancreatitis.

Complications

Acute pancreatitis
Duodenal leakage

Further Reading

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Operations for Lesions of Hepatic Duct Bifurcation

86

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Benign tumors of hepatic duct bifurcation
Carcinoma of hepatic duct bifurcation (where more extensive resection, including hepatectomy, is not deemed appropriate)
High biliary strictures

Preoperative Preparation

Computed tomography (CT) or magnetic resonance imaging (MRI) scan
Anatomical studies to delineate proximal extent of tumor
Perioperative antibiotics
Nasogastric tube

Pitfalls and Danger Points

Inadequate resection for tumor – It is absolutely crucial that the proximal extent of tumor be assessed so that an R0 resection (which may include formal lobectomy or trisegmentectomy) can be performed. The procedure described here is for small lesions or for patients who are not candidates for more extensive procedures.
Trauma to liver during transhepatic intubation at laparotomy
Trauma to portal vein or hepatic artery during tumor excision at hilus
Failure to achieve adequate drainage of bile

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Operative Strategy

Resection

Resection of malignant tumors at the bifurcation of the hepatic duct is safe when the surgeon can demonstrate that there is no invasion of the underlying portal vein or liver tissue and if the proximal extent of the tumor does not reach the secondary divisions of the hepatic ducts. The goal is to attain an R0 resection (no residual tumor), and this may require formal hepatectomy (see Chap. 87) in continuity with the excision of the ducts. In some cases, liver transplant may be the better way to resect these difficult tumors.

For strictures, resecting hepatic parenchyma is generally not necessary unless it facilitates exposure of the ducts for anastomosis.

Avoiding hemorrhage during the operation depends on careful dissection of the common hepatic duct and the tumor away from the bifurcation of the portal vein. This is best done by dividing the common bile duct (CBD), mobilizing the gallbladder, and elevating the hepatic duct together with the tumor to expose the portal vein and its bifurcation. In borderline cases, remove the gallbladder and make a preliminary assessment regarding invasion of the portal vein by dissecting underneath the common hepatic duct toward the tumor before dividing the CBD. This dissection may be facilitated if a radiologist has passed percutaneous transhepatic catheters into both the right and left main ducts. Because bifurcation of the common hepatic duct occurs outside the liver in almost all cases, palpation of these catheters helps identify the position of the ducts.

Dilating Malignant Strictures of the Hepatic Duct Bifurcation

When the tumor is nonresectable, dilatation and stenting may provide good palliation. With improved endoscopic and

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radiographic methods of determining resectability and passing stents, operative intubation is rarely needed. This procedure is included for its occasional use in difficult circumstances.

Most tumors of the hepatic duct involve the bifurcation. When nonoperative stenting is not feasible, these tumors may be dilated and stented in the operating room after they are found to be nonresectable. Silastic stents are fashioned, preferably so they are 6 mm outer diameter and fairly thick walled to prevent the tumor from occluding them. Because it is desirable to catheterize both the right and left hepatic ducts, two such stents are required. These two stents rarely fit into the CBD, so it is generally necessary to perform a Roux-en-Y hepaticojejunostomy to permit the two stents to enter the jejunum and drain the bile in this fashion. If the occlusion of the left hepatic duct cannot be dilated from below, it is often possible to identify the left hepatic duct above the tumor and pass a stent through an incision in the hepatic duct above the tumor.

Operative Technique

Resection of Bifurcation Tumors

Incision

In most cases, a midline incision from the xiphocostal angle to a point about 5–8 cm below the umbilicus is suitable. It is helpful to apply a Thompson or an Upper Hand retractor to the right costal margin to improve the exposure at the hilus of the liver.

Determination of Operability

Perform a cholecystectomy by the usual technique. Incise the layer of peritoneum overlying the common hepatic duct beginning at the level of the cystic duct stump and progressing cephalad. Unroof the peritoneum overlying the hepatic artery so the common hepatic duct and the common hepatic artery have been skeletonized (Fig. 86.1). Now dissect along the lateral and posterior walls of the common hepatic duct near the cystic stump and elevate the hepatic duct from the underlying portal vein. Try to continue the dissection along the anterior wall of the portal vein toward the tumor so a judgment can be made as to whether the tumor has invaded the portal vein. A more accurate determination is made later during the dissection after the CBD has been divided and elevated. If there are no signs of gross invasion, identify the anterior wall of the tumor and try to palpate the Ring catheters if they have been placed in the right and the left hepatic ducts prior to operation. This maneuver gives the surgeon some idea of the cephalad extent of the tumor. It is crucial that this be accurately assessed during the surgical planning stage, so that formal hepatectomy can be utilized to get an adequate proximal margin if necessary. Operative ultrasonography may be a useful adjunct.

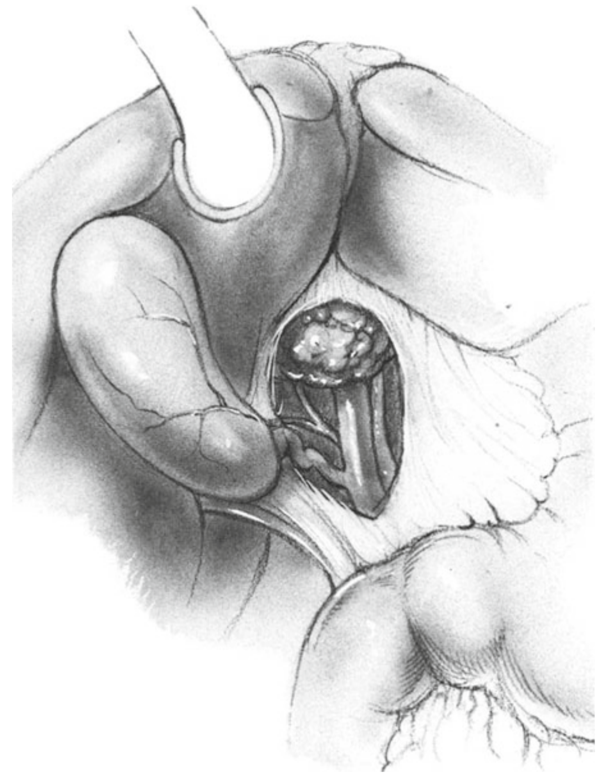

Fig. 86.1

For a final determination of the advisability of resecting the tumor, divide the CBD (Fig. 86.2) distal to the cystic duct stump. Oversew the distal end of the CBD with continuous 4-0 PG suture material. Dissect the proximal stump of the CBD off the underlying portal vein by proceeding in a cephalad direction (Fig. 86.3). Skeletonize the portal vein and sweep any lymphatic tissue toward the specimen. Carefully identify the bifurcation of the portal vein behind the tumor.

Perform this portion of the dissection with great caution because lacerating a tumor-invaded portal vein bifurcation produces hemorrhage that is difficult to correct if one side of the laceration consists of tumor. During this dissection, pay attention also to the common hepatic and the right hepatic arteries that course behind the tumor. Bifurcation tumors occasionally invade or adhere to the right hepatic artery.

After demonstrating that the tumor is clear of the underlying portal veins and hepatic arteries, continue the dissection along the posterior wall of the tumor. The right and left hepatic ducts and even secondary branches can often be identified without resecting hepatic parenchyma. It is sometimes difficult to determine the proximal extent of the tumor by palpation. If preoperative catheters have been placed, palpate the right and left ducts for the presence of the catheters. Proceed if the tumor is deemed suitable for local excision, or if a high biliary stricture is being addressed. After

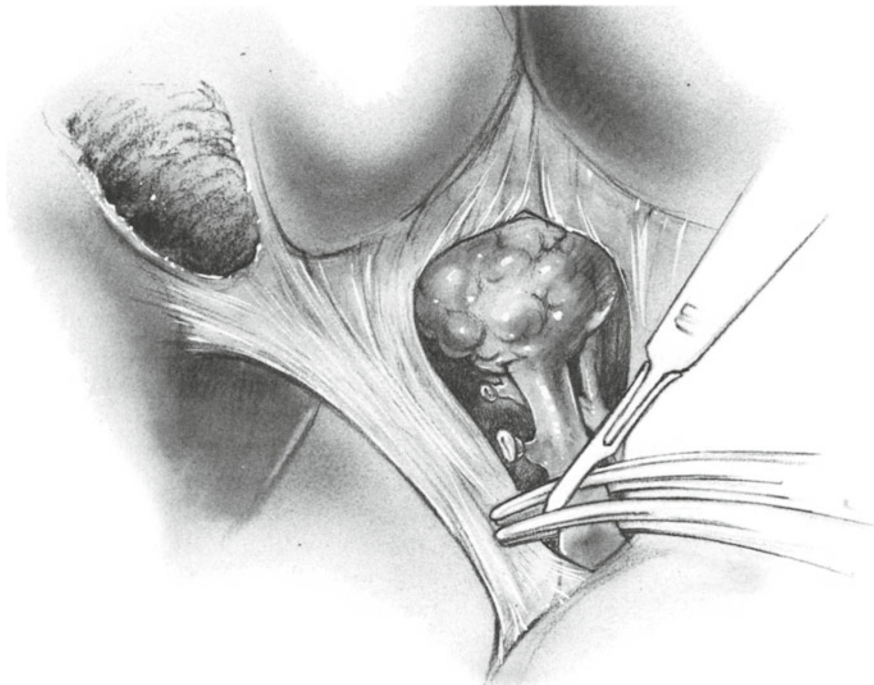

Fig. 86.2

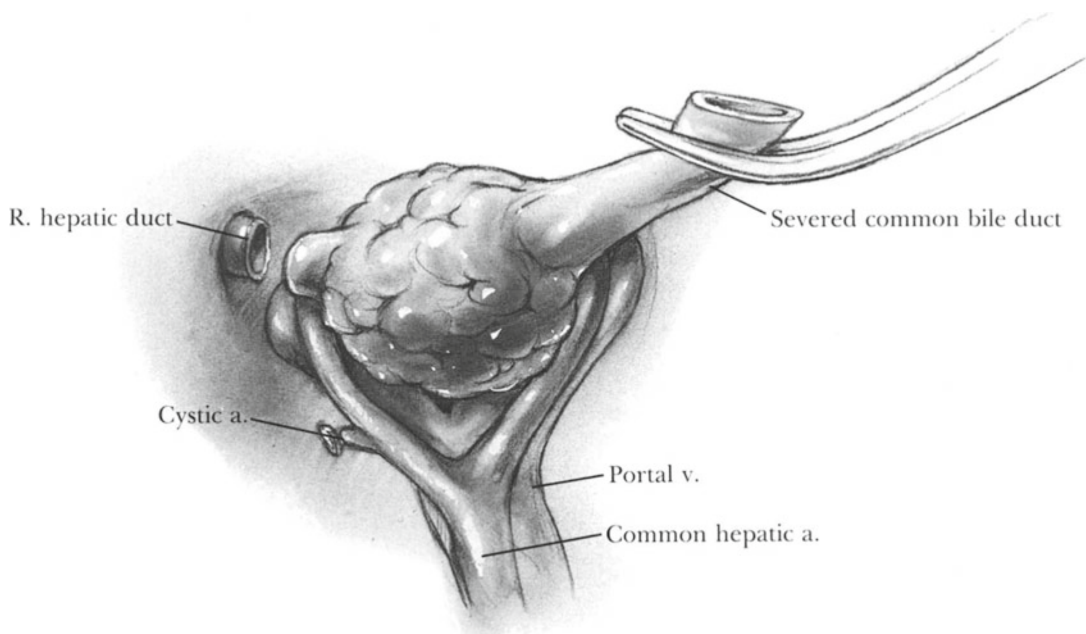

Fig. 86.3

adequate exposure has been obtained, transect the ducts and remove the tumor or strictured segment (Fig. 86.4). Perform frozen section examination of the proximal portions of the right and left ducts in the specimen to determine if the tumor has been completely removed. If the report is positive for tumor, determine whether removing a reasonable additional length of duct is feasible. If this additional duct is resected, it may be necessary to anastomose three or four hepatic ducts to the jejunum. Although some adjacent hepatic parenchyma may be left attached to the duct during blunt dissection, it may be necessary to perform a major hepatic resection for some tumors at the bifurcation. Insert Silastic tubes into each severed duct by one of the techniques described below.

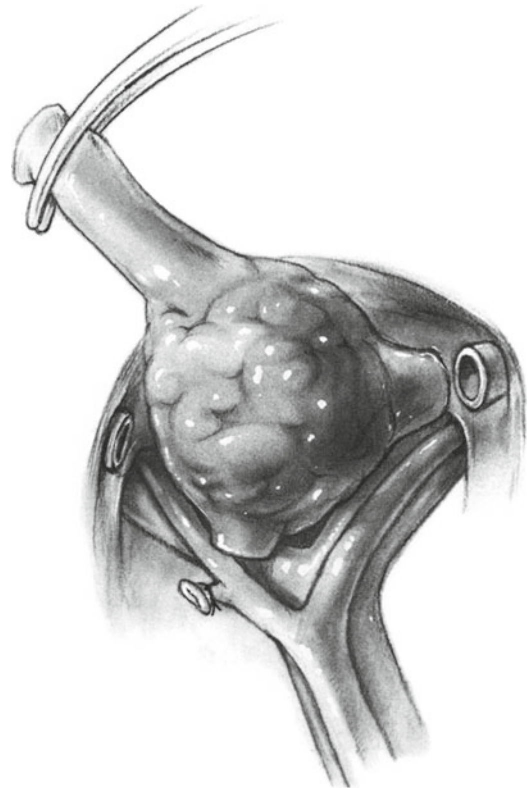

Fig. 86.4

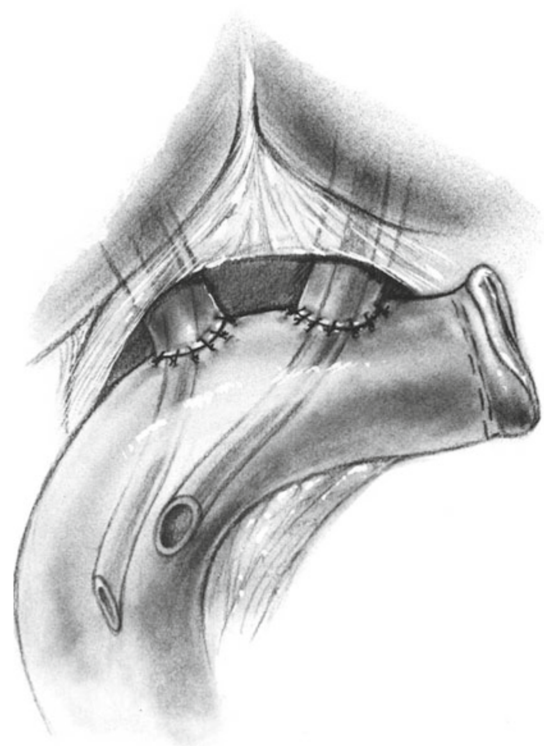

Fig. 86.5

Anastomosis

Construct a Roux-en-Y jejunal limb as described in Chap. 73 and bring the closed end of jejunum to the hilus of the liver. Make an incision in the antimesenteric border of the jejunum equal to the diameter of the open left hepatic duct. Anastomose the end of the left hepatic duct to the side jejunum with a single layer of interrupted 5-0 PG or PDS sutures. Perform the same type of anastomosis between the right hepatic duct and a second incision in the jejunum. Pass each Silastic catheter through the anastomosis into the jejunum so it projects for a distance of 5–6 cm into the jejunum (Fig. 86.5). These catheters may then be left in as stents. If no Ring catheters were placed before surgery, pass a small Silastic tube across each biliary enteric anastomosis as a stent and bring these tubes out through a jejunostomy.

Drainage and Closure

At the site where the Silastic tube enters the left hepatic duct at the dome of the liver, insert a mattress suture of 3-0 PG into the liver capsule to minimize the possibility of bile draining around the tube at this point. Tie the two tails of this suture around the Silastic tube to anchor it in place. Perform an identical maneuver at the point where the second tube enters the anterior surface of the right lobe of the liver. Then make a puncture wound through the abdominal wall in the right upper quadrant. Pass the Silastic tube through this puncture wound, leaving enough slack to compensate for some degree of abdominal distension. Suture the Silastic tube to the skin securely using 2-0 nylon. Perform an identical maneuver to pass the other Silastic tube that exits from the liver through a puncture wound in the left upper quadrant of the abdominal wall. In addition, place closed-suction drains near each of the exit wounds in the right and left lobes of the liver and bring them through abdominal stab wounds. Place a third closed-suction drain at the hilus of the liver near the hepaticojejunal anastomoses. Close the abdominal incision in routine fashion.

Intubation of Hepatic Duct Without Resecting Tumor

Incision

Make a midline incision from the xiphoid to a point 4–5 cm below the umbilicus.

Dilating the Malignant Structure

Identify the common hepatic duct below the tumor. Make a 1.5- to 2.0-cm incision in the anterior wall of the duct. If the patient has previously undergone percutaneous transhepatic catheterization of the right and left hepatic ducts and if both catheters have passed into the CBD, use these catheters to draw Silastic tubes into each hepatic duct. In the absence of

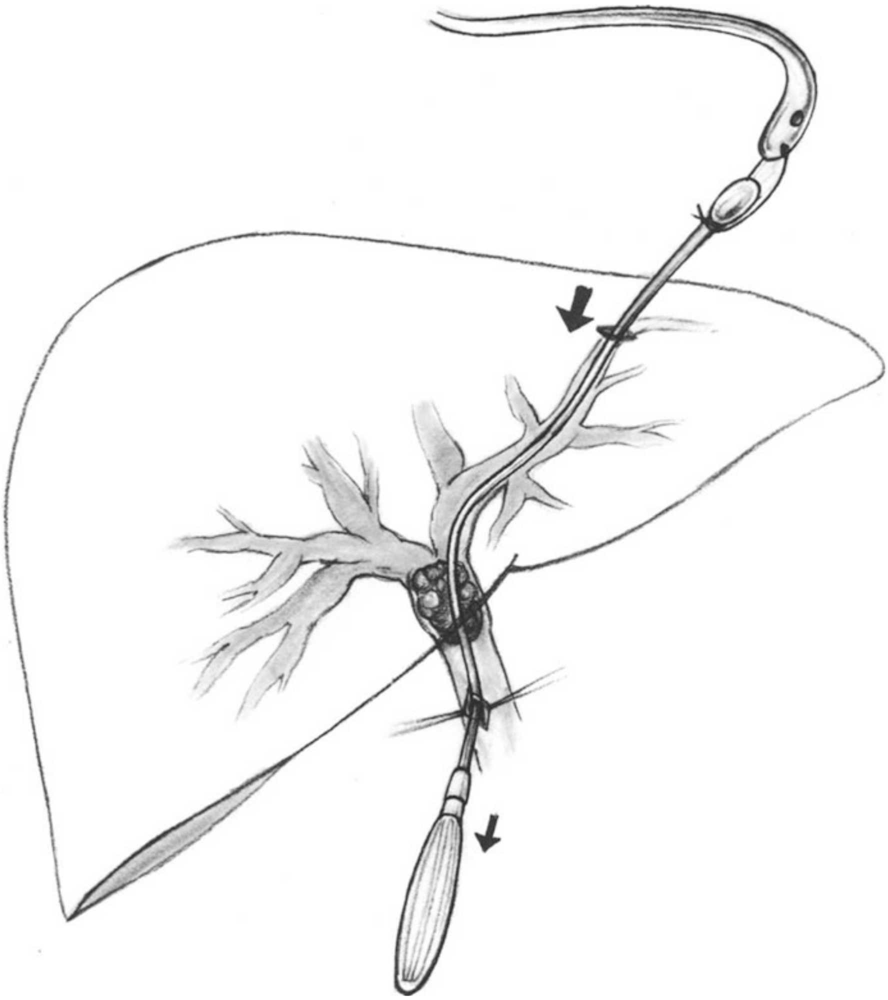

Fig. 86.6

intraductal catheters, pass a Bakes dilator into the common hepatic duct and try to establish a channel leading into the right hepatic duct. After the channel has been established, dilate the passageway by sequentially passing No. 3, 4, 5, and 6 Bakes dilators if possible. Once this has been achieved, pass a Silastic catheter into the right hepatic duct by the technique shown in Fig. 86.6.

Try to identify the channel leading from the common hepatic duct into the left hepatic duct with a No. 2 or 3 Bakes dilator (Fig. 86.7). If this channel cannot be established, try to identify the left hepatic duct just above the tumor. Having accomplished this, incise the duct and pass a Silastic tube through the duct and out the parenchyma of the liver on the anterior surface of the left lobe. It is necessary to anastomose a Roux-en-Y limb of jejunum to this opening in the left hepatic duct. Pass the Silastic tube through the anastomosis into the jejunum.

As previously discussed, the CBD may be too small to accommodate two Silastic tubes, and a Roux-en-Y hepaticojejunostomy to the divided right and left hepatic ducts may be needed. Then pass each tube down into the jejunum for a distance of at least 6 cm (Fig. 86.8). Perform the end-to-side jejunojejunostomy for completing the Roux-en-Y anastomosis at a point 60–70 cm distal to the hepaticojejunostomy using the method illustrated in Chap. 73.

Other Intubation Techniques

There are many techniques aimed at minimizing trauma when passing a tube through the liver into the hepatic ducts. It is helpful to keep the hole in Glisson's capsule as small as possible to minimize leakage of bile around the tube. If the patient has already undergone preoperative transhepatic catheterization of the hepatic duct and if the point at which this catheter penetrates the liver capsule is in a satisfactory location, one may suture a urologic filiform to the end of the intraductal catheter. Then by withdrawing the catheter through the liver, the filiform is brought through the opening in the liver capsule. Urologic filiform followers may then be attached to the end of the filiform so the path of the catheter can be dilated about 6 mm. The Silastic tube can then be

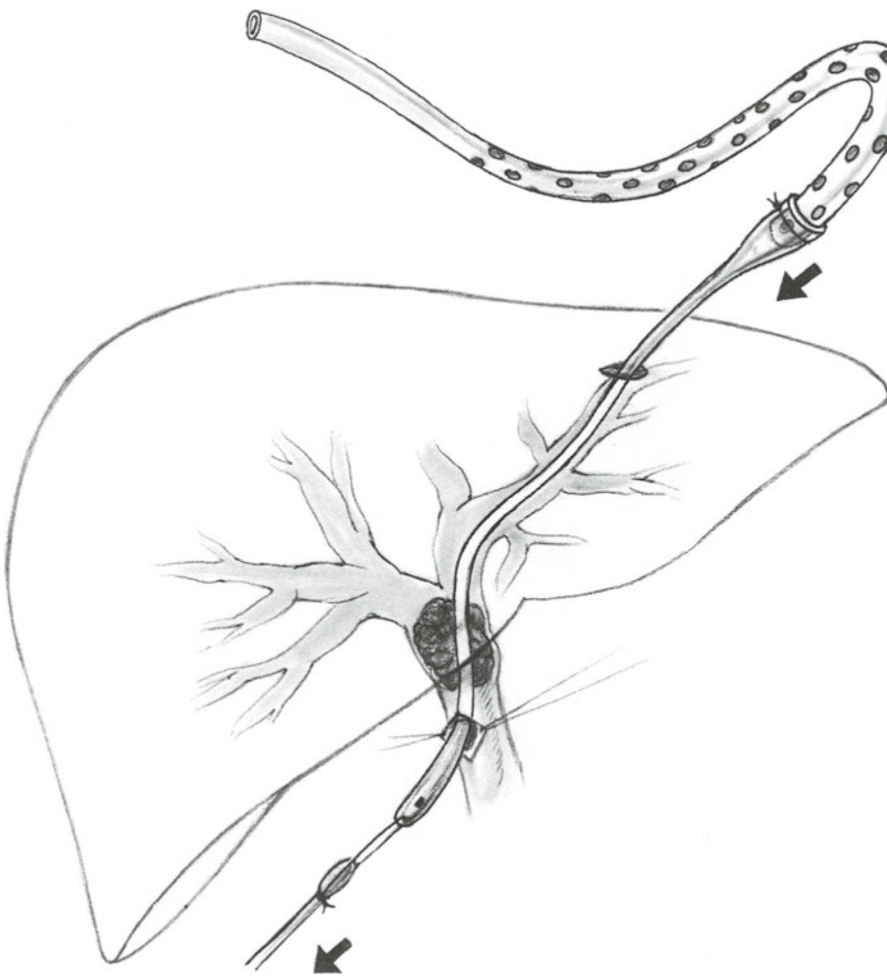

Fig. 86.7

inserted into the open end of the follower from below and sutured securely in place. By withdrawing the follower, the Silastic tube catheter can be brought through the liver with minimal trauma and then out through the skin.

In the absence of an intraductal catheter, pass a No. 2 or 3 Bakes bile duct dilator through the cut end of the right or left hepatic duct. Pass the dilator through the duct until it reaches a point about 1.0–1.5 cm from Glisson's capsule in an appropriate location on the anterior surface of the liver. The tip of the dilator can frequently be felt under the capsule of the liver. Then make a tiny incision in the capsule and push the metal dilator through the hepatic parenchyma. Suture the tip of the 10 F straight rubber catheter to the Bakes dilator (Fig. 86.6). This step may be simplified if a small hole has been drilled in the tip of the Bakes dilator to accept the suture. After drawing the Bakes dilator downward, the catheter is led into the hepatic duct at the hilus of the liver. Then insert a Silastic tube, 6 mm in outer diameter, into the flared open end of the French catheter and suture it securely in this location (Fig. 86.7). By drawing the catheter out of the hepatic duct at the hepatic hilus, the Silastic tube moves to the proper location. Make certain that holes have been punched in the Silastic tube prior to its insertion. These holes should be situated above and below the site of the tumor, so bile can flow into the catheter above and exit from the catheter below the tumor. A convenient source of this Silastic multiperforated tubing is a round Jackson-Pratt drain.

Bring the Silastic catheters out through puncture wounds in the abdominal wall. Then insert closed-suction drains into the sites from which the catheters exit from the right and left hepatic lobes. Place one drain to the hilus of the liver.

Postoperative Care

Attach the Silastic catheters to plastic bags for gravity drainage. Leave them in place until there is no bile drainage along any of the closed-suction drains. Then occlude the Silastic catheters with a stopcock. Instruct the patient to irrigate each catheter twice daily with 25 ml of sterile saline. The nylon suture fixing the catheter to the skin must be replaced approximately every 4–6 weeks.

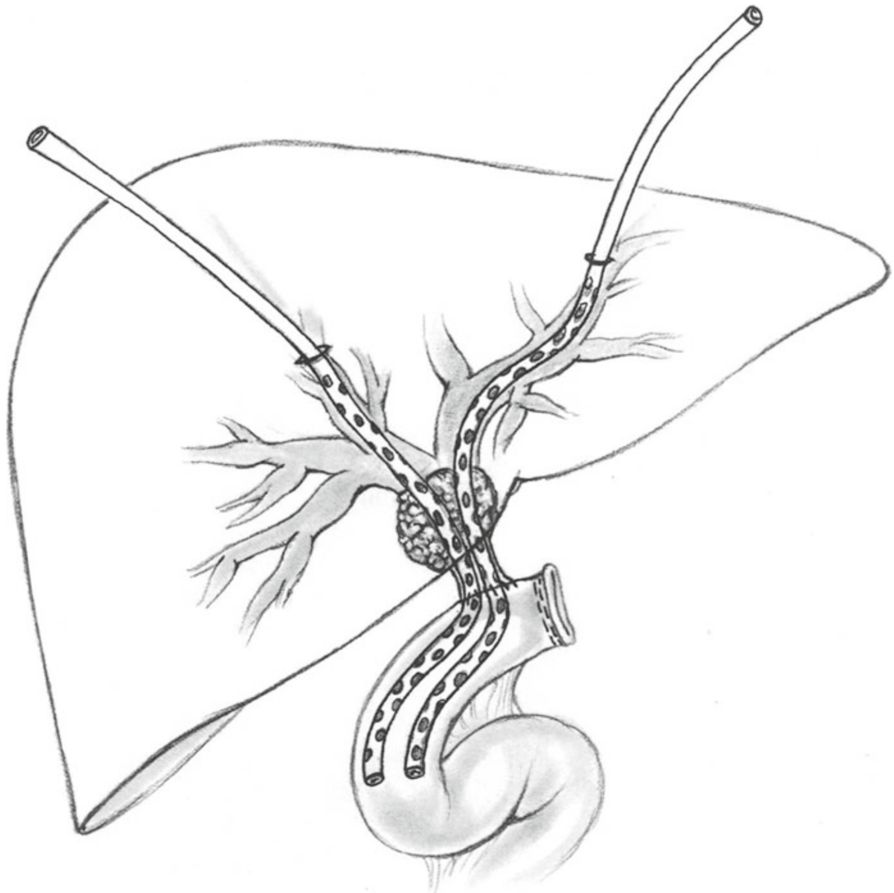

Fig. 86.8

Instruct the patient to return to the radiology department every 3 months to have the catheters replaced, as sludge tends to occlude the openings over time. The catheters are replaced by passing a sterile guidewire through the Silastic tube; the Silastic tube is then removed with sterile technique and replaced with another tube of the same type. Remove the wire and obtain a cholangiogram to confirm that the tube has been accurately placed. Then suture the tube to the skin. If the patient develops cholangitis, it may be necessary to replace the tube earlier than 3 months. Remove the closed-suction drains when there is no further drainage of bile.

Continue perioperative antibiotics until the closed-suction drains have been removed. Maintain nasogastric suction for 3–5 days. Prescribe an H_2-blocker or proton pump inhibitor intravenously to lower the incidence of postoperative gastric "stress" bleeding. Maintain this regimen until the patient has resumed a regular diet.

Modern methods of brachytherapy permit insertion of radioactive pellets into the Silastic catheters in such fashion that a large dose of radiation can be administered precisely to the bed of the tumor postoperatively. The range of radiation is limited to a precise, shallow depth.

Complications

Sepsis, *Subhepatic or Subphrenic*. Cholangitis generally does not occur unless something obstructs the drainage of bile. If the ducts draining only one lobe of the liver have been intubated, leaving the opposite hepatic duct completely occluded but not drained, cholangitis or even a liver abscess frequently appears over time. Consequently, in the presence of a tumor at the bifurcation of the hepatic duct that occludes both right and left hepatic ducts, drainage of each duct is necessary. If drainage of both ducts cannot be accomplished in the operating room, request the radiologist to insert a catheter into the undrained duct percutaneously via the transhepatic route after operation. Routine replacement of the Silastic tubes at intervals of 2–3 months prevents most cases of postoperative cholangitis.

Bile may *leak* around the Silastic tube early if the puncture wound in Glisson's capsule is larger than the diameter of the Silastic tube. If leakage occurs late during the postoperative course, attempt to replace the tube around which the bile is leaking with a tube of somewhat larger diameter. If leakage occurs during the immediate postoperative course, check the position of the Silastic tubes by performing cholangiography to ascertain that none of the side holes in the tubes is draining freely into the peritoneal cavity.

Upper gastrointestinal *hemorrhage* may occur after procedures that divert bile from the duodenum. Patients should be alerted to this possibility and treated promptly with antacid therapy and cimetidine.

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Hepatic Resection

87

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Isolated liver metastases

Symptomatic benign liver lesions

Primary hepatic malignancies

In conjunction with bile duct resection for selected cases of proximal bile duct carcinoma (see also Chap. 86)

Parasitic or bacterial infections, hepaticolithiasis, and trauma (infrequent indications)

The major *contraindications* to hepatic resections are hepatic insufficiency and advanced stage of malignancy.

Preoperative Preparation

Prescribe mechanical and antibiotic bowel preparation.

Correct coagulopathy, if present.

Provide adequate blood and blood product support.

Correct malnutrition.

Defer resection temporarily for diffuse fatty infiltration of the liver and attempt to improve nutritional parameters.

Pitfalls and Danger Points

Hemorrhage from hepatic or portal veins or hepatic arteries

Air embolism from hepatic venous injury

Injury to the bile ducts, with postoperative obstruction or fistula

Portal or hepatic vein compromise with subsequent ischemia or postsinusoidal portal hypertension

Prolonged vascular inflow occlusion leading to refractory liver ischemia

Injury to the diaphragm, inferior vena cava, or intestine (especially after prior gastric, hepatobiliary, or colon surgery)

Operative Strategy

Anatomic Basis for Liver Resection

There are three major hepatic veins: left, right, and middle. Each delineates a plane (termed a hepatic scissura) that divides the liver into functional anatomic units (Fig. 87.1).

The middle hepatic vein defines the main scissura. This anatomic plane divides the liver into two roughly equal units, the left and right liver. The terms left and right liver are used to avoid confusion with older terminology in which left and right hepatic lobes were defined by surface anatomy rather than deep anatomy. The location of this plane can be approximated by a plane running through the gallbladder fossa anterior to the left margin of the inferior vena cava posteriorly. In modern terminology, a right hepatic lobectomy consists of removing all of the right liver, and left hepatic lobectomy removes the entire left liver.

The portal pedicles contain major branches of the hepatic artery, portal vein, and bile ducts running together. These pedicles interdigitate with the hepatic veins. The territory served by the portal pedicles and their major branches define the sectors and segments of the liver (Fig. 87.2; see also Fig. 87.1).

Segments 1–4 comprise the left liver and segments 5–8 the right liver. Each segment has an identifiable portal pedicle. Segmental hepatic venous drainage is variable and anatomically separates from the portal pedicles because of the manner in which the hepatic veins interdigitate with and cross these portal pedicles inside the liver (Fig. 87.1).

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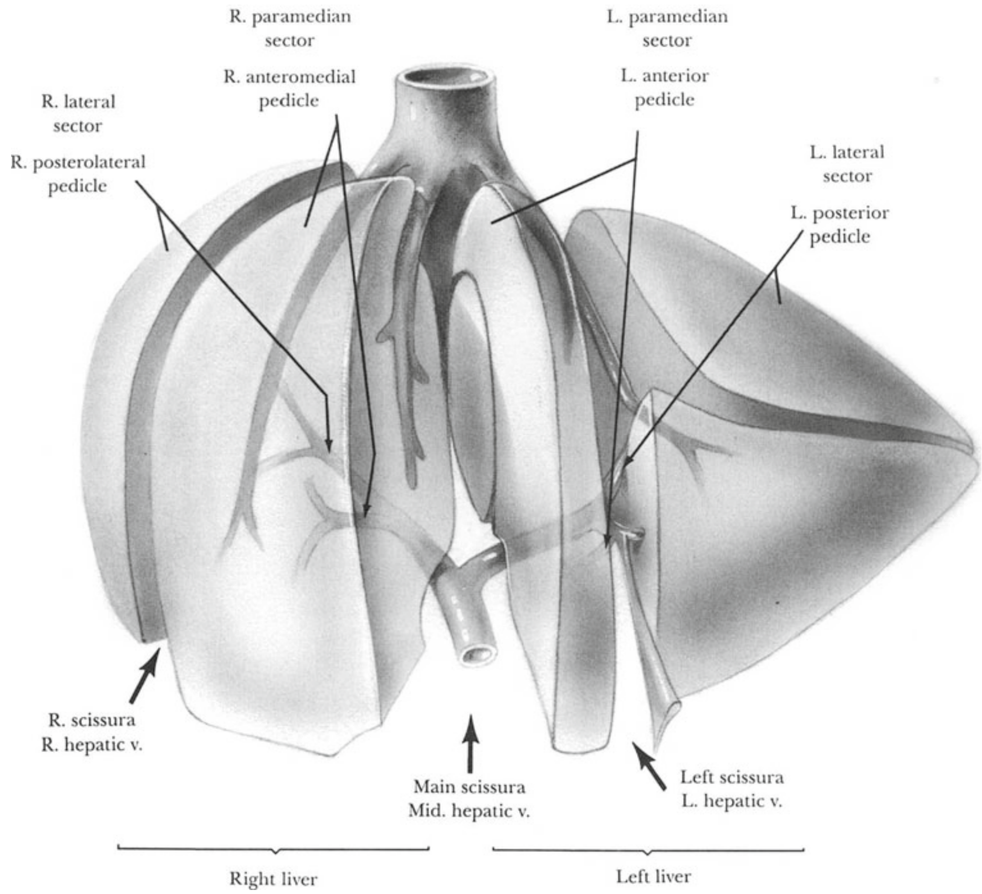

Fig. 87.1

At the hilum the portal pedicles branch into the right and left pedicles (Fig. 87.3). A continuation of peritoneum termed the cystic plate covers the right pedicle, and the left pedicle is invested by the umbilical plate. This peritoneum fuses with Glisson's capsule, and the falciform ligament attaches at the cephalad aspect of the umbilical plate. Adequate exposure of this area requires upward mobilization of segment 4 and incision of Glisson's capsule.

Extent of Resection

The need to achieve a clean resection with an adequate margin must always be balanced against the need to preserve an adequate mass of functioning liver parenchyma. Because the liver has a remarkable capacity for regeneration, patients without underlying liver disease can tolerate resection of up to six of the eight liver segments. The situation is far different when resection is contemplated in the setting of acute or chronic liver disease. Careful preoperative assessment and judicious treatment of the underlying liver disease are needed. Hence patients with known chronic liver disease or cirrhosis are best evaluated in centers performing orthotopic liver transplantation.

Excise benign lesions completely whenever possible. The specific resection strategy (enucleation versus wedge versus formal anatomic resection) depends on the size, location, and relation to the tumor of the major afferent and efferent vasculature and bile ducts. Enucleation is effective for encapsulated or sharply demarcated lesions. Wedge resections are typically subsegmental and performed without reference to anatomic boundaries. These nonanatomic resections generally are undertaken for peripheral liver masses that are not adjacent to the hilus or hepatic veins. Wedge resections are easiest for small (<4 cm) tumors arising within anterior liver segments 3–6. Formal anatomic resection should be considered for large or deeply seated lesions or those with indistinct margins, such as hepatic adenomas or some cavernous hemangiomas. This resection may be a standard right or left anatomic lobectomy, or it may be tailored along segmental boundaries in such a manner as to maximize residual functioning hepatic mass and preserve vital vascular and ductal structures to the liver remnant.

Malignant hepatic tumors, primary or metastatic, require resection with a margin of normal liver. Ideally, a 1- to 2-cm margin is preferred to reduce the risk of recurrence. Protect the afferent and efferent vasculature of the anticipated

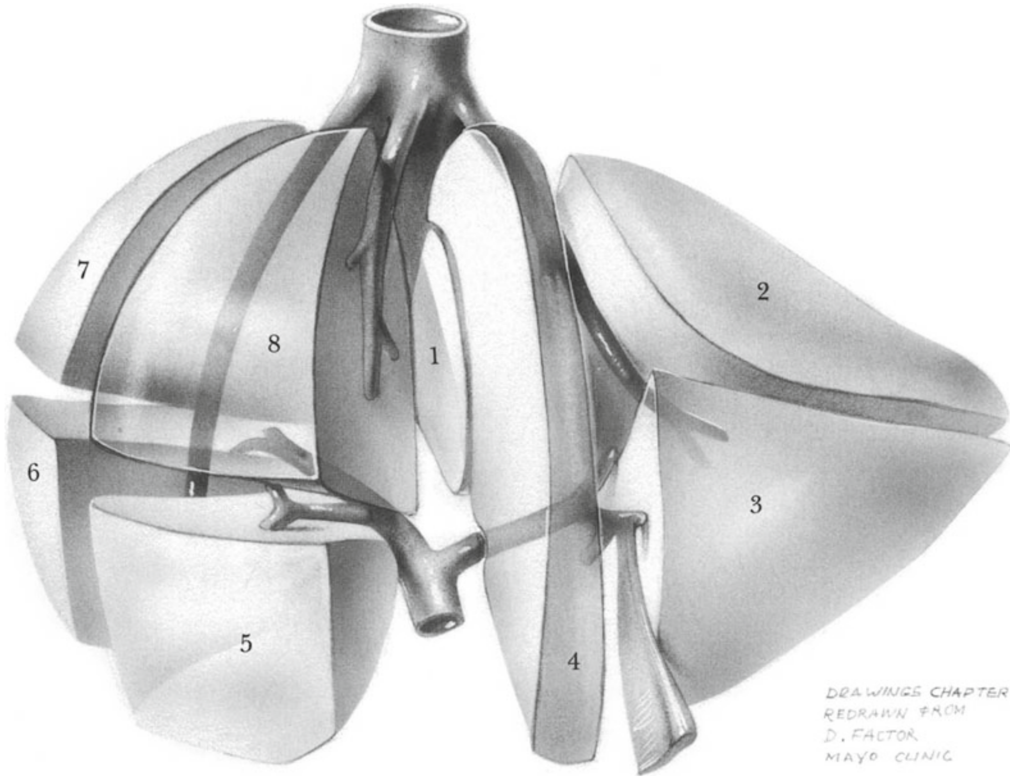

Fig. 87.2

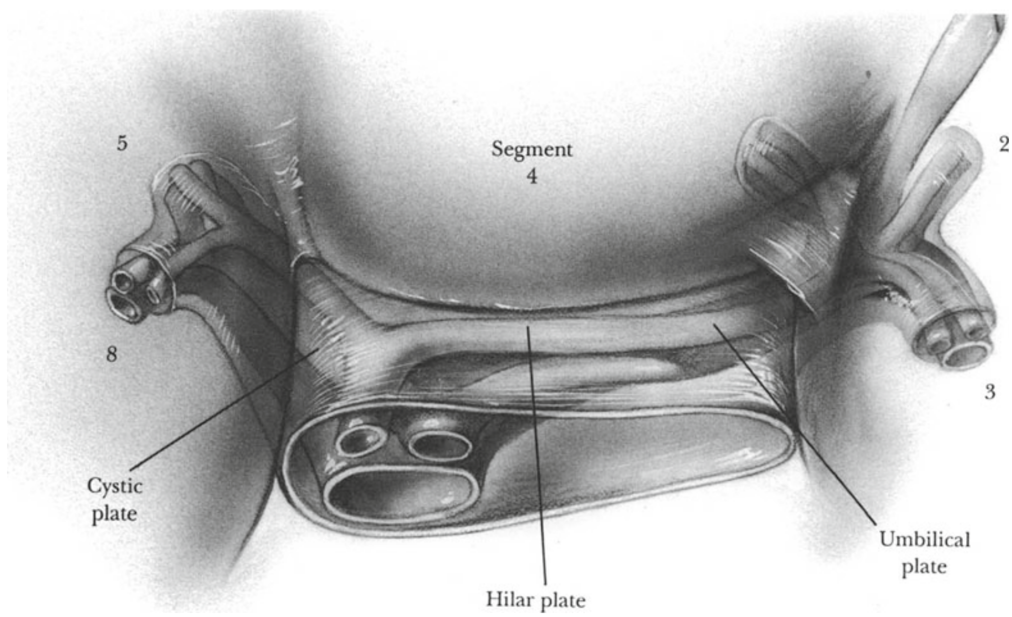

Fig. 87.3

postresection liver remnant scrupulously to prevent postoperative liver failure. Use preoperative imaging studies to exclude patients with multicentric tumor arising in both lobes and those with distant disease. Additional intraoperative findings that preclude resection are peritoneal metastases, extensive regional lymph node involvement, unexpected pulmonary metastases discovered during a thoracoabdominal approach, or malignant thromboses extending into the main portal vein or inferior vena cava. Formal anatomic resection is preferred for malignancies unless the malignancy is small and located peripherally. Intraoperative ultrasonography is a useful adjunct.

Anatomic Liver Resections

Resection of a single liver segment or multiple contiguous segments requires identification and ligation of the segmental vasculobiliary pedicle and parenchymal division through anatomic intersegmental planes. Resection along intraoperatively defined anatomic boundaries is the major difference between nonanatomic wedge resections and anatomic segmental resections. In general, anatomic resections are preferable for primary malignancies because they remove segmental intraportal metastases and enhance preservation of function in adjacent segments in cirrhotic livers.

Resection of segments 2 and 3 is commonly termed left lateral lobectomy. It consists of removing the hepatic parenchyma to the left of the falciform ligament. This deceptively easy resection is fraught with hazard, as the left hepatic vein is large and may be encountered in the plane of dissection. A second danger comes from recurring or feedback branches of the vasculobiliary pedicle to segment 4, which must be preserved. Maintaining the plane of dissection 1–2 cm to the left of the falciform ligament is crucial for safe resection.

Lobar resections have also been termed right and left hemihepatectomy, lobectomy, or hepatectomy. Lobar resections are actually polysegmental resections based on the main right or left vasculobiliary pedicles. Operative risk of significant blood loss is reduced by ligation of the appropriate lobar hepatic artery and portal vein branch prior to parenchymal transection. Subsequent ligation of the corresponding hepatic vein, if technically possible, further reduces operative blood loss. Ligation of the respective bile duct is deferred until it is unequivocally identified (Starzl et al. 1980, 1982).

Major lobar resections may be extended anatomically or nonanatomically. Anatomic extensions are performed by removing the liver segments adjacent to the principal plane. For example, a right hepatectomy (polysegmentectomy of 5–8) may be extended anatomically to include segment 4 (polysegmentectomy of 4–8), or a left hepatectomy (polysegmentectomy of 1–4) can be extended anatomically to include segments 5 and 8 (polysegmentectomy of 1–5 and 8). Anatomic extensions imply formal ligation of the appropriate segmental pedicle and transection of the liver along intersegmental planes other than the principal plane. Nonanatomic extensions are self-explanatory.

Principles of Safe Liver Resection

Liver resection can be conceptualized as involving three phases: parenchymal transection, vascular control, and identification and preservation of the bile duct to the liver remnant. The order in which these phases are performed varies. For simple enucleations and wedge resections, only parenchymal transection is required. For major anatomic resections, vascular control is obtained first. The parenchyma is then divided, and the bile ducts are divided only when the surgeon has ascertained the precise anatomy and ensured that drainage to the remnant is preserved.

Parenchymal Transection

Embedded in the soft liver parenchyma are vascular and ductal structures of greater mechanical strength. Most methods of parenchymal transection use this difference in tissue strength to surgical advantage. Conceptually, the surgeon simply disrupts the parenchyma along the planned transection plane to expose bile ducts and vessels for ligation. Because all branches of the portal pedicle are enveloped by extensions of the vasculobiliary sheath, the portal veins are less fragile than branches of the hepatic vein. Disruption of the small hepatic veins (<l–2 mm) during parenchymal transection is common. Hemorrhage from small hepatic veins is easily controlled by parenchymal compression, electrocautery, or a suture ligation.

Liver parenchyma can be disrupted by compression methods such as finger fracture, contact methods [Cavitron ultrasonic aspirator (CUSA), water jet], or thermal methods (electrocautery or laser). Each method has its advantages and disadvantages. Although the zone of parenchymal damage adjacent to the transection plane varies among these methods, the clinical significance of these microscopic zones of devitalized parenchyma is negligible unless the transection results in major damage to the vasculature of the liver remnant and significant regional ischemia occurs. We prefer finger fracture for small wedge resections and CUSA for large parenchymal transections.

The first step is always to score the capsule of the liver along the line of the planned transection with electrocautery. Parenchymal transection is most conveniently begun at a free edge, where the liver is relatively thin.

Finger fracture simply involves pinching and compressing about 1 cm of liver parenchyma between thumb and forefinger. A pill-rolling back-and-forth motion of thumb and finger while squeezing the liver disrupts normal liver easily yet preserves most vascular and ductal structures. As the fracture plane develops, the surgeon and first assistant work together to compress the parenchyma on both sides of the developing cleft and to open the cleft to expose the deeper portions. The inside part of a pool-tip sucker can be used as an adjunct to finger fracture. The CUSA is more precise but somewhat slower (Fig. 87.4). It should be set to disrupt rather than cauterize, and in this mode it functions as a mechanical disruptor with suction. It is particularly useful for delicate dissection in the region of the hilum.

Typically, any structures >2 mm require ligation. Near-circumferential exposure of intraparenchymal structures

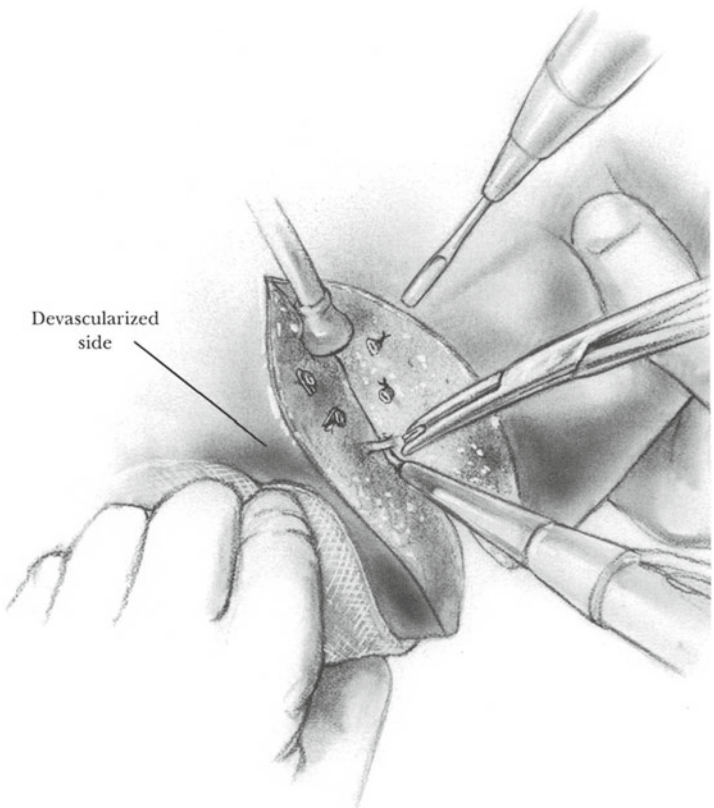

Fig. 87.4

optimizes secure ligation. Intraparenchymal portal pedicle branches and hepatic veins can be ligated between fine silk sutures, metal clips, or a combination of the two. Avulsion of small hepatic vein branches from a major hepatic vein can be particularly troublesome. Hemorrhage from the orifice of an avulsed hepatic vein branch of an exposed major hepatic vein is best controlled by a fine vascular suture material (5-0 or 6-0 Prolene) while carefully maintaining blood flow through the main hepatic vein. If bleeding results from a small hepatic vein without exposure of its major hepatic vein, a single figure-of-eight suture ligature is adequate. Conceptualize a transection plane during parenchymal transection. Transection along the plane without deviation results in a reduced risk of hemorrhage and elimination of partial devascularization of the adjacent liver segment at the interface.

Vascular Control

Safe major hepatic resection primarily depends on avoiding and controlling hemorrhage. Early during the dissection, obtain circumferential access to the hepatoduodenal ligament. This permits total hepatic vascular inflow occlusion (Pringle maneuver) to control hemorrhage from the high-pressure afferent vasculature at any time during resection. Control hemorrhage from the low-pressure hepatic venous system temporarily by digital pressure, parenchymal compression, or packing.

Exposure of the hepatic veins at the junction of the inferior vena cava requires complete division of the ligamentous attachments to the liver. In particular, the retrocaval ligament bridging segments 6 and 7 must be completely divided to expose the right hepatic vein. Approach the hepatic veins only after controlling the afferent vessels. If tumor obscures the hepatic venous anatomy at its junction with the inferior vena cava, consider total hepatic vascular isolation to permit safe exposure and control. Circumferentially expose the inferior vena cava above (infradiaphragmatic) and below (suprarenal) the liver and apply large vascular clamps. No lumbar veins enter the retrohepatic inferior vena cava. Ligation of the right adrenal vein combined with infra- and suprahepatic inferior vena cava clamping and inflow vascular occlusion of the hepatoduodenal ligament results in total hepatic vasculature isolation. The hepatic veins can then be exposed in a controlled fashion (Delva et al. 1987).

Preservation of Bile Ducts

Bile duct injury is a potential source of major morbidity following hepatic resection. Identify the ductal confluence unequivocally before ligating any major lobar branches during formal or extended lobectomy. If ductal anatomy is in question, two options exist. First, major lobar branches can always be clearly identified by deferring ductal ligation until parenchymal transection exposes the major ducts at the level of the hilar plate. With the surrounding parenchyma transected, the major ducts can be traced from the parenchyma to the confluence and ligated or preserved accordingly. Parenchyma around the major ducts can be excised by CUSA if necessary. Division of the ducts within the parenchyma and probe cannulation distally allows unequivocal confirmation of patency of the ductal confluence. Alternatively, a choledochotomy permits cannulation of the proximal ducts with Bakes dilators or other intraluminal devices, which in turn allows tactile and visual identification of the major ducts for appropriate management.

Operative Technique

Incision and Exposure

A bilateral subcostal incision affords wide exposure for most hepatic resections (Fig. 87.5). We use a vertical midline extension with a partial or complete sternotomy if necessary for additional exposure in difficult situations. Some surgeons prefer a right thoracic extension for this purpose.

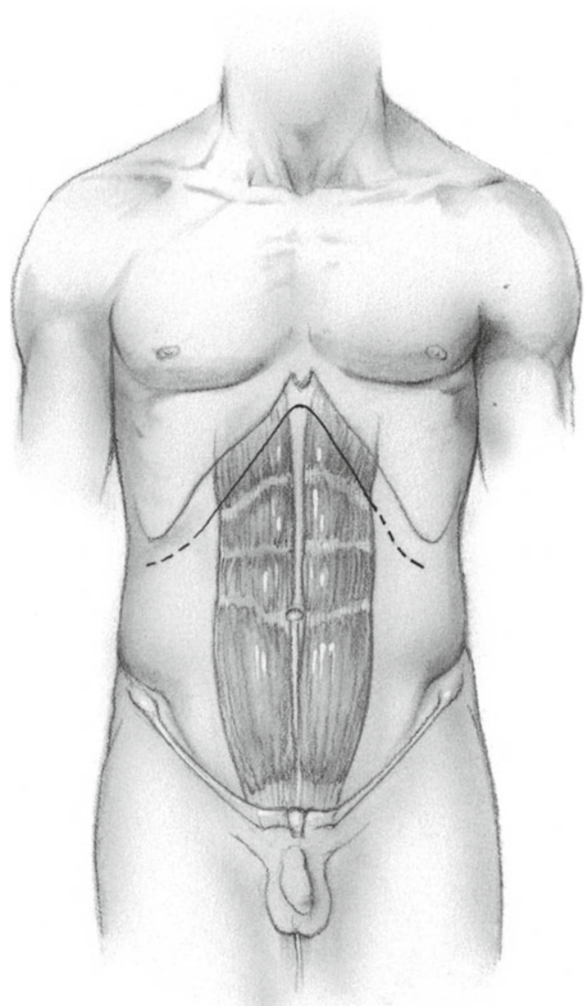

Fig. 87.5

For limited resections of segments 2 through 6, a vertical midline incision may provide sufficient exposure. Tumor involving segments 7 and 8 or extended lobar resections are approached more safely through a bilateral subcostal incision with an upper midline extension if necessary.

Divide any perihepatic adhesions. Fully mobilize the liver by dividing the ligamentous attachments (Fig. 87.6a, b, c, d). Divide the gastrohepatic omentum and expose the foramen of Winslow for inflow vascular occlusion. Use an Upper Hand or Thompson retractor to elevate the rib cage cephalad, and place additional retractors as needed to retract the hollow viscera caudally.

Wedge (Nonanatomic, Subsegmental, or Peripheral) Resection

For a wedge resection, after mobilizing the liver, place laparotomy pads posteriorly between the liver and diaphragm to enhance exposure by anterior displacement. Estimate the planned margin of resection by palpation and score the liver capsule with cautery to outline the margin. Transect the parenchyma with cautery, finger fracture, or CUSA (Fig. 87.4). Clip or ligate bile ducts or vessels >2 mm. After obtaining local bile stasis and hemostasis, close the abdomen. Drainage is generally not necessary for simple wedge resections within a single segment or adjacent segments unless concurrent biliary tract disease is present.

Anatomic Unisegmental and Polysegmental Resections

For anatomic uni- or polysegmental resections, define the segmental location of the tumor with intraoperative ultrasonography. Identify the portal pedicle(s) supplying the segment(s). These structures must be ligated for accurate anatomic segmental resection. They may be accessed by proximal dissection from the hilar bile ducts and vasculature to the appropriate pedicle or by direct rapid parenchymal transection along an estimated intersegmental plane with ultrasound guidance. Dissection from the hilus is most applicable for anterior segments 3–6. The parenchymal transection approach is more appropriate for ligation of the posterior segmental pedicles to segments 7 and 8. Both approaches are greatly facilitated by using temporary vascular inflow occlusion to reduce hemorrhage and using CUSA for rapid exposure of the pedicle through the intervening parenchyma. Alternatively, methylene blue injection of the segmental or portal pedicle using ultrasound guidance can provide accurate segmental or sectoral definition. Once the appropriate portal venous branch is injected, segmental boundaries are defined by parenchymal staining, and resection proceeds according to the defined boundaries. Although precise, this approach is more technically demanding and requires expertise in operative ultrasonography.

To approach anterior liver segments 3, 4, 5, and 8 for resection, mobilize the liver and incise the hilar plate. Identify the appropriate lobar pedicle. Dissection proceeds proximally until the segmental pedicle is exposed. Confirm accurate segmental pedicle identification by ultrasonography. Temporarily occlude the pedicle to (Starzl et al. 1980) outline the segmental boundaries with cautery, (Starzl et al. 1982) ensure that the tumor is included within the segmental demarcation, and (Delva et al. 1987) confirm that the pedicle provides adequate margins. If appropriate, ligate the segmental pedicle with a silk suture. Transect the parenchyma by cautery, finger fracture, or CUSA. Use temporary inflow vascular occlusion during dissection of the pedicle and parenchymal transection as needed. Few vessels or ducts require ligation if the resection is truly along intersegmental planes. Hepatic veins do require ligation, and they

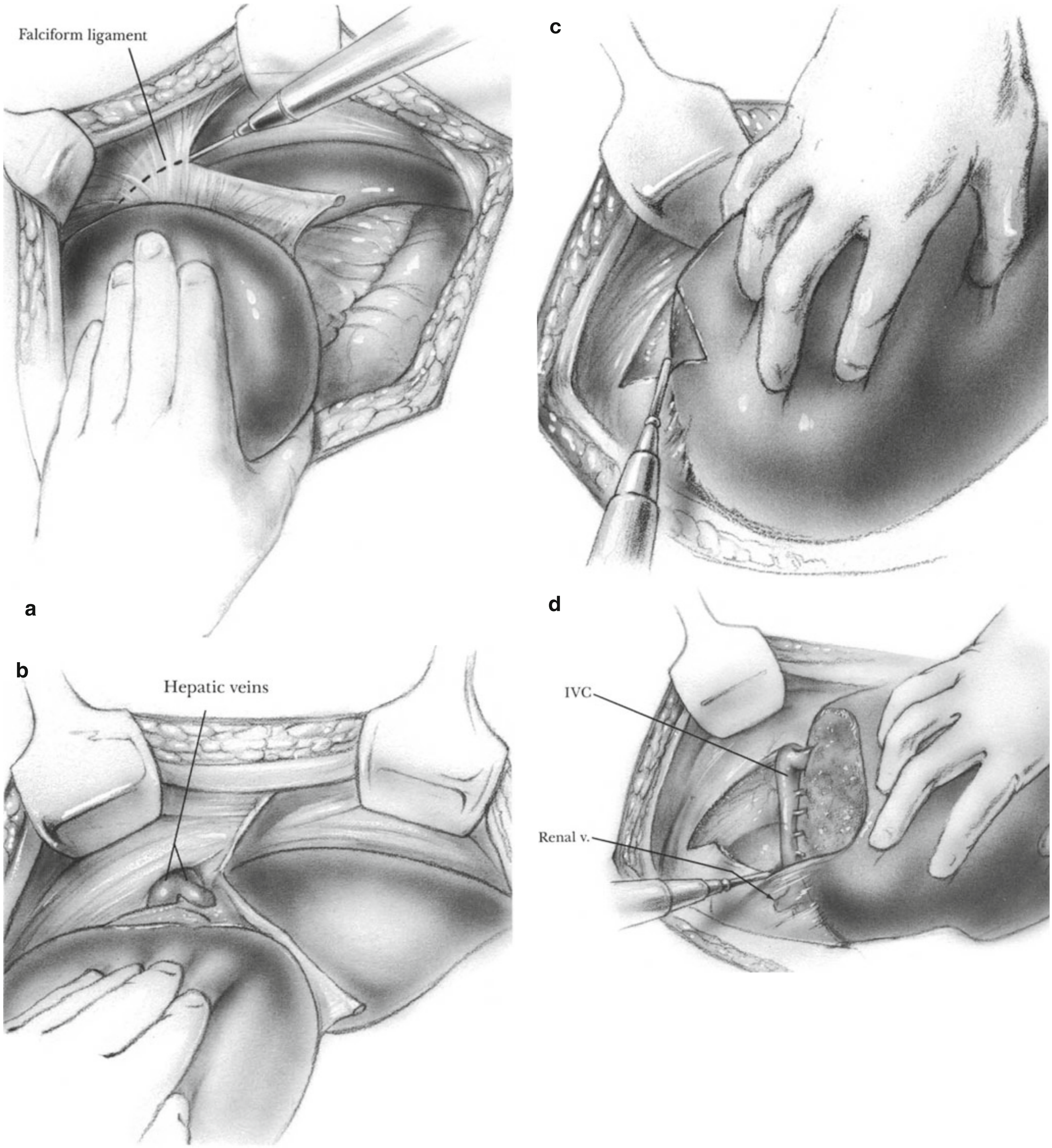

Fig. 87.6

are individually ligated with silk. If the margins are narrow, extend the resection either nonanatomically into contiguous liver segments or anatomically by adjacent segmentectomy. After securing bile stasis and hemostasis, place a single suction drain in the resection bed and close the abdomen.

Polysegmentectomy is performed in a manner similar to unisegmentectomy except that each segmental pedicle is ligated sequentially before extending the parenchymal transection. Once all appropriate pedicles are ligated, the contiguous liver segments are removed en bloc.

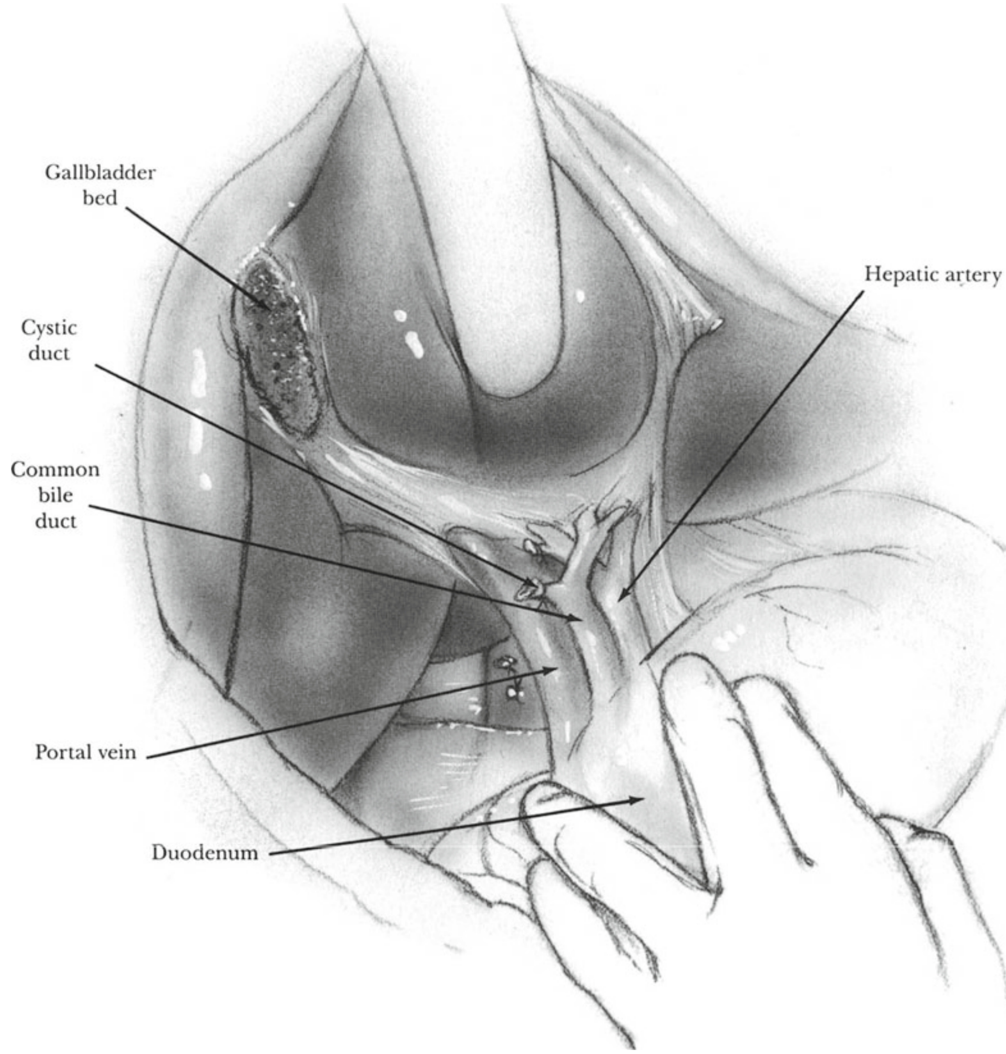

Fig. 87.7

Resection of Segments 2 and 3 (Left Lateral Lobectomy)

For a left lateral lobectomy, mobilize the left lobe of the liver by dividing the left triangular ligament (Fig. 87.6a, b). Take care to avoid the left hepatic vein. Identify and separately ligate the vasculobiliary pedicles to segments 2 and 3. Seek and preserve any recurring or feedback structures that drain and supply segment 4 (Fig. 87.3). Divide the parenchyma, taking care to remain to the left of and preserve the left hepatic vein by remaining well to the left of the falciform ligament.

Anatomic Right Hepatectomy (Right Hepatic Lobectomy)

For right hepatic lobectomy, fully mobilize the liver and perform cholecystectomy to enhance exposure of the hilar vasculature. First, ligate the right hepatic artery, which generally traverses the triangle of Calot. Excise the peri-choledochal lymph nodes to further expose the bile duct, portal vein, and hepatic artery. Incise the right lateral aspect of the hepatoduodenal ligament longitudinally just posterior to the bile duct (Fig. 87.7). The hepatic arteries are always found lateral to the common hepatic duct, at the point where they enter the liver parenchyma. Ligate lymphatic vessels around the hepatic arteries before dividing them to reduce postoperative lymph drainage. Temporarily occlude the right hepatic artery while palpating the artery to the opposite lobe to ensure patency of the arterial supply to the liver remnant. Having confirmed this, double-ligate the right hepatic artery with heavy silk and divide it (Fig. 87.8a).

Retract the bile duct anteriorly with a vein retractor to expose the portal vein bifurcation. Expose the right portal vein from the right of the hepatoduodenal ligament. The two

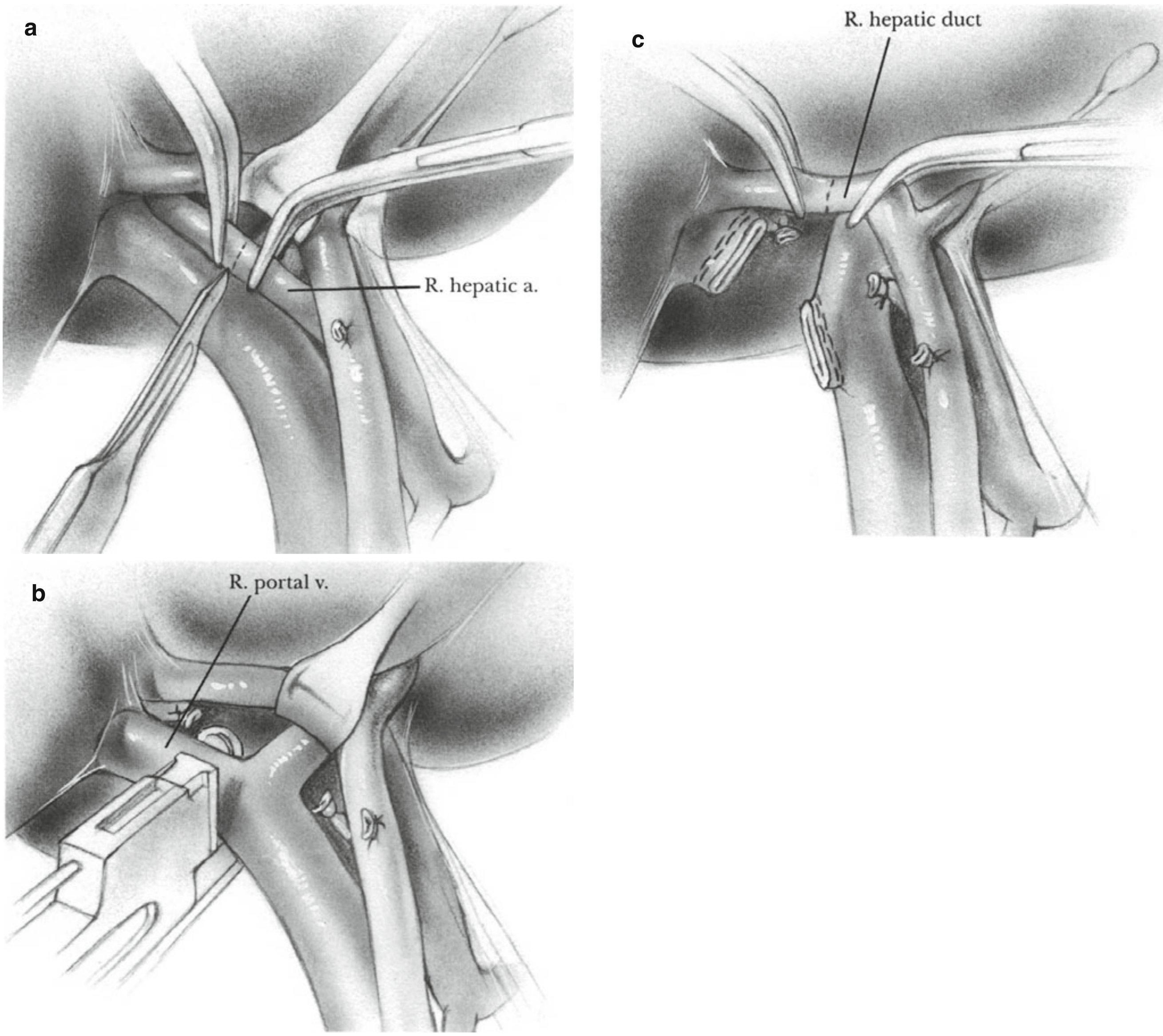

Fig. 87.8

major branches of the right portal vein (anterior and posterior) may arise separately without a common trunk, resulting in a portal vein trifurcation. Free the right portal vein branch from surrounding lymphoareolar tissue and ligate it with a vascular stapler or a running vascular suture after division between clamps (Fig. 87.8b). Do not use a simple ligature because dislodgement risks life-threatening hemorrhage. The bile duct to the right lobe may be ligated and divided at this time if the anatomy is clear (Fig. 87.8c), or this step may be deferred until further dissection has been completed. A clear line of vascular demarcation along the principal liver plane between lobes confirms appropriate and complete lobar ligation (Fig. 87.9).

After the afferent vessels are controlled, approach the hepatic veins. Multiple small short hepatic veins between the inferior vena cava and segments 1, 6, and 7 must be ligated as the liver is retracted anteriorly and to the left (Fig. 87.10). Ligation starts infrahepatically and proceeds cephalad. Occasionally a large, right inferior hepatic vein enters the inferior vena cava from the posterior aspect of segment 6. Staple or suture closure for secure ligation is preferred.

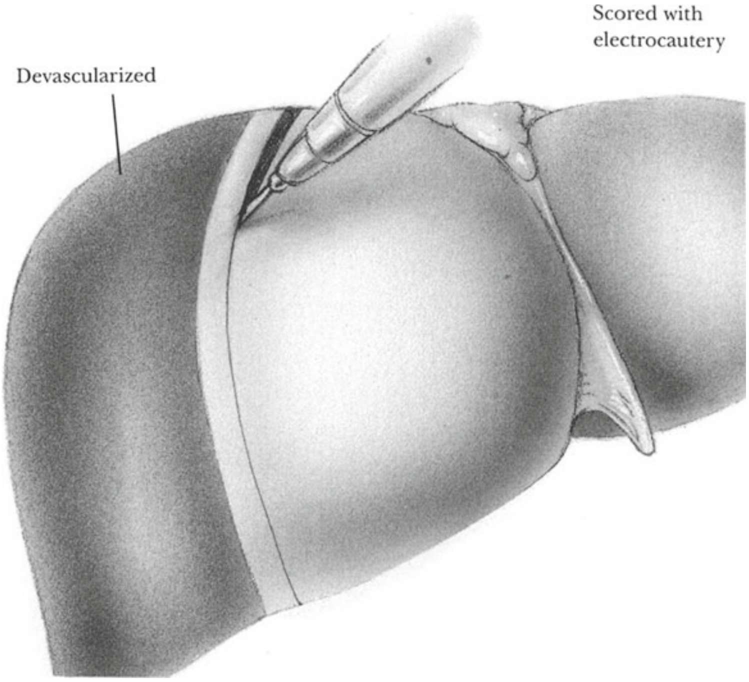

Fig. 87.9

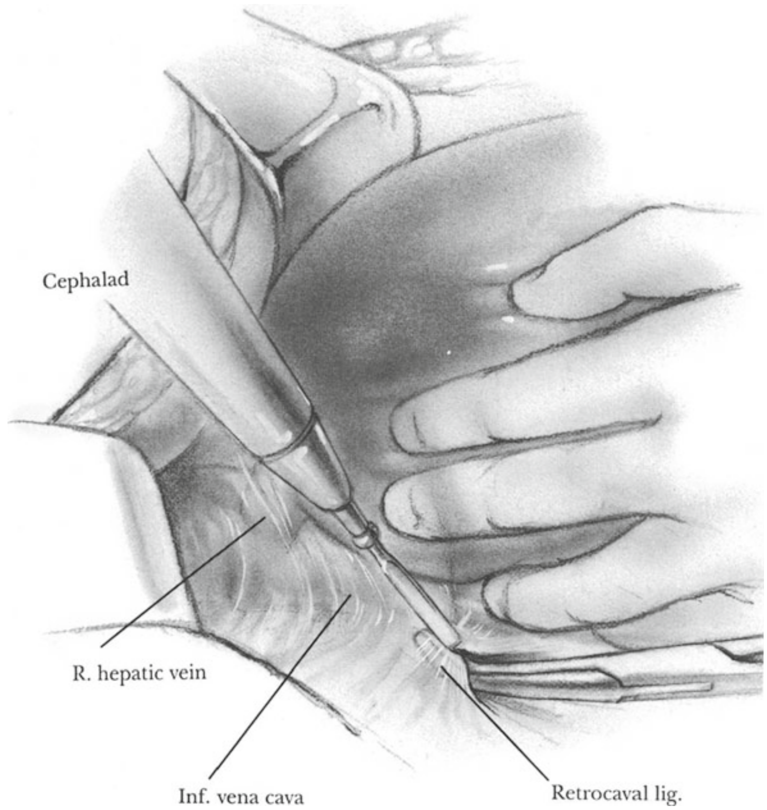

Fig. 87.11

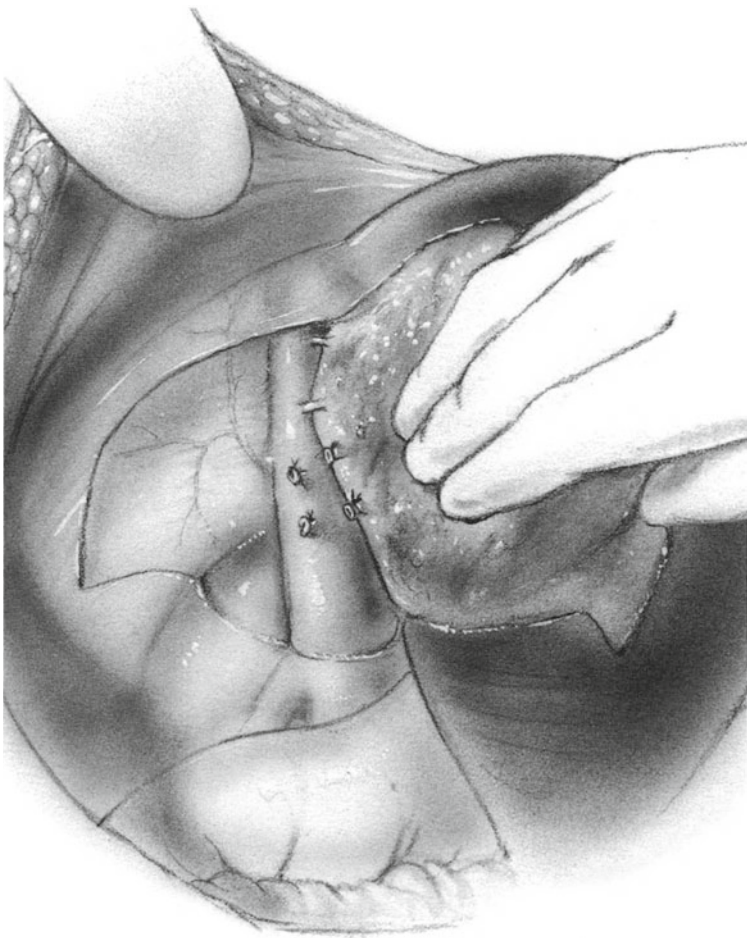

Fig. 87.10

To expose the main right hepatic vein, divide the retrocaval ligament bridging segments 1 and 7 (Fig. 87.11). A moderate-sized vein frequently traverses the ligament and requires ligation. Then dissect the main right hepatic vein from the inferior vena cava and liver. Unless a large tumor precludes access, transect the right hepatic vein with a vascular stapler (McEntee and Nagorney 1991) and ligate the parenchymal side with a running vascular suture before parenchymal transection (Fig. 87.12). Alternatively, ligate the right hepatic vein as the final step of a formal lobectomy after parenchymal transection.

Transect the parenchyma on the line of vascular demarcation along the principal plane by finger fracture, cautery, or CUSA (Fig. 87.13). Clip bile ducts or vessels on the resection side of the liver, and ligate them on the remnant side to reduce artifact image distortion on postoperative follow-up computed tomography (CT) scans. Ligate the middle hepatic vein during the parenchymal phase as encountered. As the hilus is approached, the bile ducts to the lobe being resected are exposed. Again, ligation is performed only when patency of the remaining lobar duct can be ensured. Look for the smaller ducts to segment 1 posterior to the main ductal confluence, and ligate them if encountered. Next, transect the parenchyma of the caudate process, or that liver substance between the posterior aspect of the portal vein and the

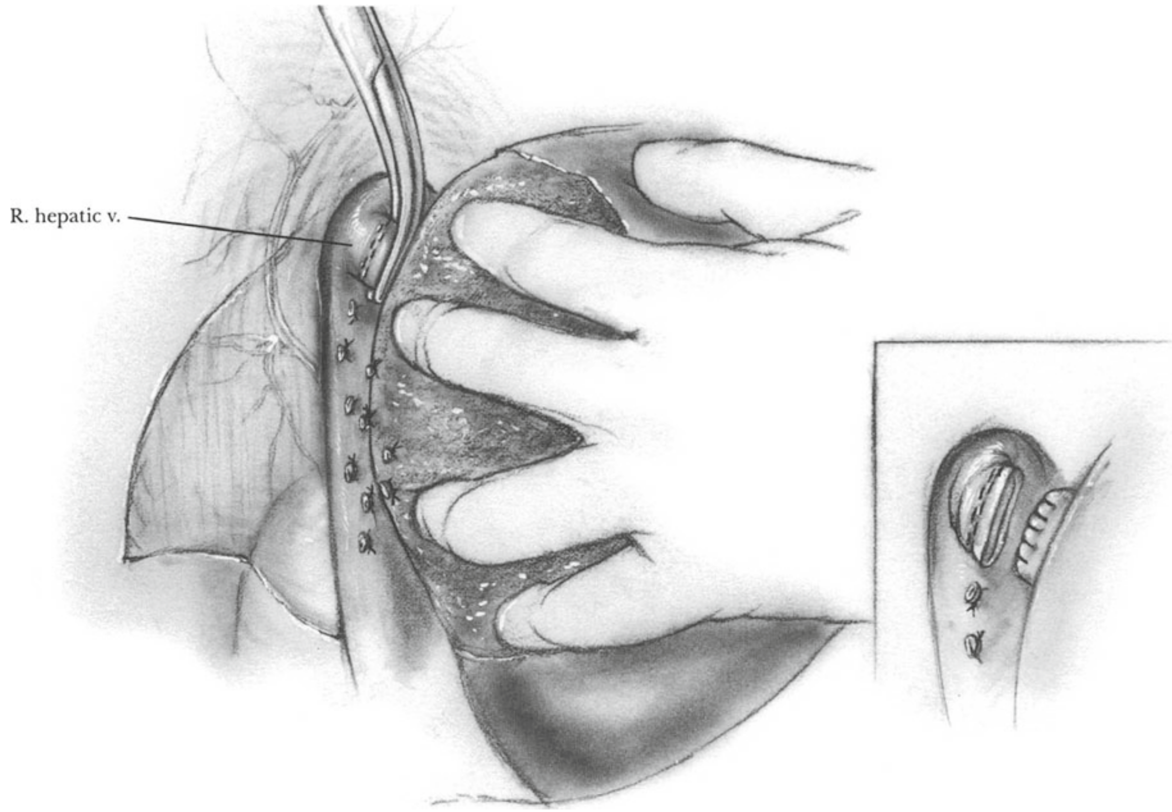

Fig. 87.12

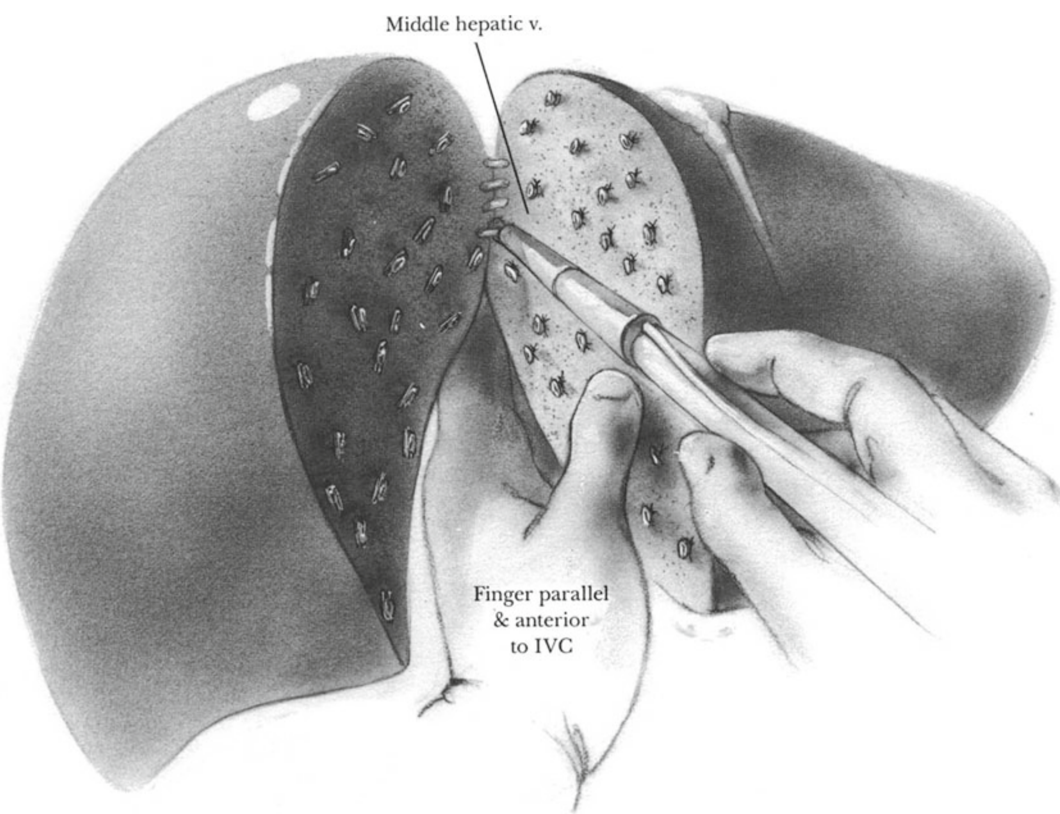

Fig. 87.13

inferior vena cava, to expose the anterior surface of the inferior vena cava. Continue parenchymal transection along the principal plane until the main hepatic veins are encountered. If the major hepatic vein has been ligated, simply remove the lobe. If not, clamp or divide the hepatic veins with a vascular stapler. Use inflow vascular occlusion during parenchymal transection to reduce intraoperative hemorrhage if necessary.

Obtain hemostasis and bile stasis but avoid large interlocking parenchymal liver sutures. Figure 87.14 shows the appearance of the hepatic remnant after right hepatic lobectomy. A suction drain is placed adjacent to the transected liver surface and bought out dependently through the abdominal wall. Occasionally the divided falciform is reapproximated to prevent torsion of the liver remnant and postoperative vascular compromise. The omentum is not attached to the parenchyma. The abdomen is closed in standard fashion.

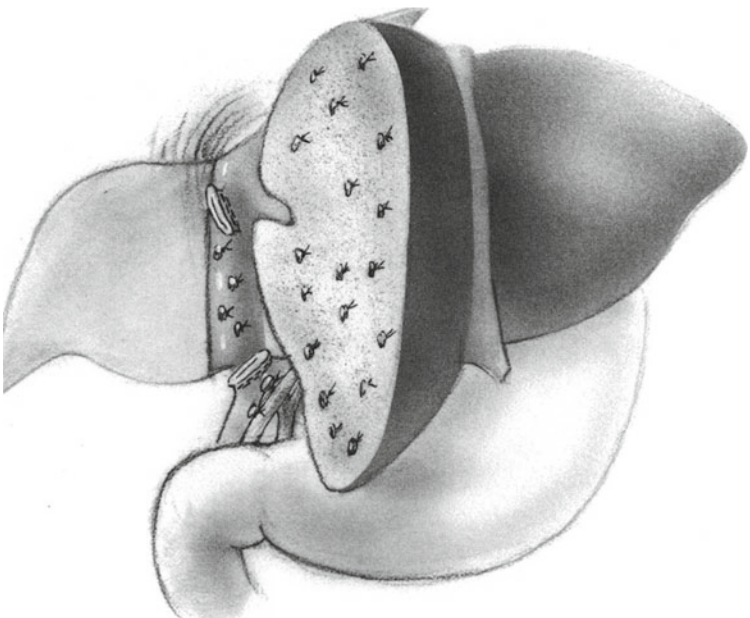

Fig. 87.14

Anatomic Left Hepatectomy (Left Hepatic Lobectomy)

For anatomic left hepatectomy, in a manner analogous to that used for the anatomic right hepatic lobectomy, first identify and divide the left hepatic artery and portal vein. After division of the gastrohepatic omentum, approach the left hepatic artery through the lesser sac via the left lateral aspect of the hepatoduodenal ligament. The main left hepatic artery is generally found just inferior to the base of the round ligament as it enters the left lobe between segments 3 and 4 (Fig. 87.15). An accessory left hepatic artery, arising from the left gastric artery, always courses through the gastrohepatic omentum and is often divided during division of the gastrohepatic omentum. Confirm the patency of the arterial supply to the right liver by temporarily occluding the left hepatic artery before clamping, ligating, and dividing the vessel (Fig. 87.15a).

While retracting the bile duct with a vein retractor, identify the left portal vein at the left aspect of the hepatoduodenal ligament. The main left portal vein branch always bifurcates from the right main branch at approximately 90° and courses anterolaterally. Divide it with a vascular stapler (Fig. 87.15b) or running suture as previously described. Note the developing line of transection, as the left liver lobe should now be completely devascularized. If the ductal anatomy is clear, double-ligate and divide the left hepatic duct (Fig. 87.15c); if the anatomy is in doubt, defer this step until later in the dissection.

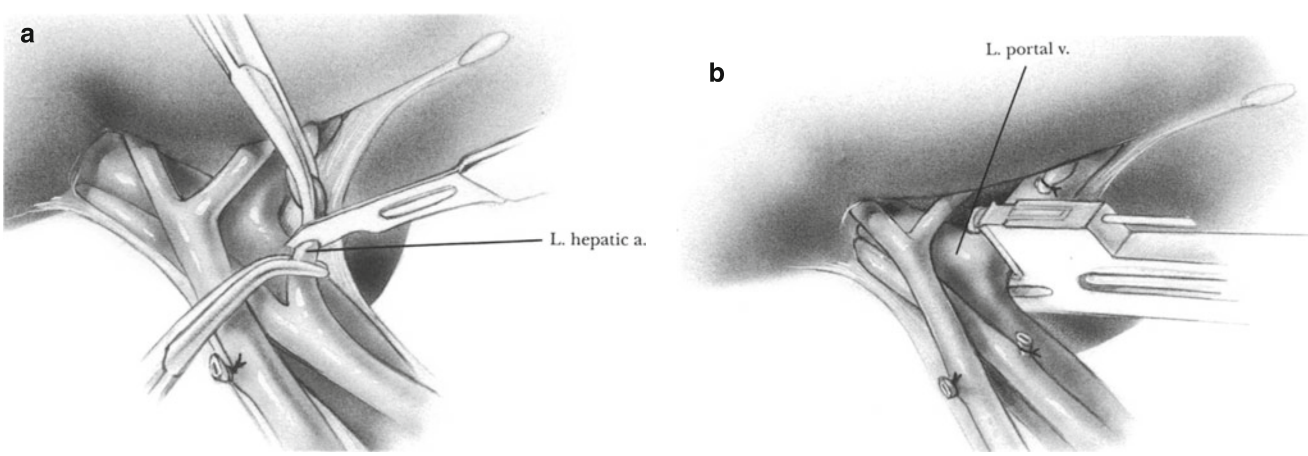

Fig. 87.15

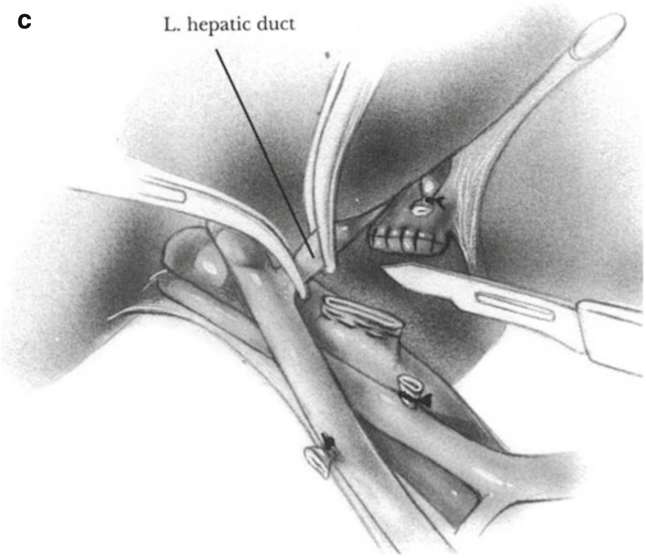

Fig 87.15 (continued)

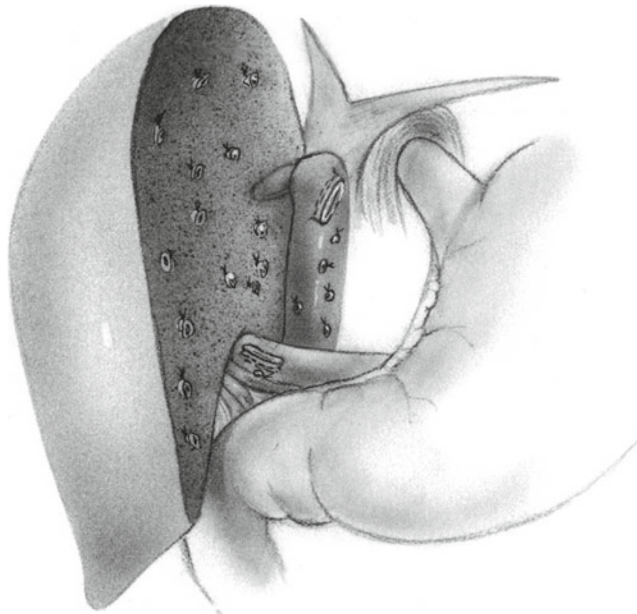

Fig. 87.17

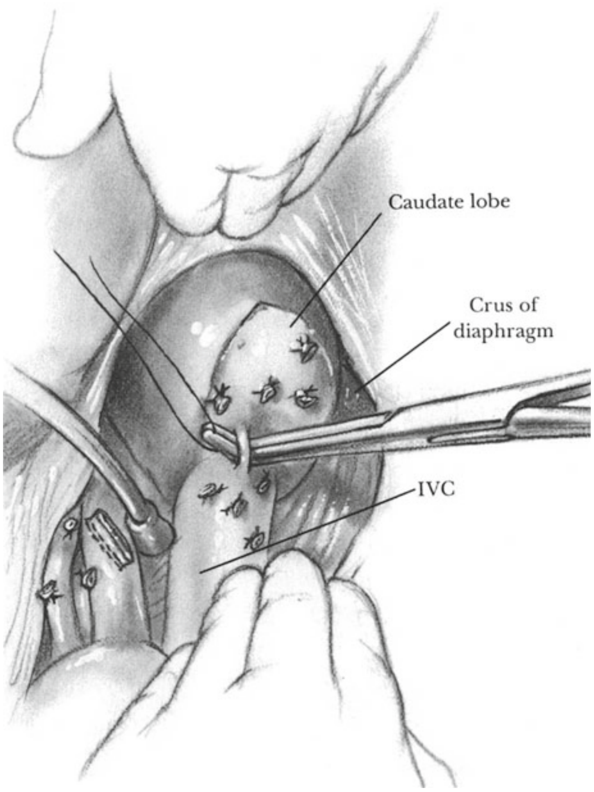

Fig. 87.16

The main left hepatic vein frequently joins the middle hepatic vein. In contrast to right hepatic lobectomy, postpone ligation of the main left hepatic vein until parenchymal transection is complete because extrahepatic exposure is generally not feasible. Ligate the short, direct, hepatic veins between the inferior vena cava and segment 1 (caudate lobe) initially from the right of the hepatoduodenal ligament until segment 1 is mobilized inferiorly (Fig. 87.16). As the veins are ligated and divided, segment 1 can be retracted anteriorly, and the remainder of the hepatic veins between the inferior vena cava and caudate lobe can be divided safely. Division of the retrocaval ligament from the left side of the inferior vena cava allows complete mobilization of segment 1.

The remainder of the resection proceeds much as previously described. The completed operative field is shown in Fig. 87.17.

Postoperative Care

Postoperative care requires appropriate fluid administration, using colloids in addition to crystalloid to reduce postoperative weight gain and maintain adequate urine output. Mild acidosis and coagulation abnormalities are common and need not be treated unless symptomatic. Nasogastric intubation is continued overnight to prevent the risk of aspiration. Epidural analgesia postoperatively markedly improves pulmonary function and pain control.

Complications

The major complications of hepatic resection are hemorrhage, biliary fistula, intra-abdominal infection, and liver failure. All complications are best treated by careful intraoperative prophylaxis. Hemostasis is secured meticulously, as is bile stasis. Hepatic insufficiency is treated as clinically indicated. Hepatic failure may require orthotopic liver transplantation.

Acknowledgment Dr. David M. Nagorney authored this chapter in the previous edition. The current version was informed by Dr. Nagorney's previous contribution.

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Part VIII

Pancreas

Concepts in Surgery of the Pancreas

88

Carol E.H. Scott-Conner and Jameson L. Chassin†

Surgical Anatomy

The pancreas lies in a relatively protected and inaccessible location in the upper abdomen. The head of the pancreas nestles in the C-loop of the duodenum, and the body and tail drape over the retroperitoneum, extending out toward the hilum of the spleen.

The pancreas has a rich and somewhat variable arterial blood supply. The head and neck are supplied by the anterior and posterior pancreaticoduodenal arches (which form anastomoses between the celiac and superior mesenteric circulations), and the neck, body, and tail are supplied by the greater pancreatic artery, the dorsal and inferior pancreatic arteries, and the artery to the tail of the pancreas.

Regional lymph nodes include the superior and inferior pancreaticoduodenal nodes; the celiac, hepatic, and superior mesenteric nodes; the superior pancreatic nodes (which drain the body and tail); and the splenic nodes.

The pancreas develops embryologically as dorsal and ventral anlages which fuse during development. The main pattern duct usually receives contributions from both the dorsal and ventral anlage, but variations abound. In the most common pattern, the ducts of the pancreas converge into the main pancreatic duct (of Wirsung) which drains into the duodenum through the major duodenal papilla (of Vater) in conjunction with the terminal portion of the bile duct. A second, smaller duct, the duct of Santorini, drains into a minor duodenal papilla cephalad to the major papilla. Annular pancreas is a common anomaly in which a complete ring of pancreatic tissue encircles the duodenum, usually causing duodenal obstruction early in life.

Adequate exposure of the body and tail of pancreas requires wide entry into the lesser sac. This is best accomplished by opening the gastrocolic omentum and reflecting the stomach cephalad. To elevate the body and tail of the pancreas, incise the peritoneum along the inferior aspect of the pancreas. Expose the head and neck of the pancreas by first mobilizing the hepatic flexure of the colon and reflecting the right and transverse colon inferiorly. Perform a generous Kocher maneuver to elevate the duodenum and head of pancreas and palpate the head.

Trauma

Pancreatic injuries are uncommon because of the relatively sheltered position of the gland. Blunt trauma to the upper abdomen may result in pancreatic contusion or complete transection, most commonly at the point where the pancreas drapes over the vertebral column. Penetrating injuries to the pancreas are usually accompanied by injuries to overlying viscera and major vascular structures – stomach, duodenum, spleen colon, or small intestine.

During trauma laparotomy, explore any hematoma in Zone I (upper central) of the retroperitoneum (see Chap. 8). The AAST grading system for pancreatic injuries lists five grades, of which the first two (grade I and grade II) do not involve injury to the main pancreatic duct. These are best treated by drainage. Grade III injuries consist of distal transections and are generally managed by distal pancreatectomy, and this is probably the commonest resection performed for trauma.

Grade IV and V injuries are more complex proximal injuries. There may be accompanying duodenal trauma or injury to the common duct or liver. Bleeding is often a major problem, due to the rich blood supply of the pancreas and numerous arteries in the region. Pancreatoduodenectomy for trauma carries a high mortality and morbidity rate, but may be unavoidable. Consider the principles of damage control

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laparotomy; obtaining temporary hemostasis, control of bile and gastrointestinal leakage, and other temporizing maneuvers may allow resection to be done more safely at a second procedure when the patient is in better condition.

Pseudocysts are often associated with chronic pancreatitis. Adequate relief of pain generally requires that both the pseudocyst and the underlying chronic pancreatitis be addressed.

Chronic Pancreatitis

Diagnosis

The diagnosis of chronic pancreatitis depends on a combination of episodic or daily moderate to severe upper abdominal pain radiating to the back associated with structural or functional derangements in the pancreas. Such derangements distinguish this entity from recurring acute pancreatitis or from acute relapsing pancreatitis. The functional derangements are endocrine (diabetes) or exocrine (malabsorption).

Generally spiral CT scan will be performed as the initial diagnostic modality, followed by targeted studies designed to elucidate ductal anatomy. CT- or endoscopic ultrasound (EUS)-directed biopsies help exclude or confirm the presence of a carcinoma.

Secondary ductula**r** ectasia, changes seen only in the side branches of the main pancreatic duct, is the first sign of chronic pancreatitis. This is best demonstrated on ERCP. As the disease progresses, areas of stricture and dilatation are seen in the main pancreatic duct. Here MRCP and ERCP both demonstrate changes well. The degree of dilatation varies, in some cases resembling a cystic mass and in others being minimal. A mass effect is common and may reach the extreme of a mass in the head of the pancreas measuring 10 cm in diameter. The term dominant mass in the head of the pancreas is generally reserved for patients with a mass >5 cm in diameter. Parenchymal calcification occurs in approximately 60 % of patients with chronic pancreatitis.

Secondary narrowing of the terminal common bile duct may be found in 30–50 % of patients, accompanied by significant proximal ductal dilatation. Typically the alkaline phosphatase is markedly elevated but the bilirubin is normal. True obstructive jaundice is rare.

There is significant geographic variation in incidence and manifestations, and this must be kept in mind when reports from other parts of the world are evaluated. For example, a dominant mass associated with chronic pancreatitis appears to be far more common in middle Europe than in the United States, and hence, resectional therapy is more routine there. In another example, the variant of chronic pancreatitis with non-dilated ducts, the so-called small duct variant of chronic pancreatitis, appears to be more common in Great Britain, and resectional therapy predominates there. Dilated ducts with a variably significant mass and head of the pancreas appear to be more common in the United States. Thus, US reports tend to include more of a mix of drainage procedures and resectional therapy.

Treatment of Chronic Pancreatitis

The typical patient with chronic pancreatitis generally requires a period of intensive medical therapy before any consideration for surgery. Narcotic dependence is common and may be complicated by alcohol dependence or abuse which often causes the disease. Nutritional depletion is common owing to exocrine or endocrine failure or to severe postprandial pain. Supplementing with insulin or pancreatic enzymes is a significant first step.

Two kinds of abdominal pain are commonly seen with this disease. Unrelenting abdominal pain may occur daily, requiring chronic narcotic use. Episodes of exacerbation of pain unassociated with enzyme elevations or other signs may nonetheless be mistaken for an episode of acute pancreatitis. Some patients have daily pain without exacerbations, many have both, and certain patients have intermittent attacks only.

Octreotide (the somatostatin analog), anticholinergic medications, and oral enzyme supplementation have all been used for pain relief in the past. Results have been mixed at best. Endoscopic stenting is being investigated; it appears to provide temporary relief in some patients and may be predictive of results after operative decompression.

The indications for surgery are severe, unrelenting abdominal pain, in most cases resulting in narcotic dependence. The need for intermittent hospitalization is another important indicator supporting the use of invasive, potentially lethal treatments. It is generally advised that patients be weaned from narcotics before surgery.

Choice of Operation

In general terms the operative procedures for chronic pancreatitis include resection, drainage or decompression, and nerve ablation. The primary goal of each of these operative procedures is pain relief. Pancreaticoduodenectomy, typically performed as pylorus-preserving resection of the pancreatic head, is the classic resection. Indications for pancreaticoduodenectomy are the symptoms previously described combined with a dominant mass in the head of the pancreas. Resection is further indicated in any patient in whom there remains the suspicion of malignancy based on imaging studies or the relatively inaccurate CA 19-9 tumor marker. Resection is also considered reasonable after failure of a previous drainage procedure and is advocated in patients with a so-called small duct variance of chronic pancreatitis. A variation of the classic Whipple resection known as the duodenum-preserving pancreatic head resection has been devised. The specific advantages suggested for duodenum preservation include enhanced nutritional status and better gastric emptying. The body of the pancreas is divided in a manner similar to that for the Whipple resection, and pancreatic tissue is excavated from the C-loop of the duodenum, preserving the floor of this dissection plane and leaving a small remnant of pancreas along the edges of the duodenum. Reconstruction is performed by placing a Roux limb of jejunum over the excavated head of the pancreas and similarly into the remnant of the body and tail of the pancreas after it has been divided.

This innovation forms the basis for a number of modifications that appear to be intermediary between drainage procedures and resections. They include the so-called Frey procedure, in which more limited excavation of the head of the pancreas is combined with longitudinal drainage of the main pancreatic duct. No division of the body of the pancreas is performed during this procedure. After Frey's original description many have explored the effectiveness of the procedure, and the results have been favorable. The indications for this modification include a dilated main pancreatic duct throughout the gland associated with the mass and the head of the pancreas. A more recent innovation by Izbicki focuses on small duct disease treated with a V-shaped excavation along the body of the pancreas down to the main pancreatic duct. The concept behind this procedure is to extract the inflammatory tissue surrounding the duct and create an operative equivalent of a Puestow-type drainage procedure. Unfortunately, the only data available regarding this procedure are those developed by Izbicki, who reported a high level of persistent pain relief after this procedure with apparent preservation of function. One important precept of surgery for chronic pancreatitis is that preservation of the pancreatic parenchyma is a goal, and all efforts to preserve function while providing adequate pain relief are desirable. Near-total or 95 % pancreatectomy is almost never utilized, and we have no enthusiasm for this procedure.

Drainage Procedures

When the main pancreatic duct is dilated, a drainage procedure should be considered. The classic drainage procedure is the Puestow procedure. It was developed as a modification of the Duval procedure: resection of the tail of the pancreas and Roux-en-Y jejunal drainage of the distal duct. Puestow modified the Duval procedure by combining resection of the tail of the pancreas with a longitudinal incision along the main pancreatic duct. This procedure has been evaluated extensively in clinical series and achieves 85–95 % clearance of pain.

The Puestow procedure provides persistent relief of pain while preserving parenchyma. The mortality and morbidity associated with this procedure are considerably lower than that associated with major pancreatic resections. The underlying disease will, however, continue to progress (although progression may be slowed by ductal decompression).

Successful outcomes after a Puestow procedure appear to be limited to ducts >6 mm in diameter. The diameter of a normal pancreatic duct is 2–3 mm. Ducts that have been less dilated have been associated with less success in pain relief. It is conceivable that the rate improves when the modification previously described by Izbicki is used.

Biliary Decompression

Biliary stenosis and dilatation occur in 30–50 % of patients with chronic pancreatitis. The problems vary from an obvious narrowing seen by an imaging study with normal blood chemistries to a massively dilated common bile duct associated with significant elevations in the serum alkaline phosphatase levels (often above 1,000 U/dl). Because the narrow area of the common bile duct is elongated, extending well beyond the wall of the duodenum, neither sphincterotomy nor long-term stenting is generally useful. There is some concern that prolonged obstruction of the bile duct results in ongoing fibrosis of the liver and finally leads to biliary cirrhosis. We generally reserve consideration of a simultaneous biliary drainage procedure for patients with significant dilatation of the common bile duct (>10 mm in diameter) associated with a chronically elevated alkaline phosphatase level (>400 U/dl). Although the purported advantage of biliary bypass is protecting the patient from biliary cirrhosis, the risk of developing biliary cirrhosis in this setting is not known. It is possible that some additional pain relief may result from adequate biliary decompression.

Nerve Ablation

Nerve ablation, most commonly performed percutaneously under CT or ultrasound guidance, may be successful in some patients.

Adenocarcinoma of the Pancreas

Diagnosis

The standard description of a patient above the age of 55 with a complaint of "painless jaundice" belies the significant pain that develops as carcinoma of the pancreas progresses. The presence or absence of pain should never be used to eliminate this diagnosis. Early symptoms consist of dyspepsia and weight loss, often without jaundice. Recognition of jaundice frequently triggers an imaging workup with ultrasound or CT.

Imaging

Spiral CT scanners can now clearly define the boundaries of a carcinoma in the midst of the otherwise enlarged head of the pancreas. This single development has greatly enhanced our ability to define exact sizes of tumors preoperatively and greatly facilitates CT-directed fine-needle and core biopsies of a pancreatic cancer, which may be necessary prior to operation. Thus, even though a patient may have had a conventional CT scan before coming to the surgeon, it is advised that a multidetector spiral CT scan be obtained to provide additional and more precise information regarding the tumor. A specific protocol with thin slices taken through the pancreas at specific times after injection of contrast (pancreatic arterial and portal venous phases) should be ordered.

Endoscopic ultrasonography (EUS) allows identification and biopsy of lymph nodes and pancreatic masses in sufficient proximity to the probe. Identification of vascular structures, particularly the superior mesenteric artery and the splenic vein, portal vein, and superior mesenteric vein, is excellent with EUS. Clear planes between structures can normally be identified; hence, invasion into the walls of any of these structures is clearly delineated. All layers of the intestinal wall can be demarcated, and any invasion into one of these layers identified. The one limitation worth mentioning with EUS is failure to evaluate the liver fully. The decision regarding resectability of the carcinoma of the pancreas depends on a number of issues, but clearly hepatic metastasis is an important one. Thus, in the absence of another form of imaging, the EUS is unlikely to give a full evaluation of resectability.

Mesenteric arteriography, routinely used in the past to evaluate vascular involvement, has been abandoned by most experienced pancreatic surgeons in favor of less invasive methods. The spiral CT scan shows the vascular anatomy clearly and is now established as the more appropriate imaging technique for evaluating the resectability of carcinoma of the pancreas.

Magnetic resonance imaging (MRI) and *magnetic resonance cholangiopancreatography* (MRCP) are related technologies. Clear anatomic features of the main pancreatic duct (MPD) and the common bile duct (CBD) allow stones and tumors to be easily defined with MRCP. Vascular anatomy can be delineated with *MR angiography* (MRA). If the signal weighting is altered, an adequate view of the liver and of peripancreatic lymph nodes can be obtained. These studies can be obtained quickly and noninvasively. Although no data have yet been developed to establish its superiority, one might argue that this procedure is capable of defining all of the necessary features to establish both diagnosis and resectability. If one flaw exists regarding this modality, it is that the fine anatomy of the MPD and the CBD may be less clear than that obtainable with EUS or endoscopic retrograde cholangiopancreatography (ERCP). Finally, specialized MR studies are not yet universally available.

Endoscopic retrograde cholangiopancreatography is currently used selectively in these patients. Because the lesion originates in the ducts, it should not be surprising that 94–96 % of patients with this diagnosis have an abnormal pancreatogram. If preoperative biliary drainage is desired, ERCP can help accomplish it. Unfortunately, there are no data to suggest the therapeutic value of this strategy. In some regards, stent placement may be unavoidable if ERCP is performed. During ERCP the instrument traverses the (contaminated) intestinal tract before injecting contrast into an obstructed bile duct, placing the patient immediately at risk for cholangitis. Once this entity is recognized, the endoscopist has no choice but to place a stent to prevent the development of cholangitis. We believe that ERCP, if used at all, should be implemented within 24 h of operation, so any information that helps with the diagnosis is obtained when the risk of sepsis is extremely low. The procedure is of potential value in patients in whom the diagnosis is equivocal or if choledocholithiasis is suspected, as choledocholithiasis can be diagnosed and treated by ERCP by simply adding endoscopic sphincterotomy and stone extraction.

Percutaneous transhepatic cholangiography (PTC) may establish a diagnosis and an access point for biliary decompression but is rarely used in current practice. When obstructive jaundice is diagnosed by PTC, a transhepatic stent must be placed to avoid bile leak and bile peritonitis.

Finally, it should be stressed that for an experienced pancreatic surgeon, *tissue documentation of the diagnosis of pancreatic carcinoma is not considered mandatory*. In major centers as many as half of the resections in these patients are performed without the benefit of tissue confirmation. This should not convey the message that pancreaticoduodenectomy is an operation undertaken lightly. A mass in the head of the pancreas, obstructive jaundice, weight loss, and nonspecific dyspeptic symptoms in a patient over the age of 55 form a constellation of signs and symptoms highly suspicious for the diagnosis of carcinoma of the pancreas.

Preoperative biopsies are required in patients who are enlisted for *neoadjuvant chemoradiation* in an attempt to increase resectability. Patients undergo 8–12 weeks of therapy before operation. The diagnosis must be confirmed by fine-needle aspiration or core biopsy under CT or EUS guidance before initiating therapy. Because of the delay prior to operative therapy, patients enlisted in this program also routinely undergo biliary decompression. Thus, patients enlisted in neoadjuvant chemoradiation require two treatment modalities not routinely used when operation is performed first.

Determination of Resectability

Many of the same modalities used for diagnosis can also be employed to determine resectability. Three categories of factors determine resectability: local invasion of the tumor into contiguous structures that should be preserved (e.g., vascular structures), tumor spread in the abdomen to sites remote from the primary tumor, and hepatic metastasis. Each is discussed separately.

Vascular Invasion

Invasion, encasement, or obliteration of the superior mesenteric artery or the celiac trunk precludes resection. Invasion into the portal vein or the superior mesenteric vein/splenic vein confluence may or may not represent an unresectable lesion because resection and reconstruction of the portal vein is an established modality. A segmental resection of part of the circumference of the vein with a patch graft or complete vein resection can be performed. These operative procedures are longer in duration than conventional pancreaticoduodenectomy, and blood loss is higher. Survival appears to be considerably better with segmental resection and the patch graft than with complete resection of the vein, possibly reflecting the extent of invasion required to proceed to complete vein resection versus a simple patch graft. As previously mentioned, vascular invasion may be judged by spiral CT, MRA, or EUS.

Tumor Extension Remote from the Primary Tumor

Local extension may be paraaortic disease, extension into the colon or stomach, or carcinomatosis. Spiral CT, EUS, MRI, or laparoscopy may define this entity, but often it is established only at laparotomy.

Hepatic Metastasis

Spiral CT scan and MRI may be helpful for detecting hepatic metastases; ERCP and PTC are not. *Transabdominal ultrasonography* sometimes demonstrates hepatic metastases more clearly than routine spiral CT. Portal-enhanced CT scans may more clearly delineate hepatic metastases, but do not provide additional information about the pancreas.

Resectability may be further evaluated intraoperatively. Preliminary minilaparotomy or laparoscopy, with washings for cytology and/or the use of ultrasound, may identify spread beyond the projected operative field. In these cases, nonoperative palliative methods may be applied.

Treatment

Neoadjuvant Chemoradiation

Neoadjuvant chemoradiation protocols may be employed in an attempt to downstage tumors and improve resection rates and, ultimately, long-term outcomes.

Operative Management

Surgical resection provides the only hope for cure of this disease. Most patients are treated with a *pylorus-preserving pancreaticoduodenectomy*. A number of important margins are considered in this resection. As a routine, the bile duct is divided above the cystic duct entry, and the common hepatic duct is a margin, which is sent for frozen section analysis. The body of the pancreas is typically divided at or slightly to the left of the area that overlies the portal vein and the superior mesentery vein/splenic vein confluence. The duodenum is divided just past the pylorus. Each of these margins should be sent for frozen section pathologic analysis during the operative procedure; a report of positive margins is an indication for further resection. Perhaps the most problematic margin is that at the uncinate process as it abuts the superior mesenteric artery. This and the radial margin of the uncinate process extending down into the retroperitoneum are commonly found to be unexpectedly involved in tumor at final pathology. In some regards, these margins are not correctable because we would not consider resecting the superior mesenteric artery, and a deeper dissection into the retroperitoneum is not considered reasonable because of the proximity of the vena cava and the aorta.

Total pancreatectomy has been proposed to treat cancer of the pancreas. It appears to be a rare patient whose lesion is considered resectable yet requires total pancreatectomy. In most cases resection of the body and tail with a distal pancreatectomy or resection of the head and body with a pancreaticoduodenectomy is sufficient to achieve cure. There are no data to suggest that total pancreatectomy enhances survival. Multicentricity of carcinoma of the pancreas is rarely described.

Essentially all pancreatic surgeons agree that a *truncal vagotomy is not necessary* after pancreaticoduodenectomy. As many as 65 % of patients complain of delayed gastric emptying early after Whipple resection, a concern that dictates omitting vagotomy, which might potentiate the problem. It was hoped that this complication would be less common when the pylorus is preserved. Unfortunately, pylorus-preserving pancreatic head resection is still associated with a reasonable rate of delayed gastric emptying. Some surgeons routinely employ a prokinetic agent during the immediate postoperative period after this procedure. Fortunately, long-term delayed gastric emptying is reported far less frequently. Pharmacologic acid suppression may be necessary.

Islet Cell Tumors

Islet cell tumors, which are rare, are well known to be diagnostically elusive. Their clinical presentation may be subtle, and localization of the tumor once the endocrinopathy has been defined is even more challenging. A number of modalities are utilized. Ultrasonography or spiral CT scans comprise a good initial approach. As with other potentially malignant lesions of the pancreas, ultrasonography is more effective for evaluating the liver for metastatic lesions, and spiral CT scanning is much more effective for evaluating the pancreas. Unfortunately, neither of these modalities is typically associated with significant success. Selective venous sampling (portal and splenic veins and venous tributaries from the pancreas), sometimes combined with the use of secretagogues such as secretin, has been used in the past with varying success.

The innovation of a radioisotope scan using *octreotide* as the marker has had some success for detecting all known islet cell tumors. It has been known for years that immunocytochemistry evaluation of islet cell tumors routinely yields the presence of various other islet cell products in addition to the primary one associated with the endocrinopathy in individual patients. In other words, a patient with an insulinoma is likely to have somatostatin and possibly glucagon or gastrin in the islets present within the insulinoma. In view of the added specificity of octreotide scanning, it is most recommend that it be performed early in the diagnostic workup of patients with suspected islet cell tumors.

The role of EUS and of laparoscopic ultrasonography remains uncertain. These modalities may reveal lesions not found using conventional imaging techniques. An advantage for both procedures is their ability to access the duodenal wall, which is the most common site of extrapancreatic gastrinoma.

Once diagnosed, the problem of intraoperative localization remains. *Intraoperative ultrasonography* plays a major role. The so-called gastrinoma triangle is bounded by a vertical line drawn between the pylorus and the third portion of the duodenum. The apex of the triangle is the hilum of the liver, which is a reasonable starting point for assessing the possible locations of this entity. For all other islet cell tumors, the primary site is almost always within the pancreatic parenchyma. In this regard, we simply advise careful evaluation of the uncinate process and the inferior border of the pancreas as the superior mesenteric vein progresses underneath it. Each of these sites is somewhat remote until adequate dissection has been performed.

Where possible, perform enucleation. If there is any evidence of extension beyond the capsule or if lymph node involvement (and certainly hepatic involvement) is evident, the tumor may be malignant, and thus, a more extensive resection may be required. It is important to realize that gastrinoma metastatic to the liver may be present in a patient for decades. A formal resection may also be required when the lesion is strongly suspected to be in a particular lesion but cannot be easily defined in the operating room. One exception to the operative approach to islet cell tumors is when a gastrinoma is associated with multiple endocrine neoplasia type I. These patients have multiple sites of gastrinoma, and it is the general consensus that complete resection of each of these multiple lesions is unreasonable.

Cystic Lesions of the Pancreas

Pseudocysts of the pancreas occur with both acute and chronic pancreatitis. Pseudocysts seen in association with acute pancreatitis will generally resolve. Those seen with chronic pancreatitis rarely do so and may require drainage.

In general, the choices include operative decompression of a cyst, percutaneous decompression of the cyst by interventional radiologists, and endoscopic transluminal decompression of a pseudocyst or endoscopic endoluminal transpapillary decompression of the cyst by placing a stent in the main pancreatic duct. Long-term success rates for percutaneous endoscopic and endoluminal decompression have been approximately 70 %. These data are comparable to the known operative success rates for external drainage of pseudocysts established decades ago, which typically were about 70 % as well. Although some endoscopic and some interventional studies have reported slightly higher success rates, long-term follow-up has been scant.

Infectious complications have been common after percutaneous or endoscopic drainage procedures. This is not altogether surprising, as many cysts contain solid or semisolid material that is unlikely to be adequately drained through passive drainage with relatively small catheters. It poses a risk for secondary infection after being exposed to microorganisms via drainage tubes.

The options for providing operative drainage include cystogastrostomy and Roux-en-Y cyst jejunostomy. Resection of the pancreatic pseudocyst is also an option and is generally reserved for cysts in the body and tail of the pancreas. Always obtain an intraoperative frozen section biopsy specimen of the wall of the cyst to rule out the presence of a cystic neoplasm.

With regard to *cystic neoplasms*, the presence of a cystadenoma in a cyst surrounding the pancreas has been recognized as a possibility for decades. More recently, the important distinction between serous and mucinous adenomas has been established. Serous cystadenomas are rarely malignant, but mucinous cystadenomas are considered to be premalignant or may be frankly malignant. Thus, patients with recognized mucinous cystadenomas are candidates for resection at all times.

Preoperative establishment of this diagnosis depends on a number of features. It is possible to aspirate fluid and measure mucin levels in the fluid. In addition, several investigators have suggested measuring tumor markers including carcinoembryonic antigen (CEA), CA 19-9, and pancreatitis-associated peptide (PAP). The presence of mucin is confirmatory, but the markers are not. Cytology may also be undertaken, and some studies have looked at CA 72-4 in cyst fluid levels. They concluded that pancreatic cysts with high serum CA 19-9 levels, positive cytology, or high CA 72-4 levels in the fluid should be considered for resection.

Intraductal papillary mucinous neoplasm (*IPMN*) *of the pancreas* and the related cystic papillary neoplasms are uncommon. Up to 50 % of resected IPMN specimens may have an associated invasive carcinoma at diagnosis, and both carcinoma in situ and dysplastic changes are common. The head and uncinate process are commonly involved. Diagnosis is suspected when copious mucus is seen exuding from the pancreatic duct at ERCP. Resection is indicated; total pancreatectomy is rarely employed even though the disease may extend along the duct, due to the morbidity inherent in this procedure.

Complications of Pancreatic Surgery

Any pancreatic resection carries an associated risk of *pancreatic fistula*. In the past, this complication was considered to be the cause of the high mortality rate associated with these resections. Pancreaticoduodenectomy adds the risk of bile and gastrointestinal anastomotic leakage. Because of the rich vascular anatomy in the area of the head of the pancreas, *major bleeding* can also occur. Somewhat less recognized are the *vascular accidents* seen with this procedure. The dissection planes include the superior mesenteric vein, portal vein, common hepatic artery, and superior mesenteric artery. In a worst-case scenario, it is possible to interrupt completely the vascular supply to the liver (portal vein and hepatic artery) or the vascular supply or venous drainage to the intestine (superior mesenteric artery and portal vein). Thus, necrosis of the liver and necrosis of intestine are known risks of this procedure.

Most pancreatic surgeons now place closed-suction drainage in the area of the pancreaticojejunostomy and the hepaticojejunostomy. Some believe this practice is responsible for the higher rate of reported pancreatic fistula than was seen in the past. This might be viewed with alarm were it not for the fact that the overall mortality for this procedure has now reached well below 5 % and in capable hands may be 2–3 %. In this regard, there appears to be conflicting data for the high rates of pancreatic fistula and low mortality rates. Most believe that the correlation of pancreatic fistula to mortality in the past was related to the coexistence of abdominal sepsis. Pancreatic fistulas are far more common when the texture of the pancreas is essentially normal and soft (as in resection for trauma); it is consequently poorly prepared to hold a stitch. With chronic pancreatitis or pancreatic carcinoma, the parenchyma is firm and holds sutures quite well. Technical faults may account for some of these fistulas. It should be stressed that a well-drained pancreatic fistula in most series is a relatively harmless complication, and spontaneous closure of such fistulas can be anticipated in more than 98 % of patients.

Bile fistula may be more lethal than pancreatic fistula. Controlled bile fistula should be a fairly benign event when managed with closed-suction drainage. Spontaneous closure again should be anticipated in more than 98 % of patients. An uncontrolled bile fistula, however, can result in bile peritonitis, and sepsis and may represent an extremely morbid complication.

Dehiscence of the gastrointestinal anastomoses represents the least frequent of all complications. Prevent this problem by following the normal precepts of intestinal anastomotic technique.

Prevention of *vascular accidents* depends entirely on recognition of these structures, particularly the hepatic artery and the superior mesenteric artery. Each of these vessels may be unintentionally ligated. For that reason clear dissection of these structures is recommended. Unfortunately, superior mesenteric vein and portal vein injuries may occur simply because of dense adhesion to these structures due to chronic pancreatitis or to invasion of these structures by carcinoma.

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Partial Pancreatoduodenectomy

89

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Carcinoma of ampulla, head of pancreas, distal bile duct, or duodenum

Select patients with chronic pancreatitis and intractable pain whose disease is limited to the head of the pancreas (see Chap. 88)

Contraindications

Distant metastases (liver or peritoneal surfaces)

Distant lymph node metastases (celiac axis)

More than minimal invasion of portal vein, superior mesenteric vessels, or root of small bowel mesentery

Absence of a surgical team experienced in pancreatoduodenectomy. When a patient suffering from obstructive jaundice has been found to have operable ampullary or pancreatic cancer, refer the patient to an appropriate center of expertise.

Preoperative Preparation

Correct hypoprothrombinemia with vitamin K.

Accomplish nutritional rehabilitation, if necessary.

Perform diagnostic procedures. Selective use of computed tomography (CT), endoscopic retrograde cholangiopancreatography (ERCP), magnetic resonance imaging (MRI), endoscopic ultrasonography (EUS), and preoperative laparoscopy helps with accurate staging and minimizes nontherapeutic laparotomy for cancer of the pancreas.

Prescribe perioperative antibiotics.

Preoperative biliary decompression, formerly advocated, has not been shown to be beneficial and is rarely employed.

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Pitfalls and Danger Points

Intraoperative hemorrhage

Trauma to or inadvertent ligation of superior mesenteric artery or vein, an anomalous hepatic artery, or the portal vein

Failure of pancreaticojejunal anastomosis with leakage

Failure of choledochojejunal anastomosis with leakage (rare)

Postoperative hemorrhage

Postoperative sepsis

Postoperative acute pancreatitis

Postoperative marginal ulcer with bleeding

Operative Strategy

The operation may be conceptualized as consisting of three stages: assessment of pathology to determine resectability, resection, and reconstruction. Standard pancreaticoduodenectomy, described first, includes a gastric resection. Pylorus-preserving pancreaticoduodenectomy avoids this resection, decreasing the operating time and producing a more physiologic result. This procedure is described second.

Assessment of Pathology to Determine Resectability

Better preoperative staging has decreased the probability of finding unexpected peritoneal metastases at laparotomy.

†Deceased

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Obvious disease outside the surgical field precludes resection; if none is found, the pancreas is mobilized to determine if local invasion (most commonly into the portal vein) precludes resection. Full mobilization is performed before committing to resection.

A generous Kocher maneuver is performed to confirm that the pancreas is not adherent to the inferior vena cava. The lesser sac is entered and the stomach elevated to display the pancreas. The most hazardous part of the operation occurs next, when the pancreas is gently elevated from the portal vein.

Avoiding and Managing Intraoperative Hemorrhage

The greatest risk of major intraoperative hemorrhage occurs when the surgeon is dissecting the portal vein away from the neck of the pancreas. This is especially true when an inexperienced pancreatic surgeon has misjudged the resectability of a carcinoma of the pancreas. In this case, while injudiciously trying to separate the portal vein from an invading carcinoma, one can produce a major laceration of the portal vein before achieving sufficient exposure to effect a repair. Freeing the portal vein is the most dangerous step in this operation.

Temporary control of hemorrhage is generally possible in this situation if the surgeon compresses the portal and superior mesenteric veins against the tumor by passing the left hand behind the head of the pancreas. An experienced assistant then divides the neck of the pancreas anterior and just to the left of the portal vein. In some cases it is necessary to isolate and temporarily occlude the splenic, inferior mesenteric, superior mesenteric, coronary, and portal veins to achieve proximal and distal control. If tumor has indeed invaded the portal vein, a patch or a segment of vein may have to be excised to be replaced by a saphenous vein patch or, in some cases, a vein graft. An end-to-end anastomosis of the portal vein to the superior mesenteric vein is possible when the segment to be resected is short. To replace longer segments of resected portal vein, interpose a saphenous vein graft. Ligating the portal vein is often fatal unless the superior mesenteric vein is preserved and is free to drain *into the intact splenic and then into the short gastric veins*.

Avoiding Postoperative Hemorrhage

Postoperative hemorrhage is a preventable and potentially lethal complication. It stems from one of four major causes: (1) gastric stress ulcers or gastritis, (2) marginal ulcer, (3) digestion of the retroperitoneal blood vessels by combined leakage of both bile and pancreatic juice, or (4) inadequate ligature of the innumerable blood vessels divided during surgery.

Gastric Stress Ulcers or Gastritis. After surgery, use an H_2-blocker or proton pump inhibitor to maintain the gastric pH at ≥5.0. Follow the protocol in the intensive care unit for surgical patients who are at risk of developing stress bleeding.

Marginal Ulcer

With the standard pancreaticoduodenectomy, the incidence of marginal ulcer is decreased by performing an adequate antrectomy and/or adding truncal vagotomy. This is less of a concern with current methods of pharmacological control of ulcer diathesis. Preservation of the pylorus may reduce the incidence of postoperative ulcers.

Hemorrhage secondary to the digestion of retroperitoneal tissues by activated pancreatic juice is best prevented by observing the operative strategy (outlined below) aimed at minimizing the chance of pancreatojejunal anastomotic leak. Hemorrhage that results from a ligature slipping off the gastroduodenal or right gastric artery is a result of careless operative technique. During pancreatectomy carefully *skeletonize* each of these two arteries prior to ligating them. Use nonabsorbable ligature material and *always leave an adequate stump of vessel distal to the ligature* to prevent slipping. The same principles apply to the branches of the portal and superior mesenteric veins.

Avoiding Leakage from the Pancreaticojejunal Anastomosis

Failure of the pancreaticojejunal anastomosis has in our experience been the most common serious technical complication of pancreatoduodenectomy. Failure of the anastomosis is more common in patients who have carcinoma of the distal portion of the common bile duct (CBD) or the duodenum because many of these patients do not develop obstruction of the pancreatic duct, which is frequently accompanied by some degree of pancreatitis. Both obstruction and pancreatitis produce thickening of the pancreatic duct and the pancreatic parenchyma.

In the absence of this thickening, sewing a small thin-walled duct to the jejunum produces a high failure rate. When a small duct and soft pancreatic parenchyma are encountered, some surgeons believe that total pancreatectomy is the safest alternative, even though it produces postoperative diabetes. This option is rarely needed. If the patient has a soft pancreas and a pancreatic duct that is not markedly enlarged, do not try to construct a duct-to-mucosa anastomosis. Rather, invaginate the pancreatic remnant into the lumen of the jejunum for a depth of at least 2 cm with two layers of sutures, as described later in the chapter. When the remaining pancreas is thickened with fibrosis and the duct has been markedly enlarged by the chronic obstruction, careful construction of an anastomosis between the pancreatic duct and the jejunal mucosa has a high likelihood of success. Rossi and Braasch insert a small catheter into the pancreatic duct in most patients and then lead the catheter through a puncture wound in the wall of the jejunum and out through the abdominal wall to drain the pancreatic secretions away from the healing anastomosis into a drainage bag. When we use this type of drainage, we leave the catheter in at least 2 weeks.

If leakage of pancreatic juice occurs, it is important to have adequate drains in the area of the anastomosis. Leakage of pure pancreatic juice that has not been activated does not damage the surrounding tissues, and the pancreatocutaneous fistula generally closes spontaneously without damaging the patient. On the other hand, if leakage from the pancreaticojejunostomy is accompanied by simultaneous seepage of bile into the same region, the pancreatic enzymes become activated and begin to digest the surrounding retroperitoneal tissues, leading to sepsis and bleeding—complications that constitute the chief causes of death following pancreatoduodenectomy. Consequently, make every attempt to divert the flow of bile from the area of the pancreaticojejunostomy, allowing an adequate length of jejunum to separate these anastomoses. This may help prevent the bile from refluxing up into the pancreatojejunal anastomosis.

Treating a Pancreatic Fistula by Removing the Pancreatic Stump

When a patient suffers a pancreatocutaneous fistula that leaks clear pancreatic juice, only expectant therapy is necessary. If the clear, watery secretion turns green after a few days, indicating bile admixture, the situation is much more serious. A major leak of bile and pancreatic juice is associated with a high mortality rate. If the patient's condition begins to deteriorate despite adequate drainage, serious consideration should be given to exploration and removing the remnant of pancreas together with the spleen. Under certain conditions converting the Whipple operation to a total pancreatectomy constitutes a lifesaving operation. Trede and Schwall reported success with this reoperation.

Avoiding Trauma to an Anomalous Hepatic Artery Arising from the Superior Mesenteric Artery

About 18–20 % of individuals have an anomaly in which the common hepatic artery or right hepatic artery arises from the superior mesenteric artery, generally running posterior to the pancreas into the hepatoduodenal ligament. Such a vessel is encountered in the operative field and may be injured. Sometimes this anomaly is identified on preoperative imaging studies. In 1 % of the cases in the anatomic study, the common hepatic artery arose from the superior mesenteric and passed *through* the head of the pancreas on its way to the liver; in this case pancreaticoduodenectomy necessitates dividing and ligating this vessel. The adequacy of the collateral circulation determines the effect on hepatic perfusion and ultimately on liver function.

Proper anatomic dissection of the superior mesenteric vessels away from the superior uncinate process *with alert palpation of the posterior pancreas* allows the surgeon to identify this anomaly if it is not demonstrated on preoperative studies.

Documentation Basics

- Findings
- Pylorus sparing or not?

Operative Technique

Standard pancreaticoduodenectomy

Incision

Make a midline incision from the xiphoid to a point 10 cm below the umbilicus. In stocky patients with a broad subcostal arch, a bilateral subcostal incision is an excellent alternative.

Evaluation of Pathology: Confirmation of Malignancy

If no tissue diagnosis has been obtained preoperatively, attempt to confirm the diagnosis by biopsy or fine-needle aspiration cytology (FNAC). Divide the omentum between hemostats to expose the anterior surface of the pancreatic head (Fig. 89.1). If a stony-hard area of tumor is visible on the anterior or posterior surface of the pancreas, shave the surface of the tumor with a scalpel or remove a wedge of tissue. If the tumor appears to be deep, perform FNAC by inserting a 22 gauge needle into the tumor. Use a 10 ml syringe containing 4–5 ml of air. Aspirate and then expel the sample on a sterile slide, spray the slide *promptly* with a fixation solution, and submit the slide for immediate cytologic study. In most cases we have found FNAC both safe and accurate.

If the results are not confirmatory for cancer, perform a biopsy by passing a cutting biopsy needle through both walls of the duodenum on its way to the pancreas. This technique helps avoid a postoperative pancreatic fistula. When lesions of the distal common duct are suspected, obtain a tissue sample by passing a small curet through a cholodochotomy incision and scrape the region of the suspected malignancy.

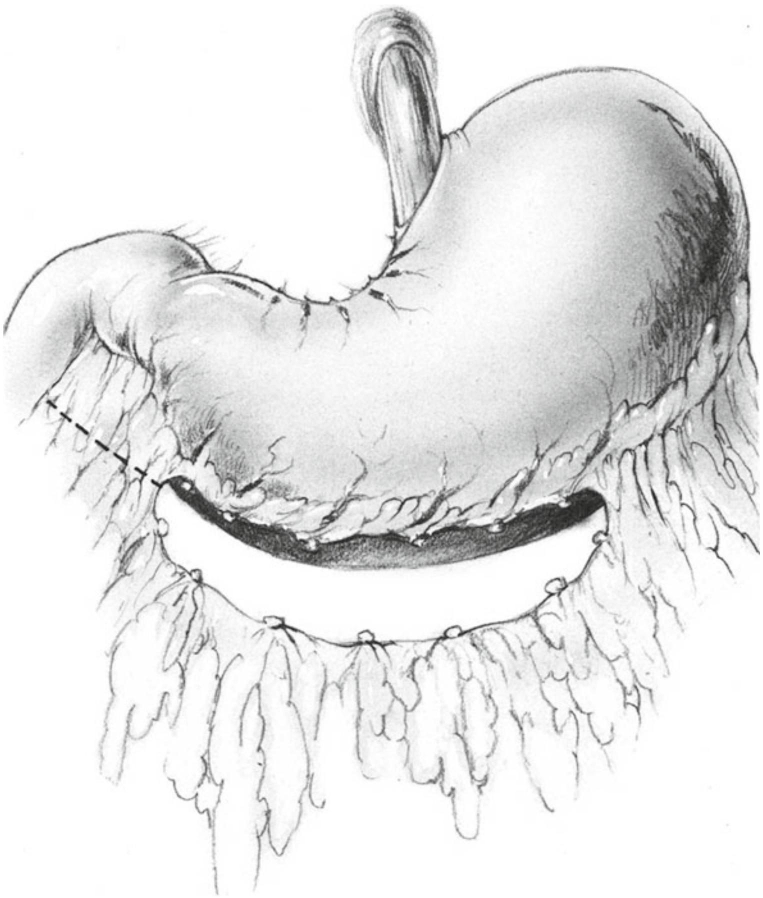


Fig. 89.1

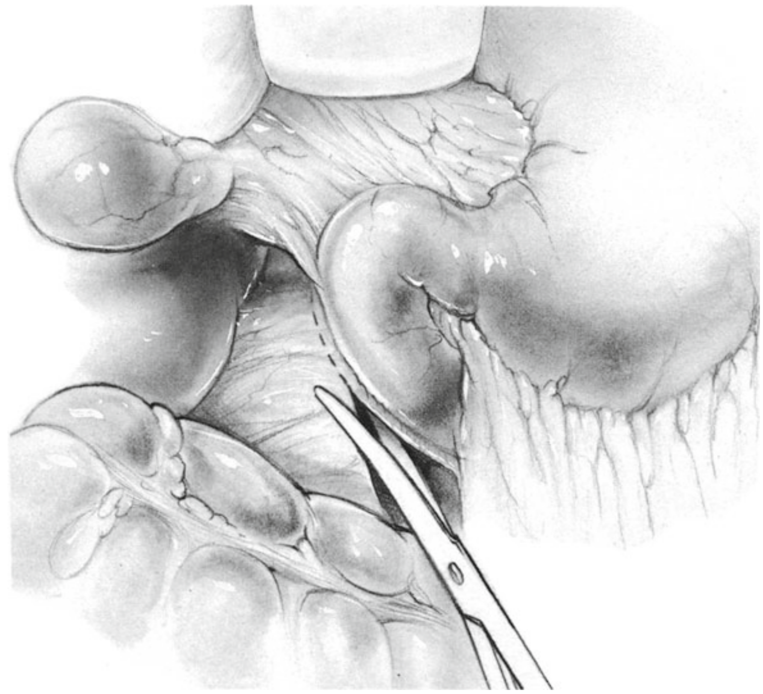


Fig. 89.2

Choledochoscopy is an excellent means for obtaining a biopsy of common duct tumors. If a tumor is palpable in the region of the ampulla, make a longitudinal or oblique duodenotomy incision over the mass and excise a sample under direct vision. Close the duodenotomy. Discard all instruments that have come into contact with the tumor during the biopsy and redrape the field. Occasionally it is necessary to proceed without confirmation of malignancy.

If malignancy has *not* been confirmed and there is not excellent preoperative radiographic visualization of the CBD, perform operative cholangiography or choledochoscopy to rule out an impacted common duct stone as the cause of the patient's jaundice. Next, evaluate the lesion for operability. Check for metastatic involvement of the liver, the root of the small bowel mesentery, and the celiac axis lymph nodes. Metastasis to a lymph node along the gastrohepatic or gastroduodenal artery adjacent to the malignancy does not contraindicate resection.

Determination of Resectability: Dissection of Portal and Superior Mesenteric Veins

Perform an extensive Kocher maneuver by incising the peritoneal attachment (Fig. 89.2) along the lateral portion of the descending duodenum. Divide the lateral duodenal ligament to the point where the superior mesenteric vein crosses the transverse duodenum (Fig. 89.3). Avoid excessive upward traction on the duodenum and pancreas, as it may tear the superior mesenteric vein. Liberate the duodenum superiorly as far as the foramen of Winslow.

If the head of the pancreas is replaced by a relatively bulky tumor, it may be difficult to expose the superior mesenteric vein. In such cases, after dividing the omentum to expose the anterior surface of the pancreas, identify the middle colic vein and trace it to its junction with the superior mesenteric vein (Fig. 89.4). Although this junction may be hidden from view by the neck of the pancreas, one can generally identify the superior mesenteric vein without difficulty by following the middle colic vein. Gentle dissection is important in this area as there are often large fragile branches joining both the middle colic and the superior mesenteric veins with the inferior pancreaticoduodenal vein. If these branches are torn, control of bleeding behind the neck of the pancreas is difficult.

Gross invasion of the vena cava or the superior mesenteric vein contraindicates resection. Identify the hepatic artery medial to the lesser curvature of the stomach after incising the filmy avascular portion of the gastrohepatic omentum. Incise the peritoneum overlying the common hepatic artery and sweep the lymph nodes toward the specimen. Continuing this dissection toward the patient's right reveals the origin of the gastroduodenal artery. Dissect this artery free using a Mixter clamp (Fig. 89.5) and divide the vessel between two

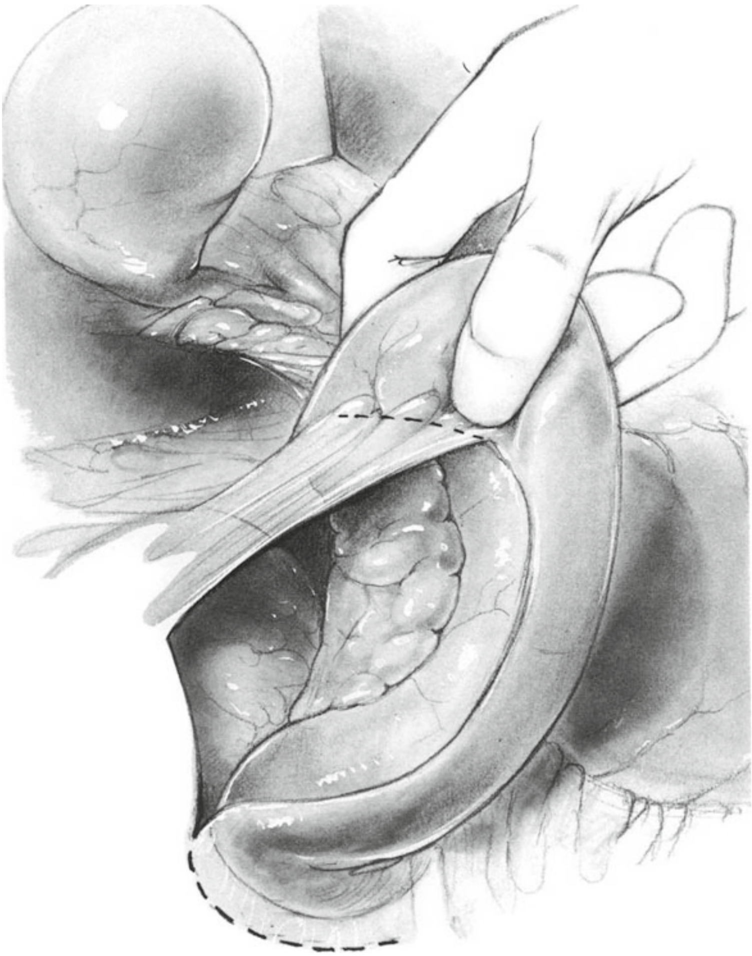


Fig. 89.3

ligatures of 2-0 silk, leaving about 1 cm beyond the proximal tie to prevent the possibility of the ligature slipping off. Continue the dissection just deep and slightly medial to the divided gastroduodenal artery and identify the anterior aspect of the portal vein (Fig. 89.6). In the presence of carcinoma near the head of the pancreas, there are often numerous small veins superficial to the portal vein. *Do not use hemostatic clips in this area* because they would be inadvertently wiped away during the subsequent dissection and manipulation. Individually divide and ligate each vessel with 3-0 or 4-0 silk ligatures.

After identifying the shiny surface of the portal vein, gently free this vein from the overlying pancreas using a peanut sponge dissector. If there is no invasion of the portal vein by tumor, there is no attachment between the anterior wall of the portal vein and the overlying pancreas; thus, a finger can be passed between this vein and the neck of the pancreas (Fig. 89.7). Maximize the distance from the tumor by staying slightly on the left, rather than the right, as this dissection is performed. Occasionally, this is easier to accomplish by inserting the finger from below the pancreas between the superior mesenteric vein and the overlying gland. With one finger inserted between the neck of the pancreas and the superior mesenteric vein, pass the other hand behind the head of the pancreas and try to determine if the tumor has invaded the uncinate process, the posterior side of the portal vein, or the superior mesenteric vessels. If all of the above conditions have been fulfilled, the tumor is probably resectable, and one may proceed now with pancreatectomy. Execute this dissection carefully, as it is the most hazardous during the entire procedure. If the tumor has invaded the portal vein and the finger dissection produces laceration of the vein, controlling the hemorrhage is extremely difficult. (See discussion above under Operative Strategy.)

Continue the dissection of the hepatic artery by dividing and ligating the right gastric artery. Incise the peritoneum over the common hepatic artery as far as the porta hepatis. Unroof and expose the CBD and sweep the lymphatic tissue from the porta hepatis down to the specimen, thereby skeletonizing the hepatic artery and CBD.

Cholecystectomy

Perform a cholecystectomy in the usual manner (see Chap. 77 and Fig. 90.12). Encircle the common hepatic duct just proximal to the point where it is joined by the cystic duct. Apply an occluding temporary ligature or clamp to the hepatic duct and divide it distal to the ligature or clamp, sweeping lymphatic tissue toward the specimen.

Vagotomy and Antrectomy

Proceed with vagotomy (if desired) and antrectomy (see Chaps. 29 and 33; see also Fig. 90.11). Swing the divided stomach to the right to expose the body of the pancreas fully.

Division of Pancreas

In patients with periampullary or distal CBD tumors, there may be no obstruction of the pancreatic duct. Place the line of division of the pancreas 3 cm to the left of the superior mesenteric vessels. This leaves a remnant of pancreatic tail that is suitable for implanting into the open end of the jejunum when the pancreatic duct is too small for a good anastomosis. If this method is elected, carefully free the neck and body of the pancreas from the underlying splenic vein by working from above and from below. A few small branches from the pancreas to the splenic vein may require division.

After the neck and body of the pancreas have been elevated, apply a 35/3.5 mm linear stapler across the pancreas (Fig. 89.8a). Fire the stapling device and divide the pancreas *to the left* of the stapling device (Fig. 89.8b). Identify the pancreatic duct and insert a plastic catheter into the duct to prevent its being occluded by sutures (Fig. 89.9).

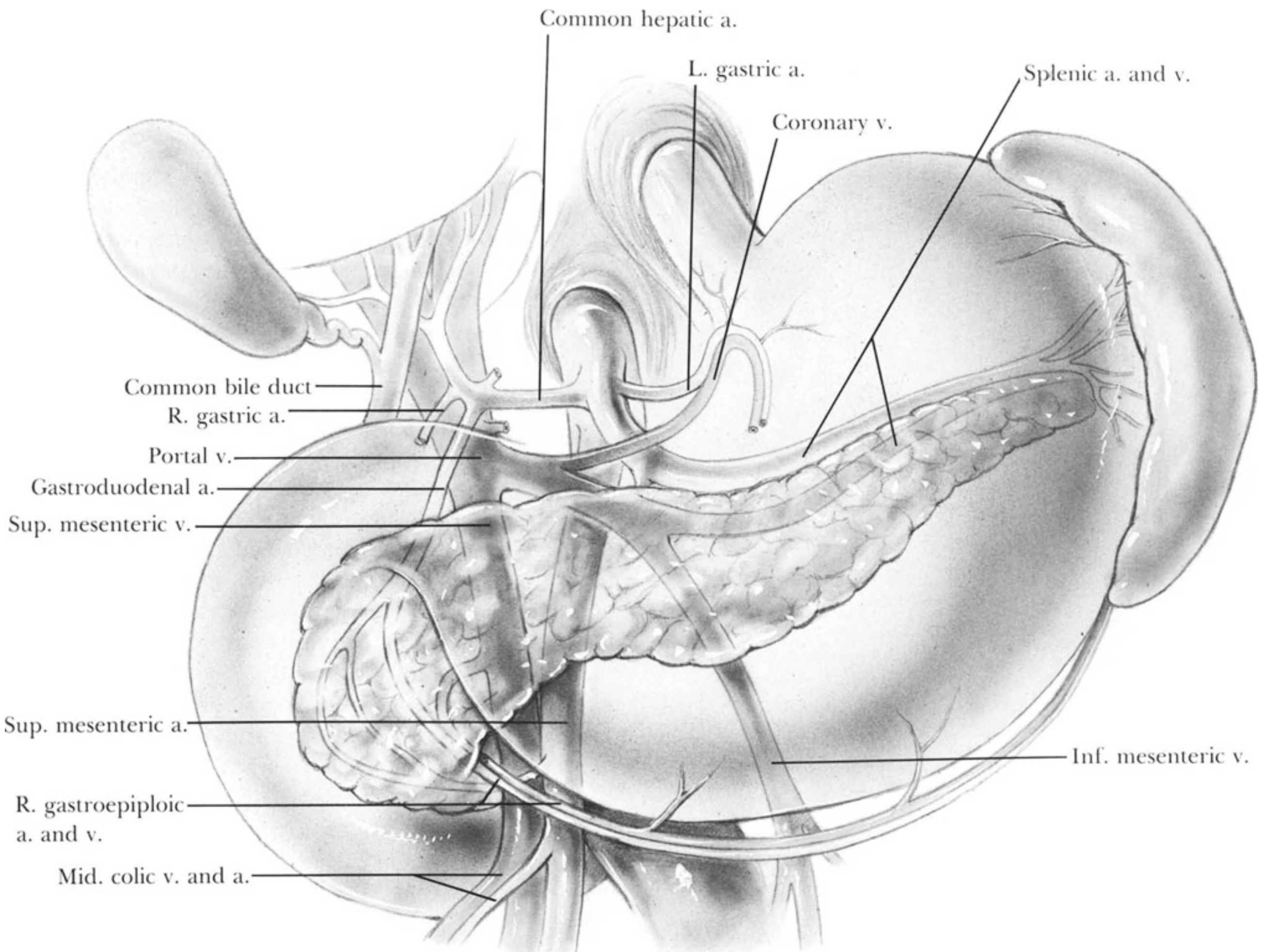


Fig. 89.4

In patients who have an ampullary carcinoma that obstructs the pancreatic duct, the thickened, dilated duct together with the secondary pancreatitis produced by this obstruction makes both the duct and the pancreas suitable for accurate suturing. The same technique of division is used. Generally, it is necessary to suture-ligate a superior and an inferior pancreatic artery in the pancreatic stump.

Dissection of Uncinate Process

Retract the cut, stapled end of pancreas and the divided stomach toward the patient's right, exposing the anterior surface of the superior mesenteric and portal veins (Fig. 89.10). Two or three arterial branches of the superior mesenteric artery pass deep to the superior mesenteric vein and into the head of the pancreas and are generally easy to identify. Divide and ligate each with 3-0 silk. Several branches from the pancreas drain into the superior mesenteric vein from the patient's right. These too are divided and ligated. The superior mesenteric vein may now be gently retracted to the patient's left, revealing the superior mesenteric artery. The uncinate process may terminate at this point in some fibroareolar tissue. Divide it under direct vision. More often a tongue of uncinate process is attached to the posterior surface of the superior mesenteric artery. First pass the left hand behind the uncinate process *to check again that there is no major anomalous hepatic artery* coming from the superior mesenteric. Use electrocautery to divide the uncinate process (Figs. 89.11 and 89.12). Another convenient method is to apply a 55/3.5 mm linear stapler across the uncinate process prior to dividing it. Be certain to avoid injuring the superior mesenteric vein and artery. At the end of this dissection, the gastric antrum, duodenum, and head of the pancreas are attached only at the duodenojejunal junction (Fig. 89.13).

It is possible to save 10–12 min of operating time by applying a cutting linear stapler across the fourth portion of duodenum and dividing the duodenum, thereby releasing the specimen from all of its attachments. The proximal and distal segments of divided duodenum are thus closed by staples, which avoids the need to divide the proximal jejunal mesentery and free the duodenojejunal junction from the ligament of Treitz. The stomach, hepatic duct, and pancreas can each then be anastomosed end to side to the jejunum. Most

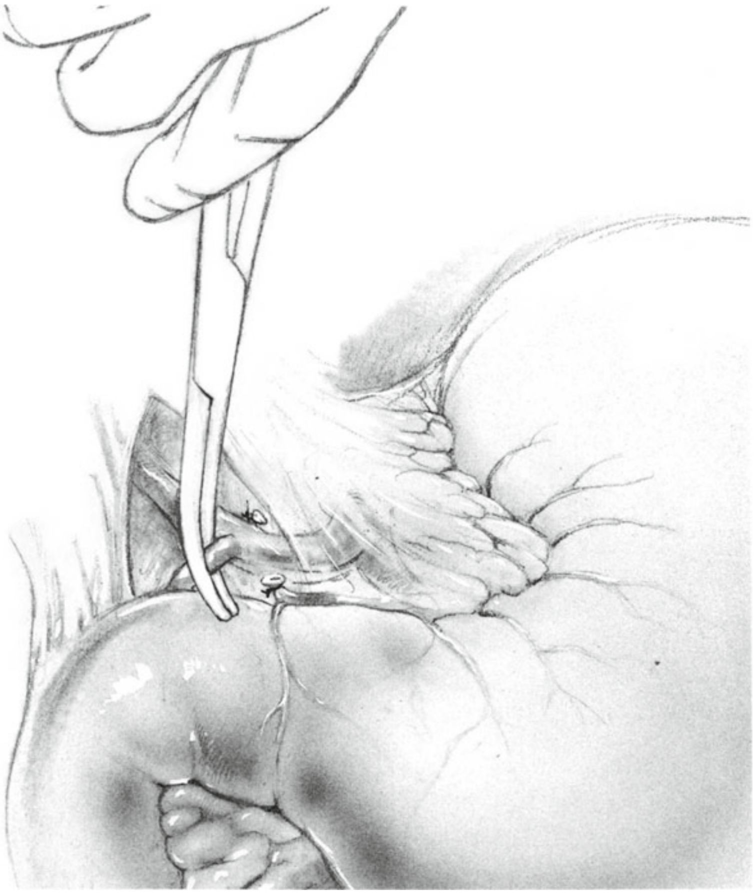


Fig. 89.5

surgeons do free the duodenojejunal junction from the ligament of Treitz, divide the mesentery in this region, and divide the jejunum a few centimeters beyond the ligament of Treitz. This procedure is described in the next section.

Dissection and Division of Proximal Jejunum

Expose the ligament of Treitz under the transverse mesocolon and divide it so the duodenojejunal junction is completely free. Serially clamp, divide, and ligate each of the mesenteric branches from the superior mesenteric vessel to the proximal 6–8 cm of the jejunum. This maneuver releases the proximal jejunum. Unless it is planned to implant the pancreatic tail into the open end of jejunum, apply a 55/3.5 mm linear stapling device across the proximal jejunum and fire it (see Fig. 90.14). Then using a scalpel divide the jejunum flush with the stapler. Lightly electrocoagulate the everted mucosa and remove the stapling device (see Fig. 90.15). It is not necessary to invert this staple line with a row of sutures. Remove the specimen.

Pancreaticojejunal Duct-to-Mucosa Anastomosis

Pass 12–13 cm of proximal jejunum through the aperture in the transverse mesocolon. Construct an end-to-side pancreaticojejunostomy along the antimesenteric aspect of the jejunum, beginning at a point about 3 cm from the staple line. Use interrupted 4-0 Prolene stitches to suture the posterior capsule of the pancreas to the seromuscular layer of jejunum (Fig. 89.14). Then make a small incision slightly larger than

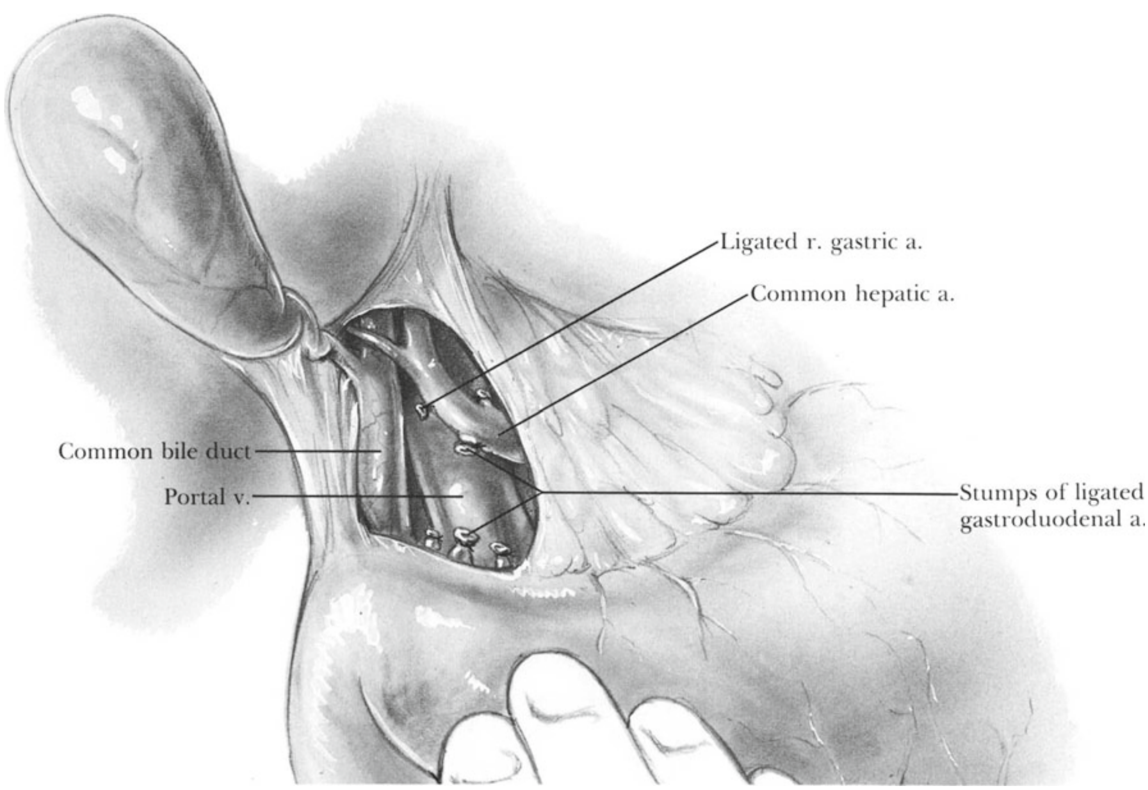


Fig. 89.6

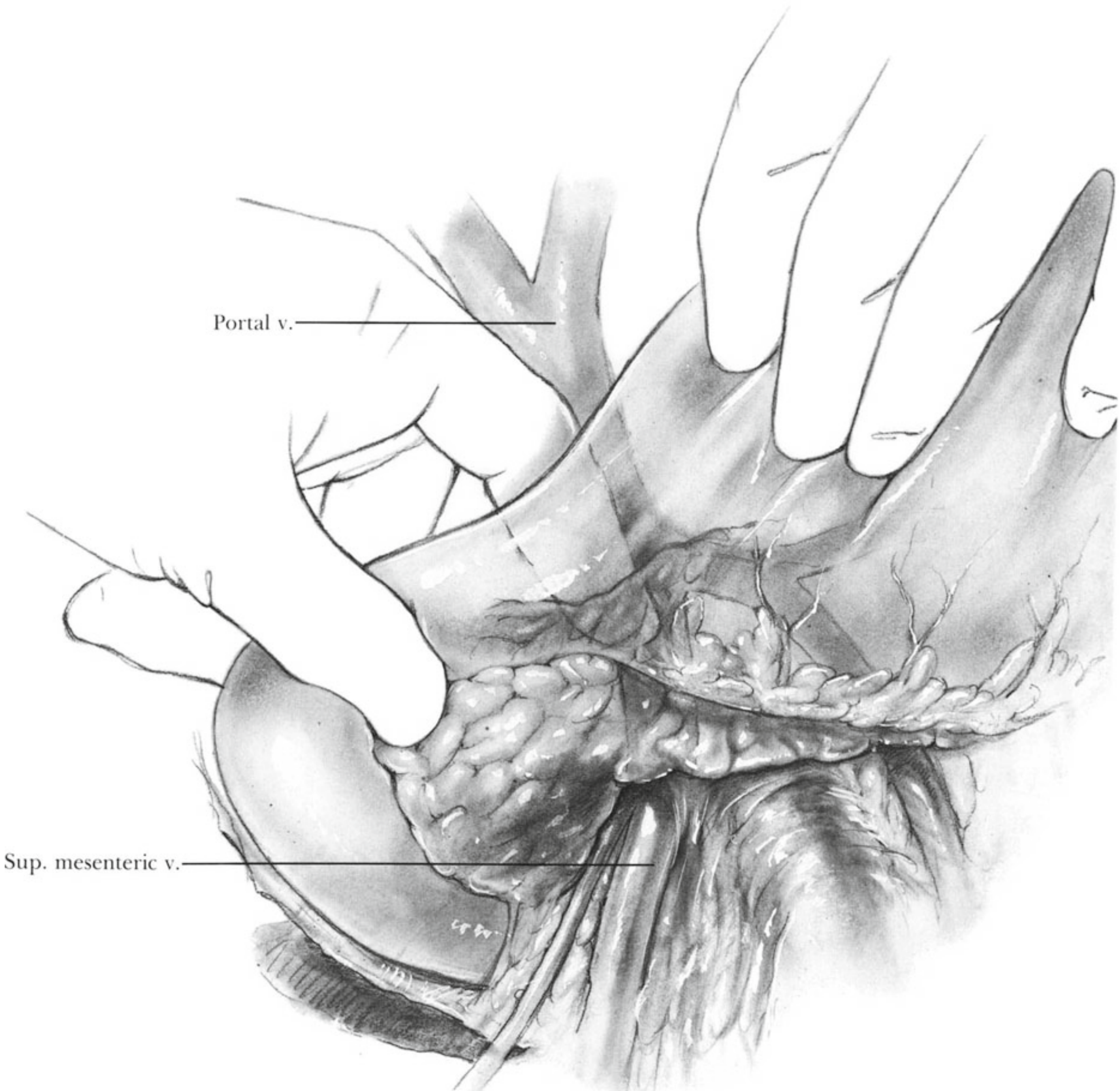


Fig. 89.7

the diameter of the pancreatic duct (Fig. 89.15). Approximate the pancreatic duct to the full thickness of the jejunal wall using interrupted 6-0 Prolene or PDS sutures (Fig. 89.16). Wearing telescopic lenses with **2.5**× magnification is helpful for ensuring an accurate anastomosis. After the posterior half of this anastomosis has been completed, insert an 8–10F pediatric feeding tube into the pancreatic duct. Thread the long end of the catheter into the jejunum. Make no holes in the catheter on the jejunal side of the anastomosis. The catheter is brought out from the jejunum about 10 cm beyond this anastomosis and passed through a stab wound in the abdominal wall for drainage to the outside. Insert a 4-0 silk purse-string suture around the hole in the jejunum through which the catheter exits. Then complete the duct-to-jejunum anastomosis with 6-0 Prolene or PDS sutures (Fig. 89.17). Carefully buttress the remainder of the pancreas into the anterior wall of jejunum with additional 4-0 sutures (Fig. 89.18). It is important to suture the catheter to the pancreas by means of a single 5-0 PG stitch; otherwise it is easily dislodged during subsequent steps of the operation. Also suture the jejunostomy site to the stab wound of the abdominal wall if possible.

Pancreaticojejunal Anastomosis by Invagination

An alternative method for anastomosing pancreas to jejunum is to invaginate 2–3 cm of the pancreatic stump into the lumen. First insert a catheter into the pancreatic duct as described above. Suture the catheter into the duct with fine

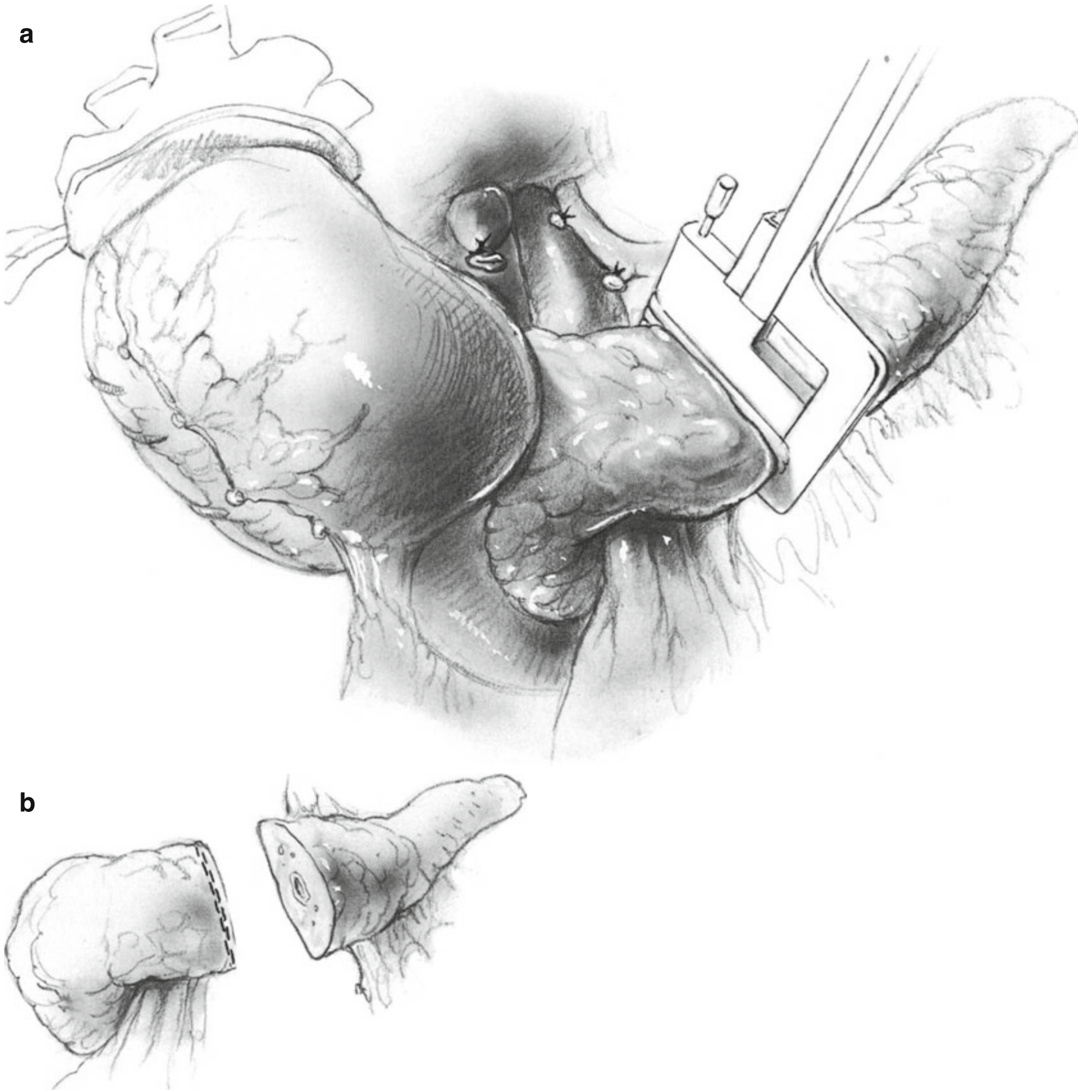


Fig. 89.8

PG. Pass 3 cm of the pancreatic stump into the open proximal end of the jejunum, which is easily accomplished by inserting guide sutures at the superior and inferior margins of the anastomosis. Use 4-0 Prolene and insert the needle into the superior aspect of the jejunum 3 cm away from its proximal margin (Fig. 89.19a).

Using the same needle, take a bite of the superior margin of the pancreas. Then return the same suture from the lumen out through the open end of the jejunum, emerging 3 cm from the cut edge. Place an identical suture at the inferior margin of the jejunum and pancreas. By putting traction on these two sutures, the pancreas can be brought into the open end of the jejunum. If the jejunum does not accommodate the pancreas because the pancreatic stump is too large, inject glucagon (1 mg) intravenously to relax the jejunum. If the jejunum still cannot accommodate the pancreatic stump after glucagon injection, utilize the techniques described below where the pancreatic stump is invaginated into the jejunum through an incision in the jejunum along its antimesenteric margin. Bring the catheter out of the jejunum through a small stab wound 6–8 cm distal to the pancreaticojejunal anastomosis. If an external drainage catheter is not used, insert a short segment (4–5 cm) of catheter into the pancreatic duct so about 1–2 cm projects beyond the cut edge of the duct. This helps prevent some of the sutures used to create the anastomosis from encompassing the duct and thereby occluding it. This tube is ejected into the intestinal stream spontaneously at a later date. Now insert additional 4-0 Prolene sutures to fix the cut edge of the pancreas to the circumference of the jejunum (Fig. 89.19b). If the sutures are inserted but not tied, this step can be accomplished under direct vision to avoid damage to the pancreatic duct. When the sutures have been inserted, the pancreas is readjusted in its new location inside the jejunal lumen, and each of the

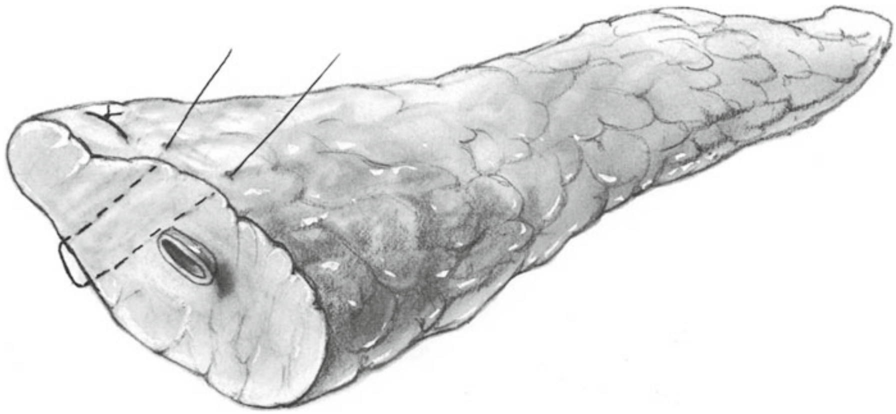


Fig. 89.9

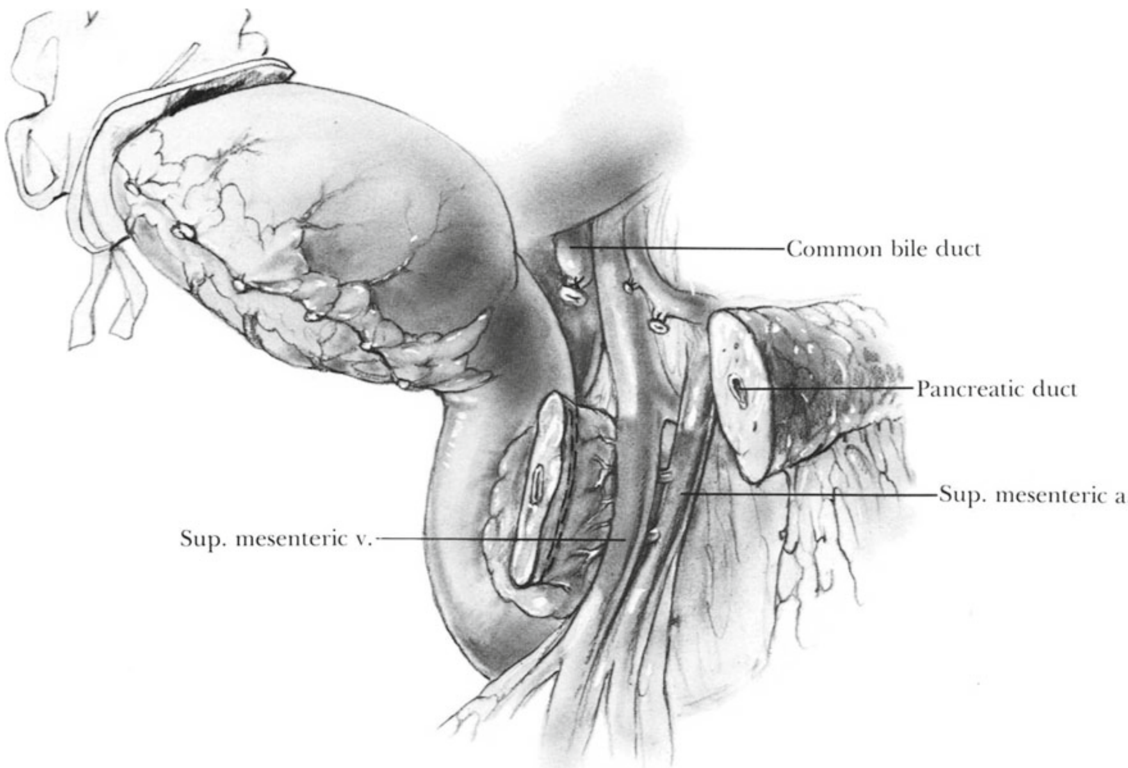


Fig. 89.10

sutures is tied. A second layer of Lembert sutures is inserted from the proximal cut edge of the jejunum to the periphery of the pancreas in such fashion that the jejunal mucosa is inverted (Fig. 89.20).

Another method for intussuscepting the pancreatic stump into the jejunum is described beginning with Fig. 89.21. Using interrupted 4-0 Prolene or silk, insert Lembert-type stitches to approximate the pancreas to the jejunum at a point 2.5 cm from their proximal margins, as shown. After completing this seromuscular layer of sutures, insert a second layer, approximating the proximal margin of the pancreas to the full thickness of jejunum, as demonstrated in Fig. 89.22. If the pancreatic duct is large enough, include the posterior wall of the pancreatic duct in the suture line as shown. The first layer in the anterior suture line is demonstrated in Fig. 89.23. Use Lembert sutures to invert the mucosa of the jejunum into the parenchyma of the pancreas. The final anterior row of sutures between the seromuscular coat of jejunum to the pancreas completes the intussusception of the pancreas into the jejunum, as shown in Figs. 89.24 and 89.25.

When the stump of the pancreas is too large to be invaginated into the lumen of the jejunum even after administration of glucagon, another method may be employed. As shown in

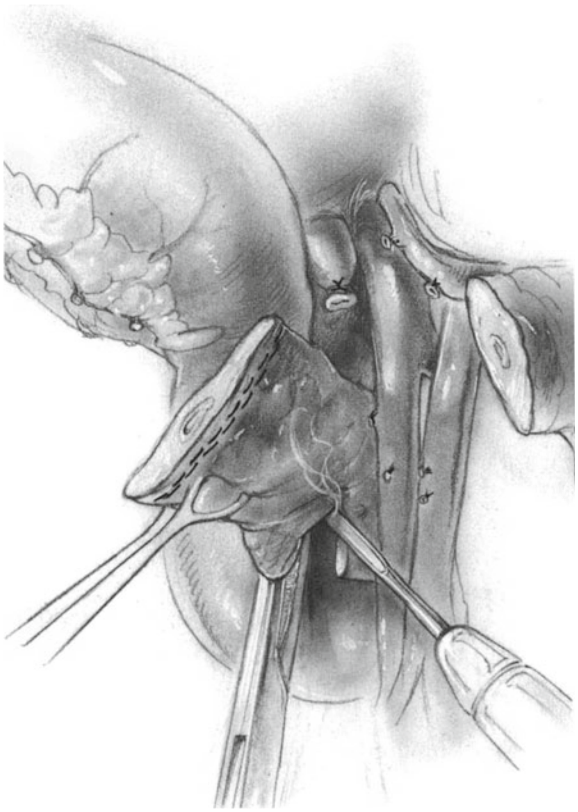


Fig. 89.11

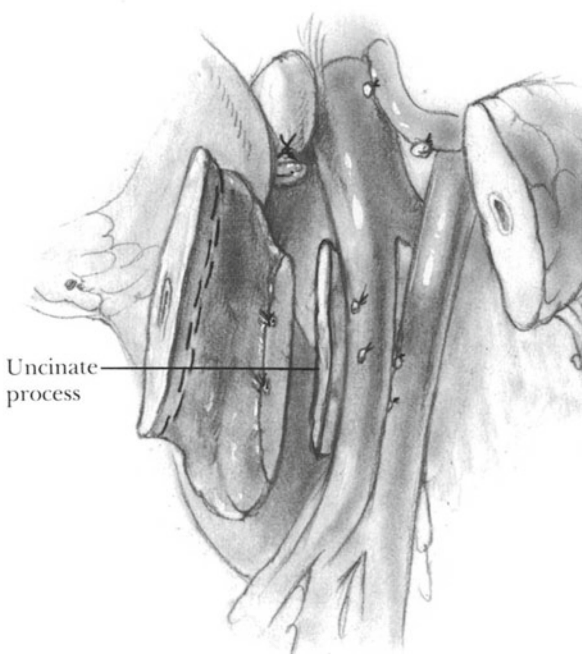


Fig. 89.12

Fig. 89.26, close the cut end of the jejunum with a 55/3.5 mm linear stapling device. This need not be inverted by a layer of sutures. Approximate the cut edge of the pancreas to the antimesenteric border of the jejunum to complete an end-to-side anastomosis, leaving 1–2 cm of jejunum hanging freely beyond the anastomosis. Insert 4-0 sutures of the Lembert type, approximating the seromuscular coat of the jejunum to the pancreas. The pancreatic sutures should be inserted about 1.5 cm away from its cut edge. When this layer is complete, make an incision along the antimesenteric border of the jejunum slightly shorter than the diameter of the pancreas, as seen in Fig. 89.27. Then insert sutures between the posterior edge of the pancreas, taking the full thickness of the jejunum in interrupted fashion to constitute the second posterior layer. If the pancreatic duct is large enough, include the posterior wall of the pancreatic duct in the sutures (Fig. 89.28). Again, use interrupted 4-0 sutures to approximate the anterior edge of the pancreas to the full thickness of the jejunum, as in Fig. 89.29. The final anterior layer of sutures complete the invagination of the pancreas by approximating the anterior wall of the pancreas to the seromuscular coat of the jejunum, as in Fig. 89.30.

Hepaticojejunal Anastomosis

Before anastomosing the hepatic duct to jejunum, make a tiny stab wound in the anterior wall of the hepatic duct about 3 cm proximal to its cut end. Insert a Mixter clamp into the hepatic duct through the stab wound. Grasp the *long arm* of a 16F or 18F T-tube (Fig. 89.31) and draw it through the stab wound (Fig. 89.32). The purpose of this T-tube is to drain bile to the outside until the pancreaticojejunostomy has completely healed.

Make an incision on the antimesenteric border of the jejunum (Fig. 89.33) about 15–20 cm distal to the pancreaticojejunostomy. The jejunal incision should be approximately equal to the diameter of the hepatic duct. Use one layer of interrupted 5-0 PDS or PG sutures to approximate the full thickness of hepatic duct to the full thickness of jejunum (Fig. 89.34). Tie the knots of the posterior layer of sutures in the lumen. The anterior knots are placed on the serosal surface of the hepaticojejunal anastomosis. On the jejunal side of the anterior layer, use a seromucosal-type stitch (see Fig. 4.13). Leave only 3–4 mm of space between sutures (Fig. 89.35). We have not found it necessary to insert two layers of sutures. If the diameter of the hepatic duct is small, enlarge the ductal orifice by making a small Cheatle incision in the anterior wall of the duct.

Gastrojejunostomy

Identify the proximal jejunum and bring it to the gastric pouch in an antecolic fashion. Place the antimesenteric border of jejunum in apposition with the posterior wall of the residual gastric pouch for the gastrojejunal anastomosis. Leave 10–20 cm between the hepaticojejunostomy and the gastric anastomosis. Insert a guy stitch approximating the antimesenteric wall of the jejunum to the greater curvature of

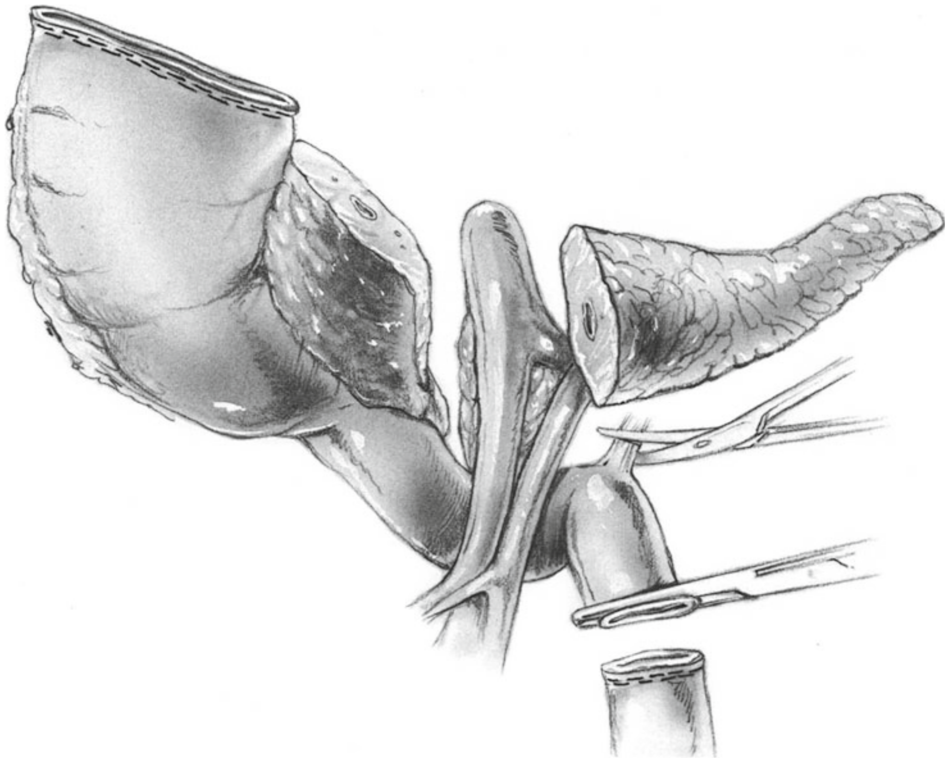


Fig. 89.13

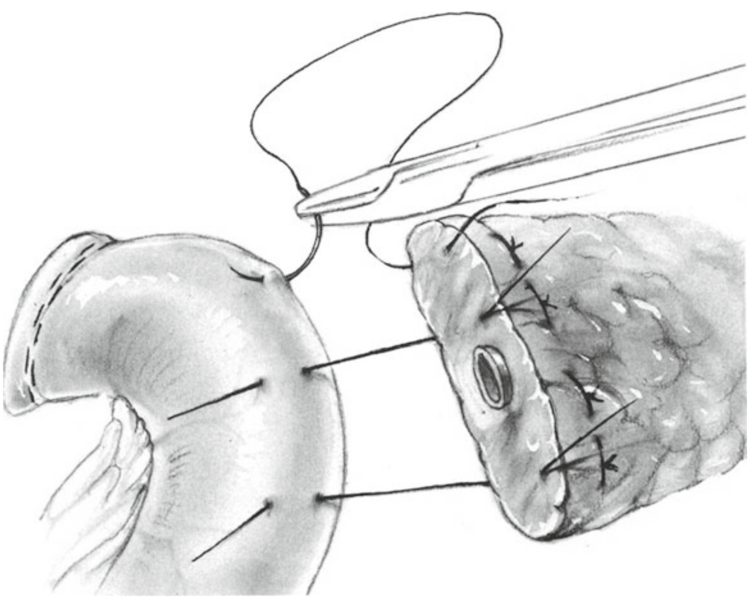


Fig. 89.14

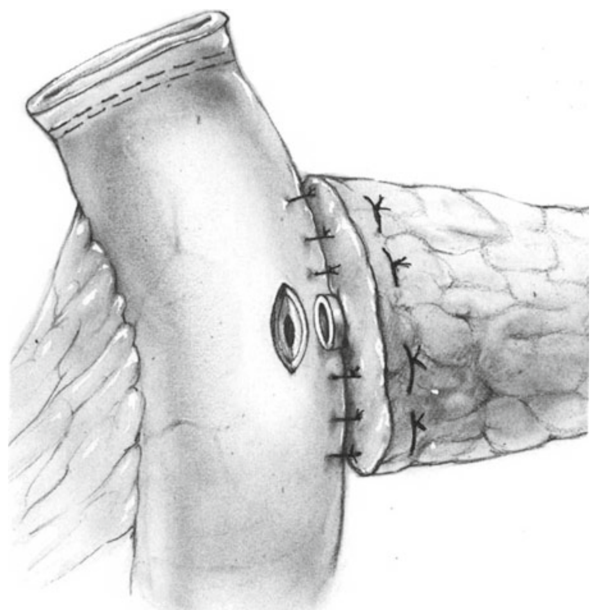


Fig. 89.15

the stomach at a point about 3 cm proximal to the previously placed staple line. Then, with electrocautery make small stab wounds in the posterior wall of the stomach and the jejunum. Insert the linear cutting stapling device, one fork in the gastric lumen and one in the jejunum (see Fig. 33.44). Be certain there is no extraneous tissue between the walls of the stomach and the jejunum. After locking the stapler, insert a single Lembert stitch to approximate the stomach and jejunum at the tip of the stapler; then fire and remove it. Carefully inspect the staple line for bleeding, which should be corrected by cautious electrocoagulation or insertion of 4-0 PG sutures. Apply Allis clamps to the anterior and posterior terminations of the staple line. Use additional Allis clamps to

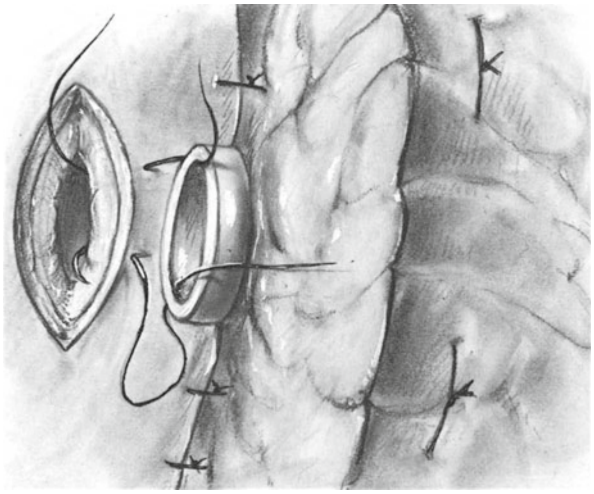


Fig. 89.16

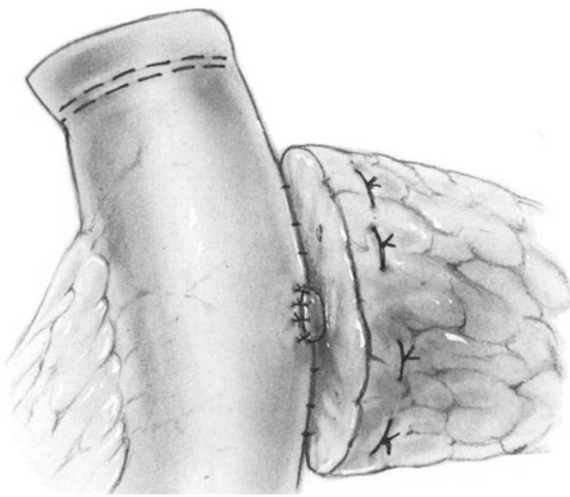


Fig. 89.17

close the remaining aperture in the gastrojejunal anastomosis. Apply a 55 mm linear stapler deep to the line of Allis clamps and fire the staples. (The details of this technique are described in Chap. 33.)

Close the defect in the mesocolon at the region of Treitz's ligament by means of continuous and interrupted sutures of 4-0 PG around the jejunum and its mesentery. Try to isolate the hepaticojejunal anastomosis from the pancreatic anastomosis by suturing the free edge of the omentum to the remaining hepatoduodenal ligament overlying the hepatic duct. Intermittently during the entire operation, a dilute antibiotic solution is used to irrigate the operative field. Figure 89.36 illustrates the completed operation.

Insertion of Drains

Insert a closed-suction drain through a stab wound in the right upper quadrant down to the vicinity of the hepaticojejunostomy. Allow the T-tube to exit through a separate stab wound in the right upper quadrant.

Bring the pancreatic catheter through a tiny stab wound in the antimesenteric wall of the jejunum about 10 cm distal to the pancreatic anastomosis. Place a 4-0 silk purse-string suture around this tiny stab wound; then make a stab wound in the appropriate portion of the abdominal wall, generally in the right upper quadrant, and bring the catheter through this stab wound. If feasible, fix the jejunum to the abdominal wall around the catheter's exit point using four sutures of interrupted 3-0 PG, one suture to each quadrant. This prevents intraperitoneal leakage of jejunal contents. Connect this catheter to a plastic collecting bag. Alternatively, bring the catheter through a stab wound in the *proximal* jejunum as depicted in Fig. 89.37. Through stab wounds in the left upper quadrant, insert Jackson-Pratt closed-suction drains and

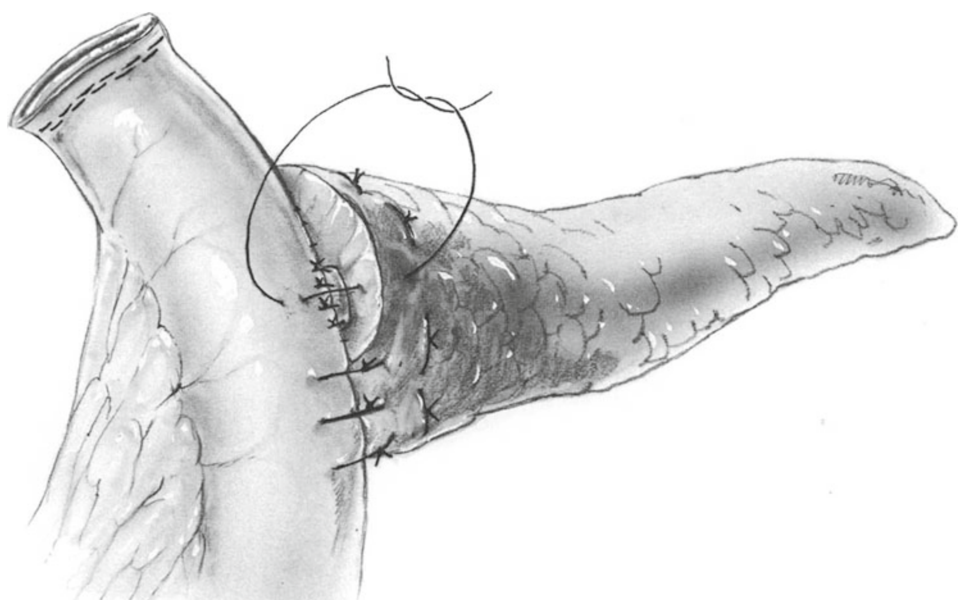
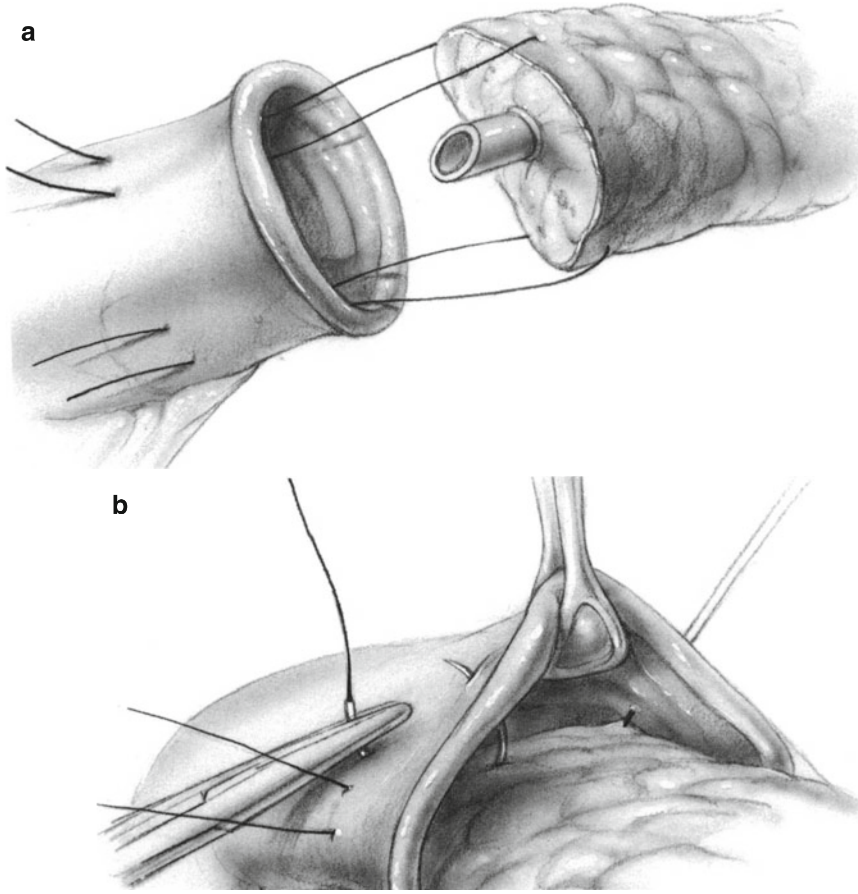


Fig. 89.18

Fig. 89.19



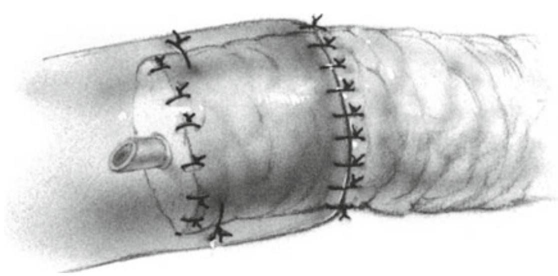


Fig. 89.20

place them in the vicinity of the pancreaticojejunostomy and subhepatic spaces.

Needle-Catheter Jejunostomy

Consider performing a needle-catheter jejunostomy during all pancreatoduodenectomies. If the patient should suffer from delayed gastrointestinal function due to leakage of one of the anastomoses, jejunal feedings are superior to total parenteral nutrition.

Closure

Close the abdominal wall using No. 1 PDS sutures in the usual fashion.

Partial Pancreatoduodenectomy with Preservation of Stomach and Pylorus

The important steps of partial pancreatoduodenectomy are identical with the standard Whipple pancreatoduodenectomy except that the pylorus, 2 cm of duodenum, and all of the vagus nerve branches are preserved. In the hope of reducing the risk of marginal ulceration, we place the duodenojejunal anastomosis closer to the biliary and pancreaticojejunal anastomoses than is the case with the Whipple operation.

Included in this operative description is a method for bringing the pancreatic catheter to the abdominal wall through a tiny stab wound near the closed proximal end of the jejunal segment (Fig. 89.37). This has the important advantage that the length of the catheter between the pancreatic duct and the abdominal wall is much less than that described for the Whipple operation (above).

Operative Technique

Follow the procedure described in the first part of this chapter with the following exceptions:

1. Do not perform a vagotomy.
2. Dissect the posterior wall of the duodenum off the head of the pancreas for a distance of 2.5 cm after dividing and

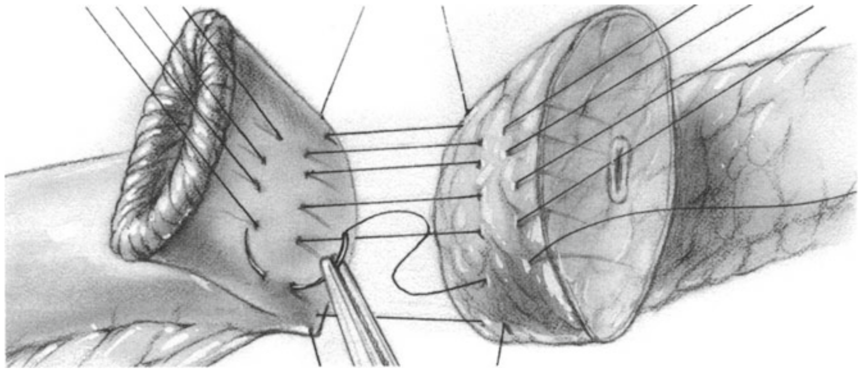


Fig. 89.21

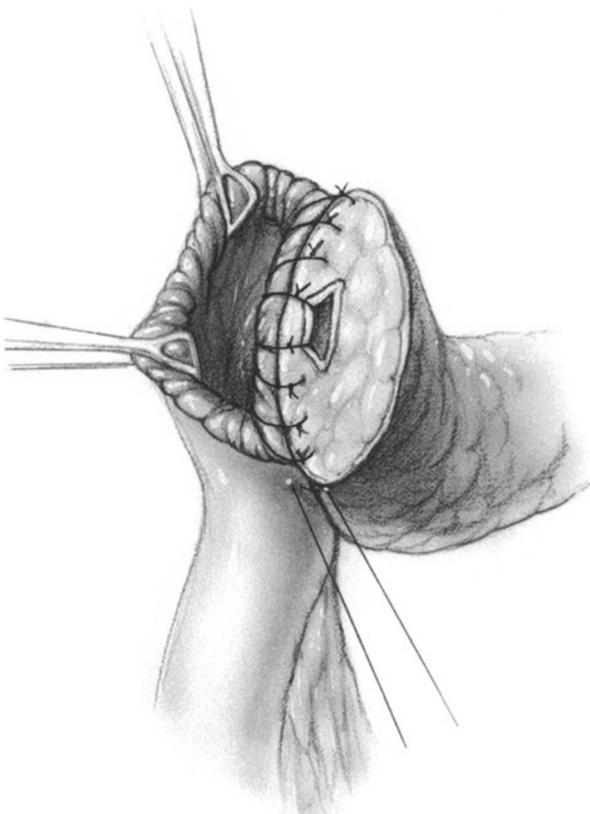


Fig. 89.22

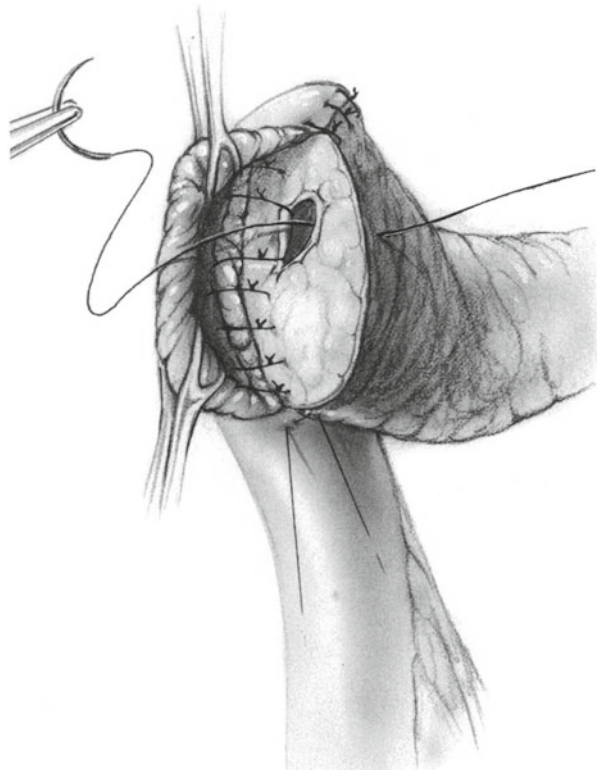


Fig. 89.23

ligating the gastroduodenal and right gastric arteries as described above.

3. Apply the cutting linear stapling device to the duodenum at a point about 2.5 cm distal to the pylorus. Fire the stapling device. This transects the duodenum and staples closed the proximal and distal ends of the divided duodenum.
4. *Be careful to avoid injuring the gastroepiploic arcade* in the greater omentum along the greater curvature of the stomach, as much of the blood supply to the proximal duodenum now comes from the intact left gastroepiploic artery down to the pylorus. Beyond this point the duodenum is fed by the intramural circulation. Additional blood supply comes from the left gastric artery along the lesser curve of the stomach.
5. Anastomose the end of the duodenum to the antimesenteric side of the jejunum at a point about 20 cm distal to the hepaticojejunal anastomosis. Bring the jejunum fairly directly from the hepaticojejunostomy to the duodenum for an end-to-side duodenojejunal anastomosis in the supramesocolic space.
6. The first step when preparing for the anastomosis is to apply several Allis clamps to the line of staples closing the duodenum. Then excise the staple line with scissors, leaving the duodenum wide open. Observe the cut duodenum for adequacy of bleeding. Although pulsatile flow is

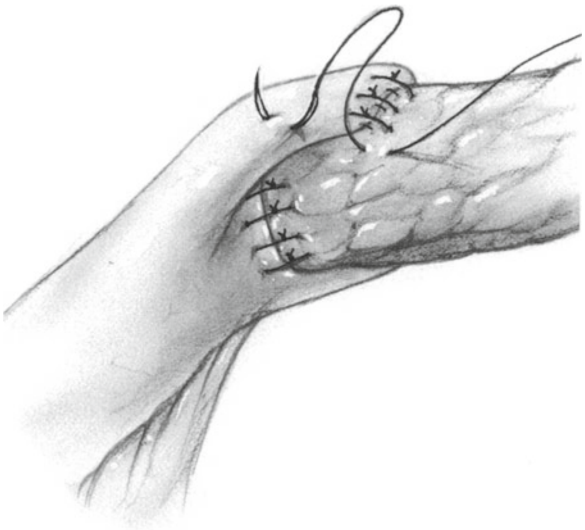


Fig. 89.24

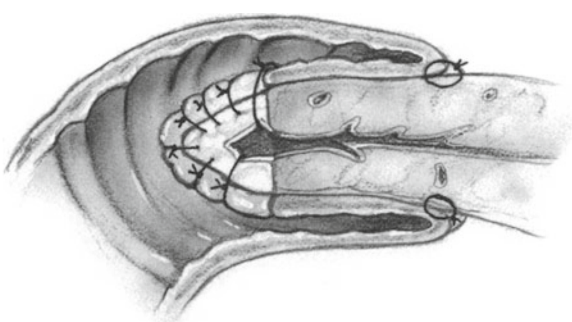


Fig. 89.25

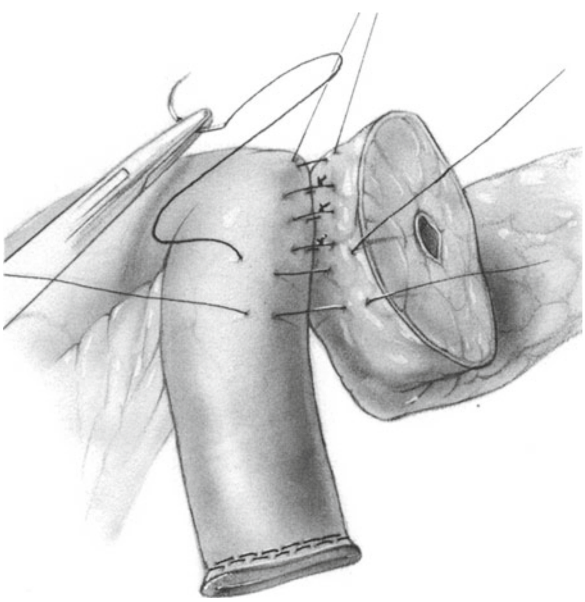


Fig. 89.26

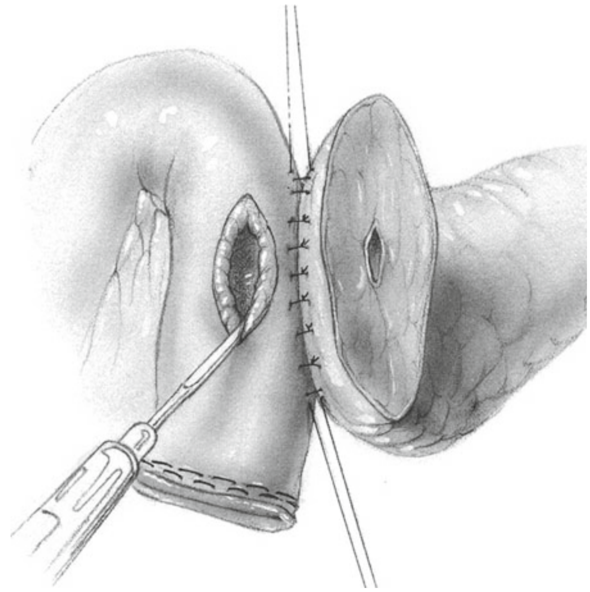


Fig. 89.27

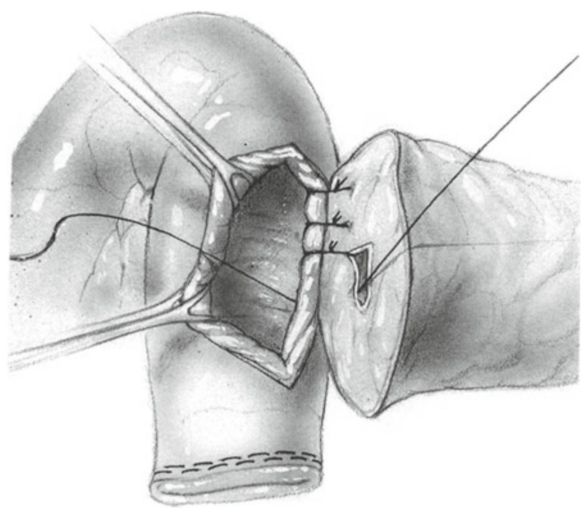


Fig. 89.28

not generally seen and the duodenum may be somewhat cyanotic, fairly brisk oozing of red blood is an indication of satisfactory circulation.

7. Do not place the anastomosis close to the pylorus because the close proximity of the suture line to the pylorus interferes with pyloric function and results in gastric retention. Insert a layer of 4-0 interrupted silk Lembert sutures to approximate the posterior seromuscular coat of the duodenum to the antimesenteric border of the jejunum. After this has been done, make an incision in the antimesenteric border of the jejunum. Obtain hemostasis with absorbable sutures or electrocoagulation. Then begin the mucosal layer. Use 5-0 atraumatic Vicryl suture material and place the first stitch in the middle of the posterior layer of the anastomosis. Run a continuous locked stitch from this point to the

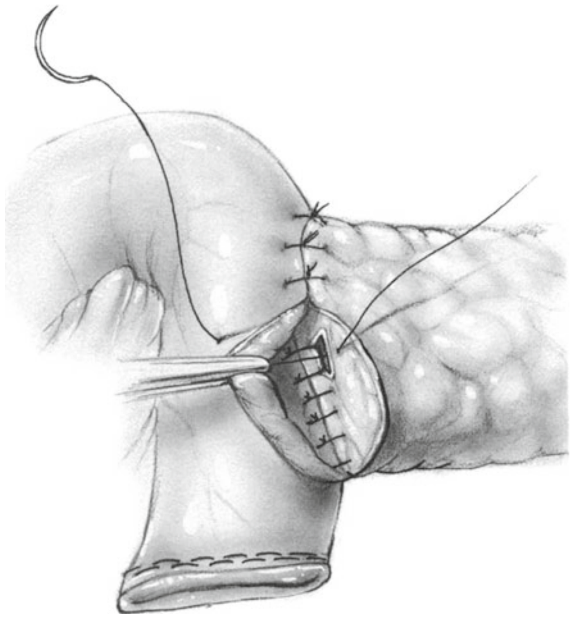


Fig. 89.29

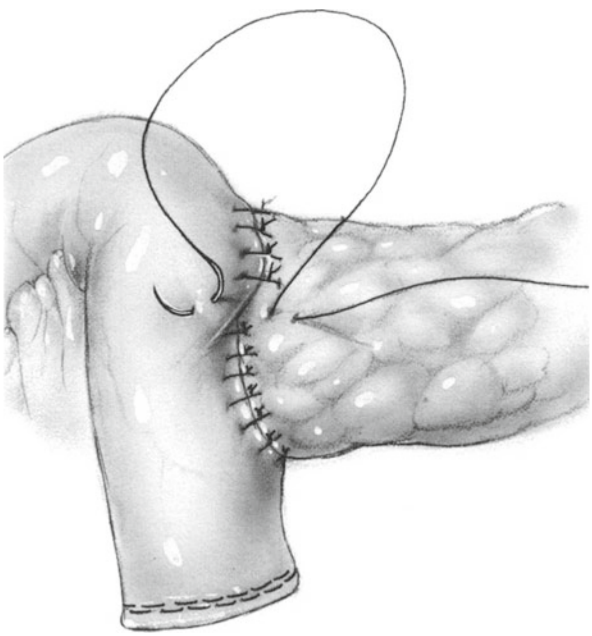


Fig. 89.30

left-hand termination of the posterior layer. Take relatively small bites through the full thickness of duodenum and jejunum. If the bites are small, the continuous suture does not act as a purse string to narrow the anastomosis.

8. Insert a second 5-0 PG suture adjacent to the first one at the midpoint of the posterior layer. Run this stitch in a continuous locked fashion toward the patient's right. Accomplish closure of the first anterior layer of the anastomosis using the same 5-0 PG as a Connell, a Cushing, or a seromucosal stitch (Fig. 89.38). Terminate

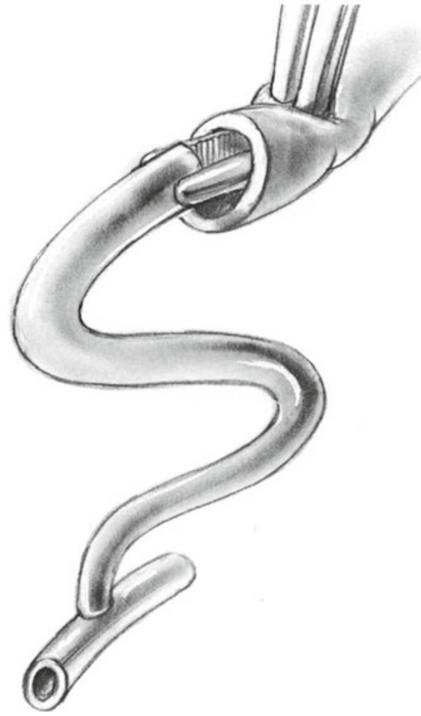


Fig. 89.31

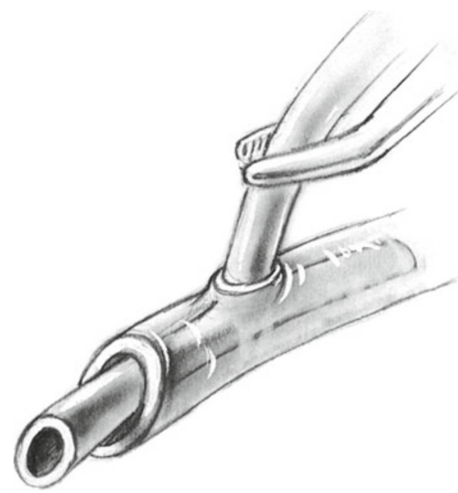


Fig. 89.32

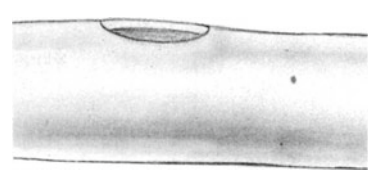


Fig. 89.33

this layer by tying the ends of the two continuous PG sutures to each other in the middle of the anterior layer. Complete the anterior layer of the anastomosis by inserting interrupted 4-0 silk Lembert seromuscular

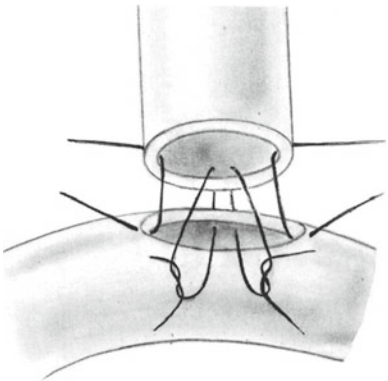


Fig. 89.34

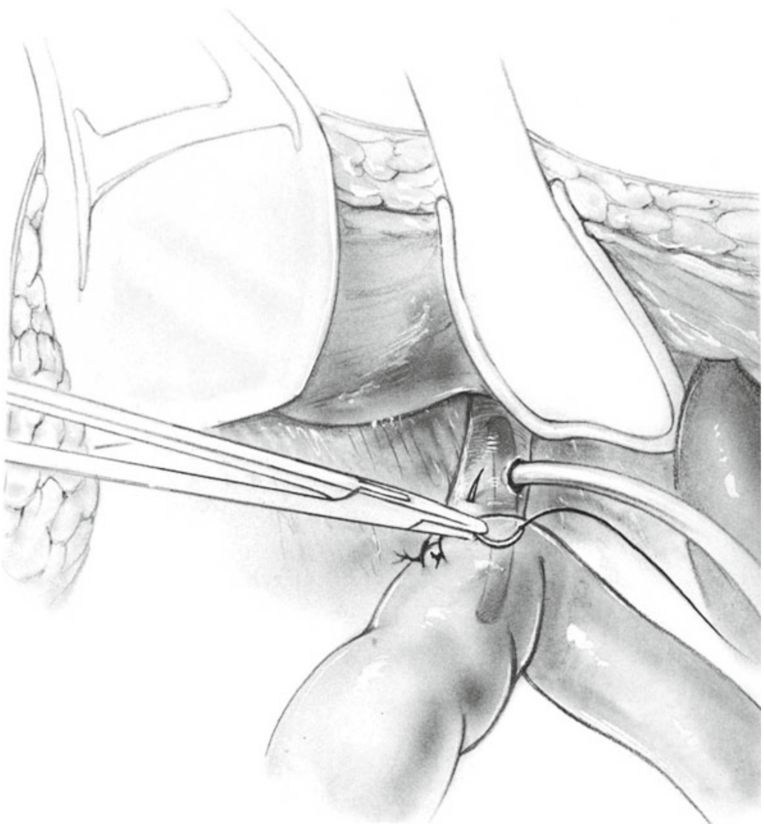


Fig. 89.35

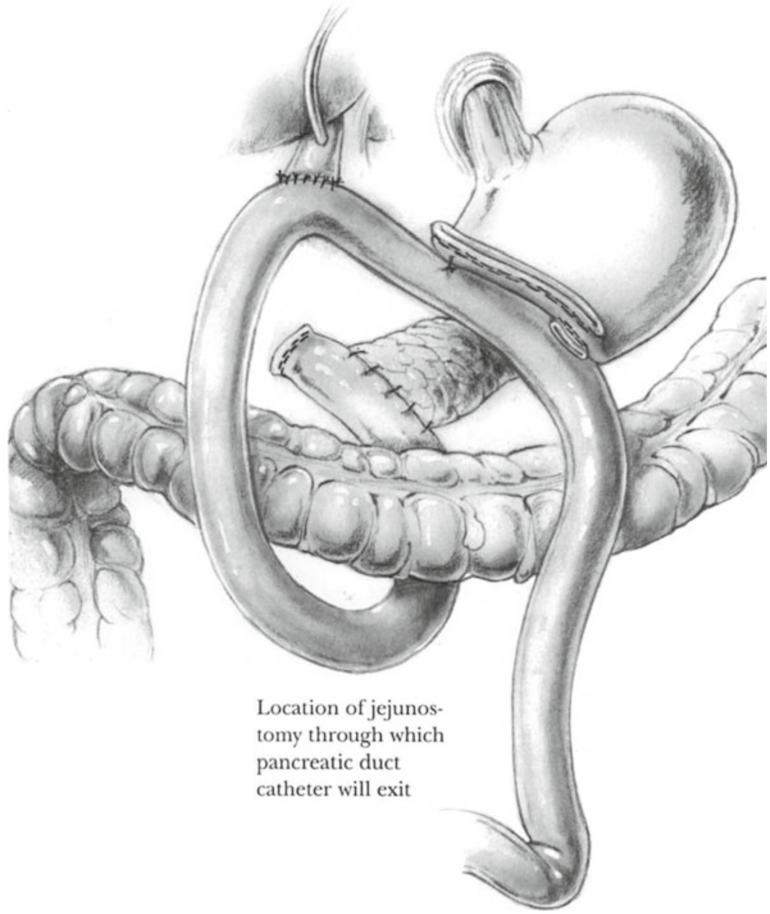


Fig. 89.36

sutures (Fig. 89.39a, b). Figure 89.37 illustrates the method of draining the pancreatic duct. Insert the pediatric feeding tube into the pancreatic duct after completing the posterior layers of the pancreaticojejunostomy. Suture the catheter to the pancreas with a 3-0 PG stitch; then bring it through a puncture wound in the proximal jejunum. Close the jejunal puncture wound around the catheter with a 4-0 silk purse-string suture. Bring the catheter through a puncture wound of the abdominal wall to the left of the midline incision and transfix it to the skin with a suture. In most cases it is possible to suture the jejunum to the parietal peritoneum around the puncture wound through which the catheter exits.

Figure 89.40 illustrates the end result of this operation without a catheter in the pancreatic duct but with the pancreatic stump invaginated into the jejunal lumen. Insert a closed-section drainage catheter near the pancreatic anastomosis. Bring the catheter out through a puncture wound in the upper abdominal wall.

Complications

Delayed Gastric Emptying. This complication occurs if the duodenojejunal suture line abuts the pyloric sphincter muscle and thus interferes with this sphincter's proper functioning. Most cases of delayed gastric emptying subsequent to a pancreatoduodenectomy are due to leakage from the pancreaticojejunal or hepaticojejunal anastomoses or intraperitoneal sepsis rather than some intrinsic disorder of gastric function. Evacuation of intraperitoneal collections or abscesses accelerates the return to normal gastric emptying. Most of these abscesses can be evacuated by percutaneous CT-guided insertion of drainage catheters.

Pyloroduodenal Ulcer. Superficial ulceration may follow impairment of the duodenal blood supply. Peptic ulcer of the duodenum or jejunum may occur if the gastric acidity following the operation is permitted to fall below

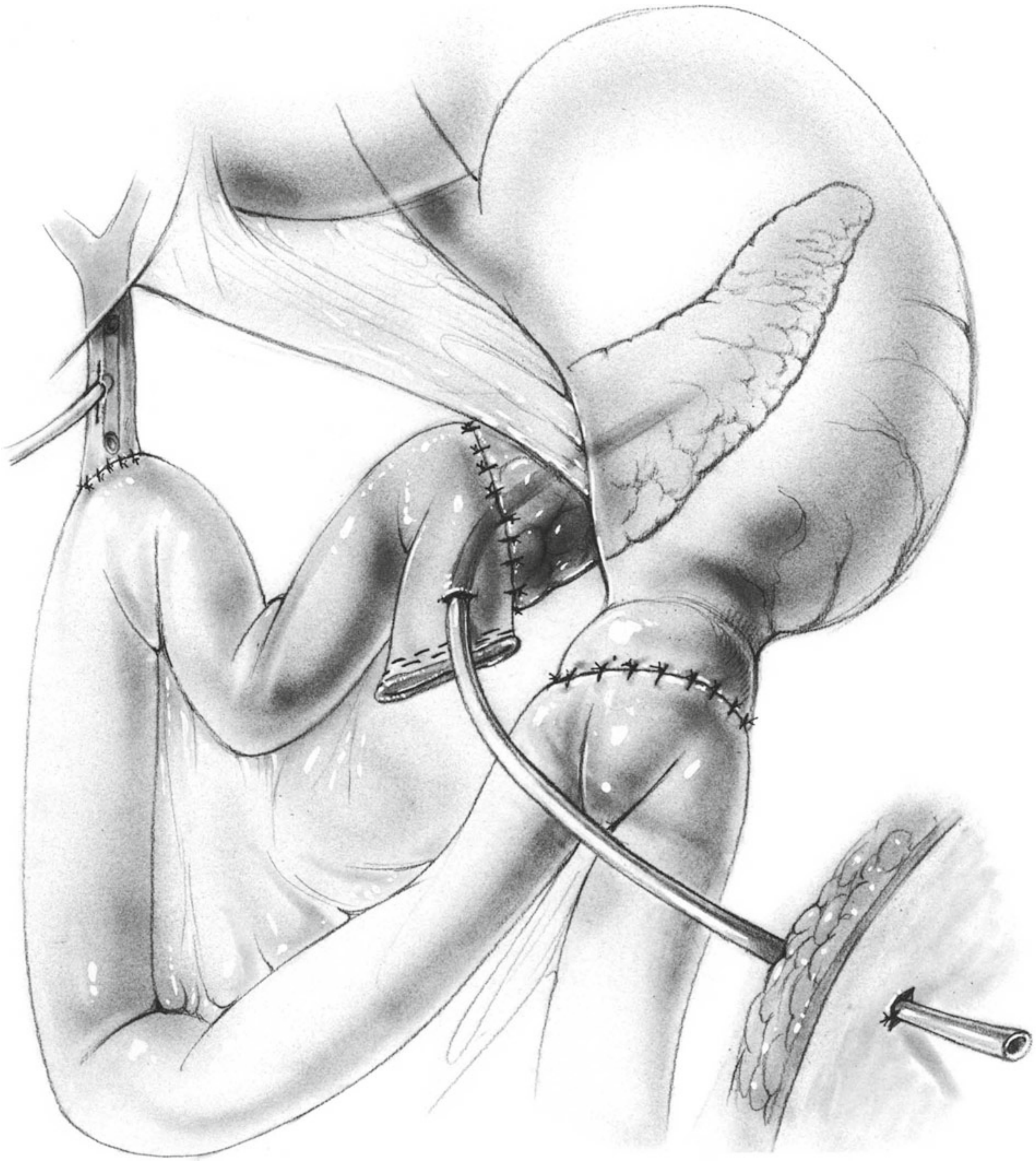


Fig. 89.37

pH 4–5. With bile diverted into the T-tube and all the pancreatic juice draining to the outside via the pancreatic duct catheter, one of our patients developed gastric pH 1 postoperatively while receiving cimetidine 100 mg/h intravenously. The patient bled from a superficial pyloroduodenal ulcer that healed when the pancreatic secretions were injected into the nasogastric tube together with antacids. During the early postoperative period, it is important to administer enough H_2-blocker to raise the gastric pH to 5.0.

Postoperative Care

Perioperative antibiotics, which were initiated prior to the operation, are repeated by the intravenous route every 4 h during the procedure and then every 6 h for four doses postoperatively. If the bile was infected prior to surgery, administer antibiotics until the infection is suppressed.

Maintain the gastric pH at or above 5.0 with parenteral agents. Test the intragastric pH on the sample of gastric juice aspirated through the nasogastric tube every 2 h. Administer

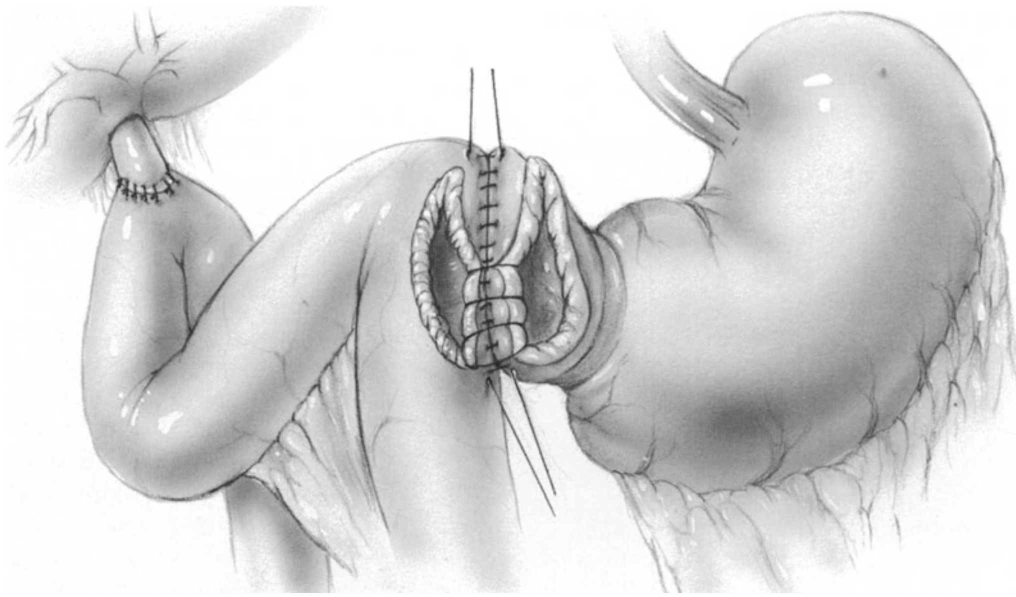


Fig. 89.38

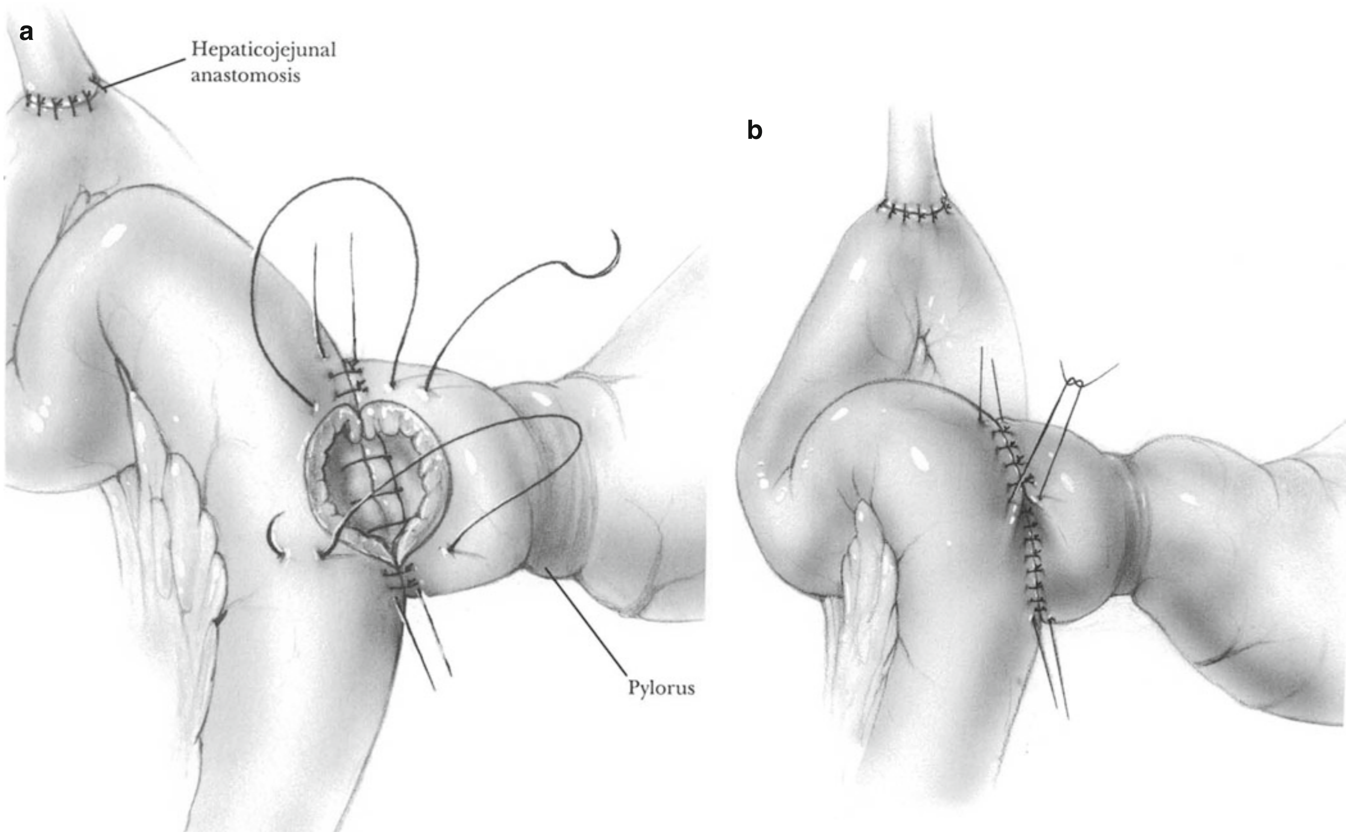


Fig. 89.39

additional antacid, if necessary, in doses sufficient to maintain the desired pH.

Intravenous fluids should be administered in sufficient quantities to ensure normal urine output. Hemodynamic monitoring is helpful in older cardiac patients. Some of our patients have required 8 l of isotonic fluid or more on the day of operation to maintain cardiovascular homeostasis even in the absence of significant blood loss. Because it is an

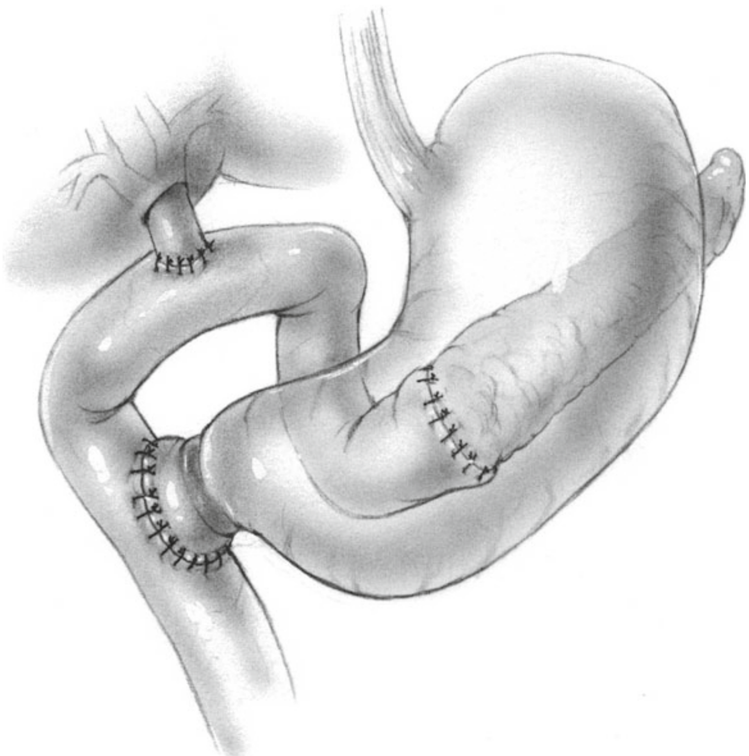


Fig. 89.40

extensive operation, one can expect considerable sequestration of fluids into the "third space." By the third postoperative day, there is frequently a brisk diuresis, at which time intravenous fluids should be limited in volume.

Initiate enteral feedings by way of the jejunostomy catheter after the operation is completed and continue these feedings until the patient is able to take a full diet by mouth.

Leave the T-tube and the pancreatic catheter in place for 21 days. If there has been no drainage of pancreatic juice or bile by the seventh or eighth day, mobilize and slowly remove the latex drains. Remove the Jackson-Pratt drain on day 8–10 unless significant amounts of fluid are being aspirated.

A clear, watery secretion draining from the operative site represents a pancreatocutaneous fistula, which will probably heal with the passage of time. Somatostatin analog therapy may decrease the incidence and severity of this problem. If this leak of pancreatic juice becomes complicated by an admixture of bile and pus, the pancreatic enzymes are activated and start digesting tissues in the vicinity of the anastomosis. This complication can be serious and even fatal. Initially, attempt conservative therapy by continuous irrigation of the anastomotic site through the catheter using sterile saline containing appropriate dilute antibiotics. A dosage of 1–2 l/day seems appropriate. If, despite this management, the patient's condition continues to deteriorate, relaparotomy to remove the remaining tail of the pancreas together with the spleen may prove lifesaving.

Complications

Leakage from pancreatic anastomosis.

Leakage from biliary anastomosis.

Postoperative sepsis.

Acute pancreatitis.

Hepatic failure.

Postoperative hemorrhage. In our experience sepsis and hemorrhage are most often the result of leakage from the pancreaticojejunal anastomosis. In some cases this is due to the development of acute pancreatitis in the pancreatic tail. As discussed above, the only solution to this vicious cycle is sometimes surgical removal of the residual pancreas.

Postoperative gastric bleeding. If the gastric pH is kept elevated by antacid therapy, bleeding due to gastric ulceration is rare.

Thrombosis of the superior mesenteric artery or vein. Although we have never encountered this complication, thrombosis can occur. It can be prevented by dissecting these two vital structures with care and precision.

Gastric bezoar. We have had two patients who developed gastric phytobezoars following pancreatoduodenectomy with vagotomy. Each was treated with gastric lavage and medication, which included papain and cellulose, with satisfactory results.

When *undrained collections* are identified on the CT scan, ask the interventional radiologist to insert a CT-guided percutaneous drain.

Further Reading

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90 Total Pancreatoduodenectomy

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Carcinoma of the pancreas (see Chap. 88)

Contraindications

Distant metastases
Absence of an experienced surgical team
Patient who lacks alertness and intelligence to manage diabetes
Invasion of portal or superior mesenteric vein

Preoperative Preparation

See Chap. 89.

Operative Strategy

Complete omentectomy is generally performed as part of a total pancreatectomy. Division of the splenic, short gastric, right gastric, and gastroduodenal arteries leaves the gastric pouch dependent on the left gastric artery for its blood supply. For this reason, do not divide the left gastric artery at its point of origin from the celiac axis. Rather, divide it along the lesser curvature distal to the point where the branches to the proximal stomach and esophagus arise. This chapter concentrates on the additional features necessary to complete the pancreatic resection and should be read in conjunction with Chap. 89.

Documentation Basics

Findings

Operative Technique

Incision

Except for extremely stocky patients, we use a long midline incision from the xiphoid to a point 10 cm below the umbilicus.

Evaluation of Pathology, Determination of Resectability, Initial Mobilization

The technique followed here is identical to that described in Figs. 89.2, 89.3, 89.4, 89.5, 89.6, and 89.7, except that the omentum is detached from the transverse colon and is removed with the specimen (Figs. 90.1 and 90.2).

Splenectomy and Truncal Vagotomy

With the stomach and omentum retracted in a cephalad direction, identify the splenic artery along the superior surface of the pancreas. Open the peritoneum over the splenic artery at a point 1–2 cm distal to its origin at the celiac axis. With a right-angle Mixter clamp, free the posterior surface of the artery and apply a 2-0 silk ligature (Fig. 90.3). Ligate the vessel but do not divide it at this point.

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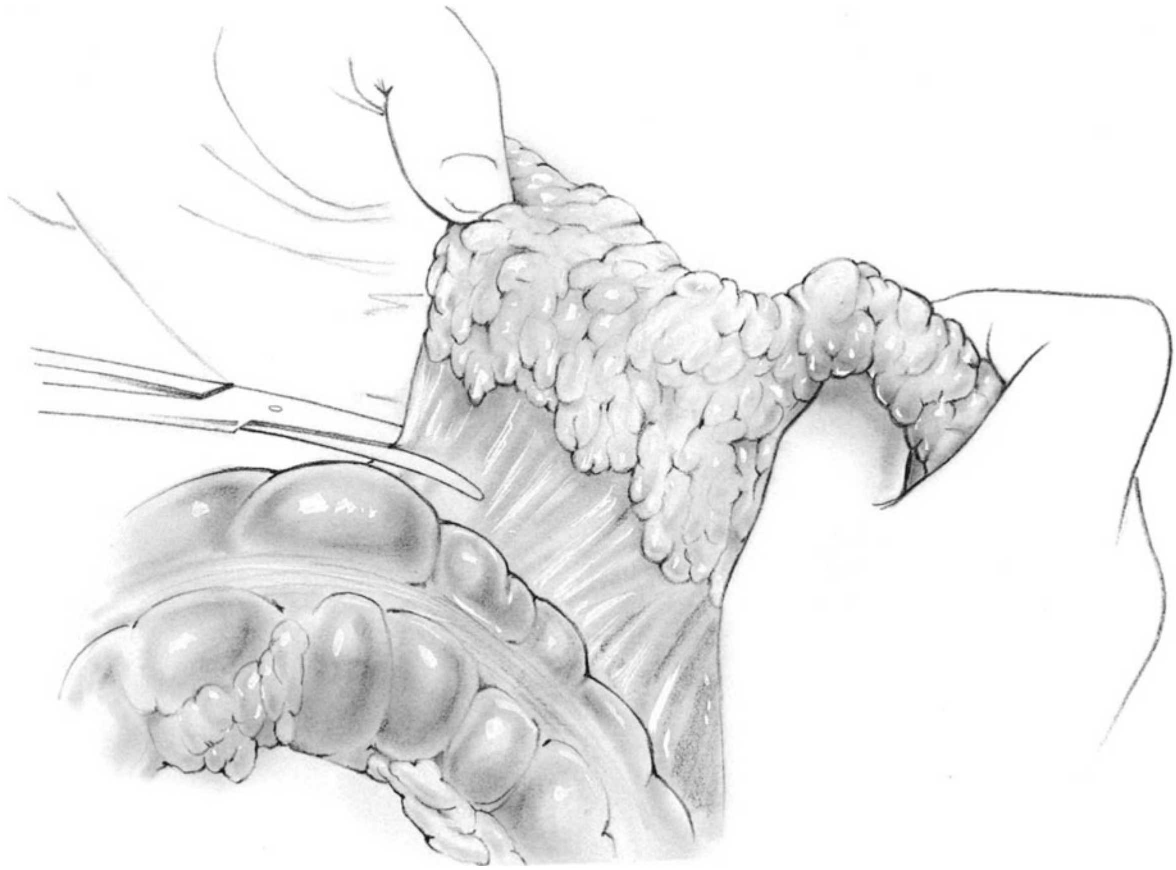

Fig. 90.1

Apply a Thompson retractor to the left costal margin to improve the exposure of the spleen. Make an incision in the avascular lienophrenic fold of the peritoneum (Fig. 90.4a, b). Electrocoagulate any bleeding vessels. Elevate the tail of the pancreas together with the spleen. Divide the attachments between the lower pole of the spleen and the colon. Expose the posterior surface of the spleen and identify the splenic artery and veins at this point. If there is any bleeding, ligate these vessels. Insert moist gauze pads into the bed of the elevated spleen.

At this time remove the Thompson retractor from the left costal margin and place it in the region of the sternum. Apply traction in a cephalad and anterior direction, exposing the abdominal esophagus. Incise the peritoneum over the abdominal esophagus. Use a peanut gauze dissector to separate the crus of the diaphragm from the esophagus (Fig. 90.5) and perform a truncal vagotomy as described in Chap. 29.

Mobilizing the Distal Pancreas

Identify the proximal short gastric vessel, and insert the left index finger underneath the gastrophrenic ligament. Apply a hemostatic clip to the distal portion of the vessel. Ligate the gastric side of the vessel with 2-0 or 3-0 silk and divide it (Fig. 90.6). Continue the dissection in this manner until all of the short gastric vessels have been divided (Fig. 90.7).

Now redirect attention to the tail and body of the pancreas, which is covered by a layer of posterior parietal peritoneum. Incise this avascular layer first along the superior border of the pancreas and then again along the inferior border of the pancreas after elevating the tissue with an index finger (Fig. 90.8). As the pancreas is elevated from the posterior abdominal wall, follow the posterior surface of the splenic vein to the point where the inferior mesenteric vein enters; then divide this vessel between 2-0 silk ligatures (Fig. 90.9). Follow the splenic artery to its point of origin, where the previous ligature can be seen. Double-ligate the proximal stump of the splenic artery and apply a similar ligature to the distal portion of the splenic artery. Divide between these ties. Carefully dissect the junction of the splenic and portal veins away from the posterior wall of the pancreas. After 2 cm of the terminal portion of the splenic vein has been cleared (Fig. 90.10), divide the splenic vein between 2-0 silk ligatures.

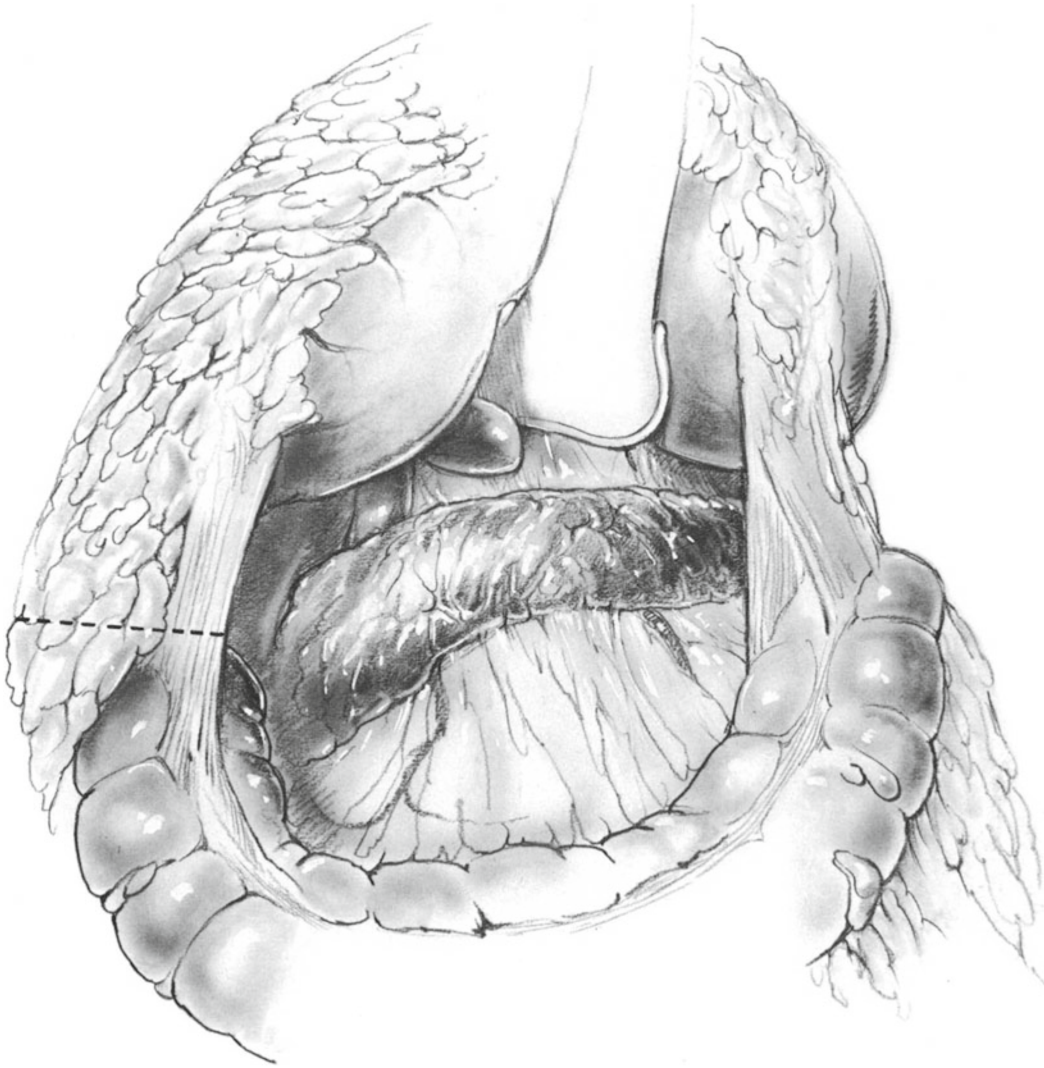

Fig. 90.2

Antrectomy

Divide the stomach as previously described (Fig. 90.11).

Cholecystectomy and Division of the Hepatic Duct

The hepatic duct, portal vein, and hepatic artery have already been stripped of overlying peritoneum and lymph nodes. At this time, divide and ligate the cystic artery. Remove the gallbladder by dissecting it out of the liver bed from above down (Fig. 90.12). Obtain complete hemostasis in the liver bed with electrocautery. Ligate the cystic duct. Divide it and remove the gallbladder.

Dissect the hepatic duct free from the portal vein at a point just above its junction with the cystic duct. Free about 1.5 cm of hepatic duct. Apply a ligature to the distal end and an atraumatic bulldog clamp to the proximal end and divide the duct.

Freeing the Uncinate Process

Retract the spleen, pancreas, and duodenum to the patient's right. Gentle dissection discloses three or four venous branches between the posterior surface of the pancreatic head and the portal-superior mesenteric veins (Fig. 90.13). Ligate each of these vessels with 3-0 silk and divide them. It is now possible gently to retract the portal vein to the right. At this point the superior mesenteric artery can generally be clearly identified. In some cases it is easy to identify several arterial branches that can be dissected free, divided, and individually ligated (Fig. 90.14). Divide the uncinate process as previously described (see Chap. 89).

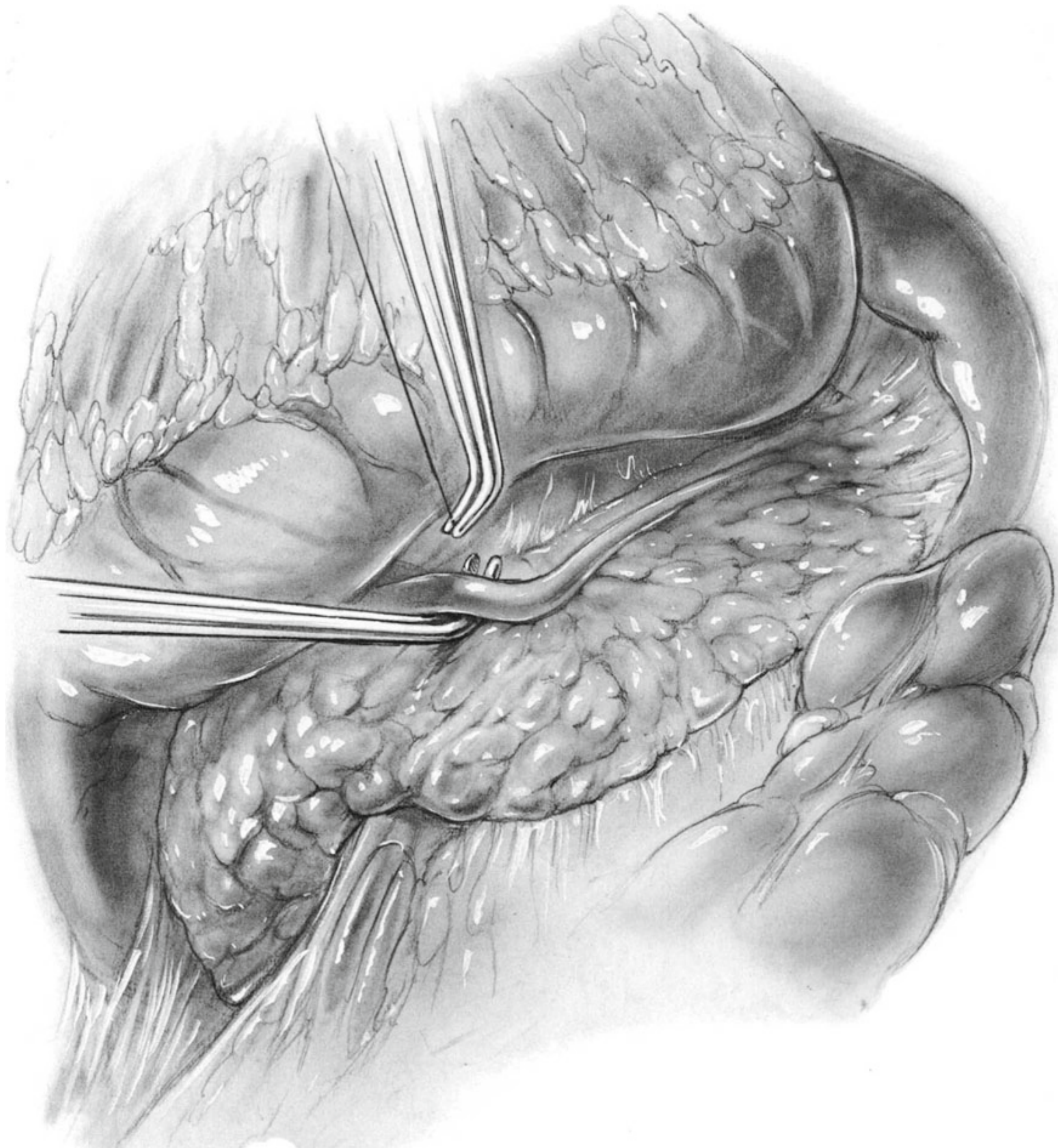

Fig. 90.3

Mobilizing the Duodenojejunal Junction

Expose the ligament of Treitz by elevating the transverse colon. Divide the jejunum as previously described and remove the specimen (Fig. 90.15; see also Fig. 90.14).

Hepaticojejunostomy

Reconstruction is simpler because no pancreatic anastomosis is needed. The hepaticojejunostomy is performed first, as described in Chap. 89.

At a point about 50 cm downstream from the hepaticojejunal anastomosis, construct a stapled gastrojejunostomy (Figs. 90.16 and 90.17). Bring the T-tube out through a stab wound in the right upper quadrant. Irrigate the entire operative field with a dilute antibiotic solution. Be certain that hemostasis is complete. Insert a large Jackson-Pratt suction-drainage catheter in the right upper quadrant of the operative field, and bring it out through a stab wound in the abdominal wall. Close the midline incision in routine fashion. Close the skin with interrupted nylon sutures or staples.

Postoperative Care

The principles of postoperative care described in Chap. 89 apply to total pancreatectomy except there is no possibility of a pancreatic fistula. The suction-drainage catheter is

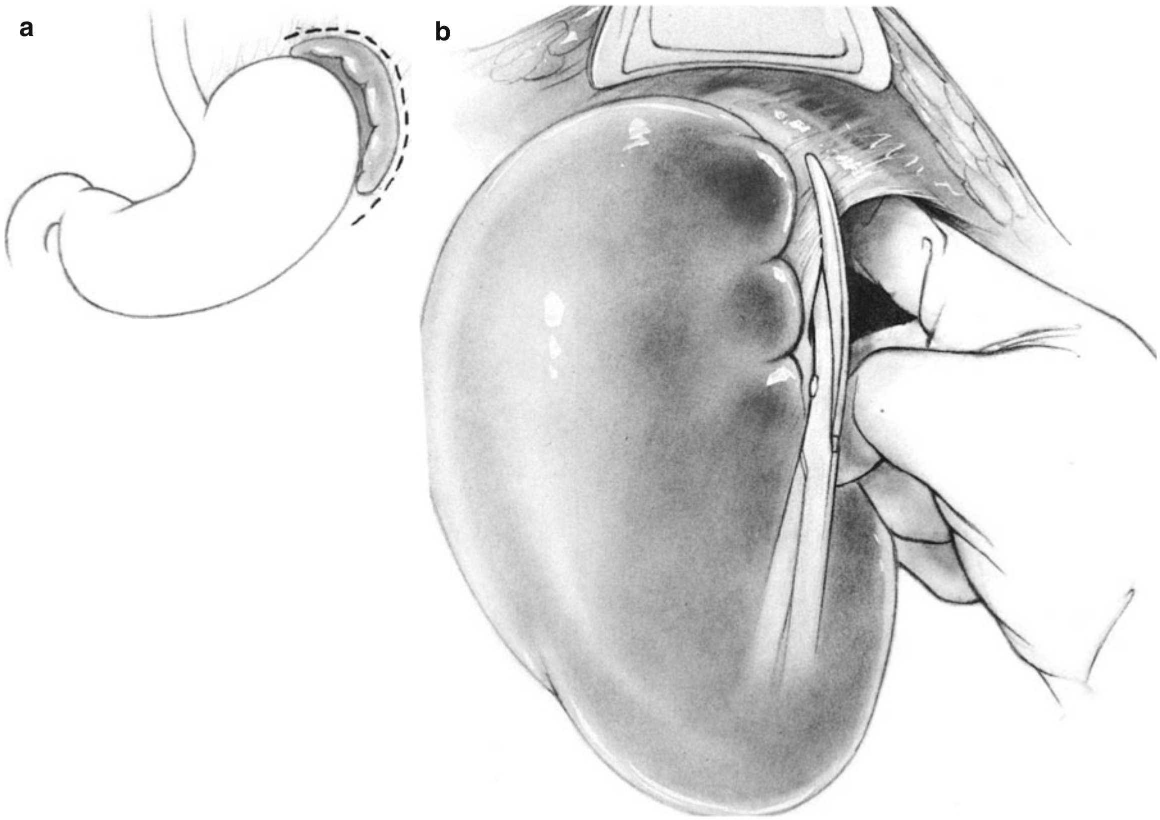

Fig. 90.4

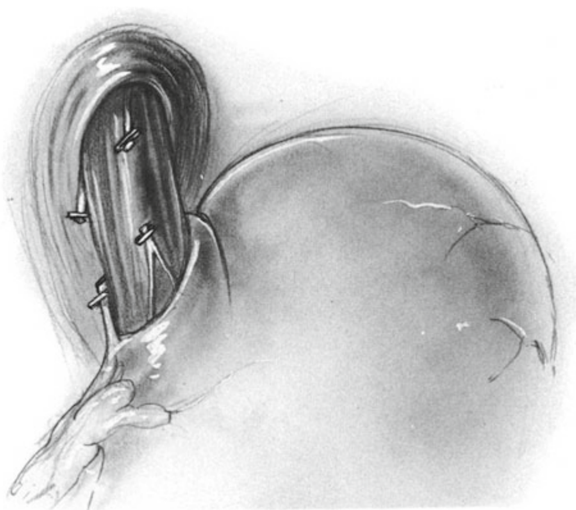

Fig. 90.5

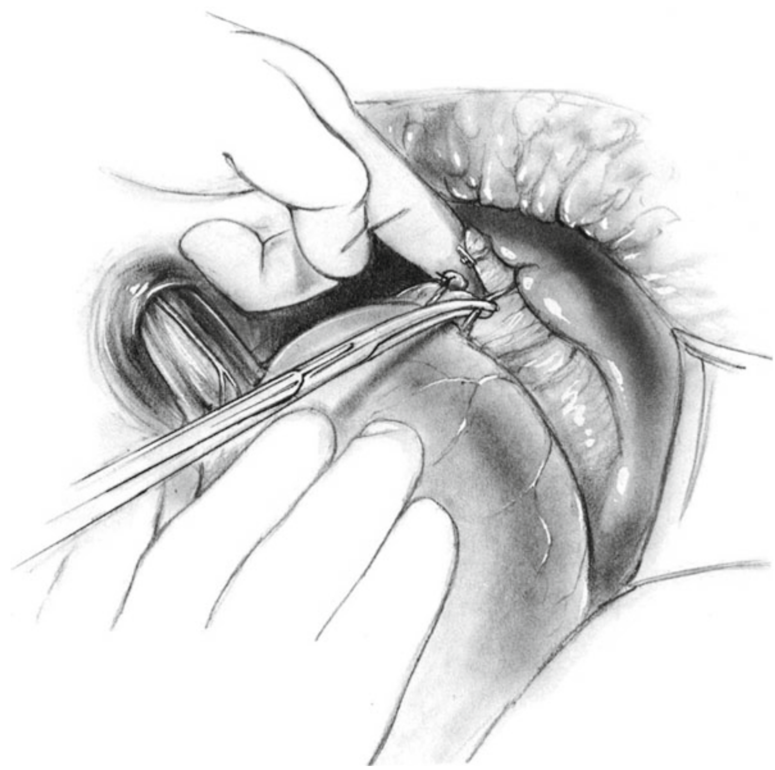

Fig. 90.6

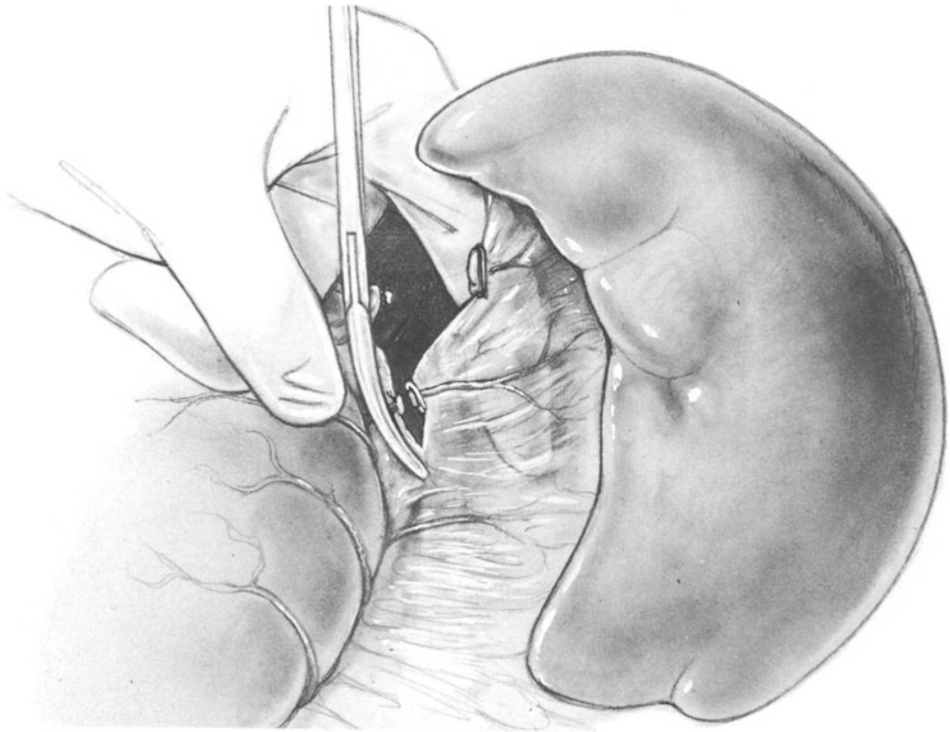

Fig. 90.7

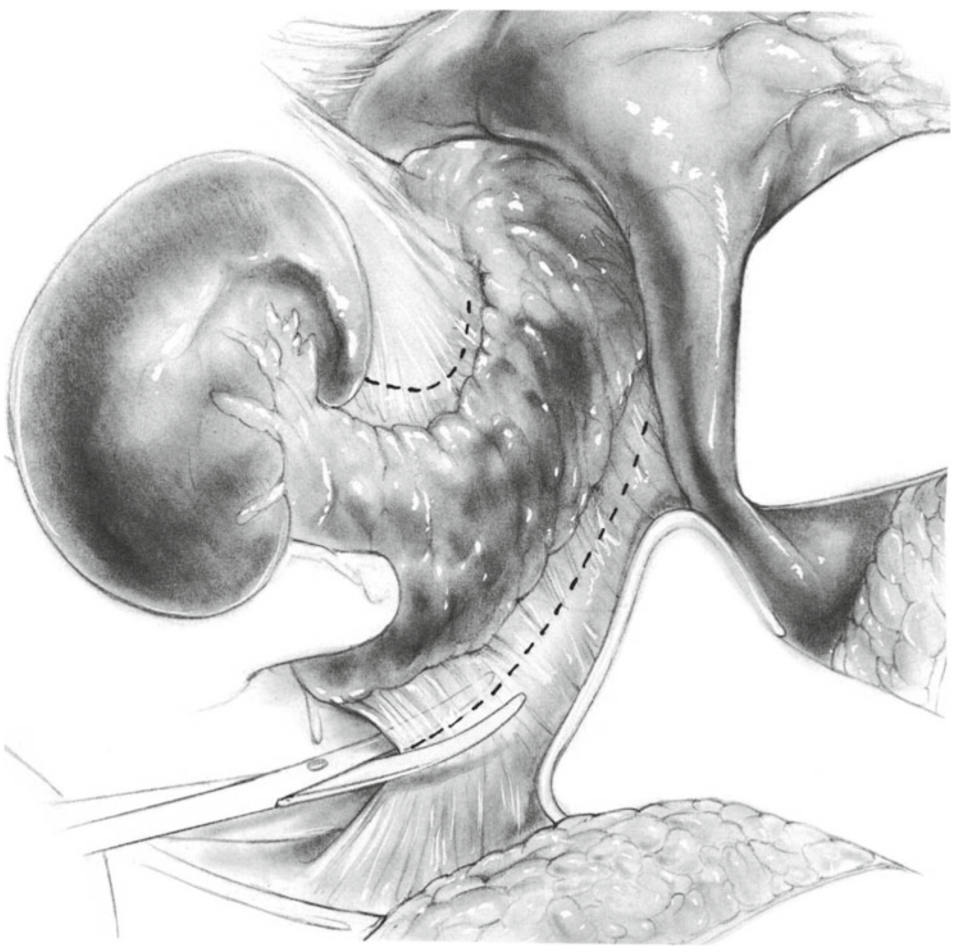

Fig. 90.8

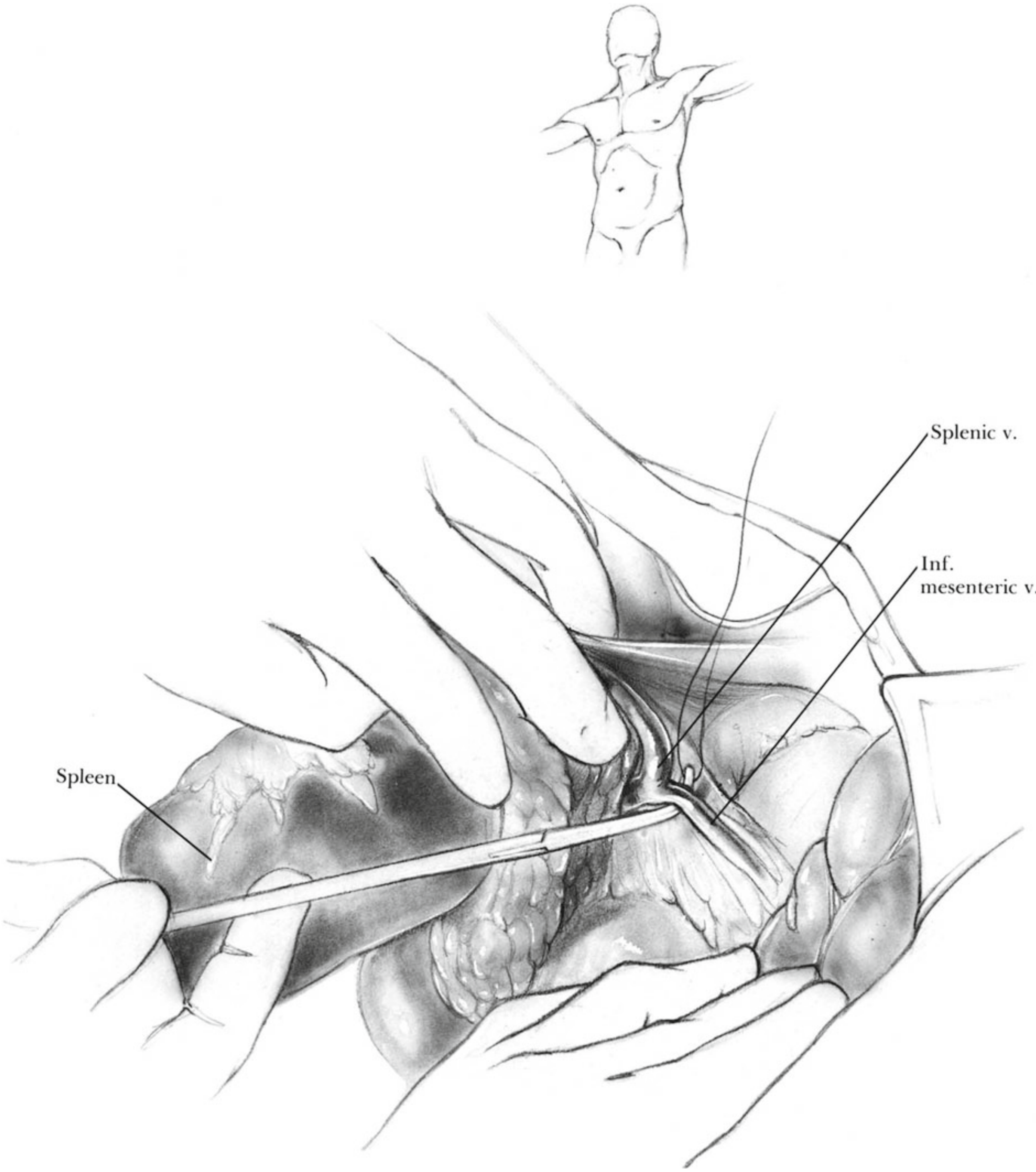

Fig. 90.9

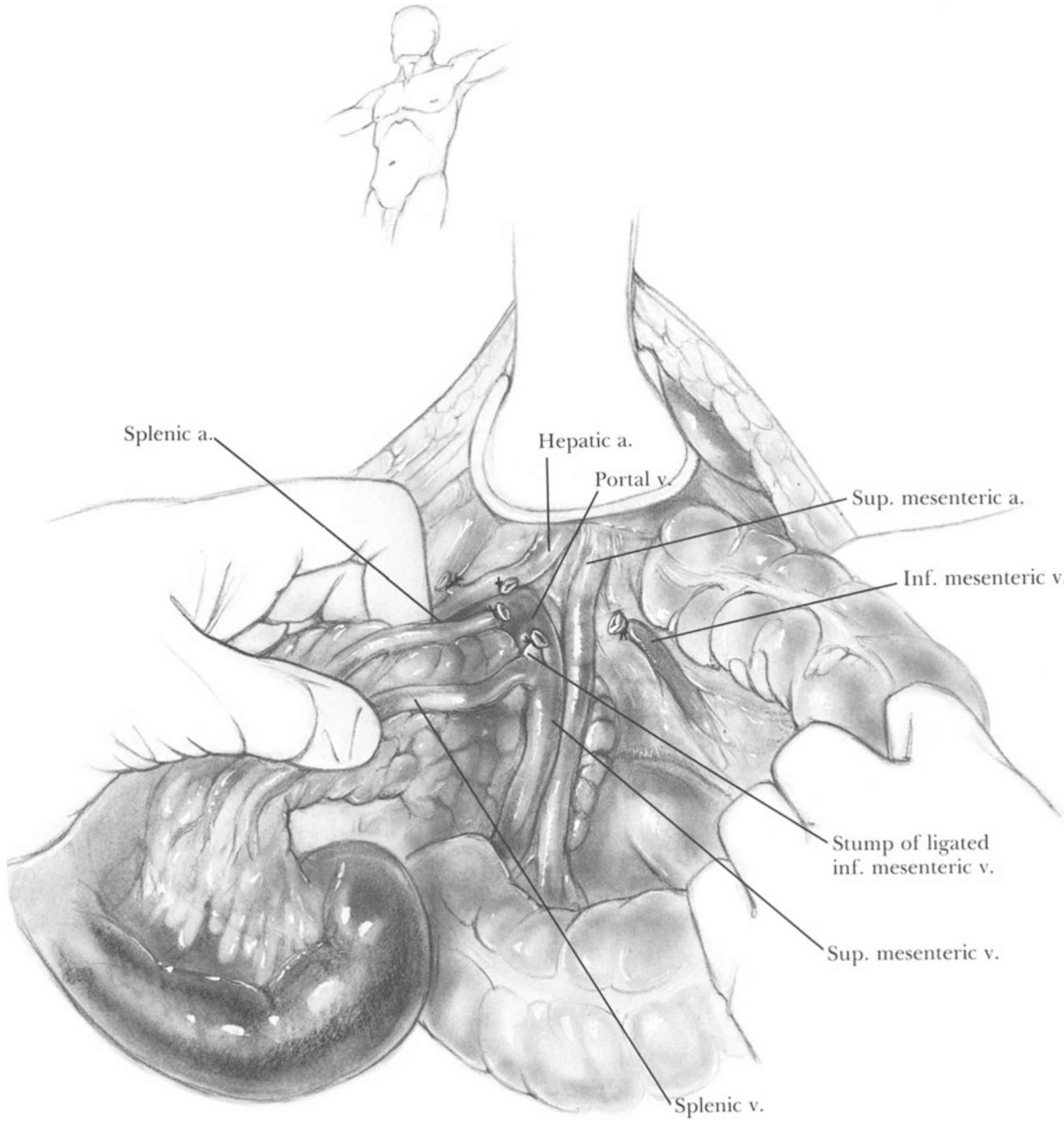
Splenic a.
Hepatic a.
Portal v.
Sup. mesenteric a.
Inf. mesenteric v.
Stump of ligated
inf. mesenteric v.
Sup. mesenteric v.
Splenic v.

Fig. 90.10

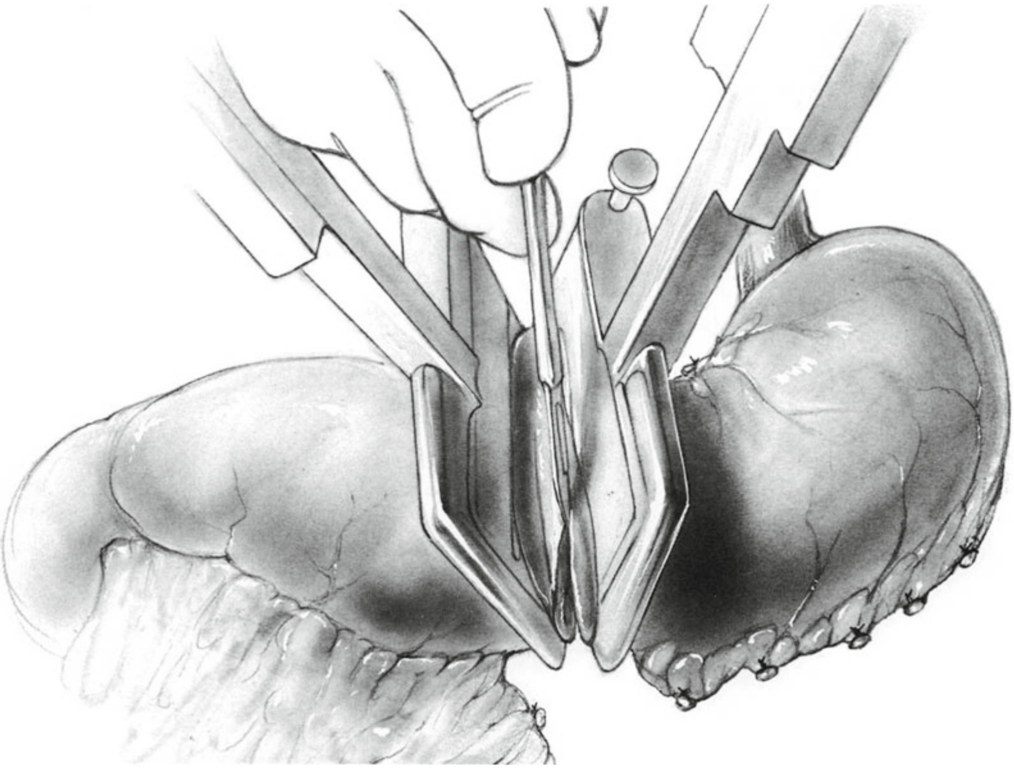

Fig. 90.11

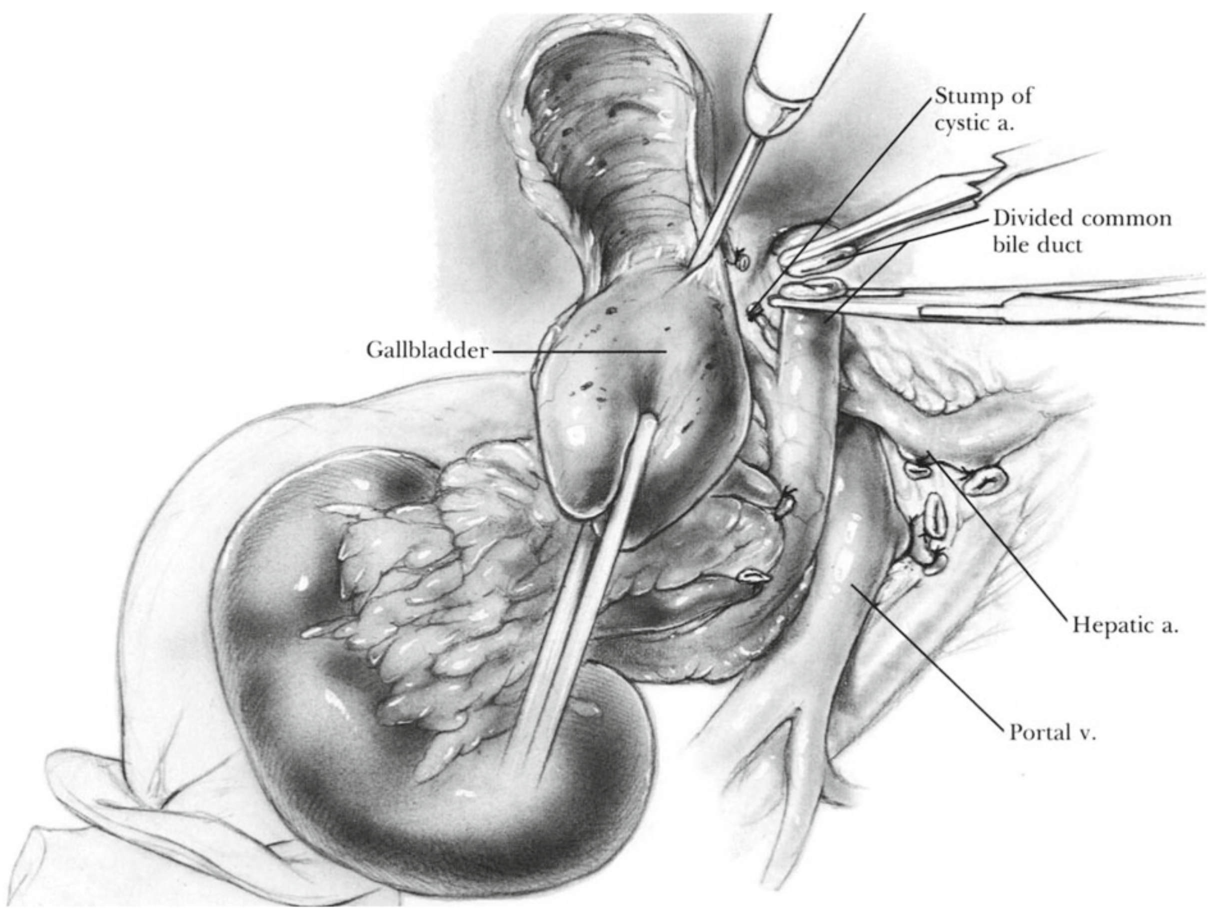

Fig. 90.12

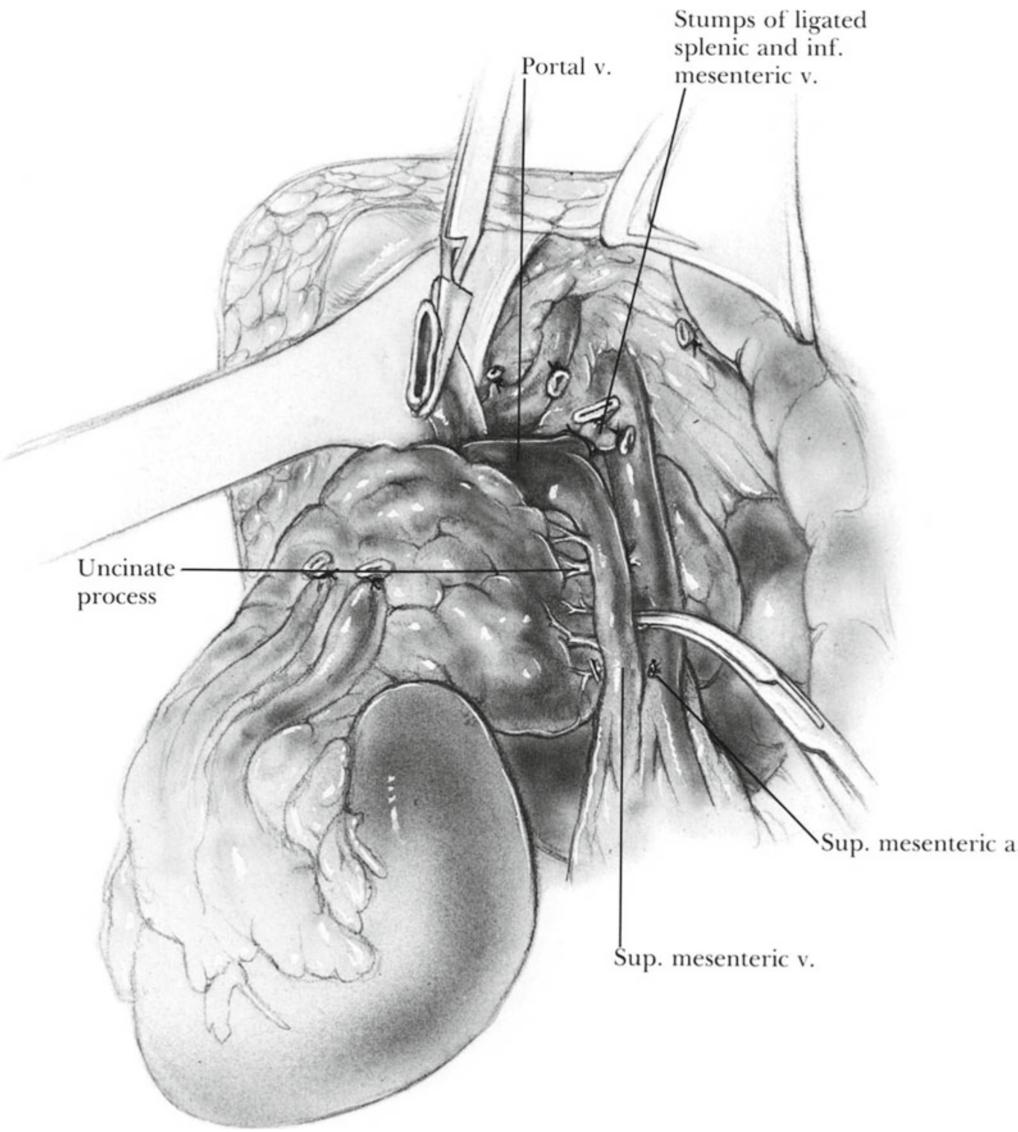

Fig. 90.13

removed sometime after the fourth postoperative day unless a significant amount of drainage persists. The T-tube is left in place for 21 days.

The most important element of postoperative care following total pancreatectomy is regulation of the resulting diabetes. The greatest danger is hypoglycemia due to administration of too much insulin. Perform blood glucose determinations every 3–4 h for the first few days. Do not try to keep the blood glucose level below 200 mg/dl. Especially during the early postoperative period, the diabetes is quite brittle, and an overdose of only a few units of insulin may produce hypoglycemic shock. There is much more danger from hypoglycemia than from diabetic acidosis. Administer regular insulin in doses of 2–5 units every few hours as necessary. Frequently no more than 10–20 units are required per day. After patients begin to eat, they may be switched to one of the longer-acting insulin products. Patients and their relatives should be carefully instructed about the symptoms of hypoglycemia.

Repeated measurements of the gastric pH are vital to prevent postoperative gastric hemorrhage. Use intravenous H_2 blockers to keep the gastric pH at 5 or above.

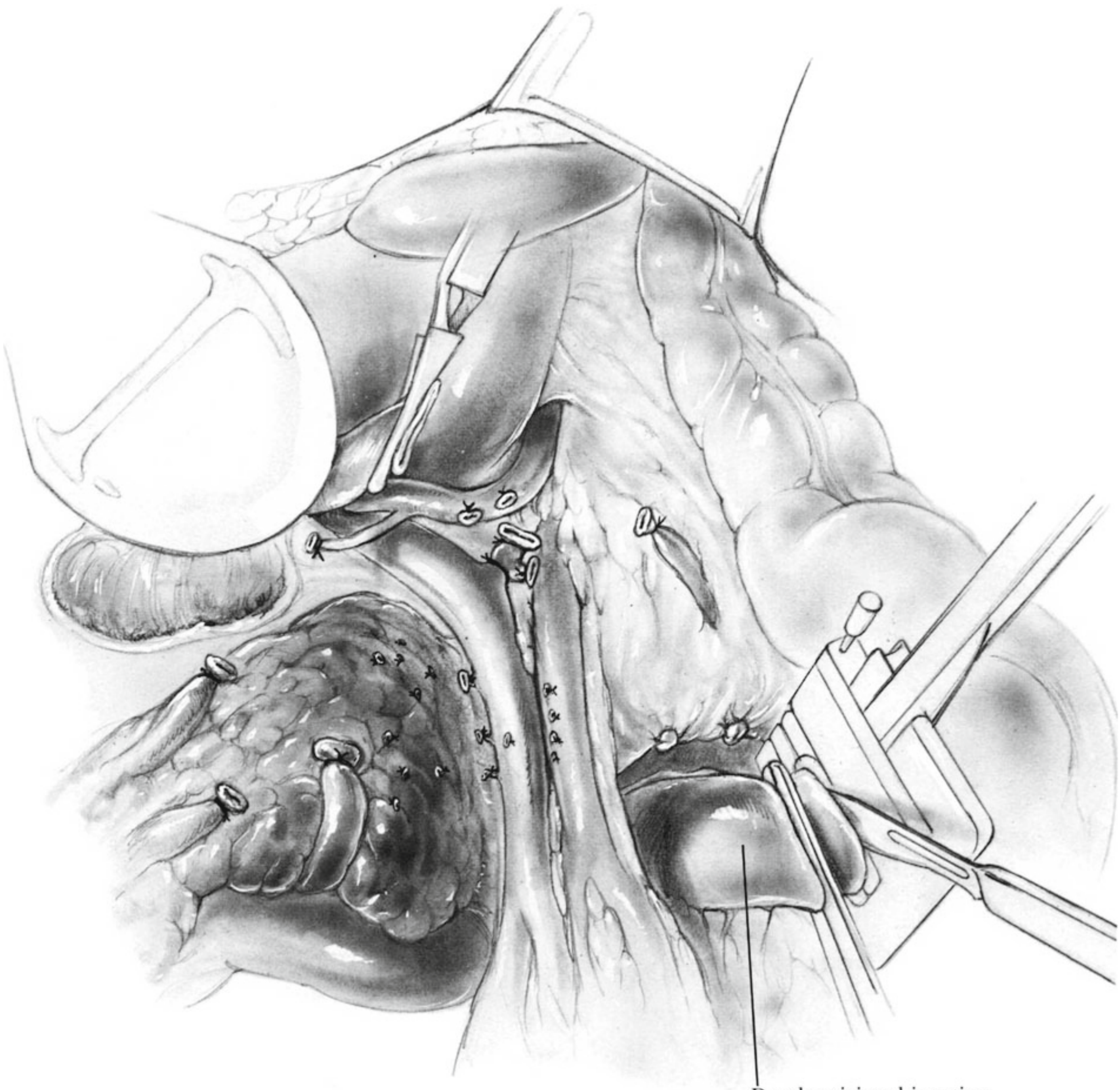

Fig. 90.14

A sufficient dose of pancreatic enzymes must be given to prevent steatorrhea. It may require three tablets of Pancrease before each meal.

Complications

Hypoglycemia or hyperglycemia
Postoperative gastric bleeding due to stress ulceration or a marginal ulcer
Postoperative hemorrhage
Postoperative sepsis
Leakage from biliary anastomosis
Mesenteric venous thrombosis
Hepatic failure

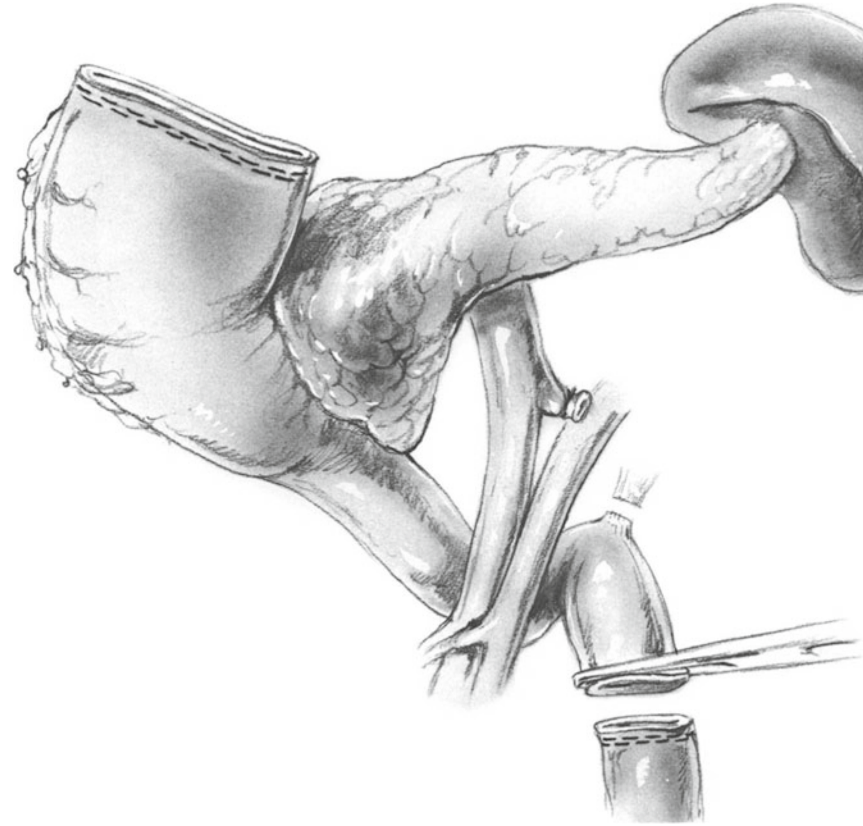

Fig. 90.15

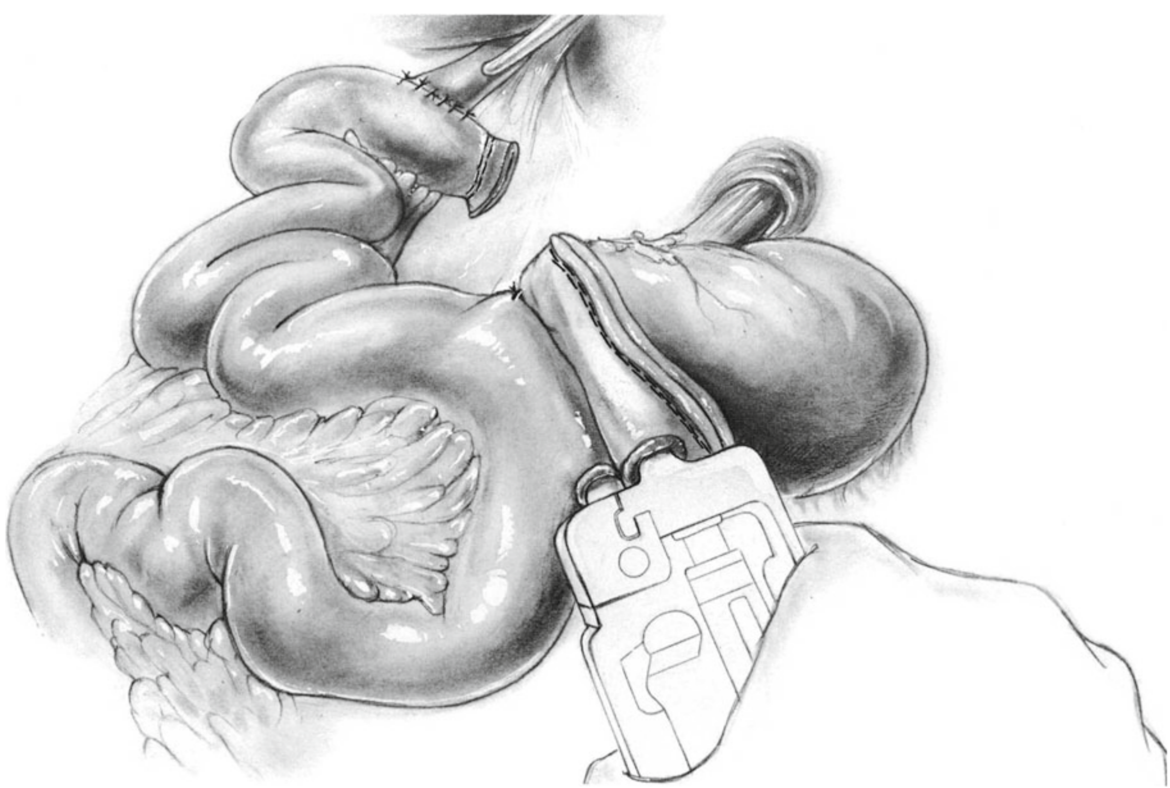

Fig. 90.16

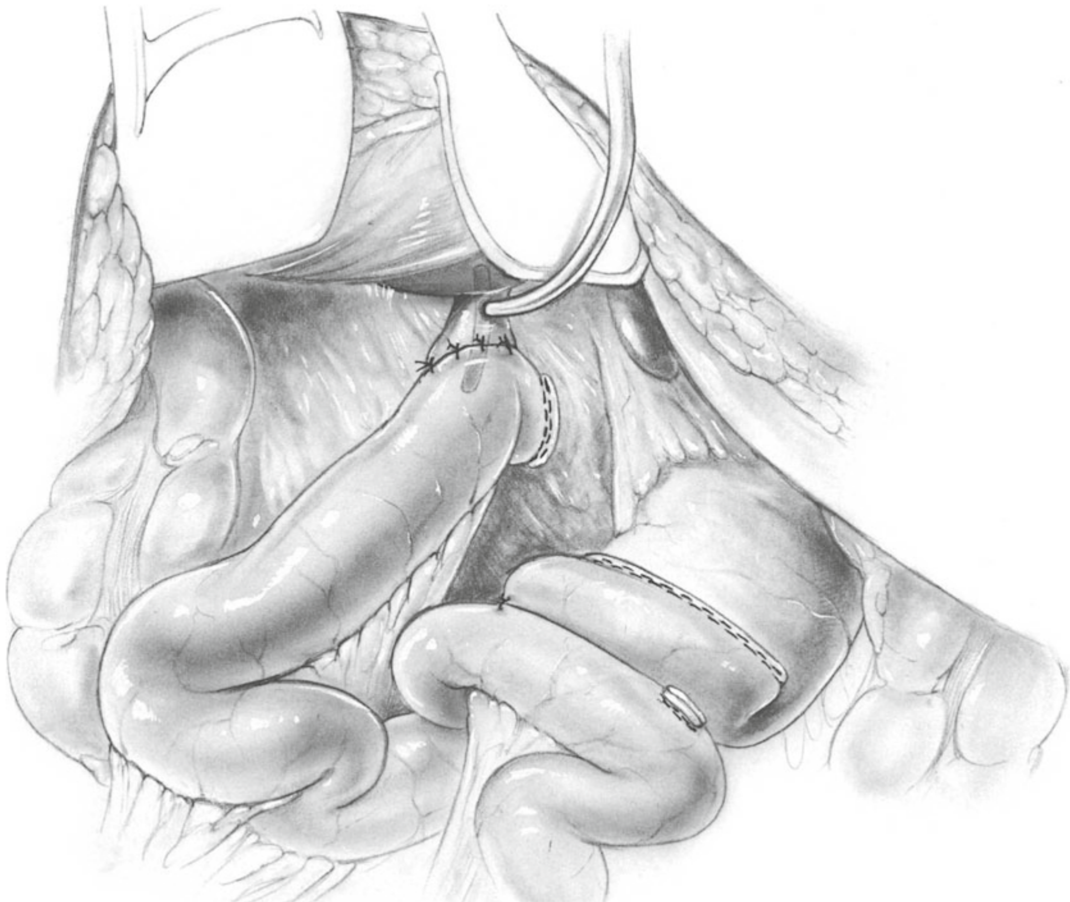

Fig. 90.17

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Distal Pancreatectomy

91

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Indications

Resectable malignant tumors located to the left of superior mesenteric vessels
Benign tumors that cannot be locally excised (e.g., insulinoma)
Pseudocysts of the tail (selected)
Chronic pancreatitis localized to the body and tail
Trauma

Preoperative Preparation

Localization maneuvers are required for small tumors such as insulinomas: computed tomography (CT), magnetic resonance imaging (MRI), angiography, and endoscopic or intraoperative ultrasonography.
Operations for insulinoma require careful monitoring of the blood glucose at frequent intervals prior to and during operation.
In patients suspected of having a gastrinoma, the diagnosis should be confirmed by serial serum gastrin levels before and after administration of intravenous secretin.

Pitfalls and Danger Points

Lacerating splenic or portal vein

Operative Strategy

Choice of Operative Approach

Splenic preservation is feasible in selected patients with benign tumors or stable trauma patients. Careful dissection of the splenic artery and vein is required (see references). Laparoscopic distal pancreatectomy is being performed in some centers and is described in the chapter which follows.

Avoiding Damage to Blood Vessels

Once the decision has been made to proceed with distal pancreatectomy and splenectomy, locate the splenic artery a few centimeters beyond its origin at the celiac axis. Ligate the vessel in continuity to reduce the size of the spleen and the volume of blood loss if the splenic capsule is ruptured during the dissection.

The greatest danger when resecting the body and tail of the pancreas arises when a malignancy in the body obscures the junction between the splenic and portal veins. Invasion of the portal vein by the tumor is an indication of inoperability. If elevation of the tail and body of the pancreas together with the tumor should result in a tear at the junction of the splenic and portal veins and this accident occurs before the tumor has been completely liberated, it may be extremely difficult to repair the lacerated portal vein. If an accident of this type should occur, it is necessary to find the plane between the neck of the pancreas and the portal vein and then divide the pancreas across its neck while manually occluding the lacerated vein. With the portal and superior mesenteric veins exposed after the neck of the pancreas has been divided, occluding vascular clamps may be applied and the laceration repaired. This complication can generally be avoided by careful inspection of the tumor after elevating the tail of the pancreas and by observing the area where the splenic vein

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joins the portal vein. If the tumor extends beyond this junction, it is probably inoperable.

Avoiding Pancreatic Fistula

We have used the 55 mm linear stapling device for years to accomplish closure of the cut end of the remaining pancreas after resecting the body and tail of this organ. When the stapler is used across the neck of a pancreas of average thickness, the staples seem to occlude the cut end of the pancreatic duct successfully; no supplementary sutures are needed to prevent a fistula. If the stapler is not used, be certain to occlude the cut pancreatic duct by inserting a nonabsorbable mattress suture. A recent randomized prospective trial (the DISPACT trial, see references) did not show any advantage for either the stapled or hand-sutured technique in preventing pancreatic fistula. We find the stapler fast and convenient.

Documentation Basics

- Extent of resection
- Findings
- Splenectomy or not?
- Manner of closure of pancreatic tail

Operative Technique

Incision and Exposure

In the average patient a long midline incision from the xiphoid to a point about 6–10 cm beyond the umbilicus provides adequate exposure for mobilizing the spleen and the tail of the pancreas. In an obese or a highly muscular individual with a wide costal angle, a long transverse or left subcostal incision is a suitable alternative.

Exploration: Liberating the Omentum

After thoroughly exploring the abdomen, expose the body and tail of the pancreas by liberating the omentum from its attachments to the transverse colon. An alternative method is to divide the omentum between hemostats, which exposed the anterior surface of the pancreas. To palpate the posterior surface of the pancreas, it is necessary to incise the layer of peritoneum that covers the pancreas and then continues down to the transverse colon, forming one leaflet of the transverse mesocolon. Incise this layer along the inferior border of the tail of the pancreas (Fig. 91.1). The only major blood vessel deep to this layer of peritoneum is the inferior mesenteric vein, which travels from the transverse mesocolon to join the inferior border of the splenic vein just before the splenic vein joins the portal vein. After completing this incision, insert the index finger behind the pancreas, and use the fingertip to elevate the peritoneum along the superior margin of the pancreas (Fig. 91.2). Incise this layer of peritoneum with scissors, avoiding the sometimes convoluted splenic artery that runs along the superior border of the pancreas deep to the layer of peritoneum. After these two peritoneal incisions have been made, palpate the tail and body of the pancreas between the thumb and forefinger to evaluate the pathology. Intraoperative ultrasonography is a useful adjunct.

If seeking a gastrinoma, perform a Kocher maneuver and palpate the descending duodenum and the head of the pancreas. Some non-beta-cell tumors of the pancreas can be palpated as small projections from the pancreas into the posterior wall of the descending duodenum. Many of the benign tumors can be excised locally or may be shelled out by gentle dissection.

Identifying Splenic Artery

Palpate the splenic artery along the upper border of the neck of the pancreas at a point a few centimeters from its origin. If there is some confusion as to the identity of the artery, occlude it with the fingertip and palpate the hepatoduodenal ligament to determine whether the hepatic artery (rather than the splenic artery) has been occluded. If hepatic artery pulsation is normal, open the peritoneum overlying the splenic artery. Encircle it with a right-angle clamp and ligate it in continuity with 2-0 silk (see Fig. 96.3).

Mobilizing the Spleen and Pancreas

Retract the spleen to the patient's right, placing the splenorenal ligament on stretch. Incise this ligament (see Fig. 97.1) with Metzenbaum scissors or electrocautery. Continue this incision up to the diaphragm and down to include the splenocolic ligament. Now elevate the spleen and the tail of the pancreas from the renal capsule by fingertip dissection. The greater omentum may be attached to the lower portion of the spleen; dissect it away from the spleen. It should now be possible to elevate the spleen and the tail and body of the pancreas up into the incision, leaving the kidney and adrenal gland behind. Cover these structures with a large moist gauze pad.

The spleen remains attached to the greater curvature of the stomach by means of the intact left gastroepiploic and

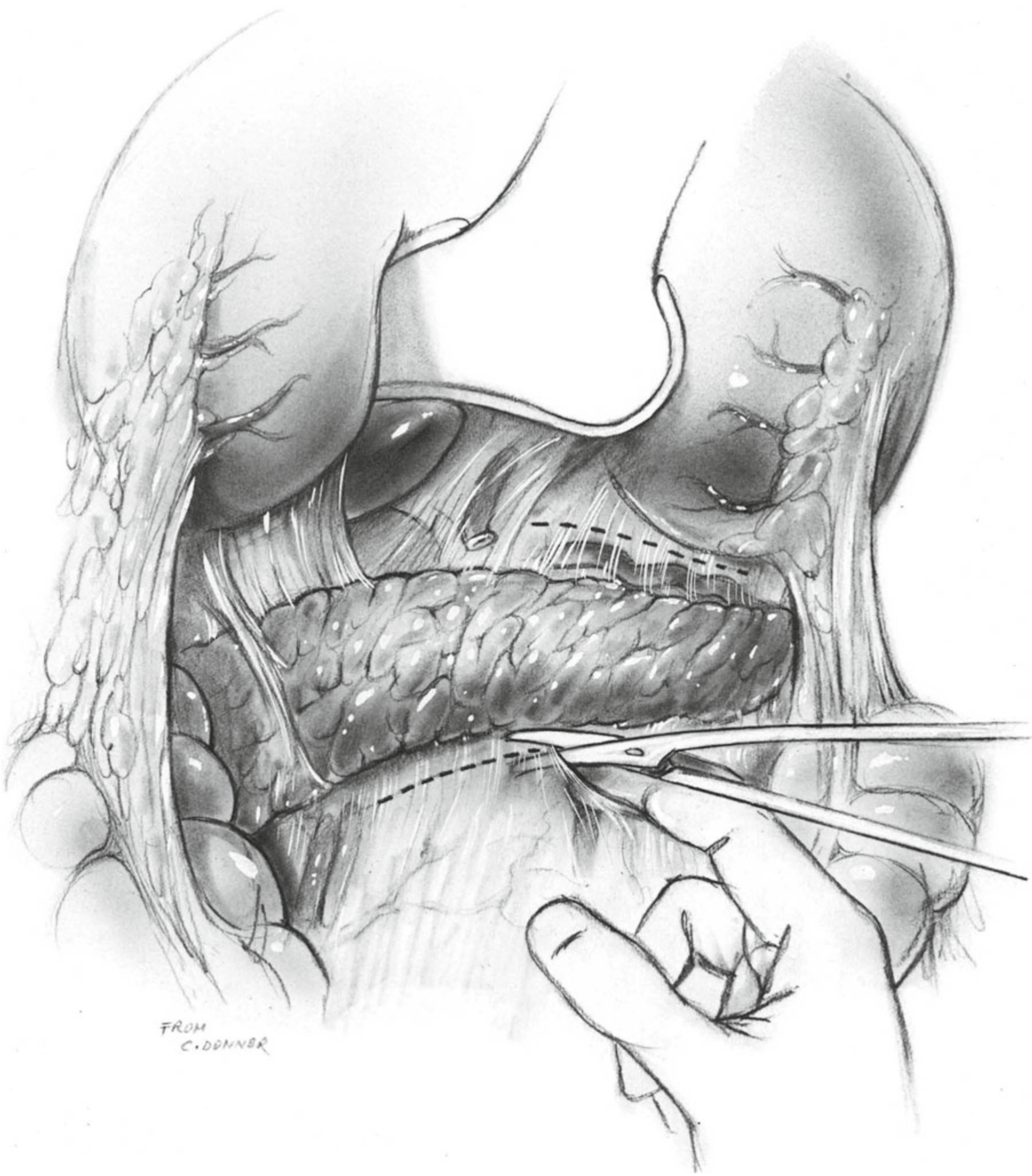

Fig. 91.1

short gastric vessels. Divide each of these structures individually between hemostats and then ligate each with 2-0 silk (see Figs. 96.2 and 96.4). Inspection of the posterior surface of the pancreas reveals the splenic vein. Dissecting along the inferior border of the pancreas unroofs the inferior mesenteric vein on its way to join the splenic vein. Identify, encircle, and divide the inferior mesenteric vein between 2-0 silk ligatures.

Dividing the Splenic Artery and Vein

Gently elevate the splenic vein by sweeping the areolar tissue away from this vessel with a peanut dissector until the junction between the splenic and portal vein is identified. At this point encircle the splenic vein with a right-angle clamp at a point about 2 cm proximal to its junction with the portal vein. Pass two ligatures of 2-0 silk around

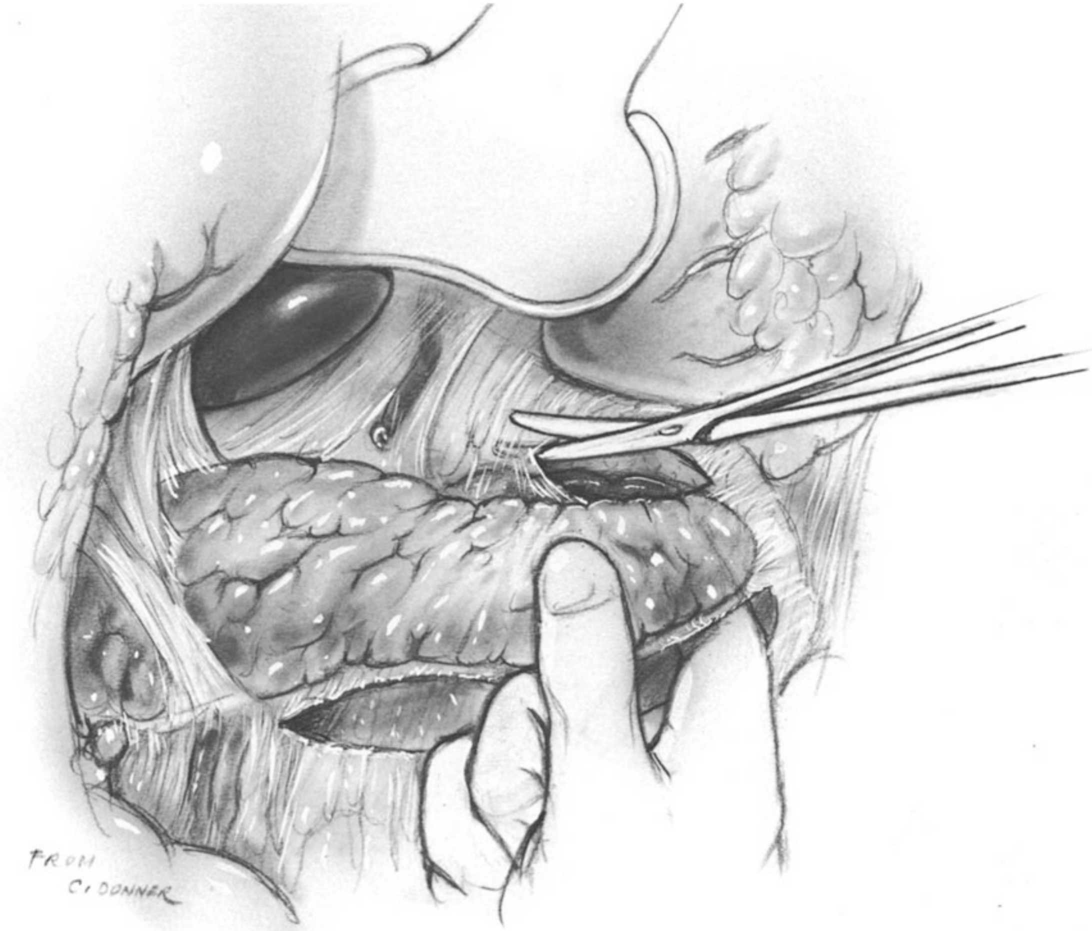

Fig. 91.2

the splenic vein and tie the ligatures about 1.5 cm apart. Divide the vein between the two ligatures (Fig. 91.3) and identify the previously ligated splenic artery. Tie a second ligature around this artery and divide the vessel distal to the two ligatures. This leaves the specimen attached only by the neck of the pancreas in the region of the portal vein.

Dividing the Pancreas

If the pancreas is of average thickness, simply apply a 55 mm linear stapler across the neck of the pancreas. Using 3.5 mm staples in most cases, fire the staples and divide the pancreas flush with the stapler using a scalpel. Remove the specimen. Then remove the stapling device and inspect the cut edge of the pancreas carefully for bleeding points (Fig. 91.4). It is frequently necessary to suture ligate a superior pancreatic artery near the upper border of the remaining pancreas. We have not found it necessary to identify or suture the pancreatic duct when using a stapled closure of the transected pancreas.

Alternatively, one may occlude the transected pancreas with interlocking interrupted mattress sutures of 3-0 nonabsorbable suture material. If the pancreatic duct is identified, occlude this duct with a separate mattress suture.

Closure and Drainage

Place a flat closed-suction drainage catheter down to the site of the divided pancreas and bring the catheter out through a puncture wound in the abdominal wall. Close the incision in routine fashion after ascertaining that complete hemostasis in the pancreatic and splenic beds has been achieved.

Postoperative Care

Attach the drainage catheter to a closed-suction system. Leave the drain in place 4–6 days. If a pancreatic duct fistula is suspected, leave the drain in place for a longer time. Occasionally check the serum amylase and blood glucose levels to detect postoperative pancreatitis and diabetes.

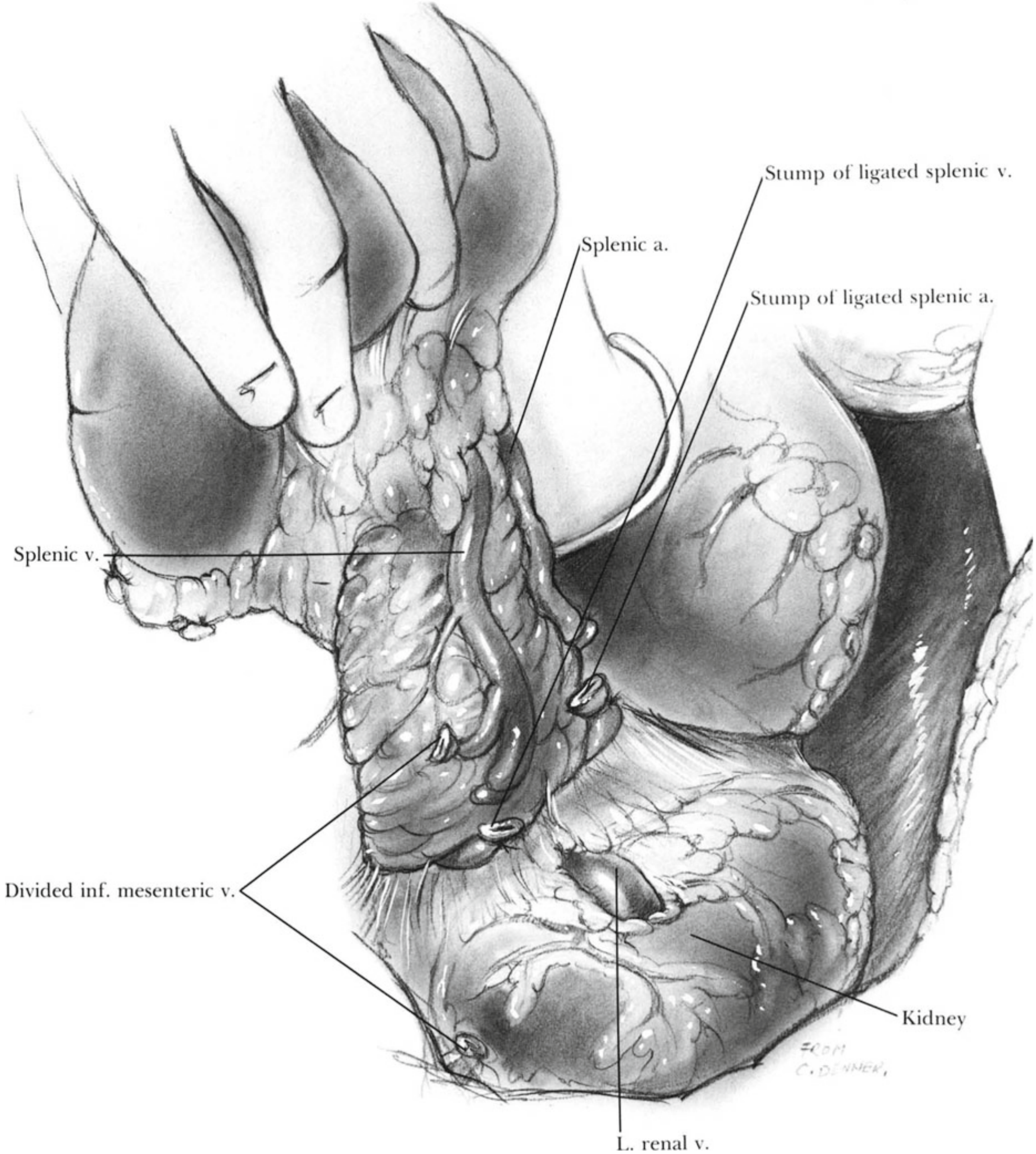
Stump of ligated splenic v.
Splenic a.
Stump of ligated splenic a.
Splenic v.
Divided inf. mesenteric v.
Kidney
L. renal v.
FROM C. DENNER

Fig. 91.3

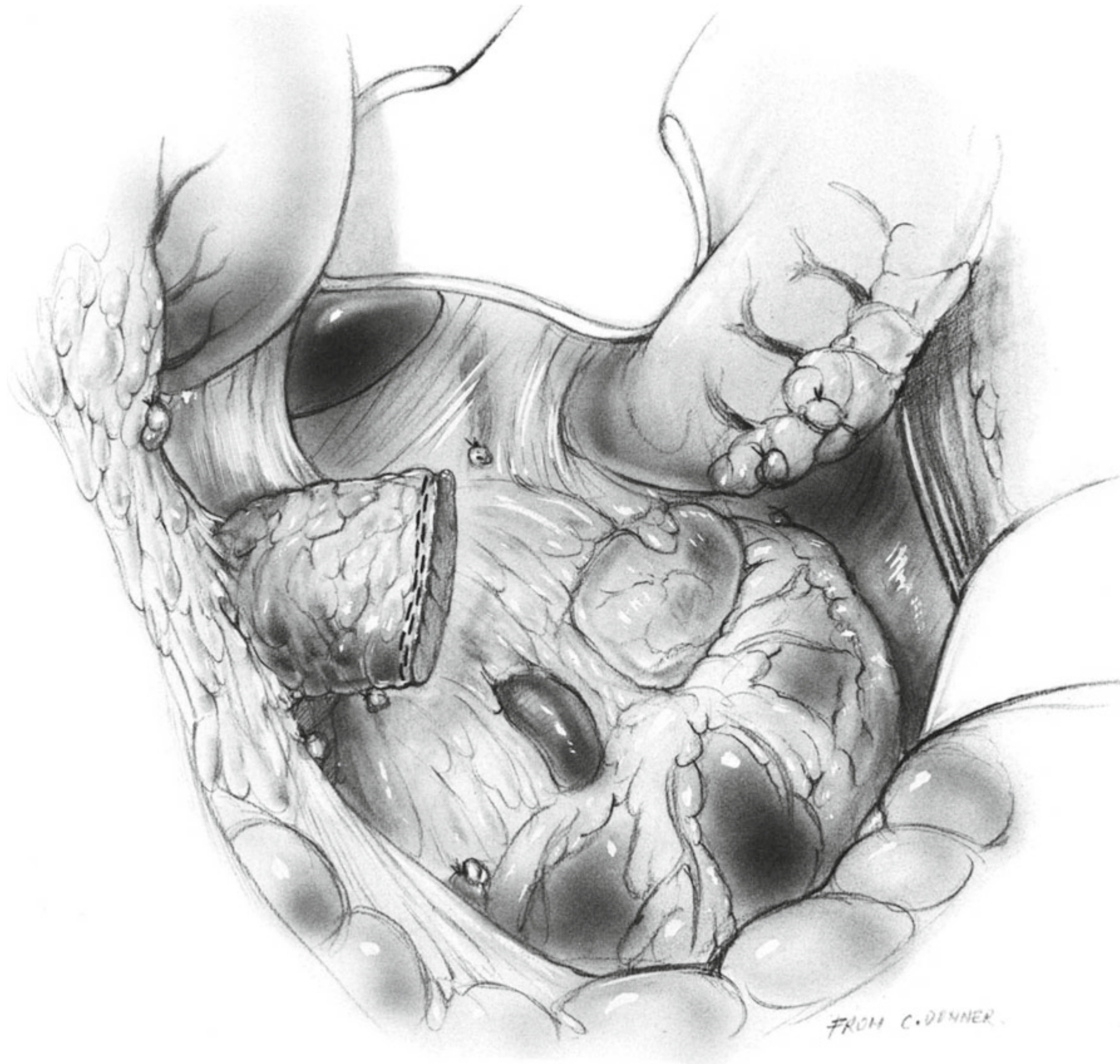

Fig. 91.4

Complications

If *pancreatic fistula* develops, it generally resolves spontaneously in 3–4 weeks. If it does not resolve during that time, obtain a radiographic sinogram with aqueous contrast medium.

Acute pancreatitis in the residual pancreas is a possible but uncommon complication.

Diabetes mellitus of mild degree sometimes occurs after an extensive distal pancreatectomy.

Subphrenic abscess may occur, requiring drainage.

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Laparoscopic Distal Pancreatectomy

92

James J. Mezhir

Indications

Malignant tumors of the pancreas deemed resectable by high-quality cross-sectional imaging and complete staging, located to the left of superior mesenteric vein: pancreatic adenocarcinoma, neuroendocrine tumors, or highly select patients with pancreatic oligometastasis.

Pancreatic cystic neoplasms (i.e., intraductal papillary mucinous tumor).

Chronic pancreatitis localized to the body and tail following failed endoscopic therapy.

Pseudocysts of the pancreatic tail (in select patients where endoscopic measures fail).

Patients who meet criteria for laparoscopic pancreatic resection should also be candidates for open resection. The indications for an operation should not change due to the availability of a minimally invasive approach.

Preoperative Preparation

Patients fit for a major operation such as a pancreatectomy undergo staging for malignant tumors including high-quality computed tomography (CT) scan of the chest, abdomen, and pelvis. Pancreas protocol CT with liver windows (2 mm cuts) will provide excellent imaging that will allow for local and distant staging for malignancy. Magnetic resonance imaging (MRI) is also acceptable for local staging. Endoscopic ultrasound (EUS) is used selectively.

Patients require at least 14 days to become fully immunized against encapsulated organisms (*Streptococcus pneumoniae*, *Haemophilus influenza type B*, and *Neisseria meningitidis*). If the patient is to undergo resection prior to a 14 day window, immunizations can be administered postoperatively once the patient recovers from the operation. Patients may also benefit from an *influenza* vaccine if the operation is during flu season.

Pitfalls and Danger Points

Intraoperative

Enteric, vascular, or soft tissue injury with port placement

Laceration or injury to major vascular structures

Inadvertent division of major vascular structures (i.e., hepatic artery)

Splenic parenchymal or hilar injury and hemorrhage early during the operation

Postoperative

Pancreatic fistula, leak, or abscess

Vascular stump leaks

Splenic vein thrombosis

Operative Strategy

The most important consideration is surgeon comfort level. The use of a hand port can provide tactile sensation which may facilitate the operation. Expertise with laparoscopic approaches to pancreatectomy is necessary for performing a safe operation.

Splenic preservation is feasible in select patients with benign tumors, small neuroendocrine tumors, or cystic neoplasms without proximity or invasion of the spleen parenchyma. Careful dissection of the splenic artery and vein is required. Recent reports indicate that splenic preservation with division of the splenic artery and vein is safe in select patients.

The surgeon should mark an incision for an open procedure in case conversion is necessary. Also, if bleeding were to occur and rapid entrance in to the abdomen were necessary, having this incision marked is critical since the abdomen will

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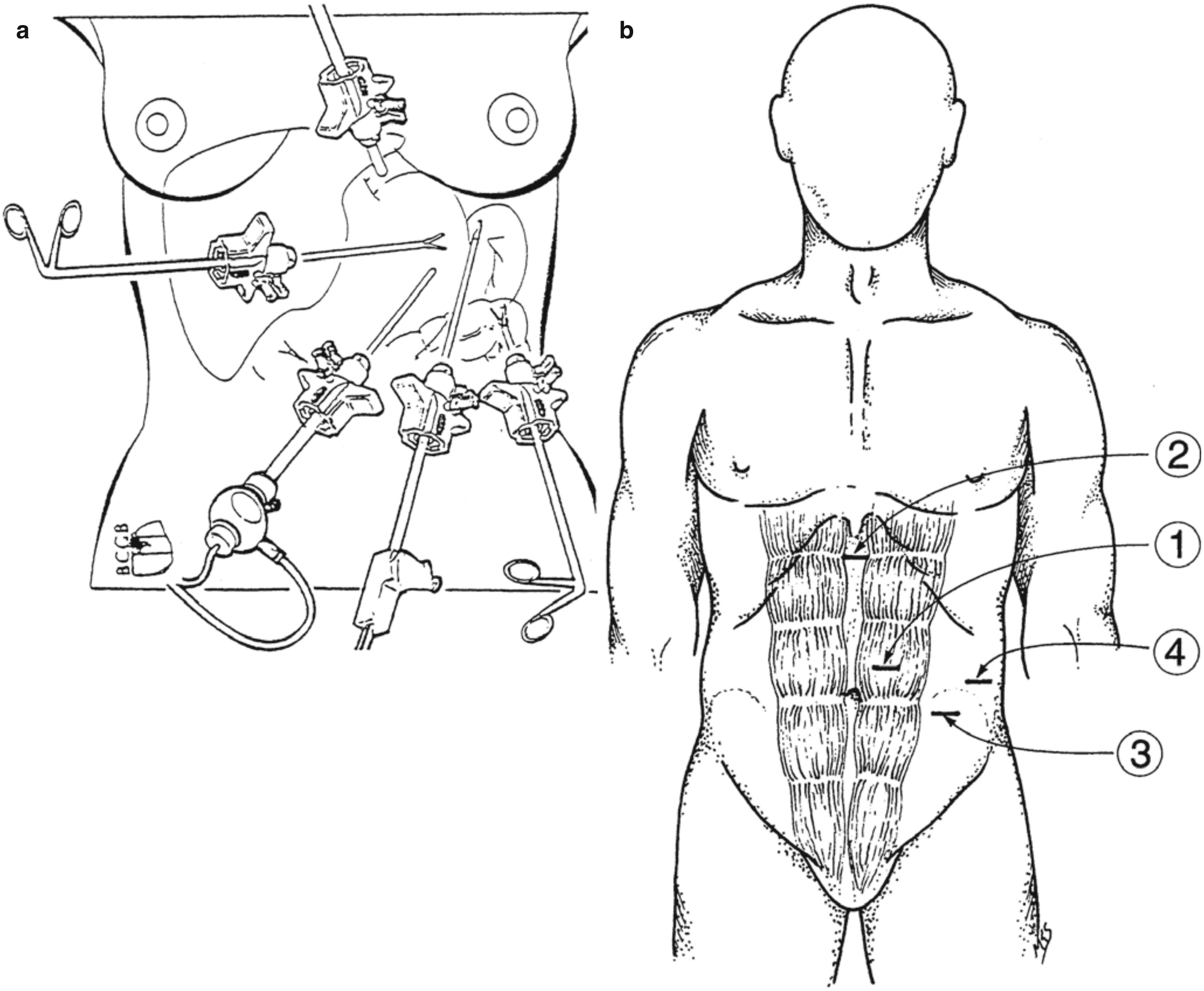

Fig. 92.1 (**a**, From Scott-Conner (2006), with permission; **b**, From Nguyen and Scott-Conner (2012), with permission)

be distorted by pneumoperitoneum. The operative team should also have an open tray of instruments available for immediate use.

Operative Technique

General Considerations

Prior to initiating the operation, it is recommended to review the patient's CT images to be familiar with the vascular anatomy. Variant anatomy may present a challenge when dividing the splenic artery where inadvertent division may occur to either the left gastric or common hepatic arteries. Replaced left gastric vessels may also appear in the operative field.

Patient positioning and port placement options are shown in Fig. 92.1. The Verres or Hassan approaches are both acceptable and are left to the discretion and comfort level of the surgeon. Port placement will be variable depending on the patient's body habitus. This operation can be performed with one 12 mm port and several 5 mm accessory ports if a 5 mm camera is also available. Two 12 mm ports with 5 mm accessory ports are also acceptable. A hand port, as mentioned above, is optional. Once a camera is placed in the supraumbilical location, a secondary port is placed to allow for exposure of the undersurface of the liver and palpation of any suspicious lesions. The initial part of the operation for malignancy is to perform a diagnostic laparoscopy to evaluate for spread of disease. The peritoneal and liver surfaces are carefully evaluated, and any suspicious lesions are biopsied and sent for frozen section analysis. If there is evidence of M1 disease in a patient with pancreatic adenocarcinoma, the operation is aborted.

After thoroughly exploring the abdomen, expose the body and tail of the pancreas by separating the left colon from the retroperitoneum and splenic attachments

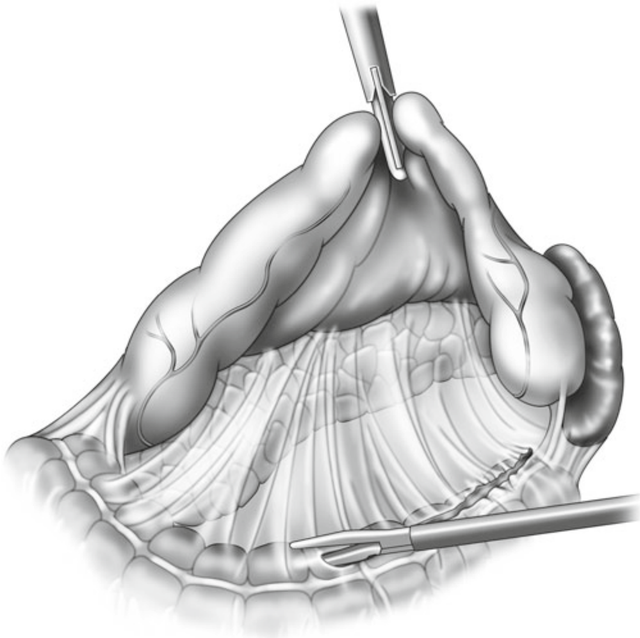

Fig. 92.2

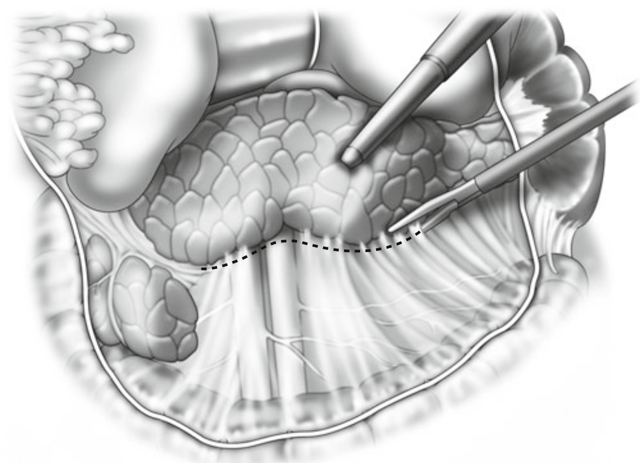

Fig. 92.3

(Fig. 92.2). There are many devices available for tissue transection, and this is left to the discretion of the surgeon. Next, liberate the omentum from its attachments to the transverse colon and enter the lesser sac. The short gastrics are then divided (if splenic preservation is not planned) up to the gastric fundus. The stomach is then tucked out of the operative field to facilitate exposure. To expose the inferior border of the pancreas, the transverse mesocolon is lowered away from its retroperitoneal attachments to the pancreas (Fig. 92.3). The anatomic landmark for medial mobilization of the pancreas is the superior mesenteric vein (SMV). Small and distal lesions do not require formal left pancreatectomy, and in these cases the pancreas may be divided medial to the SMV.

The key vascular structures in this operation are the SMV, splenic vein and artery, hepatic artery, and inferior mesenteric vein (IMV). *The importance of the hepatic artery is to have a very clear idea of its location to avoid inadvertent transection during stapling of the splenic artery*. The SMV is of major importance with regard to being a landmark for pancreatic transection and for direct identification of the splenic vein (if necessary). When dissecting free the inferior border of the pancreas, the IMV may be encountered and injury will result in annoying bleeding. This vessel can be divided if necessary. Once the pancreas is free inferiorly from the SMV to the splenic hilum, dissection under the pancreas may ensue. This can be done bluntly with fingers if using a hand port or laparoscopically with a laparoscopic Kitner or other blunt instrument. This will free-up the splenic vein and also provide access to the splenic artery. The splenic artery typically runs superior to the pancreas and is tortuous in nature. It can be stapled at any point during the operation and will slow bleeding from the spleen if the spleen is injured during exposure. Extreme care must be taken to avoid inadvertent stapling of the hepatic artery.

Endo GIA staplers are utilized for dividing the splenic vessels. A 2.0 or 2.5 mm load may be used. Once the splenic artery is divided, the spleen will shrink to facilitate extraction. Depending on the thickness of the pancreatic parenchyma, the splenic vein and parenchyma may be divided together using a 2.5 mm stapler. Otherwise the splenic vein is freed from the posterior border of the pancreas and stapled separately. The order for division of the parenchyma, splenic artery, and vein is not fixed and can be performed to optimize safety (Fig. 92.4).

Avoiding Damage to Blood Vessels

Once the decision has been made to proceed with distal pancreatectomy and splenectomy, locate the splenic artery a few centimeters beyond its origin at the celiac axis. Ligate the vessel in continuity to reduce the size of the spleen and the volume of blood loss if the splenic capsule is ruptured during the dissection.

The greatest danger when resecting the body and tail of the pancreas arises when a malignancy in the body obscures the junction between the splenic and portal veins or the splenic artery and celiac axis. This should be very clear on high-quality preoperative imaging. If elevation of the tail and body of the pancreas together with the tumor should result in a tear at the junction of the splenic and portal veins and this accident occurs before the tumor has been completely liberated, it may be extremely difficult to repair the lacerated portal vein. If an accident of this type should occur, it is necessary to find the plane between the neck of the pancreas and the portal vein and then divide the pancreas across

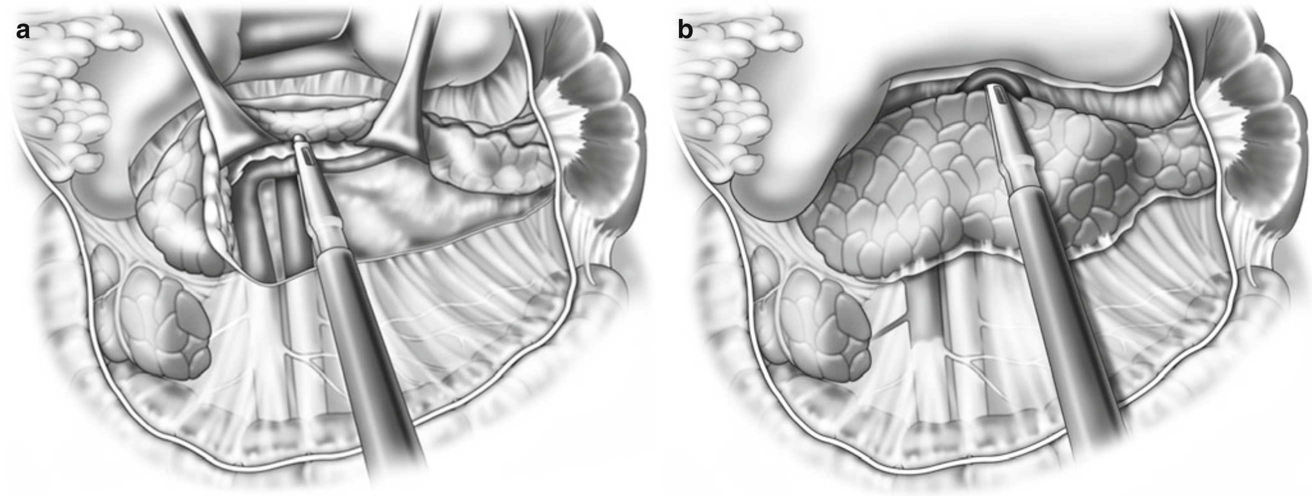

Fig. 92.4

its neck while manually occluding the lacerated vein. With the portal and superior mesenteric veins exposed after the neck of the pancreas has been divided, occluding vascular clamps may be applied and the laceration repaired. This complication can generally be avoided by careful inspection of the tumor after elevating the tail of the pancreas and by observing the area where the splenic vein joins the portal vein. If the tumor extends beyond this junction, it is probably inoperable. These maneuvers are typically performed once the operation is converted to an open approach.

Identifying Splenic Artery

Palpate (hand port) or visualize (total laparoscopic) the splenic artery along the upper border of the neck of the pancreas at a point a few centimeters from its origin. If there is some confusion as to the identity of the artery, occlude it with the fingertip and palpate the hepatoduodenal ligament to determine whether the hepatic artery (rather than the splenic artery) has been occluded. If hepatic artery pulsation is normal, open the peritoneum overlying the splenic artery. For the total laparoscopic approach, be sure to have clear visualization of the artery before dividing it. As mentioned above, a review of the patient's CT scan will ensure correct vessel identification. The vessel is stapled with a 2.0 or 2.5 mm Endo GIA stapler.

Dividing the Splenic Vein and Pancreas and Removal of the Spleen

Gently elevate the splenic vein by sweeping the areolar tissue away from this vessel until the junction between the splenic and portal vein is identified. At this point the splenic vein may be stapled approximately 2 cm proximal to its junction with the portal vein. If the pancreas is of average thickness, simply apply a 3.5 mm linear stapler across the neck of the pancreas. Once the pancreas is divided, the specimen may be removed in a medial to lateral fashion with removal of the spleen being the last step in the operation (Fig. 92.5). The spleen is freed from its retroperitoneal attachments as in a laparoscopic splenectomy (see Chap. 98).

The spleen remains attached to the greater curvature of the stomach by means of the intact left gastroepiploic and short gastric vessels. If these structures were not completely divided at the time of mobilizing the stomach, the division can be completed at this point. Keep in mind if the goal is splenic preservation, then these vessels should remain intact.

For the hand-assisted approach, the specimen can be enclosed in a specimen bag and removed through the hand port incision. In a total laparoscopic approach, the supraumbilical port site is extended to facilitate specimen extraction. Splenic morcellation as with laparoscopic splenectomy is ill advised in the setting of a malignancy.

Stump Closure

There are currently no data to suggest that one technique is superior for reducing the rate of pancreatic fistula, leak, or abscess following distal pancreatectomy. A recent multi-institution randomized controlled trial compared stapling to oversewing the pancreatic duct, and there was no difference in leak rates between groups (Diener et al. 2011).

Converting to an Open Approach

The first and foremost indication for conversion is surgeon discomfort. If there is any concern for the safety of the patient or a lack of progression, then the operation should be

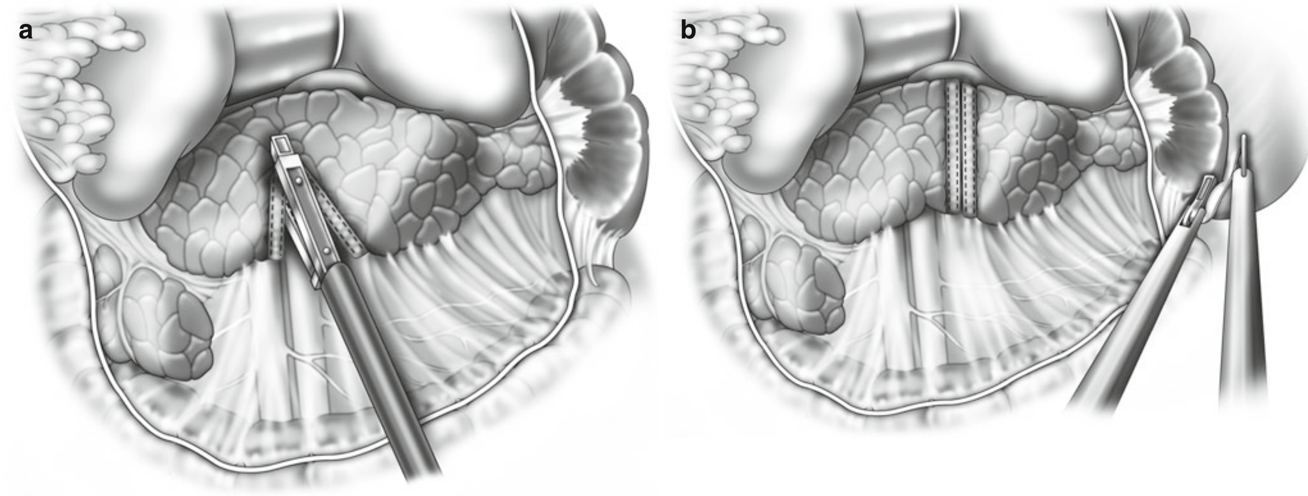

Fig. 92.5

converted. Marking out the incision ahead of time will provide a guide for quick access, and a tray of instruments should be available.

Postoperative Care

The decision to place a drain is left to the discretion of the surgeon. There is a lack of evidence to support routine drain usage (Conlon et al. 2001). If a drain is left in place, there are level I data to support early removal if drain amylase levels suggest a low risk for leak (Bassi et al. 2010). If a drain is left in place, it is recommended to place the drain to gravity to avoid injury from high negative pressure from closed suction (Grobmyer et al. 2002). Nasogastric tubes are not necessary postoperatively, and a diet may be initiated within the first 3 postoperative days if clinically appropriate. There is no evidence to suggest that the routine use of somatostatin analogues reduces leak rate after distal pancreatectomy (Yeo et al. 2000).

Complications

If pancreatic fistula develops, it generally resolves spontaneously and can take up to 6 weeks. If it does not resolve during that time, endoscopic stenting may facilitate closure (this is not supported currently by level I evidence). Patients do not require routine TPN use and can generally be maintained on a regular diet, while the fistula closes as long as it is controlled with an indwelling drainage catheter.

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Operations for Pancreatic Pseudocyst

93

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Mature (chronic) pseudocysts >5 cm seen by ultrasonography or computed tomography (CT).

Differentiate chronic pseudocysts from acute collections of fluid associated with acute pancreatitis (which generally resolve without surgery) and from cystic neoplasms.

Preoperative Preparation

Visualize the cyst by sonogram or CT scan with contrast.

Rule out the presence of gallstones or bile duct obstruction by sonography, oral cholecystography, or endoscopic retrograde cholangiopancreatography (ERCP).

Consider angiography of the splenic artery and pancreas for all chronic pseudocysts prior to surgery (CT with contrast may be given equivalent information).

Administer perioperative antibiotics.

Insert a nasogastric tube preoperatively.

Pitfalls and Danger Points

Anastomotic leak
Postoperative hemorrhage
Mistaken diagnosis (cystadenocarcinoma)
Overlooking an associated pseudoaneurysm
Recurrence

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Operative Strategy

Avoiding Anastomotic Leakage

Cystogastrostomy or cystoduodenostomy is appropriate only if the cyst is firmly attached to the wall of the stomach or duodenum. The anastomosis is simply completed through the area of attachment. If the cyst is not adherent, perform a Roux-en-Y cystojejunostomy because leakage from this anastomosis is far less dangerous to the patient than is leakage from the stomach or duodenum.

The wall of the pseudocyst must be thick enough for a safe anastomosis, particularly if a cystojejunostomy is performed. If there is doubt about the adequacy of the cyst wall, perform an external drainage operation.

Avoiding Diagnostic Errors

Always palpate the cyst for pulsation before any manipulation. A pulsatile cyst may contain a free rupture of a splenic artery pseudoaneurysm. Aspirate the cyst before opening it to confirm pancreatic juice without blood. Biopsy the cyst wall to rule out cystadenocarcinoma.

Pseudoaneurysm

When arteriography has demonstrated a leaking pseudoaneurysm of the splenic artery in a large pseudocyst, ask the angiographer to perform preoperative occlusion of the splenic artery. Sometimes the area of inflammation extends close to the origin of the splenic artery, making proximal control in the operating room, under emergency conditions, quite difficult. It is preferable to resect a cyst containing a pseudoaneurysm to prevent postoperative rupture and hemorrhage, rather than drain it.

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Jaundiced Patient

Although jaundice in the presence of a pseudocyst may well be the result of extrinsic pressure by the cyst against the distal common bile duct, it is also important to rule out the presence of calculi or periductal pancreatic fibrosis as the cause of bile duct obstruction. Preoperative ERCP is helpful, but performing operative cholangiography after the cyst has been drained determines whether further surgery of the bile duct is necessary. If the jaundice is due to chronic fibrosis in the head of the pancreas, endoscopic stenting or a bypass operation is required. It may be necessary to perform a side-to-side choledochojejunostomy to the defunctionalized limb of the Roux-en-Y distal to the cystojejunostomy.

Documentation Basics

- Cystogastrostomy or cystoduodenostomy or cystojejunostomy?
- Findings

Operative Technique

External Drainage

Make a long midline incision. Explore the abdomen and identify the pseudocyst. After making an incision in the greater omentum to expose the anterior wall of the cyst, insert a needle into the cyst to rule out the presence of fresh blood, then incise the cyst wall, and evacuate all of the cyst contents. Take a sample for bacteriologic analysis. If the cyst wall is too thin for anastomosis, insert a soft Silastic catheter and bring it out through an adequate stab wound in the left upper quadrant.

If the cyst wall is thick enough to permit suturing but the contents of the cyst appear to consist of pus and to resemble a large abscess, prepare a Gram stain. Sometimes what appears to be pus is only grumous detritus. If the Gram stain does not show a large number of bacteria, it is still possible to perform an internal drainage operation. Close the abdominal incision in the usual fashion after lavaging the abdominal cavity with a dilute antibiotic solution.

Cystogastrostomy

Make a midline incision from the xiphoid to the umbilicus. Explore the abdomen. If the gallbladder contains stones, perform cholecystectomy and cholangiography. Explore the lesser sac by exposing the posterior wall of the stomach from its lesser curvature aspect. If the cyst is densely adherent to the posterior wall of the stomach, cystogastrostomy is the operation of choice. If the retrogastric mass is pulsatile, consider seriously whether the mass represents an aortic aneurysm or a contained rupture of a splenic artery pseudoaneurysm. Expose the aorta at the hiatus of the diaphragm, and prepare a suitable large vascular clamp for emergency occlusion of this vessel should it be necessary. If the surgeon has had no previous experience with this maneuver, he or she should request the presence of a vascular surgeon. A preoperative CT scan should accurately identify the nature of the mass.

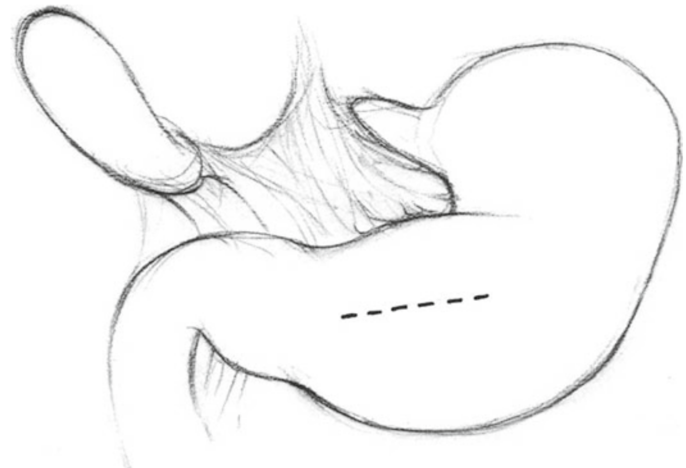

Fig. 93.1

Make a 6- to 8-cm incision in the anterior wall of the stomach (Fig. 93.1) opposite the most prominent portion of the retrogastric cyst. Obtain hemostasis with electrocautery or ligatures. Then insert an 18-gauge needle through the back wall of the stomach into the cyst and aspirate. If no blood is obtained, make an incision about 3–6 cm in length through the posterior wall of the stomach and carry it through the anterior wall of the cyst. Excise an adequate ellipse of tissue from the anterior wall of the cyst for frozen-section histopathology to rule out the presence of a cystadenoma or cystadenocarcinoma (Fig. 93.2).

Approximate the cut edges of the stomach and cyst by means of continuous or interrupted 3-0 PG sutures (Fig. 93.3). Close the defect in the anterior wall of the stomach by applying four or five Allis clamps and then perform a stapled closure using the 90 mm stapler. If the gastric wall is not thickened, use 3.5 mm staples. Lightly electrocoagulate the everted gastric mucosa. Suture-ligate any arterial bleeders with 4-0 PG.

Roux-en-Y Cystojejunostomy

Make a long midline incision and explore the abdomen. Check the gallbladder for stones. Expose the anterior wall of the cyst by dividing the omentum overlying it. Prepare a segment of jejunum at a point about 15 cm beyond the ligament

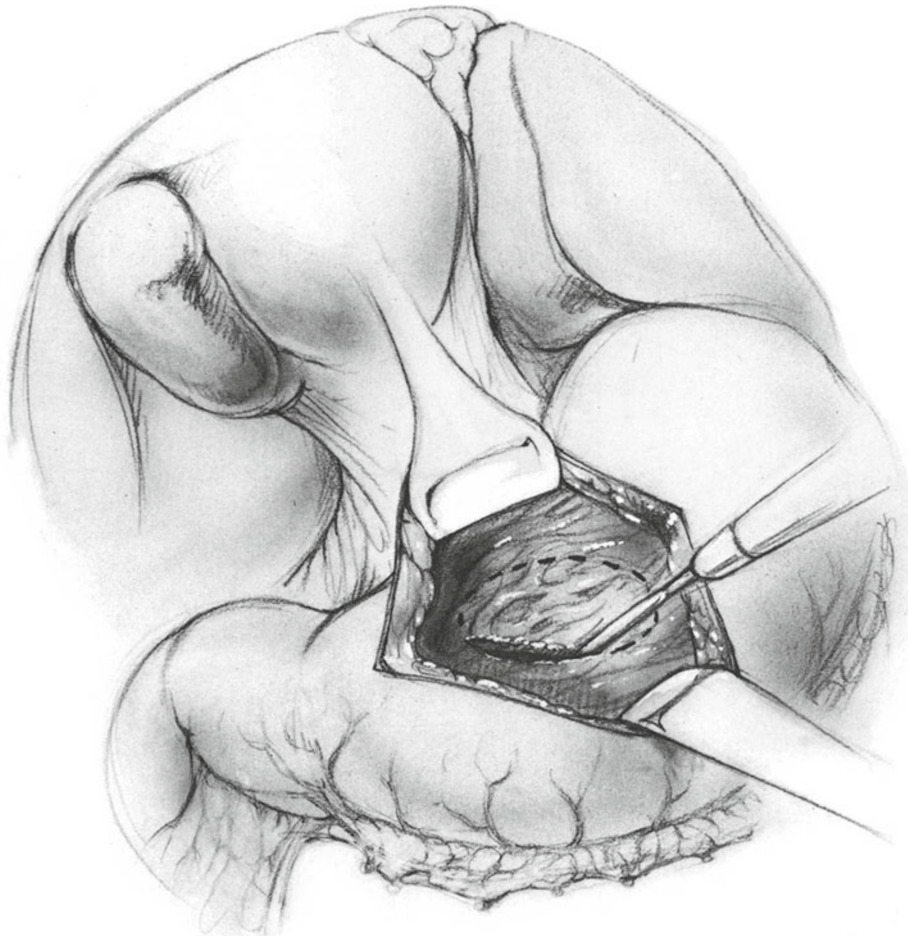

Fig. 93.2

of Treitz. Divide the jejunal mesentery as illustrated in Fig. 93.4. Then divide the jejunum between two Allen clamps. Liberate enough of the mesentery of the distal jejunal segment to permit the jejunum to reach the cyst without tension.

Make a small window in an avascular portion of the transverse mesocolon, and delivery the distal jejunal segment into the supramesocolic space. Excise a window of anterior cyst wall about 3–4 cm in diameter. Send it for frozen-section histopathologic examination. Perform a one-layer anastomosis between the open end of jejunum and the window in the anterior wall. Insert interrupted 3-0 or 4-0 PG Lembert sutures. Then use 4-0 PG sutures to attach the mesocolon to the jejunum at the point where it passes through the mesocolon.

Anastomose the divided proximal end of the jejunum to the antimesenteric border of the descending limb of the jejunum at a point 60 cm beyond the cystojejunal anastomosis. Align the open proximal end of jejunum so its opening points in a cephalad direction. Make a 1.5 cm incision in the antimesenteric border of the descending jejunum using electrocautery (see Fig. 84.7), and complete the Roux-en-Y

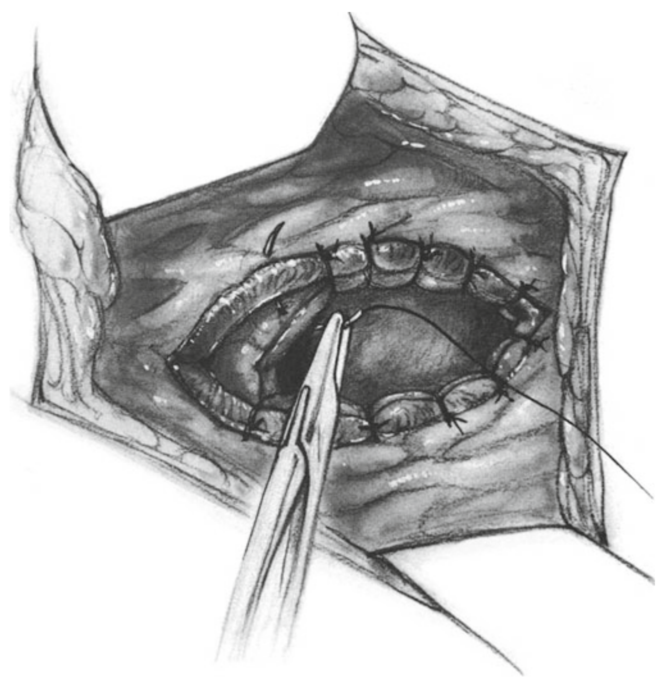

Fig. 93.3

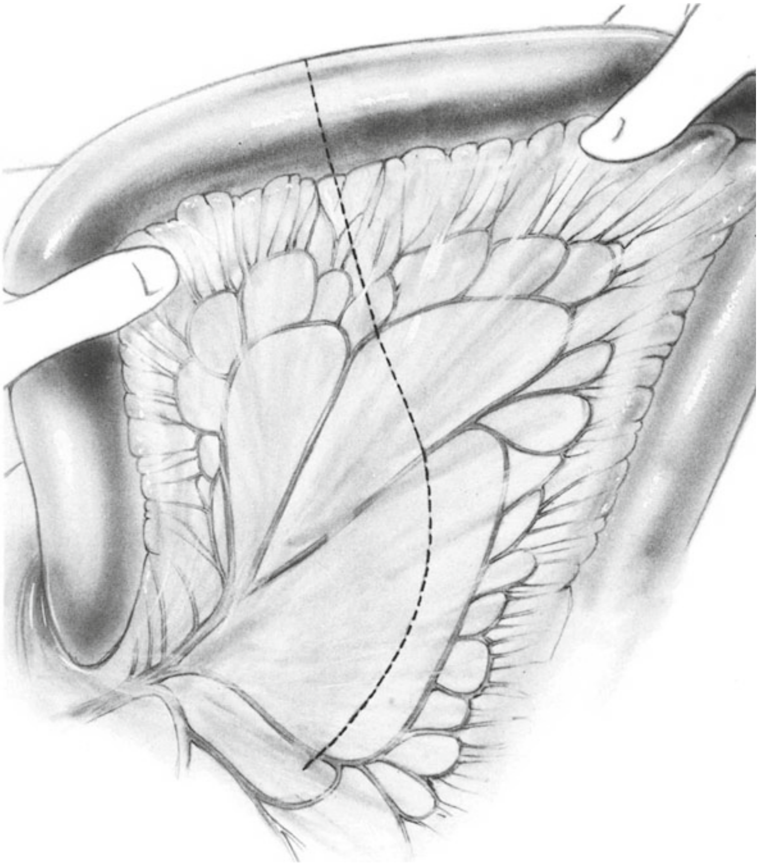

Fig. 93.4

reconstruction by performing a jejunojejunostomy in the usual manner (see Figs. 84.7, 84.8, 84.9, 84.10, 84.11, and 84.12).

Use 4-0 PG sutures to close the defect in the jejunal mesentery. The completed cystojejunostomy is illustrated in Fig. 93.5.

If the cyst wall is of adequate quality, no drains need be used. Close the incision in the usual fashion.

Pancreatic Resection

The techniques of pancreatic resection are described in Chaps. 89, 90, 91, and 92.

Postoperative Care

Apply nasogastric suction for 1–3 days.

Perioperative antibiotics are indicated. If the culture report of the cyst contents comes back positive, administer the appropriate antibiotics for 7 days. In cases of external drainage, administer antibiotics depending on the culture reports.

Consider the use of closed suction drainage. Leave the drain in place until the amount of fluid obtained is minimal and a radiographic study with aqueous contrast material shows that the cyst has contracted to the size of the drain. It may be helpful to instill a dilute antibiotic solution into the drain at intervals if the cyst is infected.

Complications

Acute pancreatitis

Persistent fistula following external drainage

Abscess

Postoperative bleeding into gastrointestinal tract (rare if pseudoaneurysms have been identified and appropriately managed)

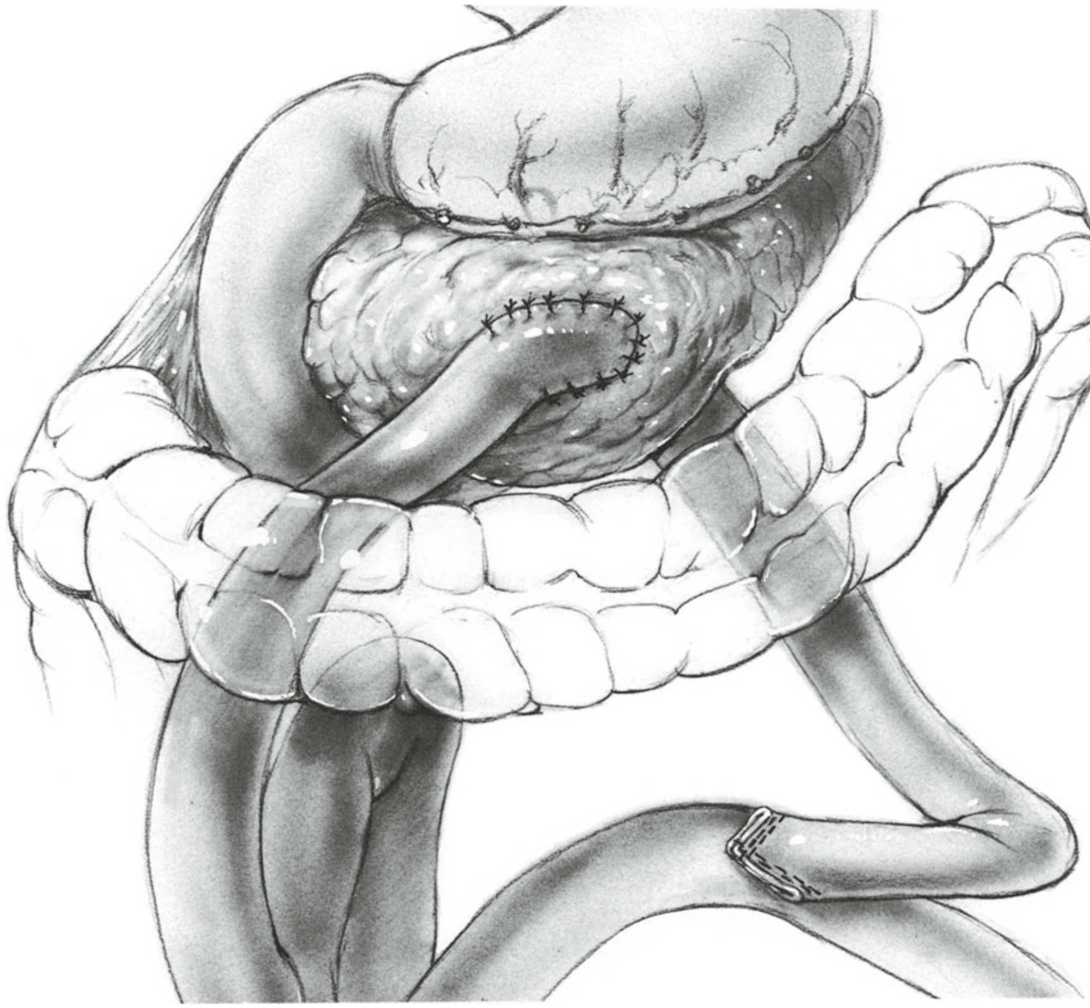

Fig. 93.5

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Pancreaticojejunostomy (Puestow) for Chronic Pancreatitis

94

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Indications

Chronic pancreatitis producing *intractable* pain not responsive to medical treatment, with a dilated (≥5–7 mm) pancreatic duct

Preoperative Preparation

Evaluate hepatic function.
Rule out portal hypertension.
Establish nutritional rehabilitation if necessary.
Order endoscopic retrograde cholangiopancreatography (ERCP) or MRCP.
Rule out biliary calculi by radiography or sonography.

Pitfalls and Danger Points

Failure to rule out portal hypertension.
Overlooking pancreatic carcinoma. Before deciding on an operative procedure, biopsy suspicious areas. Aspiration cytology in the operating room may be helpful in this situation.

Operative Strategy

Because the dilated pancreatic ducts are thick walled and fibrotic, pancreaticojejunal anastomosis is a safe procedure. One layer of sutures generally suffices. A sufficient length of pancreatic duct must be opened to allow adequate drainage. Several variations in this procedure have been described and are referenced at the end of the chapter.

Documentation Basics

- Findings
- Extent of drainage

Operative Technique

Exposure

Make a midline incision from the xiphoid to a point 4–5 cm below the umbilicus. Separate the greater omentum from the middle of the transverse colon for a distance sufficient to expose the pancreas. Divide the peritoneal attachments between the pancreas and the posterior wall of the stomach.

Incising the Pancreatic Duct

The main pancreatic duct is generally located about one-third the distance of the cephalad to the caudal margin of the pancreas. If the duct cannot be palpated, inserting a 22-gauge needle and attempting to aspirate pancreatic juice may serve to locate the pancreatic duct. If the duct has not been successfully visualized by preoperative ERCP, perform a ductogram in the operating room by aspirating 2 ml of pancreatic juice with a 22-gauge needle; then inject an equal amount of dilute Hypaque into the duct. If there is suspicion that the common duct is obstructed by chronic pancreatitis, perform cholangiography in the operating room. Once the pancreatic duct has been identified, open it by making an incision along its anterior wall. The incision should open the entire duct

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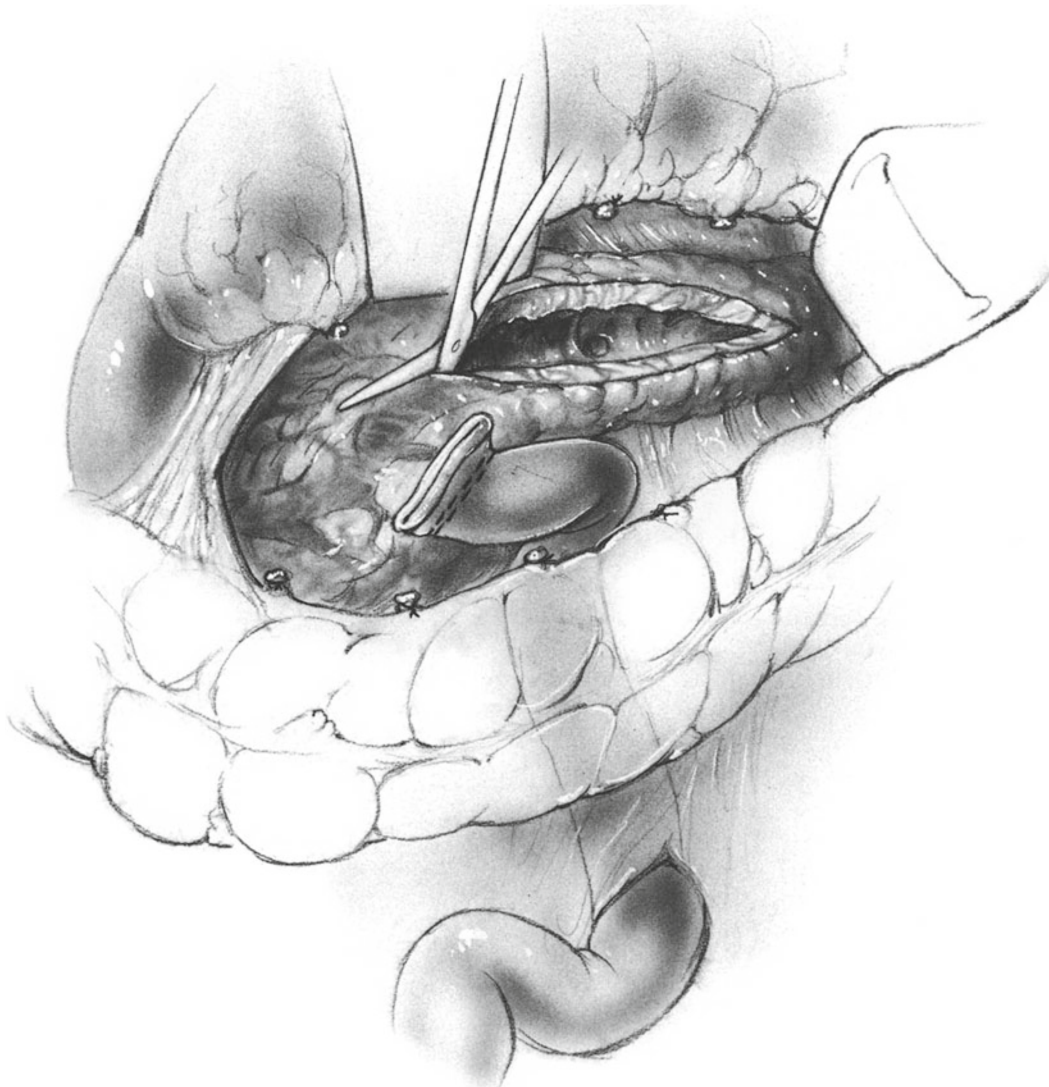

Fig. 94.1

from the head to the tail of the pancreas. This may be done with Potts scissors or a scalpel (Fig. 94.1). Continue the duct incision farther into the head of the pancreas than is shown here. Secure hemostasis with electrocautery. Occasional bleeding points may require a fine PG suture ligature. If a stricture of the pancreatic duct is encountered, insert a probe through the strictured area, and incise the anterior wall of the duct with a scalpel over the probe. Remove any calculi or debris that may have collected in the ductal system.

Constructing the Roux-en-Y Jejunostomy

Prepare the proximal jejunum for a Roux-en-Y operation as illustrated in Fig. 84.1. Select a suitable point about 12–15 cm beyond the ligament of Treitz. After a sufficient amount of mesentery has been divided, apply the 55/3.5 mm linear stapling device to the jejunum and fire it. Apply an Allen clamp just proximal to the stapling device. Divide the jejunum flush with the cephalad side of the stapler with a scalpel. Lightly electrocoagulate the everted mucosa and remove the stapler.

Make a 3 cm incision in an avascular area of the transverse mesocolon. Pass the limb of jejunum through this incision, and position it side-to-side to the open pancreatic duct. The stapled cut end of the jejunum should be approximated to the tail of the pancreas and the distal jejunum to the head. Now incise the antimesenteric border of jejunum over a length approximately equal to the incision in the pancreatic duct using a scalpel or electrocautery. Because the fibrotic pancreas accepts sutures easily, one layer of sutures is sufficient. For the posterior layer of the anastomosis, approximate the full thickness of the jejunum to the incision in the

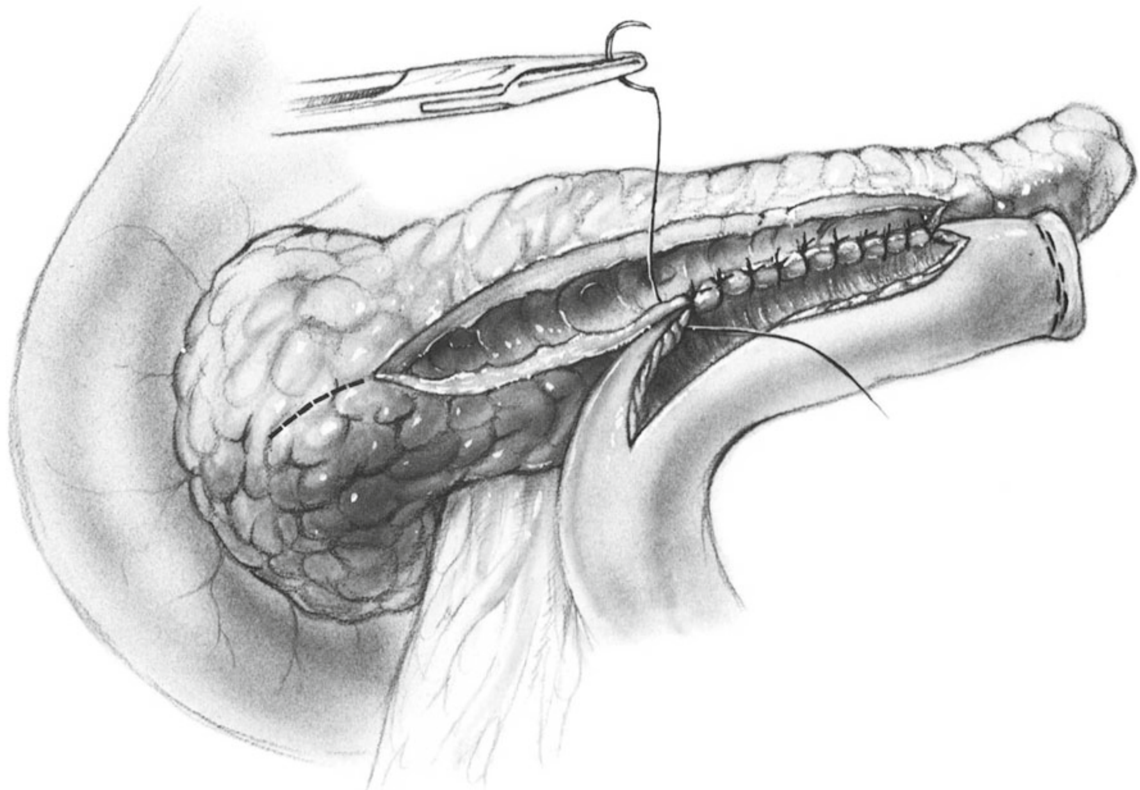

Fig. 94.2

pancreatic duct. Use 4-0 PG interrupted sutures. Insert the needle through both the mucosal and seromuscular portions of the jejunal wall. Then pass the needle through the fibrotic parenchyma of pancreas and through the pancreatic duct. Tie the suture with the knot inside the lumen of the pancreatic duct (Fig. 94.2). For the anterior layer of the anastomosis, use a seromucosal or Lembert stitch on the jejunum. Then pass the needle through the full thickness of the duct including some of the pancreatic parenchyma (Figs. 94.3 and 94.4a, b). Close the defect in the mesocolon by inserting fine interrupted sutures between the mesocolon and the serosa of the jejunum.

At a point at least 60 cm distal to the pancreaticojejunostomy, construct an end-to-side jejunojejunostomy to complete the Roux-en-Y anastomosis. We generally accomplish this anastomosis by stapling as described in Figs. 84.7, 84.8, 84.9, 84.10, 84.11, and 84.12.

If desired, make a puncture wound in the left upper quadrant, and insert a Jackson-Pratt closed-suction silicone drainage catheter down to the region of the pancreaticojejunal anastomosis. Close the abdomen in routine fashion.

Postoperative Care

Discontinue nasogastric suction in 1–3 days or sooner.
Administer perioperative antibiotics no longer than 24 h.

Complications

Pancreatic fistula
Abdominal or wound infection
Recurrent pain

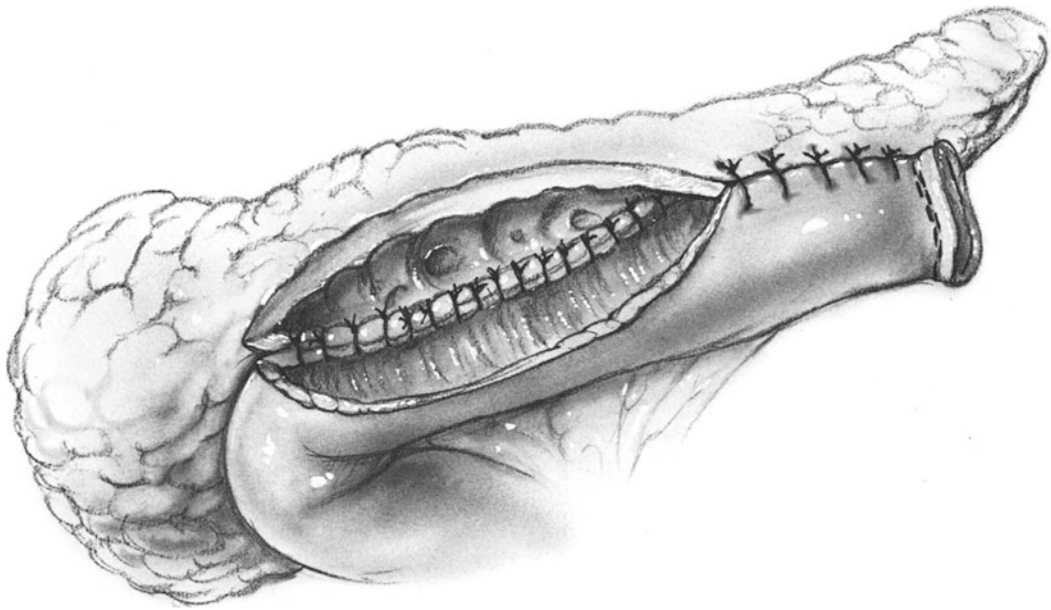

Fig. 94.3

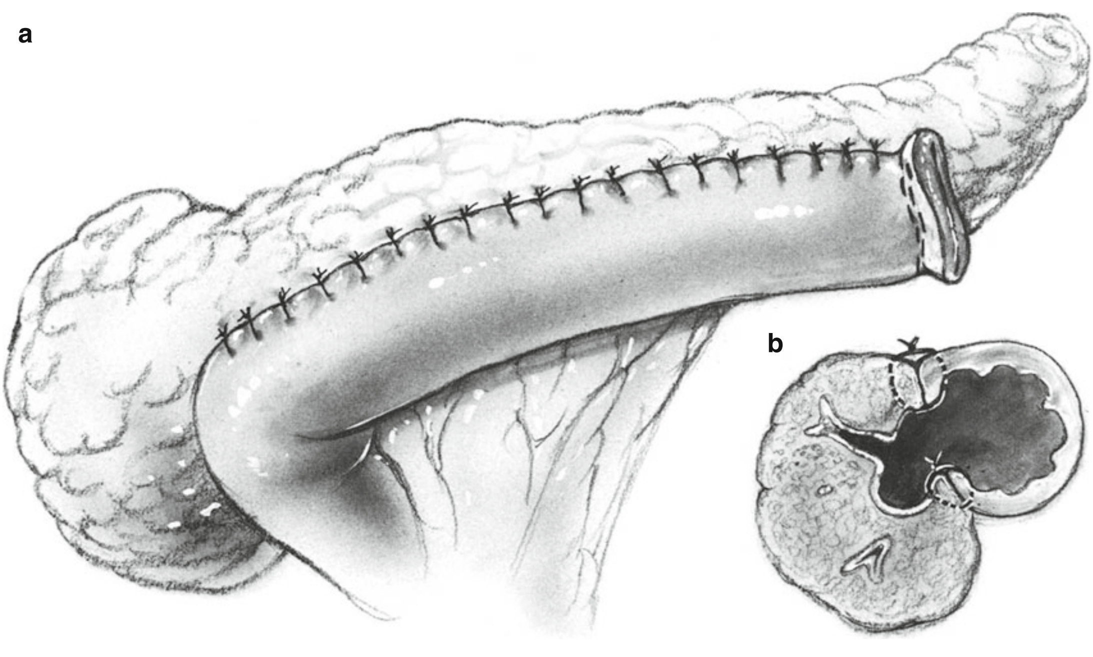

Fig. 94.4

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Part IX

Spleen

95 Concepts in Splenic Surgery

H. Leon Pachter, Michael Edye, and Amber A. Guth

Splenectomy for Disease

Although the decision to perform splenectomy for hematologic disease is generally made by the treating hematologist, the surgeon must be conversant with the hematologic disorders to ensure that the patient (1) has been preoperatively immunized with pneumococcal, meningococcal, and (when indicated) *Hemophilus* and/or hepatitis B vaccine; (2) is hematological optimized for surgery; and (3) is fit for conventional open splenectomy, as laparoscopic splenectomy may require prompt conversion to control hemorrhage.

Common hematologic indications for splenectomy are autoimmune (formerly termed idiopathic) thrombocytopenic purpura (ITP), hereditary spherocytosis, and other forms of hemolytic anemia. Elective splenectomy is also sometimes performed to palliate myelofibrosis or as part of a staging laparotomy for Hodgkin's disease (Katz and Pachter 2006; Society for Surgery of the Alimentary Tract).

Preoperative Evaluation

Standard hematologic parameters are measured. Preoperative radiologic imaging [computed tomography (CT), ultrasonography] do not reliably detect accessory splenic tissue and are rarely indicated during the first operation. When a hematologic disorder recurs owing to a missed accessory spleen, the combined use of damaged red blood cell scintigraphy and CT scanning can be helpful for localizing accessory splenic tissue. Although radiologic embolization has been employed immediately prior to splenectomy to reduce the size and vascularity of the spleen in the case of extreme splenomegaly, this approach is rarely used.

Autoimmune Thrombocytopenic Purpura

In ITP, the spleen produces antibodies directed against platelet antigens and also is the main site of platelet destruction. Characteristic findings of thrombocytopenia and presence of megakaryocytes (in the absence of splenomegaly) make the diagnosis. In children, ITP is generally a self-limited process, and surgical intervention is rarely needed. Adults are first treated with glucocorticoids, cytotoxic agents, or immunoglobulin. Splenectomy is performed for refractory cases. There are no reliable predictors of response to splenectomy; however, the vast majority of patients experience a complete or partial response. Failure to respond should prompt evaluation for possible accessory splenic tissue or splenic implants from trauma during surgery.

The majority of splenectomies performed for ITP are now done by the laparoscopic approach. It is crucial to conduct a thorough search for accessory splenic tissue, usually after splenectomy has been performed and while hemostasis is being checked. It is equally important to avoid trauma to the spleen during dissection or subsequently morcellation, as spilled splenic tissue will implant, grow, and cause recurrence of symptoms.

Although these patients are thrombocytopenic, the platelets circulating in the peripheral blood are large immature platelets with excellent hemostatic potential. Response to splenectomy is prompt, with rapid rise in platelet count. Platelet transfusions, therefore, are no longer routinely used; they are reserved for situations in which bleeding and persistent thrombocytopenia complicate the postoperative phase.

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Choice of Surgical Approach: Open Versus Laparoscopic Procedure

The ideal surgical approach for splenectomy would have the following features:

- Provide excellent surgical exposure of the splenic hilum, ligaments, and perisplenic tissues.
- Cause minimal disturbance of the abdominal wall muscles.
- Permit precise dissection of the splenic vessels and avoid splenic parenchymal injury.
- Avoid injury to the pancreas, stomach, and adjacent structures.
- Laparoscopic splenectomy fulfills these criteria in many instances and is rapidly becoming the method of choice for all forms of splenic pathology when the spleen is mildly to moderately enlarged.

If the spleen is significantly enlarged, is the laparoscopic approach truly feasible, or would a generous open incision increase the margin of safety? Massive splenectomy with myelofibrosis in which the spleen is hard, tethered, and supplied by large collateral vessels is not appropriate for minimal access surgery. The surgeon's experience determines the point at which the enlarged spleen is "too large" to remove laparoscopically.

Technical Considerations for Safe Laparoscopic Splenectomy

The spleen develops from buds in the dorsal mesogastrium that subsequently coalesce. This provides the conceptual framework for understanding the layers and contents of the splenic ligaments. The configuration of these ligaments and blood vessels is used to the surgeon's advantage during the laparoscopic approach. Until the surgeon is familiar with mobilizing and handling the organ, it is best that the ligaments of the spleen be left undisturbed until the vessels in the hilum have been divided. Dissection should occur about 10 mm away from the hilum where the vessels are less well fixed and safer to dissect (see Chap. 98). If the splenic artery is accessible above the pancreas, it can be clipped or tied in continuity. If a stapler is to be used to divide hilar vessels, do not place clips where the stapler is to be positioned to avoid stapler misfires.

Laparoscopic Management of Splenic Cysts

Thick-walled and thin-walled splenic cysts can be unroofed laparoscopically and the cyst wall removed in a retrieval bag. Care must be taken to excise a sufficient portion of the cyst wall to prevent recurrence.

Recurrent Symptoms After Splenectomy for Hematologic Disease

Overlooked *accessory splenic tissue* may hypertrophy, subsequently causing recurrence of the hematologic symptoms for which the splenectomy was initially performed. Some have questioned whether accessory spleens are more likely to be overlooked during laparoscopic splenectomy than open splenectomy (Gigot et al. 1998). Park et al. reported a 12.3 % incidence of accessory splenic tissue in their series of 203 laparoscopic splenectomies, with one patient requiring reexploration for a missed accessory spleen (Park et al. 2000). They attributed this to their ability to visualize the perisplenic tissues better laparoscopically than at open splenectomy. In our experience, the incidence of accessory spleens seen at laparoscopy is 20 %, equivalent to the rate generally cited in the literature. A small subset of patients with ITP may ultimately require a subsequent open or laparoscopic procedure to remove an accessory spleen that has caused recurrence of the ITP (Velanovich and Shurafa 2000). It seems unreasonable to impose a major abdominal wound and prolonged hospitalization on the other 80 % of patients who do not have accessory spleens.

Splenic implantation is another cause of recurrence. Care must be taken not to fracture the spleen during dissection or to spill splenic tissue during the "morcellation" process. The surgical team must be prepared for an accurate, bloodless splenectomy. All steps should be taken to protect the abdominal cavity from contamination by splenic tissue. This means gentle handling of the spleen and its attachments and use of a strong, impervious extraction bag.

Splenic Trauma

Splenectomy renders patients susceptible to the lifelong risk of infectious complications. Overwhelming postsplenectomy infection (OPSI) is rare (occurring in only 0.25–5.0 % of adult splenectomized patients); but it can occur rapidly and results in a more than 50 % mortality rate (Lynch and Kapila 1996). Recognition of this syndrome has led to the development and now universal acceptance of splenic preservation as the treatment modality of choice whenever it is safe and feasible.

The importance of splenic preservation has been recognized for more than 20 years. The method of splenic preservation, however, has undergone a remarkable evolution from operative splenorrhaphy to nonoperative management (Pachter et al. 1998). Advances in modern imaging techniques (CT scanning, ultrasonography) along with technically adept interventional radiologists have established the primacy of the nonoperative approach to splenic trauma (Sclafani et al. 1995; Pachter and Grau 2000). Nonetheless, instances arise where operative intervention is required—hence the need for familiarity with techniques such as safe splenectomy, splenorrhaphy, and splenic autotransplantation (Pister and Pachter 1994).

When operative intervention has been dictated by a patient's inability to maintain hemodynamic stability despite adequate fluid resuscitation or having sustained multiple injuries, splenectomy should be undertaken without hesitation. When splenectomy is necessary and conditions permit, it seems prudent to use the removed spleen as a source for heterotopic splenic autotransplantation. The benefits derived from heterotopic splenic autotransplantation seem to be, theoretically at least, associated with its ability to restore partially the host's reticuloendothelial function. Whether such partial restoration of reticuloendothelial function is sufficiently protective against specific antigenic challenges is presently unknown. As splenic autotransplantation can be performed with relative ease and has not to date been associated with significant complications, it seems reasonable to continue employing this technique.

In patients with splenic injuries who remain hemodynamically stable but require operative intervention, a variety of techniques can be used to achieve splenic salvage. Included in these techniques are splenorrhaphy, partial splenectomy, mesh splenorrhaphy, topical hemostatic agents, and liberal use of the argon beam laser (see Chap. 97). The current literature suggests that splenorrhaphy can be achieved in at least 75 % of patients with a cumulative success rate of 98 %.

Nonoperative Splenic Salvage

In the past splenic salvage was most often achieved (70–75 %) by operative splenorrhaphy, partial splenectomy, electrocautery, and the use of adjunctive hemostatic agents. Nonoperative management was, at best, applicable to only 15–20 % of patients with blunt injuries. Current data suggest an almost mirror-image reversal, with at least 50–65 % of patients with blunt injuries and a small group of select patients with penetrating injuries being managed nonoperatively with success rates exceeding 90 %; only 17–20 % undergo splenorrhaphy. Splenorrhaphy techniques are detailed in Chap. 85.

Nonoperative Management of Splenic Trauma

An algorithm for nonoperative splenic preservation is given in Fig. 95.1. The following criteria for nonoperative management have proven safe and effective in our hands:

- Hemodynamic stability
- CT scan documentation of the injury
- No other intraperitoneal or retroperitoneal injuries requiring operative intervention (documented by CT scan)
- Limited need for spleen-related transfusions (usually 1 unit)

The almost exponential rise in the number of patients managed nonoperatively since the early 1990s has been a direct result of including the following patients who in the past would have been excluded from nonoperative management: all hemodynamically stable patients regardless of CT grade of splenic injury, patients with intraperitoneal blood accumulation exceeding 250 ml (delineated by CT scan or ultrasonography), patients with pathologically diseased spleens (human immunodeficiency virus, leukemia, mononucleosis), selected patients with isolated stab wounds to the spleen, and neurologically impaired patients.

Prognostic Indicators of Failure of Nonoperative Management

There are certain instances where more active intervention is indicated despite the patient meeting all "conventional" criteria for nonoperative management. Irrespective of the patient's hemodynamic stability, a shattered spleen enveloped by a significant perisplenic hematoma (Fig. 95.2) in our experience eventually bleeds. It must be remembered that nonoperative management of hepatic and splenic injuries differs greatly. Hepatic injuries rarely rebleed. In contrast, even when bleeding has initially stopped, splenic injuries have a propensity to bleed late. Shattered spleens are particularly vulnerable to this complication. Prompt surgical intervention and expeditious splenectomy, preferably with splenic autotransplantation, are warranted.

Another instance where there is a high degree of sure failure of nonoperative management is when the initial CT scan reveals a "contrast blush." Figure 95.3 shows a CT scan from a patient who was injured in a motor vehicle collision, demonstrating a contrast "blush" and a large perisplenic hematoma. Such a finding indicates extravasation of contrast material, signifying active bleeding in the splenic parenchyma. One should not be lulled into a false sense of security by the patient's stable physiologic profile, however, as rapid hemodynamic deterioration can occur at any time. Failure rates of nonoperative management may well be related in part to underestimation of the significance of this finding. The hemodynamically stable patient with CT-demonstrated "contrast blush" should undergo immediate angiographic embolization of the bleeding vessel. Figure 95.4 shows selective subtraction splenic angiography revealing free extravasation of contrast from the lower pole of the spleen (same patient as in Fig. 95.3). The patient underwent successful angioembolization with a combination of autologous clot and Gelfoam (Fig. 95.5). Angioembolization has become one of the

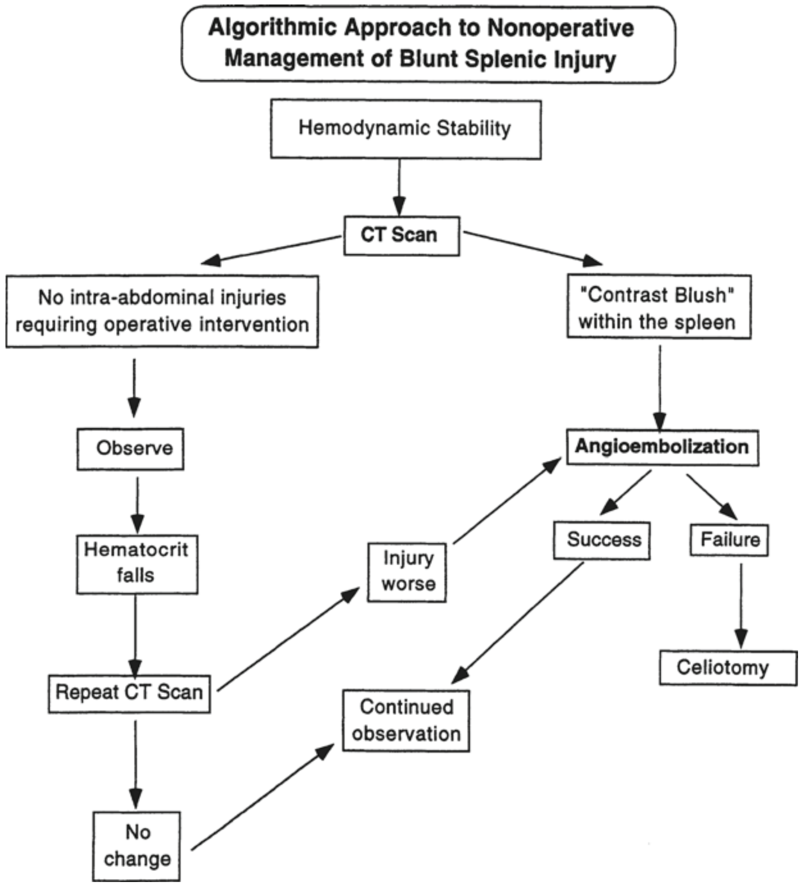

Fig. 95.1 (From Pachter et al. (1998), with permission)

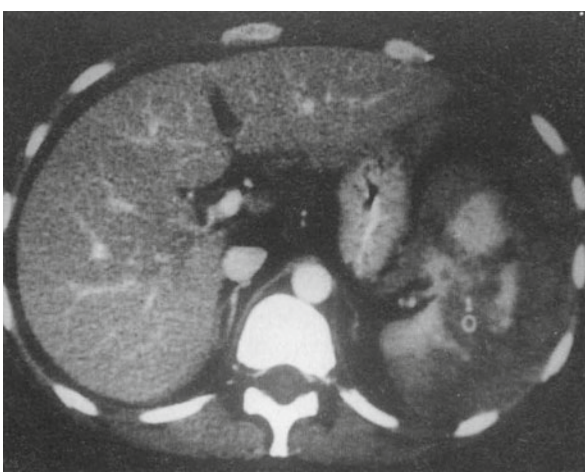

Fig. 95.2

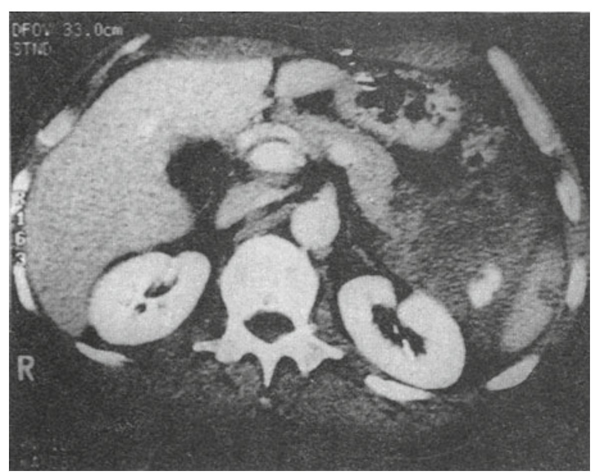

Fig. 95.3

cornerstones in the successful multidisciplinary approach to the nonoperative management of splenic injuries.

Follow-Up Imaging

Most follow-up imaging studies with CT or ultrasonography in patients with stable postobservation courses seem to be superfluous. The role of repeat CT scanning or ultrasonography should be limited to specific circumstances. Imaging may be used as a criterion for moving stable patients out of critical units sooner. All parameters being equal, an ultrasound scan showing at least "no worsening" of the injury, allow some patients to move out of the intensive care unit early. Follow-up imaging may also be helpful for determining which patients may return to

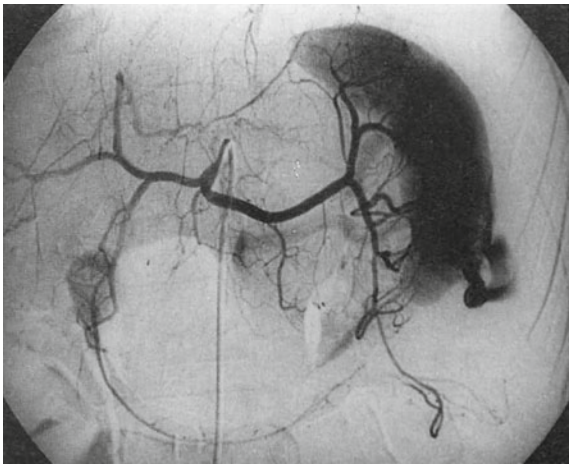

Fig. 95.4 (From Pachter and Grau (2000), with permission)

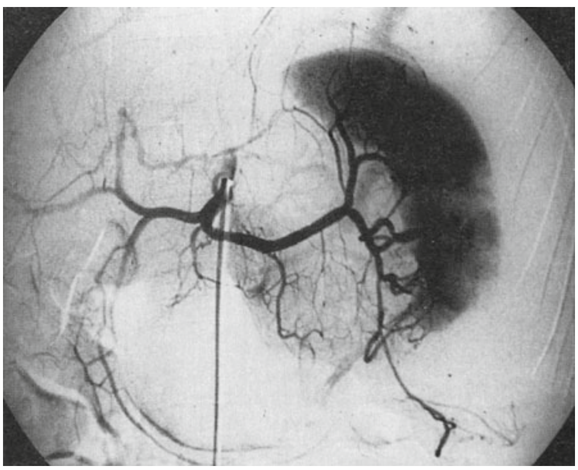

Fig. 95.5 (From Pachter and Grau (2000), with permission)

contact sports, particularly those who initially sustained an American Association for the Surgery of Trauma (AAST) grade III or greater injury. There would be understandable reluctance to allow a patient with a large intrasplenic hematoma to play tackle football without documenting complete resolution of the injury.

In summary, recognition of the pivotal role of the spleen in the immune response has resulted in almost universal policy of avoiding splenectomy when possible. Splenectomy continues to be associated with an increased need for transfusion and excessive perioperative sepsis. Splenic preservation for both blunt injuries and select penetrating injuries has become the accepted treatment protocol of choice. Splenorrhaphy, once the mainstay of splenic preservation, is rarely performed today, having been replaced for the most part by nonoperative observation alone or in conjunction with angioembolization. Nevertheless, operative splenorrhaphy, partial splenectomy, and heterotopic splenic autotransplantation must be in the trauma surgeon's armamentarium.

Laparoscopy for Management of Splenic Trauma

Laparoscopy is another tool available to the trauma surgeon dealing with the diagnosis and management of splenic trauma. Its role in elective splenic surgery is well established, and there is interest in applying the lessons learned to select trauma cases, thereby facilitating splenic salvage while obviating the need for open laparotomy.

The role of diagnostic laparoscopy in the assessment of patients with penetrating thoracoabdominal trauma is well established. Concerns about potentially missed intraperitoneal injuries or the ability to treat discovered injuries has limited the application of diagnostic and therapeutic laparoscopic techniques in this setting. However, multiple case reports have described successful laparoscopic splenic repair and salvage utilizing techniques of intracorporeal suture placement, application of fibrin glue, and absorbable mesh splenorrhaphy, and this role may continue to expand.

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Splenectomy for Disease

96

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Hematologic disorders. Splenectomy may be indicated for patients with hereditary anemias (spherocytosis, elliptocytosis, nonspherocytic hemolytic anemia), primary hypersplenism, and idiopathic thrombocytopenic purpura. Patients with autoimmune hemolytic anemia, secondary hypersplenism, thalassemia, myelofibrosis, chronic lymphatic leukemia, and lymphoma also benefit from splenectomy in selected situations. Splenectomy may be part of the staging procedure for patients with Hodgkin's disease. Because the specific therapy for diseases that require splenectomy is often in a state of flux and many of the conditions are complicated by problems of coagulation, it is important that the indications and timing for surgery be worked out in close cooperation with an experienced hematologist.

Primary splenic tumor.

Splenic abscess.

Splenic cysts, parasitic and nonparasitic.

Gastric varices due to splenic vein thrombosis.

Under unusual circumstances, a large number of other diseases may be benefited by splenectomy, such as Gaucher's disease, sarcoidosis, Felty syndrome, Niemann-Pick's disease, and Fanconi syndrome.

Note that in many of these cases, laparoscopic splenectomy may be performed (see Chap. 98). Trauma is discussed in Chap. 97.

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Preoperative Preparation

Consult with an experienced hematologist concerning blood coagulation factors in the patient and arrange for careful cross matching of an adequate quantity of blood.

Immunize the patient against pneumococcus, meningococcus, and *Hemophilus influenzae* at least 2 weeks prior to surgery.

Perform gastric decompression.

Administer perioperative antibiotics.

Preoperative transcatheter embolization of the splenic artery is a rarely used option in highly selected patients. Splenectomy should be performed promptly after completion of the splenic artery occlusion; otherwise pain, necrosis of the spleen, and sepsis are likely to occur.

Pitfalls and Danger Points

Intraoperative hemorrhage
Postoperative hemorrhage
Injuring the greater curvature of the stomach
Injuring the pancreas
Postoperative sepsis, especially in immunologically impaired patients
Failure to remove an accessory spleen

Operative Strategy

Choice of Approach: Open or Laparoscopic?

Laparoscopic splenectomy is an excellent alternative for properly selected patients. It is easiest in those with small spleens, such as individuals with idiopathic thrombocytopenic purpura (ITP). Advanced laparoscopy skills are required (see Chap. 98).

†Deceased

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Avoiding Intraoperative Hemorrhage

First, ensure that exposure is adequate for each step of the operation. Removing a large spleen requires a long incision. It is rarely necessary to perform a thoracic extension. Elevating the left costal margin with a Thompson retractor greatly improves exposure.

Next, meticulously dissect and individually ligate each major vessel to avoid lacerating the splenic vein or a major branch. When performing splenectomy for hematologic disorders, we prefer to isolate the splenic artery as the first step. This frequently allows a large spleen to diminish considerably in size and thus makes the dissection safer.

Patients with portal hypertension, such as with myelofibrosis, have collateral veins in the normally avascular splenophrenic and splenorenal ligaments. These vessels must be individually clamped and ligated.

Preventing Postoperative Hemorrhage

At the conclusion of the splenectomy, it is important to achieve complete hemostasis in the bed of the spleen, especially along the tail of the pancreas, the left adrenal gland, and the posterior abdominal wall. Some of the bleeding points can be controlled by electrocautery; others require clamping. Bleeding from the tail of the pancreas almost always necessitates insertion of fine suture-ligatures on atraumatic needles because the blood vessels tend to retract into the pancreatic tissue. If there is diffuse oozing due to thrombocytopenia or other coagulation deficiencies, administer platelets, fresh frozen plasma, and other coagulation factors as needed *after removing the spleen*. Then continue to observe the operative site until the bleeding stops. Do not simply insert a few drains and close the abdomen, as it often leads to the development of a large hematoma in the left upper quadrant, a major cause of subphrenic abscess.

Avoiding Pancreatic Injury

The greatest risk of injuring the tail of the pancreas occurs when the splenic blood supply is being ligated and divided at the hilus of the spleen. Avoid this by clearly identifying the tail of the pancreas and individually ligating vessels rather than masses of tissue. If each clamp contains only a blood vessel and not other tissue, the pancreas is not crushed by a large hemostat or inadvertently transected.

Avoiding Trauma to the Stomach

During the course of clamping and dividing the short gastric vessels, it is easy, especially when a large spleen is being removed, to include the wall of the gastric greater curvature in a hemostat aimed at a short gastric vessel. In other situations the serosa of the stomach may be denuded during the process of dissecting out these blood vessels. In either case, the injury may result in a gastric fistula, which is a serious, life-threatening complication. Consequently, take care to identify clearly each of the vessels and to achieve hemostasis and division of the short gastric vessels without damaging the stomach.

Extra security may be obtained by imbricating the greater curvature with a continuous or interrupted layer of seromuscular Lembert sutures. In this way the ligated stumps of the short gastric vessels and any possibly traumatized gastric wall are inverted together. If the short gastric vessels have been divided with great care under conditions of good visibility and well away from the greater curvature, it may not be necessary to invert this region of the stomach.

Preventing Postoperative Sepsis

Prevent subphrenic abscess by achieving good hemostasis and avoiding injury to adjacent structures. We believe that the use of prophylactic antibiotics administered intravenously at the induction of anesthesia and repeated at intervals for the next 24 h is an important means to help prevent this complication. This is especially true if there is any danger that the stomach or colon may be entered during a difficult dissection. Routine drainage of the splenic bed appears to increase the incidence of postoperative subphrenic abscess. Selective use of closed-suction drainage in patients with pancreatic injury may be appropriate. Removing the drain within 5 days appears to lower the risk of infection.

Accessory Spleen

Accessory spleens are common and, if overlooked, may in time impair the therapeutic effect of a splenectomy. Seek out and remove accessory spleens before closure.

The most common location of accessory spleen is in the hilus of the spleen and the gastrosplenic, splenocolic, and splenorenal ligaments. Also search the perirenal area, the tail of the pancreas, the small bowel mesentery, and the presacral region for accessory spleens, although these locations are less commonly the site of an accessory spleen than is the area around the splenic hilus.

Documentation Basics

- Findings
- Size of spleen
- Accessory spleens

Operative Technique

Incision

In the patient who has a small spleen, as is often the case with ITP, a long left subcostal incision reaching at least to the anterior axillary line provides excellent exposure. In some cases the subcostal incision may be improved by a Kehr extension up the middle to the xiphocostal junction, as illustrated in Fig. 96.1. A long midline incision may be preferable in patients with marked splenomegaly, especially if the patient has a narrow costal arch. Use electrocautery to incise the abdominal wall. To provide adequate exposure, a midline incision must extend a considerable distance below the umbilicus. Apply a Thompson retractor to elevate the left costal margin and to draw it in a cephalad and lateral direction.

Ligating the Splenic Artery

Incise the avascular portion of the gastrohepatic ligament along the middle of the lesser curvature portion of the stomach and elevate the stomach to expose the upper border of the pancreas. Palpate the splenic artery as it courses along the upper border of the pancreas toward the spleen. If it appears that ligating the splenic artery near the pancreatic tail will be difficult, identify the pancreas behind the lesser curvature of the stomach and incise the peritoneum over the splenic artery where it loops above the body of the pancreas. Carefully pass a blunt-tipped right-angle Mixter clamp around the splenic artery. Temporarily occlude this artery with a vascular clamp or by double-encircling it with a Silastic loop or a narrow umbilical tape fixed in place with a small hemostat.

In most cases approach the splenic artery by opening the gastrocolic omentum outside the gastroepiploic arcade, applying clamps, and dividing and ligating the gastroepiploic vessel (Fig. 96.2). Identify the splenic artery by palpating along the superior border of the pancreatic body or tail. Open the peritoneum over the artery and encircle the artery with a 2-0 silk ligature (Fig. 96.3). Then tie the ligature.

Sometimes identifying the splenic artery requires division of the lower short gastric vessels. If this step has not already been accomplished, identify, clamp, divide, and ligate these structures with 2-0 silk (Fig. 96.4). Continue

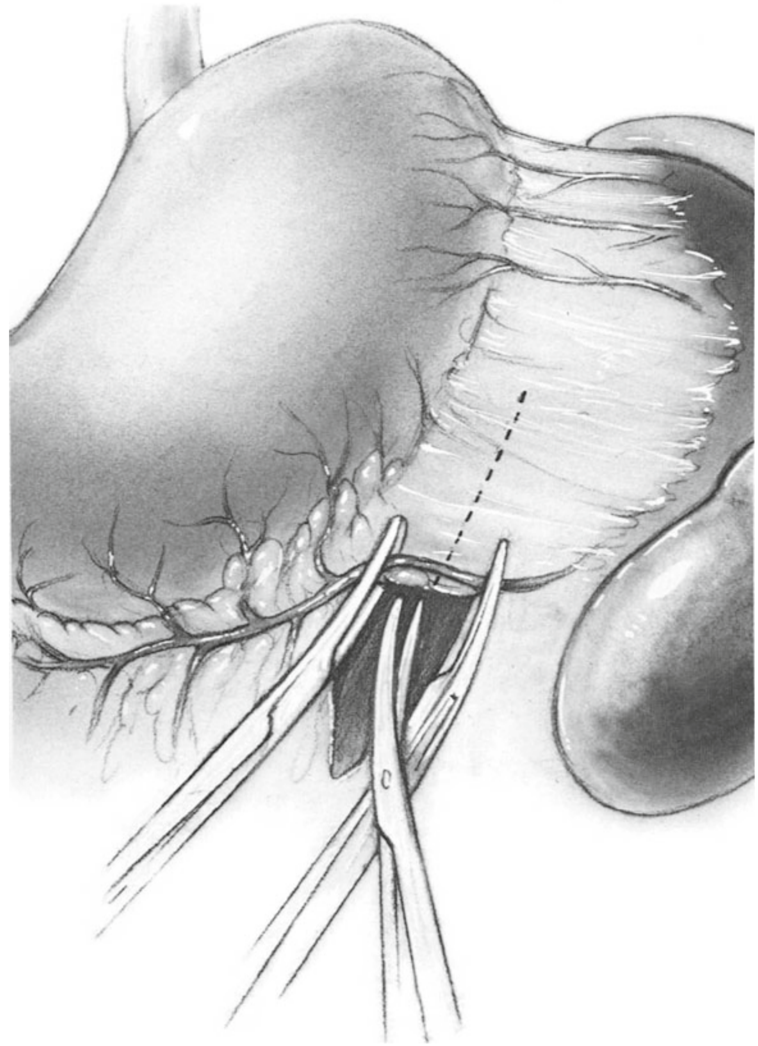

Fig. 96.2

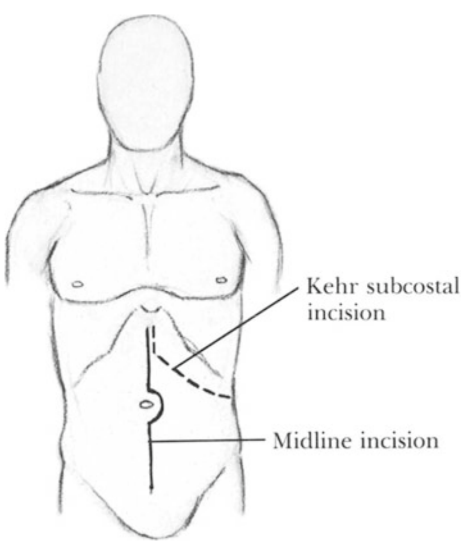

Fig. 96.1

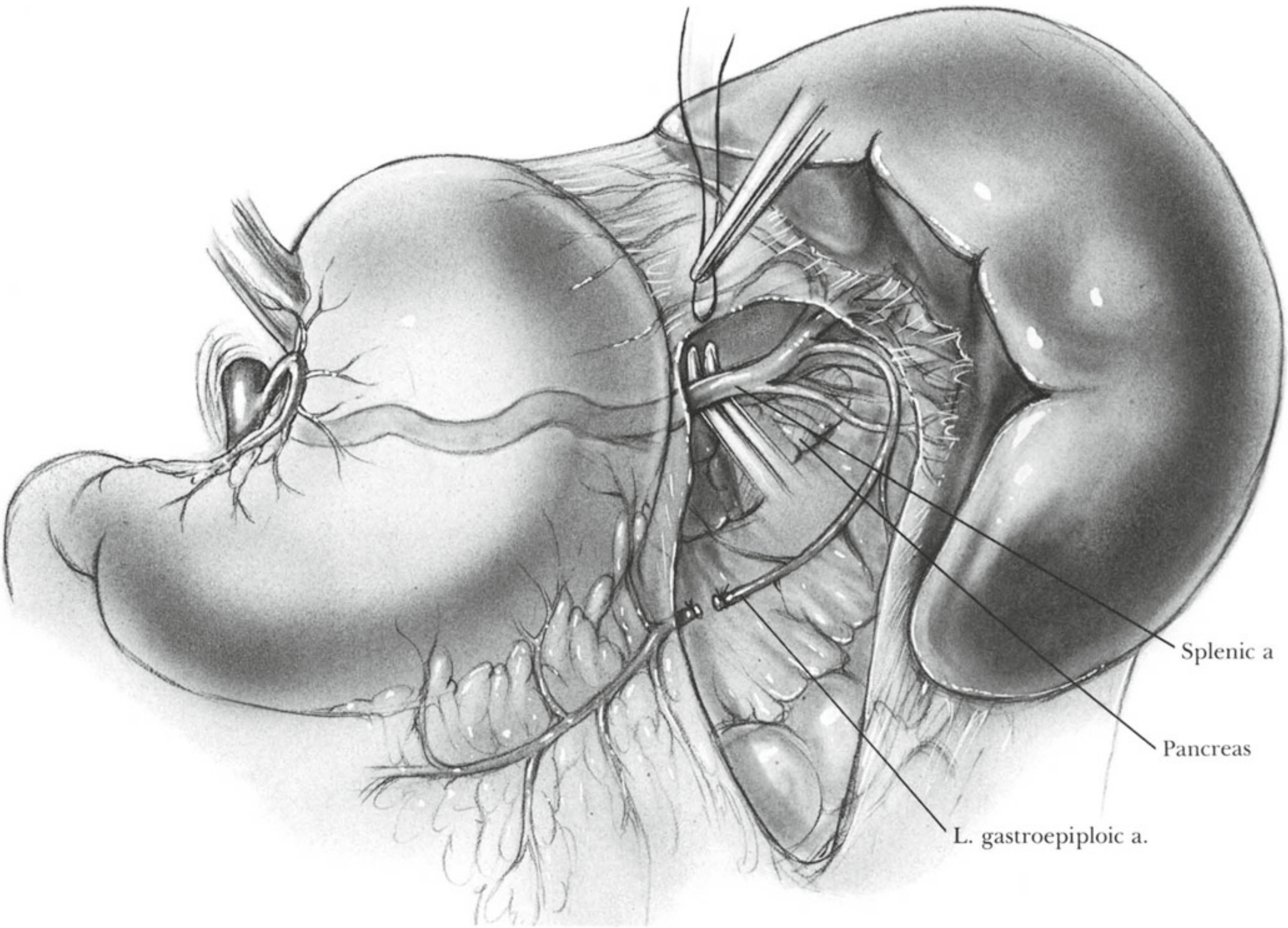

Fig. 96.3

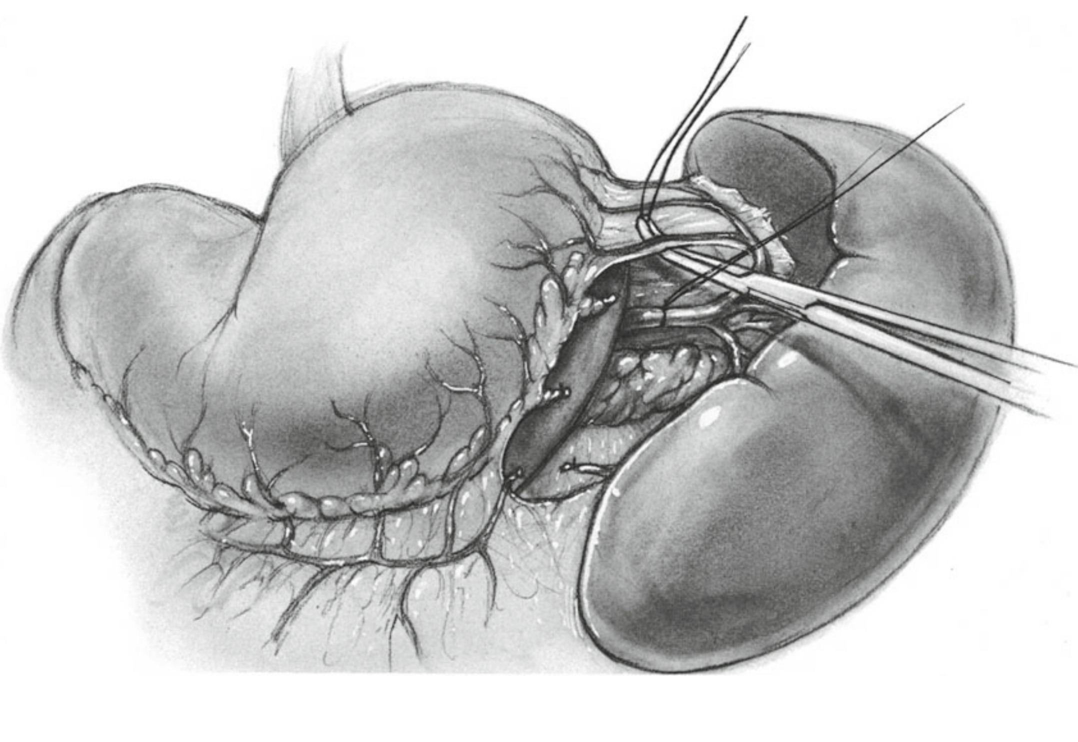

Fig. 96.4

the division of the short gastric vessels in a cephalad direction so long as the exposure is satisfactory. If the upper short gastric vessel is not long enough to be divided easily at this time, delay it until the spleen has been completely mobilized.

Mobilizing the Spleen

With the left hand, retract the spleen in a medial direction to expose the splenophrenic and splenorenal ligaments, which are generally avascular. Divide the ligaments with Metzenbaum scissors or electrocautery. Only in the presence of portal hypertension is it necessary to ligate a number of bleeding vessels in these ligaments. Insert the left index finger behind the incised splenorenal ligament and continue the incision by both sharp and blunt dissection until the spleen has been freed from the capsule of Gerota and the diaphragm (Figs. 96.5 and 96.6).

In the same plane, slide the hand behind the posterior surface of the pancreas and elevate the tail of the pancreas and the attached spleen into the abdominal incision. Tearing the splenic capsule by rough maneuvering during this step produces unnecessary bleeding and possible postoperative peritoneal splenosis. Apply a number of moist gauze pads to the bed of the spleen in the posterior abdominal wall.

Slide the index finger behind the splenocolic ligament and divide it, releasing the colon and its attached omentum from the lower pole of the spleen. This dissection leaves the spleen attached only by the splenic artery and vein and perhaps one or two remaining short gastric vessels.

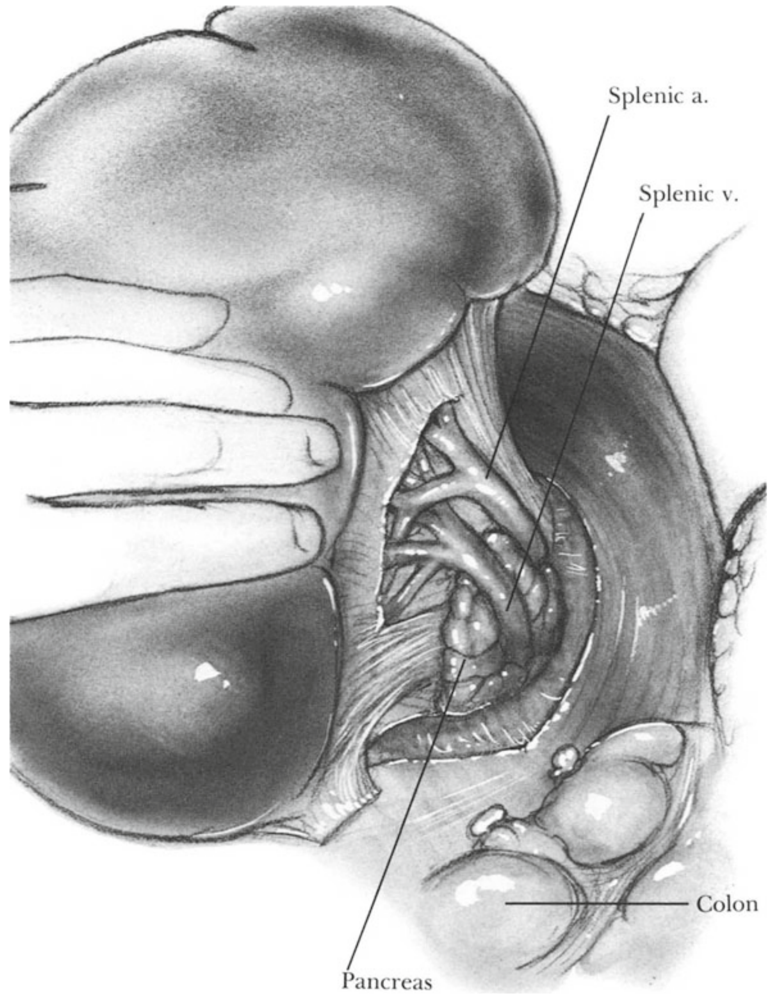

Fig. 96.6

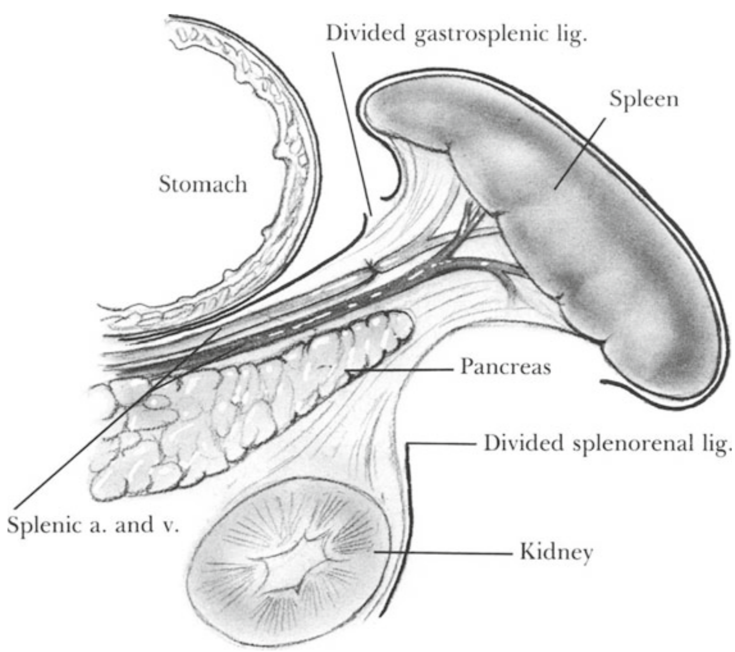

Fig. 96.5

Ligating the Splenic Vessels

With the spleen elevated out of the abdominal cavity, search the posterior aspect of the splenic hilus for the tail of the pancreas. Gently separate the tail of the pancreas from the posterior wall of the splenic artery and vein. Carefully divide and ligate small branches of the splenic vessels entering the tail of the pancreas. Identify the previously ligated splenic artery. Ligate the artery again near the hilus and divide it, leaving a sufficient stump (1 cm). Further dissection reveals the splenic vein, which may be a large structure, or it may have divided into several branches by the time it reaches the splenic hilus. Carefully encircle either the main splenic vein or each of its branches with 2-0 silk ligatures (Fig. 96.7). Tie the ligatures, divide the veins between ligatures, and remove the spleen.

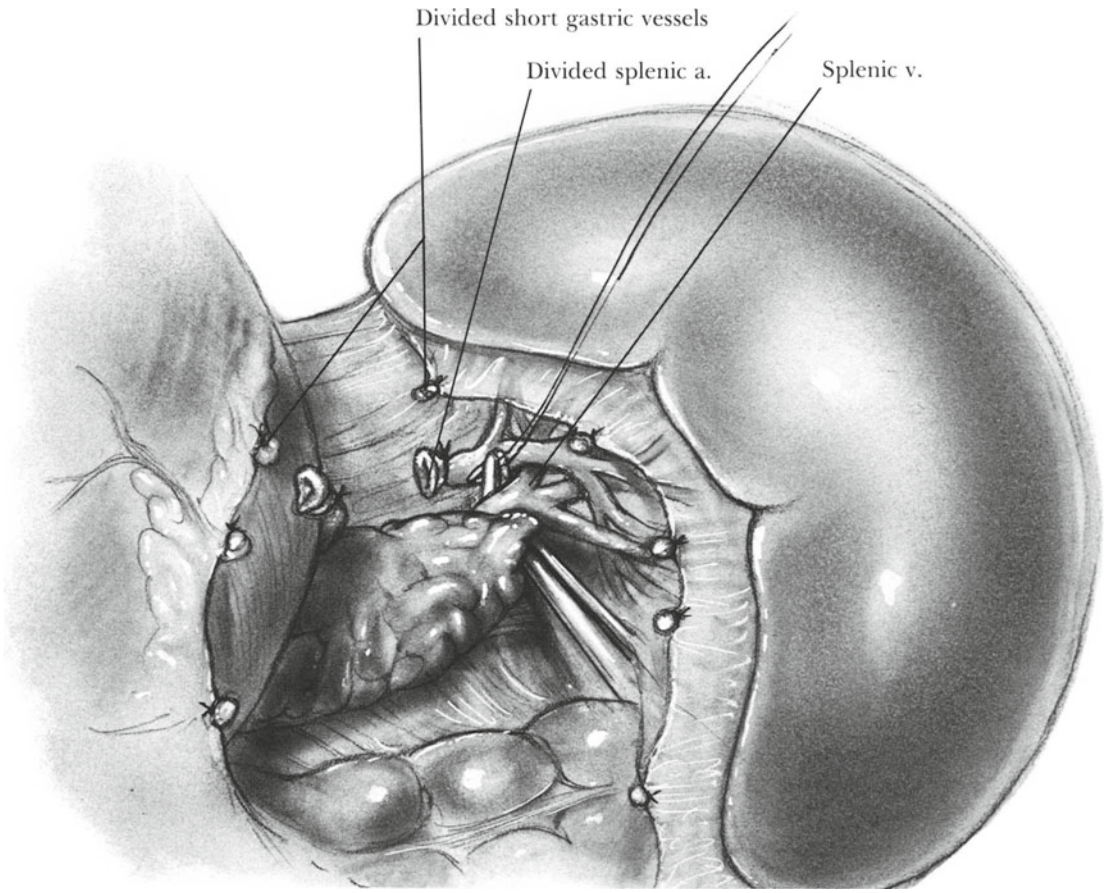

Fig. 96.7

Search for Accessory Spleens

Pack the splenic bed to encourage any minor oozing to stop. Use this time to search the area of the pancreatic tail, kidney, gastrosplenic ligament, omentum, small and large bowel mesentery, and pelvis for accessory spleens. Remove the gauze pads from the splenic bed and accomplish complete hemostasis utilizing electrocautery and ligatures.

Inverting the Greater Curvature of Stomach

Carefully inspect the greater curvature of the stomach. If there is the slightest suspicion of any damage to the tissue in this area, turn in the greater curvature together with the ligated stumps of the short gastric vessels. Use continuous or interrupted Lembert sutures of 4-0 atraumatic PG suture material to accomplish this step, which avoids a possible gastric fistula (Figs. 96.8, 96.9, 96.10, and 96.11).

Abdominal Closure

Irrigate the upper abdomen with a dilute antibiotic solution. After aspirating this solution with a suction device, close the abdomen in routine fashion. Do not insert any drains unless there has been an injury to the pancreas or complete hemostasis has not been possible. In either case, insert one or two medium-size plastic closed-suction drains of the Hemovac or Jackson-Pratt type through one or two puncture wounds in the area of the splenic bed and apply suction.

Postoperative Care

Continue nasogastric suction for 1–2 days.
Continue perioperative antibiotics for 24 h.
Continue steroid medication in patients who were on this therapy prior to and during operation.

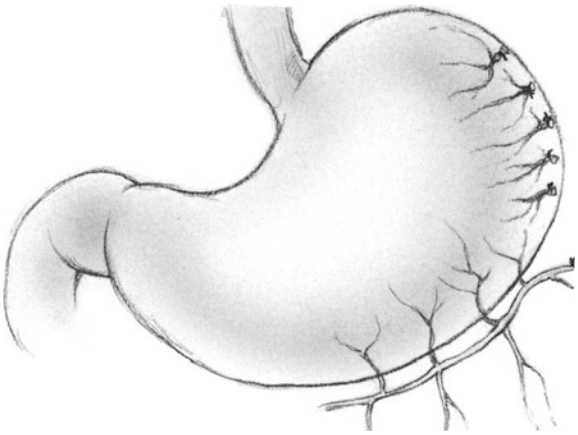

Fig. 96.8

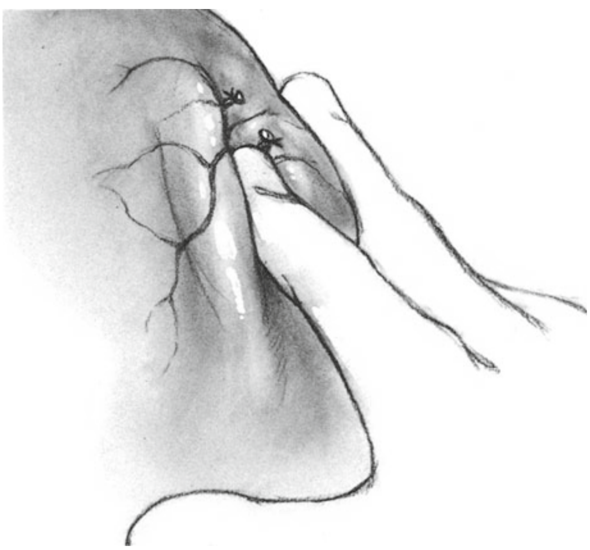

Fig. 96.9

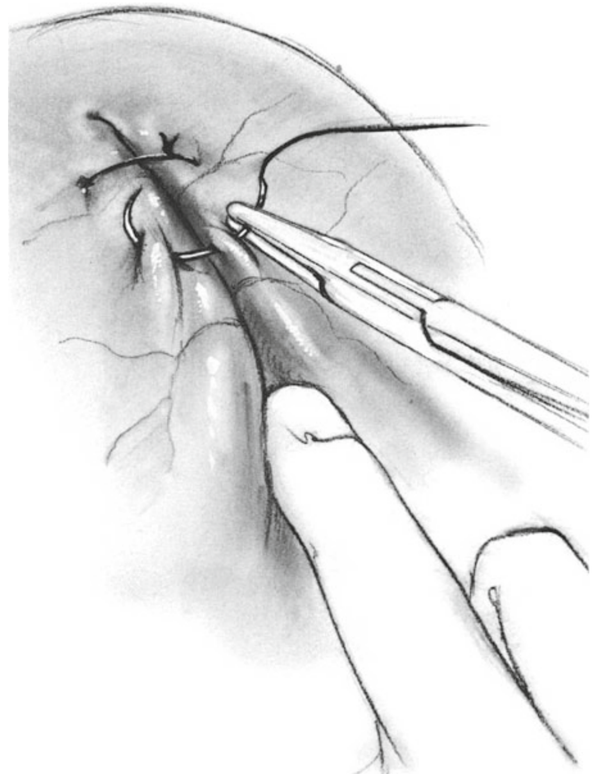

Fig. 96.10

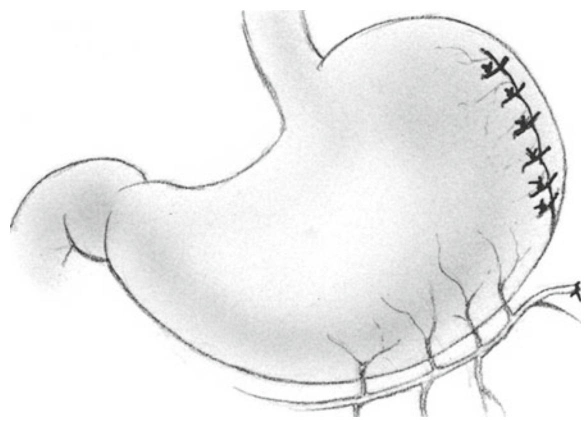

Fig. 96.11

Monitor the patient's blood coagulation status and check for postoperative bleeding. Frequently, the platelet count rises postoperatively, but it does not generally require treatment except in patients with myelofibrosis. Patients with this disease have been reported to suffer postoperative portal and mesenteric vein thrombosis.

The leukocyte count may also rise markedly following splenectomy, but it does not necessarily indicate sepsis.

If a patient has undergone total splenectomy, be certain the patient and the family are aware of the risks of overwhelming postsplenectomy sepsis. The patient should wear a MedicAlert bracelet recording the fact that he or she has undergone splenectomy. If the patient was not immunized preoperatively, administer Pneumovax and meningococcal and *H. influenzae* vaccines. Young children should receive prophylactic penicillin throughout childhood. It is not clear if prophylactic antibiotics are indicated during adult life.

Complications

Bleeding
Subphrenic abscess
Acute pancreatitis
Gastric fistula
Venous thrombosis

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97 Operations for Splenic Trauma

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Nonoperative management is appropriate in many cases of isolated splenic or hepatic trauma (see Chap. 95).

Perform splenectomy if the patient's condition is unstable, there are multiple injuries or gross fecal contamination, the spleen is fragmented beyond repair, or the spleen has been separated from its blood supply. Do not risk the patient's life at any time to preserve an injured spleen, especially in patients over age 50.

Splenorrhaphy or partial splenectomy is indicated in good-risk patients who do not have the above indications for splenectomy.

Preoperative Preparation

Resuscitate the patient by means of adequate fluid and blood replacement.

Insert a nasogastric tube.

Perform additional tests as indicated as time permits, including computed tomography (CT).

Pitfalls and Danger Points

Failure to control bleeding

Traumatizing the pancreas

Operative Strategy

Splenectomy

Unlike the technique described for removing the diseased spleen in Chap. 96, initiate the dissection by dividing the splenorenal and splenocolic ligaments as the first step. This permits rapid delivery of the spleen and the tail of the pancreas into the incision. Hemostasis can be maintained by compressing the splenic artery between the thumb and index finger during the rest of the dissection. In the rare case where a giant spleen has been traumatized, it may be advantageous to identify the splenic artery (see Fig. 96.1) and ligate it before delivering the enlarged spleen.

Iatrogenic Injuries

Most spleens injured during dissection (e.g., during colon resection) may now be salvaged. Commonly, the spleen is injured when the stomach or the transverse colon is retracted away from the spleen, and a small piece of splenic capsule is avulsed. Because the splenic pulp has not been damaged in most of these injuries, it is a simple matter to control the bleeding by applying a topical hemostatic agent, such as oxidized cellulose or Avitene, and then applying pressure with a large gauze pad. Before closing the abdomen, remove the gauze pad carefully and inspect the area for bleeding. The argon beam coagulator may assist in obtaining hemostasis. Generally it is not necessary to fully mobilize the spleen. This technique is not effective if the injury occurs at the hilus of the spleen.

Splenic Fracture

The splenic artery and vein divide into two to four trunks prior to entering the spleen. The intrasplenic branches

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generally travel in a horizontal direction. Because most splenic fractures also travel in a transverse direction, often only one or two small blood vessels have been torn. Hemostasis may require only that a hemostatic agent, hemostatic clips, or suture-ligatures be applied; that the laceration be sutured; or that a partial splenectomy be performed. Partial splenectomy is indicated if a portion of the spleen has been separated from its blood supply, which is suggested by cyanotic discoloration of the devascularized segment compared to the remainder of the spleen.

Principles basic to all splenic suturing are adequate exposure combined with *complete but atraumatic mobilization of the spleen* into the abdominal incision. This step is followed by temporary occlusion of the splenic artery by means of a Silastic loop and debridement of the devitalized tissue. Only by dividing the splenorenal and splenocolic ligaments and delivering the spleen together with the tail of the pancreas into the incision can adequate repair of a ruptured spleen be undertaken. The best suture material appears to be 2-0 chromic catgut on an atraumatic straight or curved needle.

After replacing the repaired spleen into its natural bed, always wait 10–15 min and reinspect the spleen to be sure the bleeding has indeed been completely controlled. In some cases a narrow pedicle of viable omentum is placed in a fracture and sutured in place with chromic catgut.

After removing a portion of the spleen, it is not necessary to apply sutures to close the cut end of the spleen if good hemostasis can be achieved by means of hemoclips and suture-ligatures in the splenic pulp. When sutures are inserted, they should penetrate the capsule and then be returned as a mattress stitch. When tying the sutures, take care not to tie them so tightly they rupture the capsule. If proper tension is applied to the knot, bolsters of Teflon, omentum, or Surgicel are often not necessary.

Documentation Basics

- Findings
- Technique of repair/resection
- Other injuries

Operative Technique

Incision

In the unstable patient, make a midline incision from the xiphoid to a point well below the umbilicus. In the stable patient, a midline incision is suitable for the patient with a narrow costal arch. For the wide-bodied patient, make a long left subcostal incision, dividing the muscular layers with electrocautery to speed the operation. A Kehr extension,

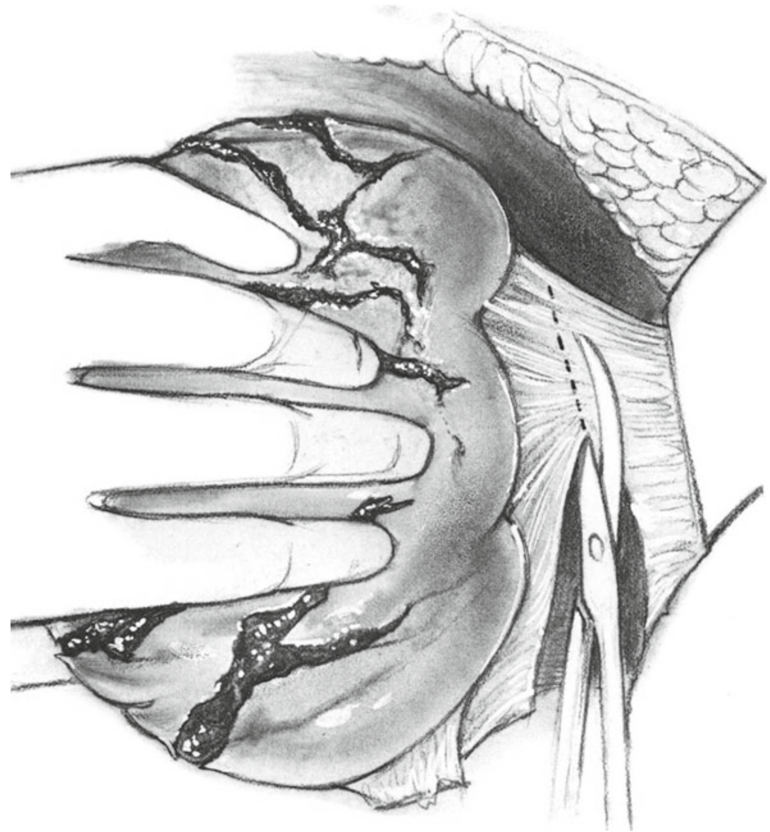

Fig. 97.1

which extends up the midline from the medial tip of the subcostal incision and divides the linea alba to the xiphocostal junction, provides excellent exposure. In both the midline and the subcostal incisions, exposure is further enhanced by retracting the left costal margin anterolaterally and in a cephalad direction by means of the Thompson retractor.

Splenectomy

When the spleen is shattered, the hilus has sustained sufficient damage to separate the spleen from its blood supply, or the patient's condition is unstable, emergency splenectomy is the operation of choice. When performing splenectomy for trauma, it is not necessary to isolate and ligate the splenic artery as a first step (as described in Chap. 96) unless the traumatized spleen is greatly enlarged owing to a preexisting disease.

Take a position on the patient's right and retract the spleen in a medial direction with the left hand. Create a working space by pulling the spleen gently in a medial direction. Then divide the splenorenal, splenophrenic, and splenocolic ligaments (Fig. 97.1). In an emergency situation the experienced surgeon can often perform much of this by blunt finger dissection. After the ligaments have been divided, slide the right hand behind the tail of the pancreas and elevate the tail of the pancreas together with the damaged spleen into the

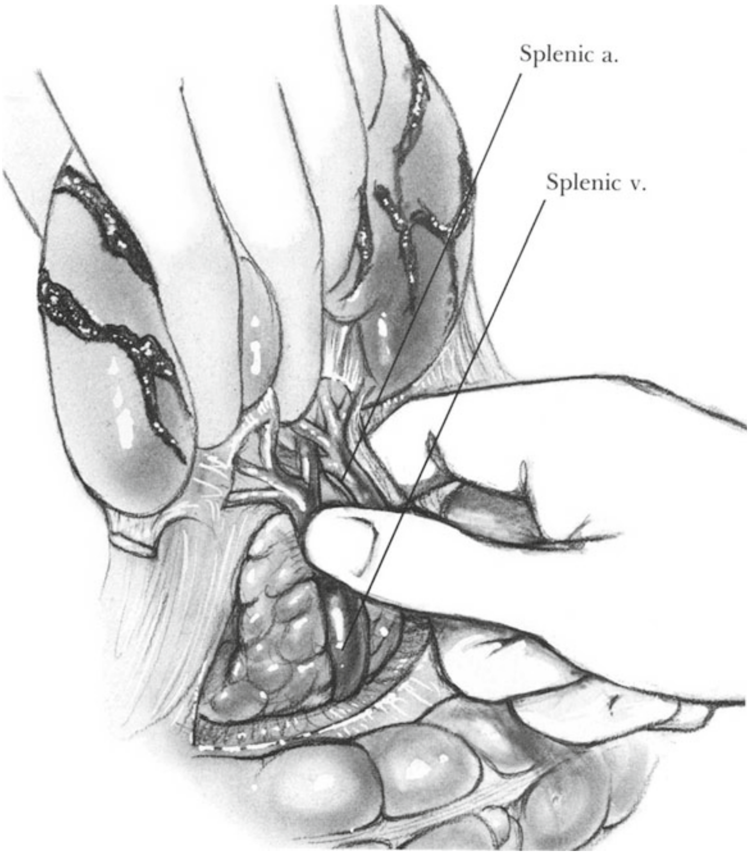

Fig. 97.2

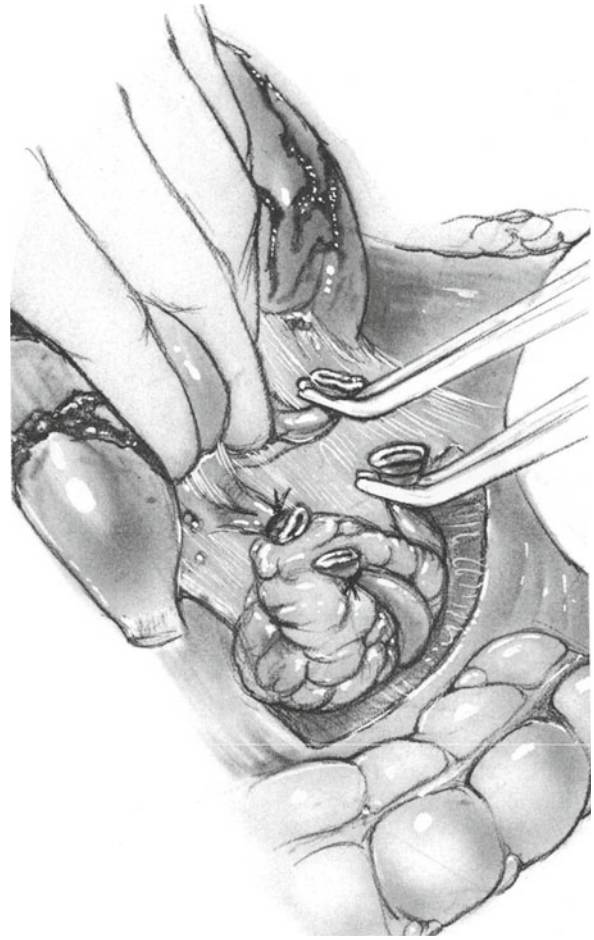

Fig. 97.3

incision. Achieve rapid hemostasis by compressing the splenic artery and vein between the thumb and index finger in the space between the tip of the pancreas and the hilus of the spleen (Fig. 97.2). Pack the posterior abdominal wall with moist gauze pads. Expose the posterior aspect of the splenic hilus and identify the splenic artery and vein. It is generally simple to divide these structures between hemostats or ligatures (Fig. 97.3), which controls most of the bleeding. Now deliberately dissect out each of the short gastric vessels and divide each vessel between Adson hemostats. Remove the spleen and then ligate each of the vessels held by hemostats with 2-0 or 3-0 silk. Be sure to apply a second ligature to the splenic artery for added security and to control the minor bleeding points around the tail of the pancreas with fine suture-ligatures. Finally, remove the gauze pads from the splenic bed and achieve complete hemostasis with ligatures and electrocautery.

With this technique there need not be any haste to obtain hemostasis because early in the operation the surgeon can control most of the bleeding by finger compression at the hilus of the spleen. This avoids hasty dissection, which may traumatize the tail of the pancreas.

Carefully inspect the greater curvature of the stomach. If there is any suspicion that the stomach wall has been injured during the dissection or the ligation of the short gastric vessels, insert Lembert sutures to invert this area of the stomach as shown in Figs. 96.8, 96.9, 96.10, and 96.11.

Splenic Preservation

If the patient is hemodynamically stable and other injuries have been managed or ruled out, splenic preservation may be selected. In this case, fully mobilize the spleen as described above but take great care not to damage the capsule and worsen the injury. In some cases full splenic mobilization may not be necessary (i.e., capsular avulsion during colon resection).

Selecting the Optimal Technique for Splenic Preservation

Avulsion of Capsule; Superficial Injuries

Iatrogenic injury to the spleen during the course of gastric surgery, hiatus hernia repair, or colon resection has constituted the most common single indication for splenectomy in

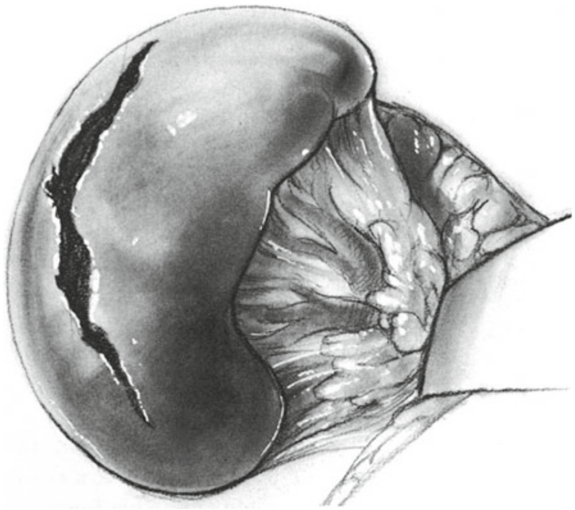

Fig. 97.4

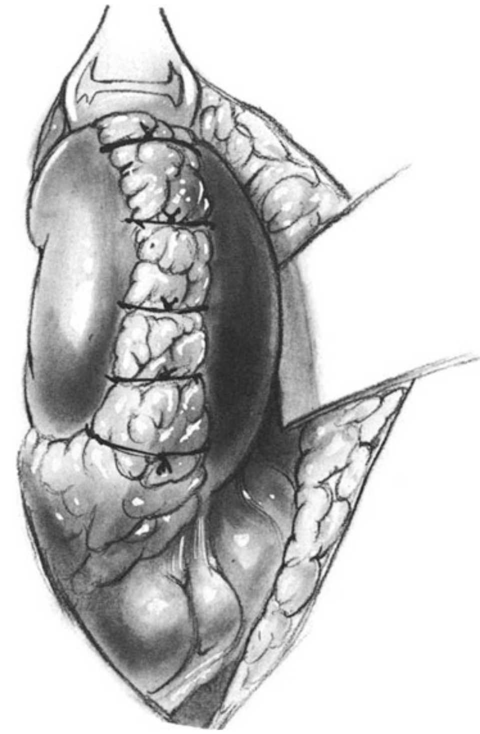

Fig. 97.5

past years. Most of these injuries have involved avulsion of a relatively small patch of splenic capsule. Superficial injuries of this type are best treated by application of topical hemostatic agents (see below) rather than splenectomy. A large subcapsular hematoma, on the other hand, is best treated by incising the capsule, exposing the bleeding points, and applying topical hemostatic agents.

The argon beam coagulator is a noncontact device for applying thermal energy. It is highly effective in controlling minor splenic injuries.

Partial Transverse Fracture

The transverse fracture that does not penetrate the entire thickness of the spleen is a common injury because of the transverse distribution of the splenic blood supply. It is eminently suitable for repair by suturing after hemostasis has been obtained. This technique is described under Splenorrhaphy, below.

Complete Transverse Fracture

When a transverse fracture of the spleen has divided the organ into two or more segments, it is necessary to determine the viability of each segment. This is easily done because the nonviable spleen develops a purple discoloration. Remove the nonviable segments and retain the viable portion of the spleen after achieving hemostasis. Preserving one-third to one-half of the normal spleen is likely to prevent significant diminution of the patient's immune response to infection. The technique for hemisplenectomy is given below. Be sure to identify and ligate the hilar artery that supplied the amputated segment of the spleen.

Longitudinal Fracture

Severe blunt injuries may produce a longitudinal fracture in the long axis of the spleen (Fig. 97.4). Because this fracture may lacerate a large number of the transverse branches of the splenic artery and vein, hemostasis is more difficult than is the case with transverse injuries. After controlling the arterial bleeders with hemoclips and suture-ligatures, the residual oozing can generally be managed by inserting a narrow pedicle of viable omentum and fixing it in place with a series of capsular sutures (Fig. 97.5).

Stellate Fracture

After exploring the depths of the fracture and removing clotted blood, treat the superficial fractures by suturing the capsule. Closing the capsule in this fashion generally controls bleeding from superficial fractures. Alternatively, applying Avitene to the stellate fracture may successfully control all but the arterial bleeders. The efficiency of this topical agent may be enhanced by also inserting capsular sutures. Absorbable mesh wrap is an alternative. Any splenic fracture that significantly involves the hilus of the spleen generally requires partial splenectomy to control hilar bleeding, rather than capsular sutures.

Applying Topical Hemostatic Agents

Most topical hemostatic agents provide a framework for deposition of platelets, which accelerates formation of a blood clot. None of these agents controls rapid bleeding. Consequently, it is necessary to slow down the bleeding from the surface of a damaged spleen by local pressure for a few minutes. If the oozing surface is fairly smooth, apply a double sheet of oxidized cellulose gauze and cover it with a dry gauze pad. Apply even pressure with the gauze pad for 10 min. Then gently remove the gauze pad while taking care not to dislodge the sheet of oxidized cellulose, which should now be adherent to the raw surface.

If the bleeding surface is irregular in nature, Avitene is a much better choice than hemostatic sheets. It is highly effective for oozing surfaces due to traumatized capillaries and venous sinusoids. When applying Avitene, make certain to use only absolutely dry instruments. Use a forceps to apply enough Avitene to cover the entire bleeding surface for a thickness of 3–4 mm. Apply the Avitene quickly and cover it with a dry gauze pad. Apply constant pressure for at least 5 min. If bleeding breaks through one portion of the Avitene, apply an additional layer of dry Avitene. If bleeding continues to break through, remove the Avitene and pursue further efforts to reduce the rate of bleeding by applying hemostatic clips or suture-ligatures. Rapid bleeding causes the Avitene to gel prematurely, making it useless as a hemostatic agent.

Splenorrhaphy

Mobilizing the Spleen

Do not try to repair the spleen without completely mobilizing the spleen and the tail of the pancreas by the technique described above (Fig. 97.1). Be sure to free any attachments between the spleen and omentum. Adequate exposure may also require division of the lower short gastric vessels. Be careful not to cause further injury to the spleen when dividing the splenic ligaments. Evacuate liquid and clotted blood from the area. Place a large gauze pad against the posterior abdominal wall in the area of the dissection and elevate the spleen and tail of the pancreas into the incision. If any of these maneuvers initiates brisk bleeding, compress the splenic artery and vein between the thumb and index finger at the hilus (Fig. 97.2). Ligate any of the small vessels at the hilus that may have been lacerated by the trauma.

Suturing the Splenic Capsule

For fractures that have not penetrated the full thickness of the spleen, remove devitalized tissue and blood clot from the traumatized areas. Use a narrow-tipped suction device to provide exposure and occlude bleeding arteries by accurately applying small- or medium-size hemostatic clips, use 4-0 or 5-0 vascular sutures to control bleeding veins or arteries that have retracted. Control residual oozing of blood from the sinusoids by closing the capsule with interrupted sutures of 2-0 chromic catgut on a medium-size gastrointestinal atraumatic needle, as illustrated in Fig. 97.6. If necessary, insert these sutures in an interlocking fashion. In other cases, a continuous suture of the same material may prove to be effective. When tying these sutures, take great care not to apply force sufficient to tear the delicate splenic capsule. Tie

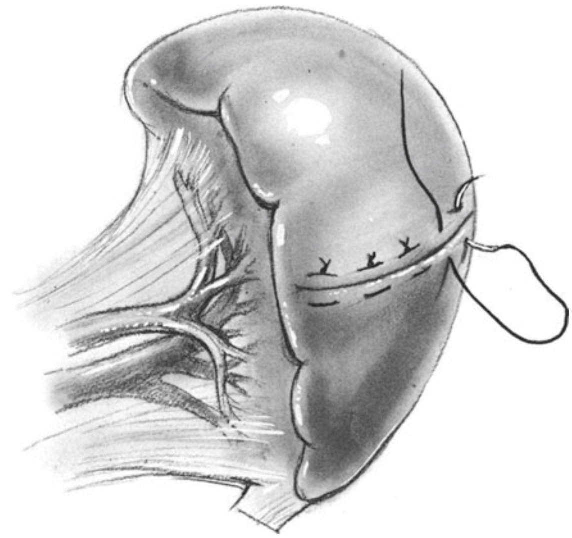

Fig. 97.6

the sutures just tight enough to achieve hemostasis without tearing the spleen. If necessary, use strips or pledgets of Teflon felt, omental pedicle, or even oxidized cellulose gauze; insert the sutures through these pledgets to protect the splenic capsule when the suture is being tied. A linear stapling device may also be used to close the capsule of a small, normal spleen after partial splenectomy.

Absorbable Mesh Wrap

When a spleen is the site of several fractures or the capsule is stripped from a significant part of the surface but the hilum is uninjured, wrapping it with a sheet of PG absorbable mesh after tailoring the mesh and suturing it so it provides even pressure to the damaged spleen may help achieve good hemostasis. Select a large sheet of PG mesh and place it behind the spleen so the edge of the mesh can be gathered around the hilum. Mark the excess, remove it, and cut it to size, leaving at least a 2 cm border all around. With the mesh on a convenient surface away from the operative field, insert a running suture of 2-0 PG around the circumference of the mesh. This suture serves as a purse string to tighten the mesh around the spleen, applying firm, even compression to the splenic pulp without occluding the hilar vessels. Replace the mesh around the spleen. Tie the purse-string suture, taking care not to tighten it around the splenic artery and vein (Fig. 97.7). If the mesh is not tight enough, plicate it with additional sutures at a convenient location. Confirm that all bleeding has been controlled and replace the spleen in its bed.

Partial Splenectomy

Dividing the Spleen

Temporarily occlude the splenic artery with a Silastic loop. Then aspirate all blood clots from the area of injury, especially at the splenic hilus. Ligate the traumatized vessels at

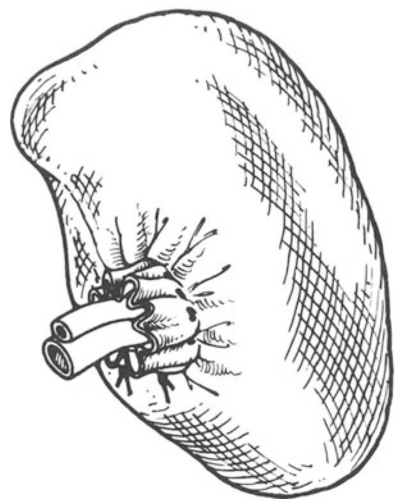

Fig. 97.7 (From Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 2009, with permission)

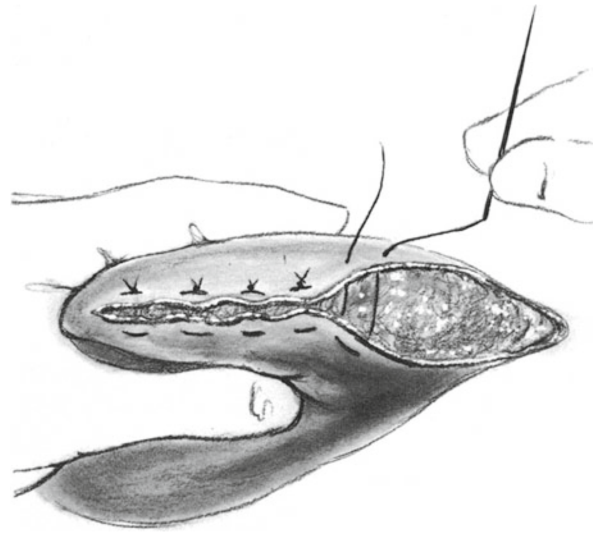

Fig. 97.8

the hilus, preserving the blood supply to the portion of the spleen that is to be retained. Release the splenic artery, observe for a line of demarcation, and mark it with electrocautery along the capsule. Secure the splenic artery again if necessary to limit blood loss.

Use a narrow-tipped suction device to expose the bleeding points in the line of the fracture. Use the suction tip to develop a transverse division of the spleen. Apply small hemostatic clips to bleeding vessels and continue the dissection until the traumatized section of the spleen has been entirely severed. Remove the specimen. Then release the Silastic loop encircling the splenic artery and observe the cut edge of the splenic remnant for hemostasis. Generally, some oozing persists, requiring suturing of the cut end of the spleen. Use 2-0 chromic catgut on an atraumatic needle (Fig. 97.8). Although their use is not often necessary, it is possible to protect the delicate splenic capsule by applying a strip of Teflon felt on the anterior surface of the spleen and a second strip on the posterior surface. Then insert the sutures through the Teflon felt as shown in Fig. 97.9. Tie each of these mattress sutures. This maneuver achieves satisfactory hemostasis along the cut edge of the spleen.

Replace the splenic remnant in its natural position after making certain that hemostasis is complete in the posterior abdominal wall and the splenic bed. Use electrocautery along the posterior abdominal wall; but if there are bleeding points in the tail of the pancreas, occlude these bleeding points with 4-0 or 5-0 suture-ligatures.

Do not close the abdominal incision for at least 10–15 min so the splenic remnant can be inspected after it has been replaced in the abdomen. Use this time to double-check for other injuries. If there is any bleeding, again deliver the remnant of the spleen into the abdominal incision and control the bleeding.

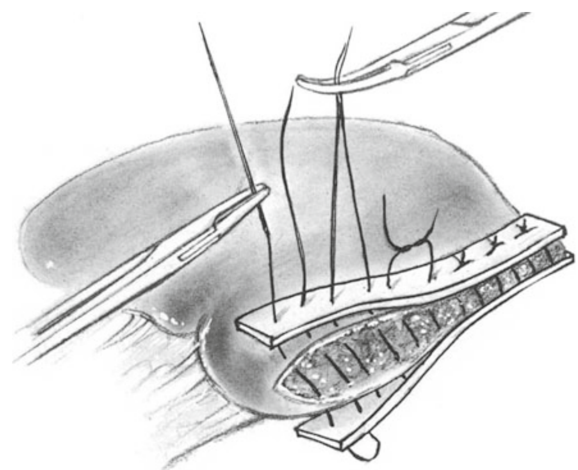

Fig. 97.9

Abdominal Closure and Drainage

Close the abdominal incision in the usual fashion without drainage. If continued hemorrhage or injury to the pancreas is suspected, place a closed-suction drain in the vicinity of the splenic bed.

Postoperative Care

Administer perioperative antibiotics for 12–24 h. Observe the patient in an intensive care unit or in another area where vital signs can be carefully monitored for 2–3 days. Follow the vital signs and the hemoglobin or hematocrit to exclude continued bleeding. If a drain was placed, remove it by the second postoperative day.

Keep the patient at bed rest for the first day or two. Thereafter cautiously resume ambulation. Patients who have had a splenorrhaphy or partial splenectomy should avoid vigorous athletic activity for 4–6 weeks.

If a patient has undergone total splenectomy, be certain that the patient and the family are aware of the risks of overwhelming postsplenectomy sepsis. The patient should wear a MedicAlert bracelet recording the fact that he or she has undergone splenectomy. Administer Pneumovax and vaccines for meningococcus and *Hemophilus influenzae*. Young children should receive prophylactic penicillin throughout childhood. It is not clear if prophylactic antibiotics are indicated during adult life.

Complications

Postoperative bleeding. If proper hemostasis has been attained during the operation, this complication is rare.

Infarction of the splenic remnant.

Further Reading

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98 Laparoscopic Splenectomy

Manish Parikh and H. Leon Pachter

In most major centers, laparoscopic splenectomy is the preferred method of elective splenectomy in all patients except for those with massive splenomegaly. The most common indication for elective splenectomy is autoimmune (idiopathic) thrombocytopenic purpura (ITP). Splenectomy typically leads to normalization of platelet count in 65–85 % of patients long term. Other hematologic indications include hereditary spherocytosis, myeloproliferative disorder (chronic and acute myeloid leukemia), and autoimmune hemolytic anemia. Occasionally elective splenectomy is performed to palliate myelofibrosis or for staging for Hodgkin's disease.

Although laparoscopic splenectomy can be performed in select situations of splenic trauma, generally the laparoscopic approach is contraindicated in emergent situations such as hemorrhagic shock secondary to splenic trauma, due to the extra time required to set up laparoscopy and position the patient and the inability to pack the patient effectively to gain rapid control of bleeding.

Indications

Laparoscopic splenectomy has been used in essentially all situations for which removal of the spleen is indicated. The most common indications include:

- Autoimmune thrombocytopenic purpura (formerly termed idiopathic thrombocytopenic purpura, ITP)
- Hemolytic anemias (hereditary spherocytosis, autoimmune hemolytic anemia)
- Felty's syndrome
- Hematologic malignancies
- Hemoglobinopathies
- Splenic abscess

Preoperative Evaluation and Preparation

The preoperative abdominal exam is important to estimate spleen size (in cases of splenomegaly). Preoperative computed tomography (CT) can determine the exact size of the spleen, which facilitates operative planning. Massive splenomegaly (>25 cm) may change the operative approach to either anterior with 45° tilt or hand-assist (or supine laparotomy). CT does not reliably detect accessory splenic tissue, and therefore it is important to explore for accessory spleen(s) at the outset of the surgery. Pneumococcal, meningococcal, and *Haemophilus influenza type B* vaccines should be administered at least 2 weeks preoperatively. Immunosuppressed patient may also benefit from immunization against hepatitis B.

Close communication with the hematologist is important. In certain situations in ITP patients (particularly if platelet count is below a certain threshold), immune globulin (2 g/kg body weight intravenous divided into two doses) is given 48 h preoperatively. IV antibiotics (first-generation cephalosporin) are frequently used for prophylaxis. In ITP patients with platelet count under 50,000, platelet transfusion is on standby and may be administered, if needed, once the splenic artery is ligated.

Pitfalls and Danger Points

As with open splenectomy, bleeding is a major concern with the laparoscopic approach. Splenic tissue can implant on peritoneal surfaces, and the resulting splenosis may cause a

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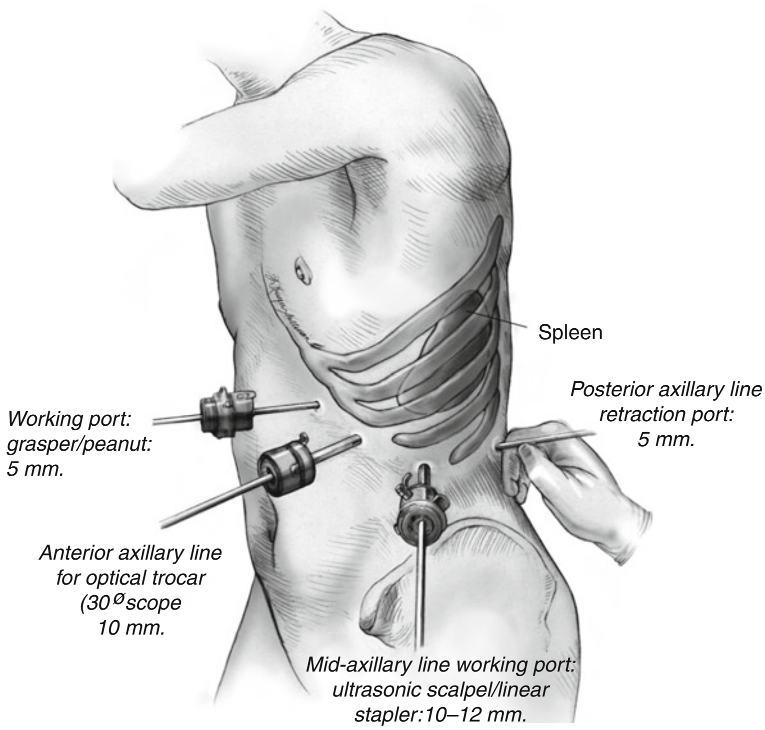


Fig. 98.1 (© Lianne Krueger Sullivan)

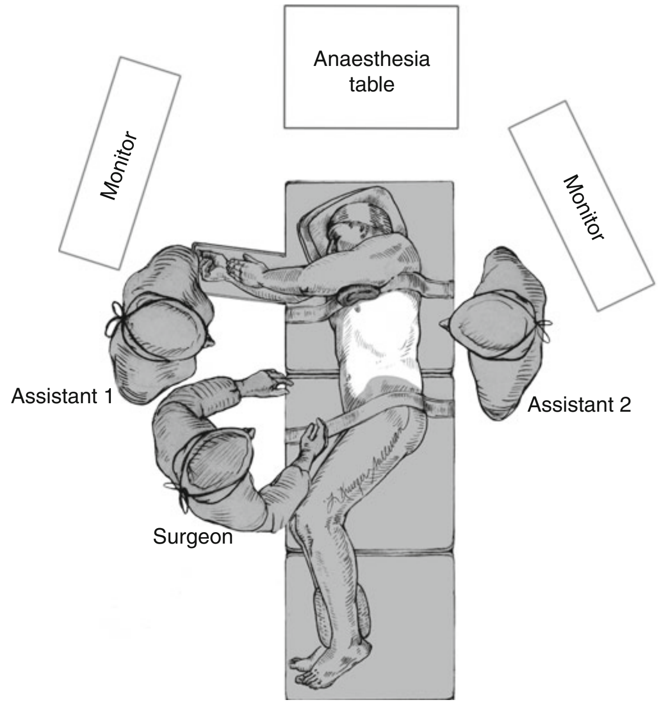


Fig. 98.2 (© Lianne Krueger Sullivan)

recurrence of hematologic problems; therefore gentle handling is essential. Careful search for accessory spleens is also mandatory to avoid recurrence.

Operative Strategy

For all but the very largest spleens, the patient is positioned in the right lateral decubitus position (the so-called "hanging spleen" maneuver). This is in contrast to the usual series of steps for open splenectomy. The spleen is exposed but allowed to hang from its posterior peritoneal attachments. A careful search for accessory spleens is made as the gastrosplenic ligament (including the short gastric vessels) and splenoclic ligaments are divided with the harmonic scalpel. The advantages of this position are that very little, if any, actual retraction of the spleen is required; trauma to the spleen is therefore minimized; and stomach, colon, and small bowel naturally fall medially out of the field of view after division of these ligaments. The posterior ligaments and hilar vessels are then divided. The spleen is placed in a sturdy retrieval bag and morcellated.

As with open splenectomy, careful search for accessory spleens is mandatory.

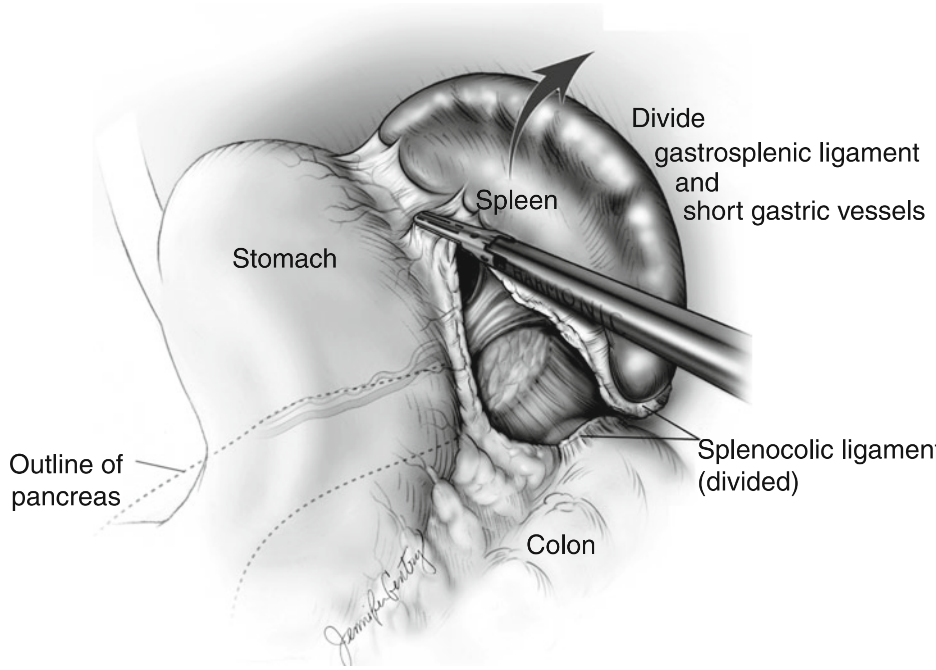
Operative Technique

For elective situations, the surgeon's experience determines the point at which the enlarged spleen is "too large" to remove laparoscopically.

The lateral approach is the most widely used patient position for laparoscopic splenectomy. Position the patient in the lateral decubitus position with the left side up. Place a beanbag under the right flank and a protective roll under the right axilla. The left arm is extended. Flex the table so as to hyperextend the left side, in order to maximize the space between the left costal margin and iliac crest (the flank muscles should appear taut). Secure the patient's torso and legs to the table with 2-in. cloth tape.

The surgical prep extends from the nipple to the anterior superior iliac spine and from the umbilicus to the spine posteriorly. The surgeon and assistant stand on the right side of the patient and the second assistant on the left (Fig. 98.1). An orogastric tube is placed to decompress the stomach. We prefer the open technique to access the abdomen 2 cm below and parallel to the costal margin, just medial to the left anterior axillary line (Fig. 98.2). Once the peritoneal cavity has been entered under direct vision, place a 10-mm trocar and insufflate to 15 mmHg.

Fig. 98.3 (© Jennifer Gentry)



Introduce a 10-mm 30° laparoscope and perform a diagnostic laparoscopy. Place a second 10-mm trocar under the eleventh rib at the midaxillary line, also parallel to the costal margin. Place a third 5-mm trocar medial and anterior to the first trocar, along the midclavicular line and lateral to the rectus muscle. Ideally, all trocars should be at least 5 cm apart to avoid crossing of instruments. If needed, place a fourth 5-mm trocar at the costovertebral angle after the splenic flexure has been mobilized.

It is important to search for accessory spleens at the outset of the case. Using a laparoscopic peanut in the surgeon's left hand for retraction and the ultrasonic scalpel in the surgeon's right hand, mobilize the splenic flexure inferomedially. If needed for extra retraction, place the fourth 5-mm trocar dorsally at the costovertebral angle.

Next, enter the lesser sac and divide the gastrosplenic ligament (including all the short gastric vessels) with the ultrasonic scalpel (Fig. 98.3). It is a good idea to turn the blade of the scalpel so the thermal blade is anterior to avoid inadvertent thermal injury to the splenic hilum, which is posterior.

Next incise the splenorenal and splenophrenic ligaments until the left crus of the diaphragm is visualized (Fig. 98.4). Take care to avoid inadvertent injury to the stomach in this area.

Now, attention can be turned to the splenic hilum. The spleen can be gently elevated to identify the hilar structures as shown in Fig. 98.5. Note how the shaft of a grasper is used as an atraumatic retractor. Avoid grasping the spleen lest splenic capsule tears (with bleeding and potential to seed the peritoneal cavity with splenic tissue) result. Many patients have a pancreas that abuts the hilum, and care must be taken to dissect the tail of the pancreas from the hilum.

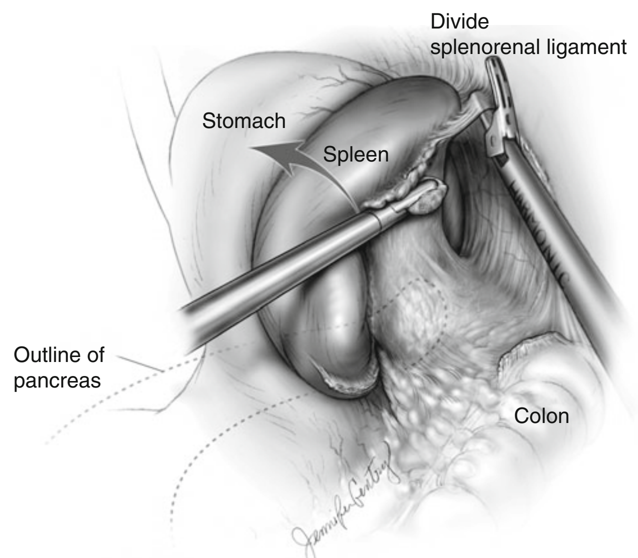


Fig. 98.4 (© Jennifer Gentry)

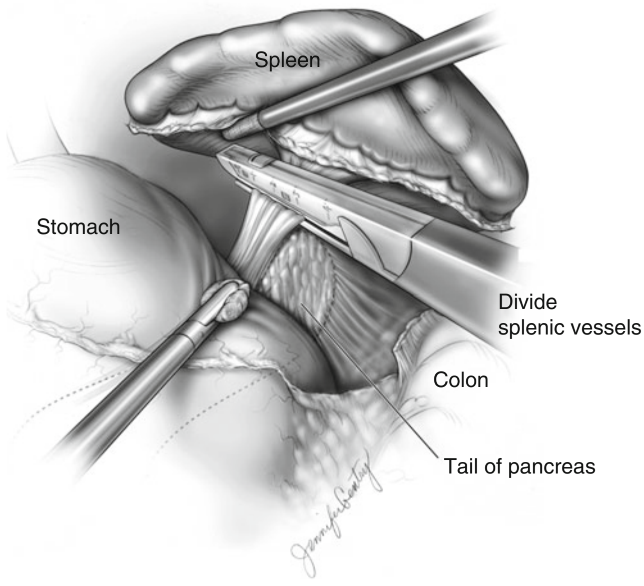


Fig. 98.5 (© Jennifer Gentry)

Once the hilum is separated from the tail of the pancreas, a 10-mm right-angle dissector is a good device to dissect the splenic vein and artery. We prefer to avoid clips in this area, because clips can interfere later with stapler transection. Our preference is to divide the vessels individually, if feasible, with a vascular load stapler. Some surgeons prefer preligation of the splenic artery with 0-silk suture; this permits platelet administration in ITP patients before hilar dissection has started. Alternatively, the hilum can be divided en masse with the vascular stapler (Fig. 98.5).

The spleen is then removed with an Endo-Catch bag. Often a 15-mm Endo-Catch bag will be needed depending on the size of the spleen. Take care not to injure the spleen during this stage. The stump of the hilar vessels provides a convenient "handle" that may be grasped to atraumatically manipulate the spleen into the bag. Pull the opening of the bag out through the trocar site. Morcellate the spleen with ring forceps (Fig. 98.6).

Check the field for hemostasis. Close all trocar sites over 5 mm in the usual fashion. Usually Jackson-Pratt drains are unnecessary unless there is a concern for pancreatic injury.

Special Consideration: Massive Splenomegaly (>25 cm)

Frequently in cases of massive splenomegaly, the anterior approach is used (patient in split-leg position, rotated 45° to the right) instead of the lateral decubitus approach. The typical challenges in massive splenomegaly are adequate retraction of the spleen to expose the hilum (addressed by extra trocars including one in the left lower quadrant specifically for 10-mm fan liver retractor to retract the spleen) and

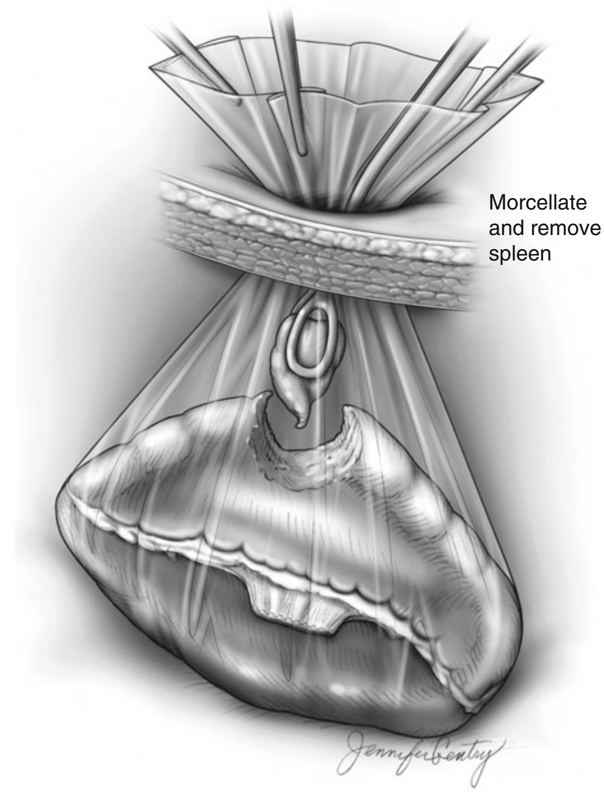


Fig. 98.6 (© Jennifer Gentry)

specimen extraction since the 15-mm Endo-Catch bag is not large enough. The LapSac® (Cook Medical, Bloomington, IN) or even a sterilized freezer bag may be useful in these scenarios. An alternative surgical strategy is using a hand-assist approach to aid in retraction of the spleen.

Preoperative splenic artery embolization has been described in cases of massive splenomegaly to facilitate laparoscopic splenectomy or hand-assist laparoscopic splenectomy. However we do not routinely practice this; our preference in these cases is to preligate the splenic artery once entering the lesser sac (and prior to hilar dissection).

Laparoscopic Management of Splenic Cysts

Indications for surgery for splenic cyst are usually determined by patient's symptoms and cyst size. Typically asymptomatic nonparasitic cysts <5 cm resolve spontaneously. For symptomatic cysts, percutaneous drainage should be avoided because of the high recurrence rate. Surgical options include complete or partial splenectomy, unroofing of the cyst, and fenestration. Generally these cysts can be unroofed laparoscopically. The patient position and trocar placement are similar to laparoscopic splenectomy described above. The key surgical maneuver is to excise a sufficient portion of the cyst wall to prevent recurrence.

Postoperative Care

Clear liquids can be started the same evening or the next morning, depending on the clinical scenario. Patients are usually discharged home by the first or second postoperative day. Ketorolac (nonsteroidal anti-inflammatory) is an effective pain medication especially for pain at the specimen extraction site.

Complications

Bleeding
Subphrenic abscess
Injury to pancreas
Injury to stomach or colon
Missed accessory spleen
Venous thrombosis

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Part X

Hernia Repairs, Operations for Necrotizing Fasciitis, Drainage of Subphrenic Abscess

Concepts in Hernia Repair, Surgery for Necrotizing Fasciitis, and Drainage of Subphrenic Abscess

99

Daniel P. Guyton and Mark C. Horattas

From a historical perspective repair of inguinal hernia in adults is one of surgery's most ancient and vexing problems. Today with approximately 750,000 operations performed annually, the associated medical and socioeconomic costs continue to fuel interest in this mechanical problem which, most likely, will not abate as population demographics and general surgery workforce issues move in opposition (Rutkow 2003; Valentine et al. 2011). According to the most recent 10-year update on surgical workloads by the American Board of Surgery, general surgeons perform approximately 87 % of "hernia" operations, while surprisingly those surgeons with additional board certification in surgical subspecialties perform the balance. As fellowship training becomes integrated into a shortened general surgical residency education, it is unclear if these subspecialists will possess the necessary skills to continue this practice (Etzioni et al. 2003). The gap between patient needs and availability of surgeons who can address these problems may widen. Issues such as patient selection, operative technique, choice of prosthetic material, disability, and cost will only become magnified.

Patient Selection

Next in this concept chapter we raise a challenge to one of the most fundamental questions regarding inguinal hernia and its treatment: Should all patients with groin hernia undergo elective repair? For generations, the answer to this question had been an emphatic yes with the exception being patients with significant medical morbidities. The intuitive thought behind this dictum was that elective repair under controlled circumstances was far safer than the alternative, that is, to wait and operate urgently in the face of potential serious complications of bowel incarceration or strangulation. In particular with surgery performed on an ambulatory basis and, in many parts of the country, freestanding hernia centers, the elective operation is associated with low morbidity making elective repair even more advisable. This thought was so ingrained that few, if any, studies ever challenged this concept. Fortunately, we have randomized prospective trials which have been conducted and now can offer our patients a specific answer to this question. The American College of Surgeons study of inguinal hernia management – watchful waiting versus operation – was completed over a 2-year period. Men with asymptomatic or minimal symptoms of inguinal hernia were randomized to watchful waiting or to elective surgery. For these men with minimally symptomatic hernias watchful waiting was found to be an acceptable option and contradicted the above commonly held belief that nonoperative approaches to inguinal hernias result in higher risk of bowel incarceration. The frequency of acute hernia problems was rare: 1.8/1,000 patient years (Fitzgibbons et al. 2006). However, the crossover rate to surgery was 23 %. Given this high crossover rate, specific patient characteristics have been identified which may portend an end to watchful waiting. These are severe pain accompanying strenuous activity, the presence of constipation, and the presence of prostatism and marital status (Sarosi et al. 2011). In our practice, the majority of patients who elect to proceed with surgery or fail a nonoperative approach do so because of ongoing or increased discomfort or pain which limits their daily activities. Since the risks and benefits of surgery can vary between patients, it is important to approach hernia management taking into account the individual's presentation, comorbidities, occupation, and daily routine.

Selection of Anesthesia

Elective operation in men or women may be performed under local, regional or epidural, or general anesthesia. Each has its distinct advantages or disadvantages and should be

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tailored to the comfort of the patient and surgeon. In practice, the choice tends to be based on community experience. Local anesthetics consisting of lidocaine or bupivacaine are readily available, easy to use, and well tolerated; they also have a markedly reduced incidence of postoperative headache, nausea, and vomiting.

If general anesthesia is chosen, it may be administered using a laryngeal mask airway (which does not require ventilatory support or muscle paralysis), thus maximizing patient comfort. An endotracheal tube is preferred when faced with an emergent operation such as incarceration where the bowel may require manipulation. Additionally, a general anesthetic is necessary when the repair is performed laparoscopically. After using all three anesthetic techniques extensively, our surgeons now prefer general anesthesia administered via a laryngeal mask airway. In addition to patient comfort and a quiet operative field, the absence of muscle relaxants with this technique allows accurate assessment of tissue tension.

Perioperative Antibiotics

Recent meta- and Cochrane analysis of wound infection and the use of prophylactic antibiotics for elective inguinal hernia repair report confusing results (Sanchez-Manual et al. 2007; Sanabria et al. 2007). We tailor the perioperative use of antibiotics to the specific patient situation. Antibiotics are given for those at high risk for wound infection such as diabetes or those on immunosuppressive agents. With the use of an alcohol-based skin preparation, universal administration of antibiotics is probably not beneficial for the prevention of wound infection.

Which Operation for Which Hernia?

Inguinal hernias are broadly classified as direct (i.e., a weakness in the transversalis fascia within Hesselbach's triangle) or indirect (a weakness in the internal inguinal ring associated with a patent processus vaginalis). Usually this distinction is not readily or accurately accomplished preoperatively and is finalized during the operation itself. Always inspect all three potential hernia sites (including femoral) when operating for a groin hernia, as a common cause of recurrence is failure to repair all defects. A femoral hernia occurs through a defect in the femoral canal, lateral to the lacunar ligament and medial to the femoral vein.

In adults the operative repair selected is based on the surgeon's experience and training and should be individualized as much as is feasible. Additionally, hernia repair represents a prime opportunity for each surgeon to analyze his or her individual rates of recurrence, postoperative complications, and resultant disability – key factors consistent with the provision of excellent professional advice. As implied earlier, the range of operative choices available for groin hernia repair is broad and is described in the chapters which follow. This chapter reviews pros and cons of primary repair, mesh or tension-free repair, and repair using laparoscopic techniques.

Primary Repair

Primary repair remains the preferred technique in the presence of contamination from incarcerated or strangulated intestine when avoidance of prosthetic mesh is desired. In women, when the round ligament is removed and the residual defect is small, primary repair with interrupted sutures can be readily accomplished without mesh and without a great deal of tension. For an adolescent boy, primary suture repair for a weakened internal ring is also appropriate. Primary repair may be accomplished using the Bassini, McVay, or Shouldice technique. The Bassini method is mentioned only for its historical context and relative simplicity. It was the first technique that led to a marked reduction in both operation mortality and recurrence. The basic technique involves recreating the floor of the inguinal canal. Bassini accomplished this with interrupted sutures sewing Poupart's ligament to the lateral border of the internal oblique or conjoined tendon. Any peritoneal sac underwent high ligation after opening to ensure the reduction of its contents and to check for a femoral component. The Shouldice technique, developed in the Shouldice Clinic in Toronto, incorporates complete dissection and reconstruction of the inguinal floor. It is tension free as the repair utilizes the opened and healthy transversalis fascia imbricated in layers over one another. Four layers of suture are placed to incorporate the transversalis, iliopubic tract, femoral sheath, and inguinal ligament. Data from the Shouldice clinic attests to the excellent long-term results coupled with minimal postoperative disability. McVay's repair is predicated on a detailed study of the anatomy of the inguinal region he performed as a surgical resident. He postulated that the central factor accompanying groin hernia was a weakened posterior floor. To remedy this problem, his method incorporates suturing the transversus abdominis to Cooper's ligament. A transition stitch is placed in the femoral sheath. McVay also popularized the concept of a relaxing incision created in the external oblique aponeurosis at its fusion with the anterior rectus sheath. The purpose was to reduce excessive tension away from the actual repair. This concept of tension and its avoidance is central to all repairs using prosthetic mesh.

Prosthetic Mesh Repair

Currently in the United States, mesh repair by the Lichtenstein technique using a precut piece of Marlex mesh or Rutkow's mesh "plug" is increasingly becoming the most popular method. Repair of groin hernias utilizing any type of prosthetic mesh relies on the mesh to first bridge the inguinal defect and then to incite a foreign body reaction with the native tissue. Both are straightforward technically and associated with low postoperative disability and a low (reportedly less than 1–4 %) incidence of recurrence. The common strategy with either method is the concept of minimal tissue dissection, anchoring the mesh with sutures, and encouraging early ambulation and return to employment. The Lichtenstein repair is remarkably free of postoperative complications. There have been several reports of "plug" migration into the abdominal cavity leading to a small bowel obstruction. Note that Gore-Tex mesh minimizes the foreign body reaction. That is useful elsewhere in the body but not in the groin where a firm scar is welcomed. Absorbable mesh has no role in the repair of inguinal hernia.

Laparoscopic Technique

Inguinal hernia may be repaired laparoscopically. However, of all laparoscopic techniques, repair of groin hernia has the steepest learning curve. The anatomy is new (and often confusing), requiring participation in 40–50 operations before a surgeon becomes experienced. Reported series consistently note a high (approaching 10 %) incidence of recurrence during the surgeon's initial operative experience. Two methods are in wide use: the totally extraperitoneal approach (TED) and the transabdominal preperitoneal (TAPP) approach. They are based on reconstruction of the weakened posterior abdominal wall. This is the one method of repair where complications can be catastrophic. Yet in the hands of experienced laparoscopic surgeons, excellent results are achieved. Proponents consistently report low disability and early return to work or fully normal activities. As the definition of postoperative disability is expanded, laparoscopic repair may be more widely utilized. This approach may evolve into the preferred technique for bilateral hernias or for a difficult recurrence, although issues of increased resource expenditure remain unresolved.

Repair of Femoral Hernia

In contrast to inguinal hernias, always repair any femoral hernia. The anatomic defect is narrow and there is a high incidence of incarceration. When a femoral hernia is diagnosed preoperatively, the surgeon has three operative approaches: low inguinal, high inguinal, or preperitoneal via a low midline incision. We favor a preperitoneal exposure if strangulation is suspected for conversion to a midline laparotomy is easily completed. For elective repair of femoral hernia, use of a 2×10 cm polypropylene mesh rolled into a tubular shape and secured by suture into the femoral defect has allowed excellent results with minimal disability (Shulman et al. 1992).

Repair of Recurrent Inguinal Hernia

When faced with a recurrent inguinal hernia in a man, the surgeon must avoid inadvertent transection of the vas deferens and devascularization of the testis. These problems are best avoided using careful slow dissection in a bloodless field. Both the internal inguinal ring and the pubic tubercle should be inspected as recurrence is common in these regions. Once identified, the recurrence may be easily repaired using the mesh "plug" that is carefully anchored to the usually rigid surrounding tissues. The laparoscopic approach avoids this occasionally difficult exposure.

Repair of Large Ventral Hernias

Repair of non-inguinal abdominal hernias is performed more than 200,000 times in the United States annually. Although ventral hernia disease is a common problem, there is no consensus on the best approach. Factors such as hernia location, size, etiology, and patient characteristics all are important in management. Standard concepts in any hernia surgery are particularly worth reemphasis including utilization of mesh reinforcement, selecting the appropriate procedure, minimizing tension of the repair, and patient selection. Non-prosthetic hernia repairs are associated with high recurrence rates and mesh reinforcement is generally utilized uniformly. Prosthetic material can be classified into several subtypes with unique attributes and applications. Nonabsorbable meshes include polypropylene (i.e., Marlex) and polyester (i.e., Parietex). These permanent meshes cause significant fibroblastic reaction and intra-abdominal contact with bowel should be avoided to prevent fistulization. Polytetrafluoroethylene (i.e., Gore-Tex) or dual layer type meshes have the benefit of minimizing adhesion formation with intestines and can be utilized for intraperitoneal onlay hernia repair as done with a laparoscopic approach. Many different commercially available synthetic materials for hernia repair are available and work in a similar fashion to keep the fibroblastic reaction to the side of the hernia repair and minimize any intra-abdominal problems and are primarily utilized in this scenario. When the risk of infection is significant biologic prosthetics may be appropriate. These grafts are derived from human, porcine, or bovine sources. Many different types are commercially marketed and generally are much more expensive than standard meshes. They are designed to provide an extracellular matrix for neovascularization and promote vessel ingrowth. In selection of the repair, the placement of the mesh can be considered to be an overlay (onlay), underlay (preperitoneal, intermuscular, retrorectus) or inlay. Securing the mesh to the edges as an inlay has higher rates of recurrence presumably related to inadequate overlap to the tissue laterally and insufficient fixation. Onlay repairs are commonly done, but associated with higher wound complications due to the need for wide undermining of the skin and subcutaneous tissue. Sublay or retromuscular placement of the mesh requires additional effort in placement, but has the advantage of potentially being more successful.

A number of fascial relaxation techniques have been described. The most common involves component separation of the abdominal musculature, allowing medialization of the rectus muscle. A longitudinal incision is made along the medial aponeurosis of the external oblique approximately 2 cm lateral to the rectus muscle. After separating the external oblique muscle from the internal oblique, significant reduction in the tension can result. Additional relaxation can be achieved by adding a longitudinal incision along the posterior rectus fascia as well (Shulman et al. 1992).

Laparoscopic ventral herniorrhaphy with mesh is another effective tension-free approach that may be particularly helpful in certain situations as well. Patient selection is also important in successful ventral hernia surgery. Patients who smoke are at increased risk of postoperative complications. Cotinine can be measured on the morning of surgery to insure smoking cessation. Other risk factors include obesity, pulmonary disease, wound healing problems, immunocompromised status, and being malnourished. Patients who have massive hernias with loss of abdominal domain may not physiologically tolerate repair of their hernia. Patients with ascites or potential bacterial contamination with fistulas or a stoma can be particularly difficult to repair as well. Appropriate informed consent in patients with increased risk factors should also highlight their increased risks of recurrence and associated potential wound problems.

Necrotizing Fasciitis

An unusual but potentially serious and life-threatening complication, necrotizing fasciitis requires early detection, urgent operation, and fearless debridement of any suspected involved tissue. Intraoperative gram stain and cultures are imperative along with the administration of broad-spectrum antibiotics. Re-exploration at 24 and 48 h is often necessary. Temporary closure of the abdominal wall using absorbable mesh can provide an excellent bridge until resolution is complete. More recently we have applied a Wound-Vac after the acute infection subsides and have found this to facilitate wound management and healing (see Chap. 8). We are reluctant to place permanent mesh in the acute situation.

Subphrenic Abscess

Most subphrenic abscesses are amendable to image-guided percutaneous drainage. If this technique is technically not feasible or is unsuccessful, an operative approach becomes necessary. The key points emphasized in Chap. 108 (a surgical legacy technique chapter) remain salient.

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100 Shouldice Repair of Inguinal Hernia

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

The Shouldice repair remains the best autologous tissue (non-mesh) repair for direct hernias.

Although some hernias can be safely observed, symptomatic direct and indirect hernias should be repaired to avoid risk of incarceration.

With the use of local anesthesia, systemic disease is rarely so serious it constitutes a contraindication to operating. Small, nonsymptomatic direct inguinal hernias in elderly patients do not require surgery because they almost never produce strangulation. Direct hernias that produce symptoms, on the other hand, should be repaired.

Preoperative Preparation

Persuade obese patients to lose weight prior to surgery. (Fat interposed between sutured layers of fascia impedes healing.)

Pitfalls and Danger Points

Injury to femoral vessels during suturing
Injury to bladder (especially with a sliding hernia)
Injury to colon (especially with a sliding hernia)
Injury to deep inferior epigastric vessels with postoperative retroperitoneal bleeding
Injury to ilioinguinal nerve

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Operative Strategy

Anesthesia

For inguinal hernia repair, local field block anesthesia is preferred. Patients are ambulatory the afternoon of operation and are able to resume a normal diet the same evening. Overdistension of the anesthetized bladder by intravenous fluids often follows the use of general anesthesia and is a major cause of postoperative urinary retention. Relief requires bladder catheterization, which in some cases of borderline prostatism necessitate prostatectomy after the hernia repair. Urinary retention is avoided with local anesthesia because it does not obtund the patient's sensation of a full bladder or the ability to urinate.

Local anesthesia does not mean that no attention is paid to the patient by anyone other than the operating team. We require that either an anesthesiologist or a nurse sit at the head of the table to monitor vital signs. Although local anesthesia allows us to manage most incarcerated hernias successfully, general anesthesia with endotracheal intubation is indicated whenever strangulation of bowel is suspected.

Avoiding Injury

The *iliac or femoral vein* may be injured by blindly inserting a suture too deeply through the iliopubic tract or the inguinal ligament during the lateral portion of the repair. If this should occur, cut the needle off and remove the suture. Then apply pressure to the vein for 5–10 min. This maneuver often avoids the need to expose the iliac vein and suture the bleeding point.

Occasionally, serious postoperative *preperitoneal hemorrhage* has been produced by injuring one of the deep inferior epigastric vessels with a deep suture. During the Shouldice technique prevent this problem by completely dissecting the

†Deceased

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transversalis fascia away from these structures after dividing the external spermatic vessels.

The *bladder* may be injured when attempting to amputate a sac in a sliding inguinal hernia. Overenthusiastic dissection on the medial aspect of an indirect sac for the mistaken notion that the higher the ligation the better may also traumatize the bladder. If a laceration of the bladder has been identified, close the defect by suturing the full thickness of the bladder wall with a continuous 3-0 PG atraumatic suture. Then invert this layer of stitches with a second continuous or interrupted layer of 3-0 PG Lembert-type sutures. Be sure the bladder remains decompressed for the next 8–10 days by means of constant drainage with an adequate indwelling Foley catheter.

Colon and bladder may be injured if the sliding nature of an inguinal hernia is not diagnosed early in the course of operation. Whenever a bulky indirect inguinal hernia is not accompanied by a thin-walled, transparent sac, suspect a sliding component.

All of these inadvertent injuries can be avoided by taking advantage of the extensive exposure that may be attained by a long incision in the transversalis fascia when using the Shouldice method. The deep inferior epigastric vessels and their branches, the iliac vessels, the peritoneum, and in case of a sliding hernia the colon are all easily identified. Visualizing these structures is the best way to prevent damage.

Avoiding Postoperative Wound Infections

Among the patients who suffer a postoperative wound infection, 40–50 % develop a recurrent hernia. The rate of infection can be minimized during hernia repair if the entire operation is performed with careful, sharp dissection. Meticulous hemostasis is also important. Irrigate the operative site to remove any blood or debris before closure. Some surgeons add topical antibiotics to the irrigation. Wound infection should be rare after this operation.

Documentation Basics

- Findings
- Quality of floor
- Presence or absence of incarceration

Operative Technique

Local Anesthesia

Use a mixture of equal parts of 0.5 % Marcaine and 2 % Nesacaine. Create a field block by injecting into the subcutaneous tissues along the lines shown in Fig. 100.1a. Inject also along the line of the incision. A total of 40 ml of anesthetic solution is required.

After making the skin incision and exposing the external oblique aponeurosis, inject another 10 ml just underneath this layer (Fig. 100.1b). Also inject the abdominal musculature along a line 5 cm cephalad to the inguinal canal. This step improves muscle relaxation for the repair. Inject 5 ml around the internal ring (Fig. 100.2a). When the peritoneal

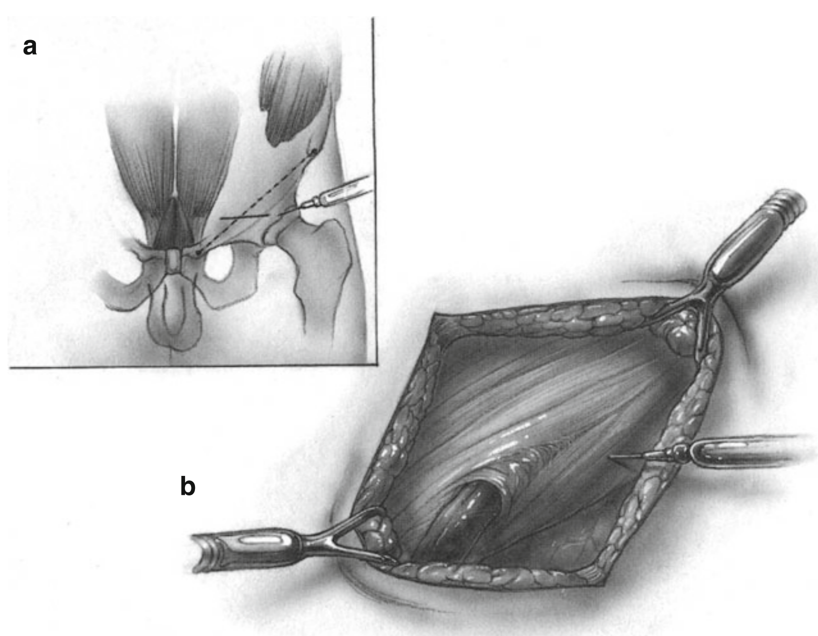

Fig. 100.1

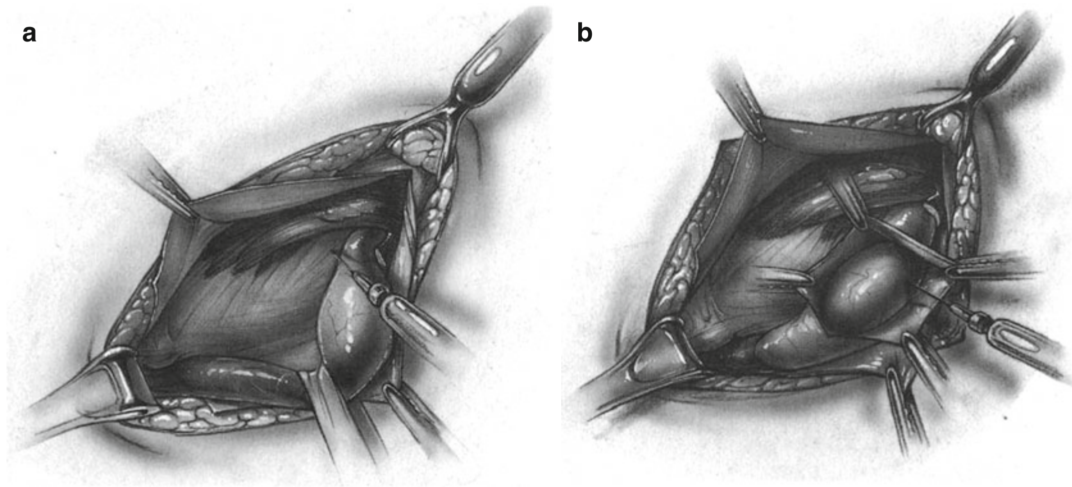

Fig. 100.2

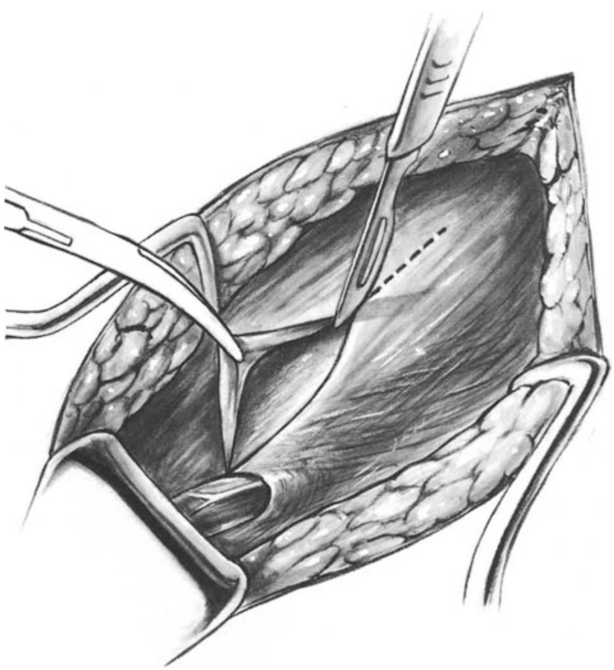

Fig. 100.3

sac is exposed, inject 5 ml into the sac (Fig. 100.2b) and around the neck of the sac. Not only does this technique of local block eliminate pain, it produces *surprisingly good muscle relaxation*.

Incision

Start the incision in the skin at a point 2.5 cm medial to the anterosuperior spine of the ilium. Continue in an oblique fashion to the point where the external ring adjoins the public tubercle.

Exposure

Clear the external oblique aponeurosis of fat and areolar tissue by sharp scalpel dissection; continue inferiorly beyond the point where the external oblique aponeurosis becomes the inguinal ligament and curves posteriorly in the upper thigh. Expose the external inguinal ring and the spermatic cord emerging from this ring. Secure any bleeding points with 4-0 PG ligatures or electrocautery. Incise the external oblique aponeurosis along the line of its fibers so the incision joins the external inguinal ring at its *cephalad* margin (Fig. 100.3).

Identify the ilioinguinal nerve and dissect it free. Occasionally, the ilioinguinal nerve runs with the spermatic cord, in close approximation to the cremaster muscle. Retract the lateral leaflet of the external oblique in a caudal direction and expose its junction with the pubic tubercle. It is important now to elevate the medial leaflet of external oblique aponeurosis from the underlying transversus muscle for a distance of at least 3–4 cm. Retract the medial leaflet cephalad by inserting one fork of the self-retaining Farr retractor underneath this leaflet; the other fork is inserted in the subcutaneous tissue of the lateral skin flap.

Excising Cremaster Muscle

Incise the cremaster muscle sharply in the direction of its fibers before encircling the cord (Fig. 100.4). Then ligate and divide excess cremaster muscle, taking care that no cord structures have inadvertently been included in the ligature. Free the spermatic cord from surrounding attachments at a point medial to the public tubercle. An attempt to encircle the cord lateral to this point may result in traumatizing the structures enclosed in a direct hernia, or it may damage the

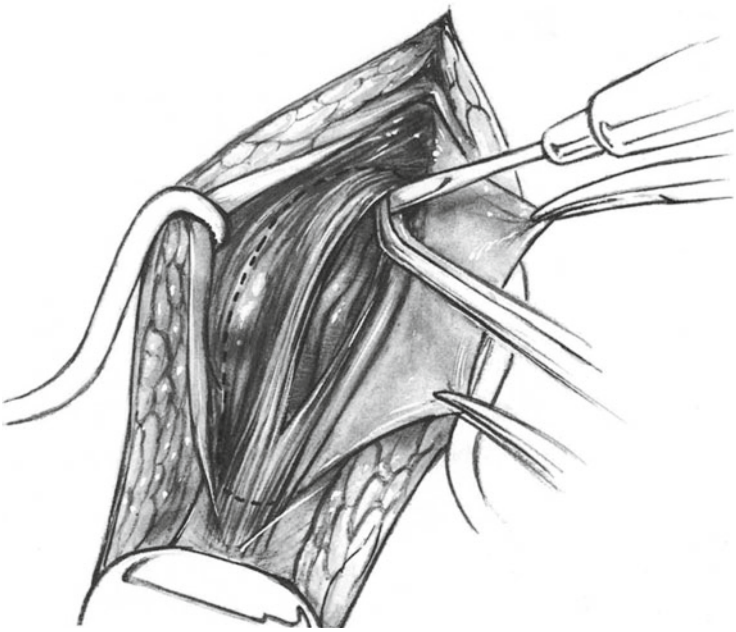

Fig. 100.4

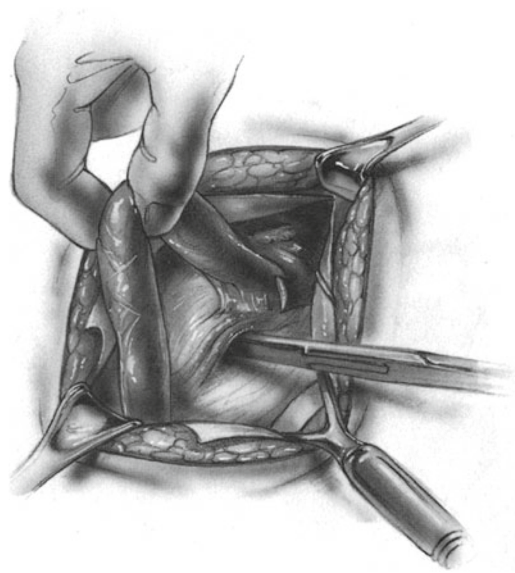

Fig. 100.5

floor of the inguinal canal. There is much less difficulty freeing the cord from surrounding structures in the medial location. Remember that in patients with a direct hernia, the hernial sac remains behind when the spermatic cord is elevated from the floor of the canal. Ensure that the posterior genitofemoral nerve and associated structures are included and not injured (Fig. 100.5). Encircle the cord with a latex drain for purposes of traction.

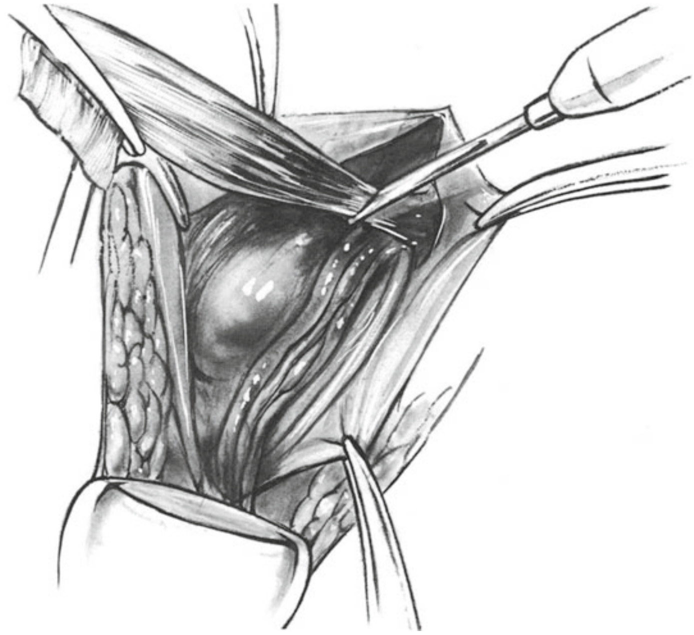

Fig. 100.6

Transect attachments between the spermatic cord and the underlying tissues with electrocautery. Resect lipomas and adipose tissue. To reduce the diameter of the cord, excise the *entire cremaster muscle* from the portion of the spermatic cord that remains in the inguinal canal. This minimizes the diameter of the internal inguinal ring when it is reconstructed. Be sure to remove all the cremaster muscle fibers from their attachments to the iliopubic tract, the femoral sheath, and the transversalis fascia (Fig. 100.6). Only after removing all these fibers is there clear visualization of these important structures. Clearly identify the vas deferens and the internal spermatic vessels before resecting the cremaster.

Excising Indirect Sac

At this point, place the left index finger behind the cord near the internal ring and dissect out the cord structures to rule out the presence of an indirect sac in the cord. If the patient has a combined indirect and direct hernia, deal with each sac individually. Simply free the indirect sac to its neck; then explore the sac (Fig. 100.7), transfix it with a single suture-ligature (Fig. 100.8a), and amputate the redundant portion (Fig. 100.8b). It is important to free the neck of the sac from surrounding structures so the stump of the ligated sac can retract into the abdomen. Now remove the hemostat retracting the lateral leaflet of the external oblique aponeurosis. Place the cord and ilioinguinal nerve lateral to this leaflet and replace the hemostat (Fig. 100.9).

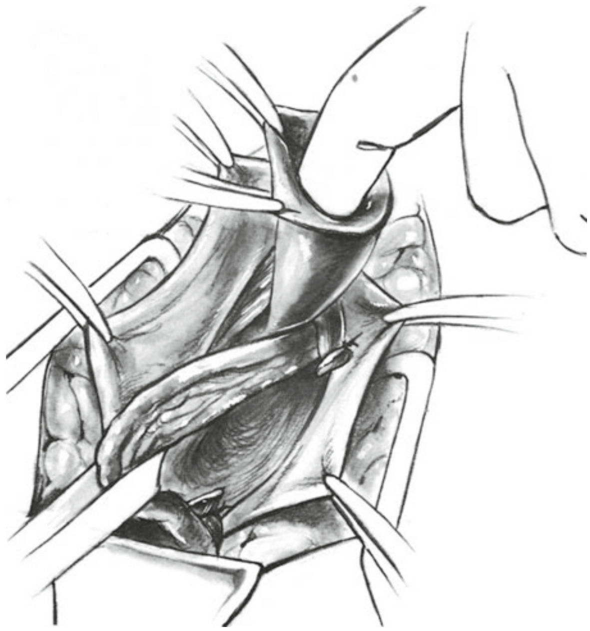

Fig. 100.7

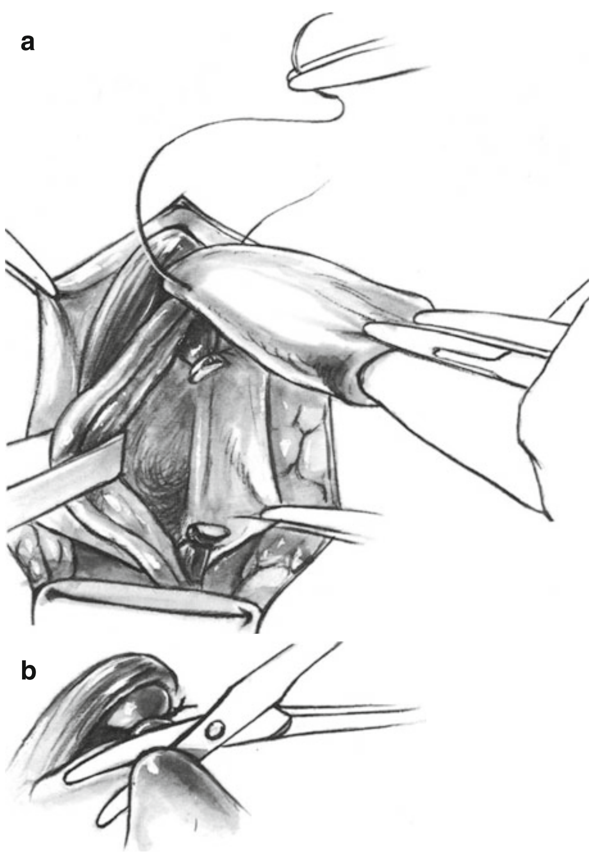

Fig. 100.8

Transversalis Dissection

A bulge or weakness in Hesselbach's triangle constitutes the direct "sac." Identify the *external* spermatic vessels, which branch off the deep inferior epigastric artery and vein and lie superficial to the transversalis fascia (Fig. 100.9). Resect the external spermatic vessels between two ligatures of 2-0 PG: one at their junction with the deep inferior epigastric vessels and the other at the pubic tubercle (Fig. 100.10). Often a small branch of the genitofemoral nerve runs along the floor of the inguinal canal together with the external spermatic vessels. Excise this nerve together with the vessels. These steps clear the entire floor of Hesselbach's triangle. Make a scalpel incision through the bulging attenuated transversalis fascia from the pubic tubercle to a point just medial to the deep inferior epigastric vessels (Fig. 100.11). When lobules of preperitoneal fat bulge through the scalpel incision, extend the incision with Metzenbaum scissors if preferred. If one is in the proper plane of dissection, the deep inferior epigastric vessels have been entirely cleared of areolar tissue; Cooper's ligament is clearly visible laterally, and the preperitoneal fat is easily separated from the deep surface of the transversalis fascia in a cephalad direction (Fig. 100.12). If any branches of the deep inferior epigastric vessels join the deep surface of the transversalis fascia, carefully divide and ligate them so the epigastric vessels can be pushed down away from the repair. Otherwise, retroperitoneal bleeding may be caused by inadvertently piercing these vessels with a needle while suturing the transversalis layer. Excise the attenuated portions of transversalis fascia and apply straight hemostats to the free cut edge of the medial leaflet of the transversalis fascia for purposes of traction. Apply a moist gauze sponge in a sponge holder to the preperitoneal fat and bladder to push these structures posteriorly.

Shouldice Repair

Layer 1

Anchor the initial stitch (3-0 Tevdek on a C-5 atraumatic needle) by catching the lacunar ligament and pubic periosteum in one bite and the undersurface of the medial flap of transversalis with overlying rectus fascia in the other. Tie this stitch. Apply upward traction on the straight clamps holding the medial leaflet of transversalis fascia; this maneuver reveals a "white line" of fibrous tissue on the undersurface of the transversalis fascia. The "white line" represents the aponeurosis of the transversus muscle as seen through the transversalis fascia. This aponeurosis of the transversus abdominis muscle is thought by McVay and Halverson and by Nyhus and Condon to be the most important tissue

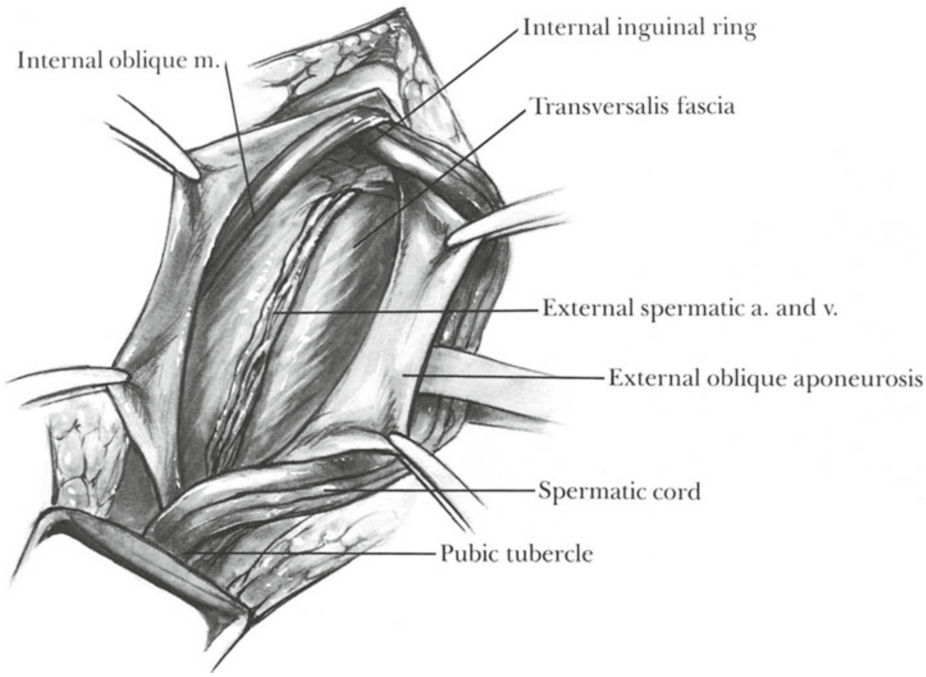

Fig. 100.9

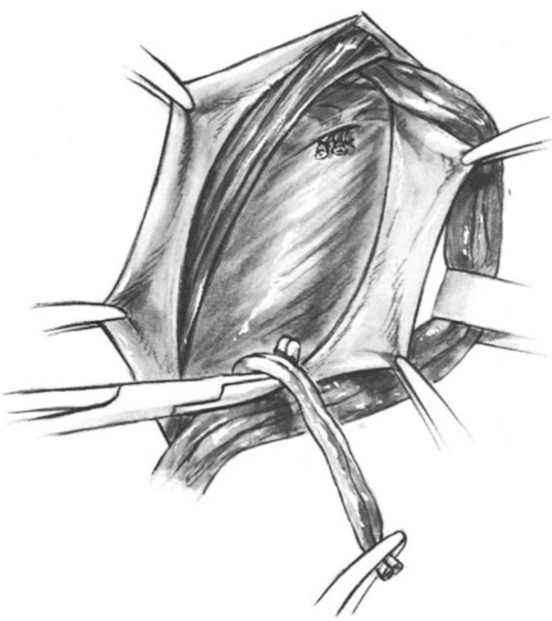

Fig. 100.10

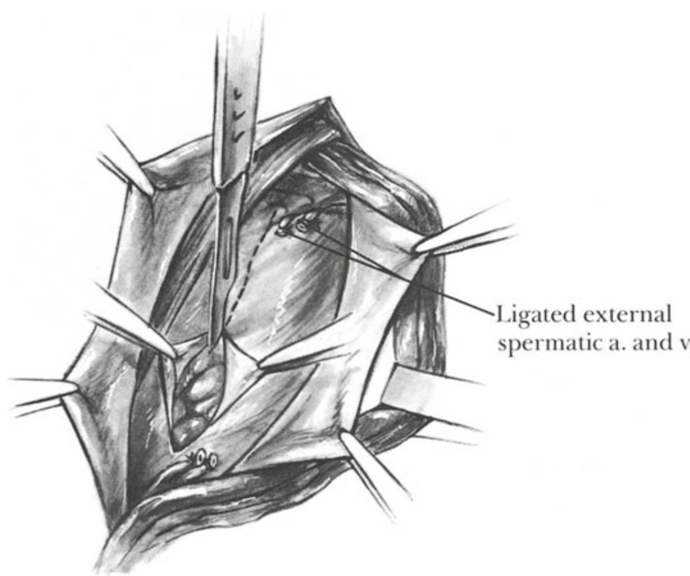

Fig. 100.11

involved in inguinal hernia repair. This arch of aponeurotic tissue becomes muscular as it approaches the internal inguinal ring. Include the "white line" in the continuous stitch that attaches the cut lateral edge of the transversalis fascia to the undersurface of the medial leaf of the transversalis (Fig. 100.12). Insert the needle into the lateral leaflet of transversalis fascia near the point where this layer appears to attach to the inguinal ligament (Fig. 100.13). This condensation of the caudal margin of the transversalis fascia is also termed the iliopubic tract. Be sure to remove all the cremaster muscle fibers that cover the iliopubic tract and femoral sheath. Otherwise it is not possible to identify these structures accurately for proper suturing.

Each stitch should contain 4–6 mm of tissue. Continue the suture in a lateral direction until the newly constructed

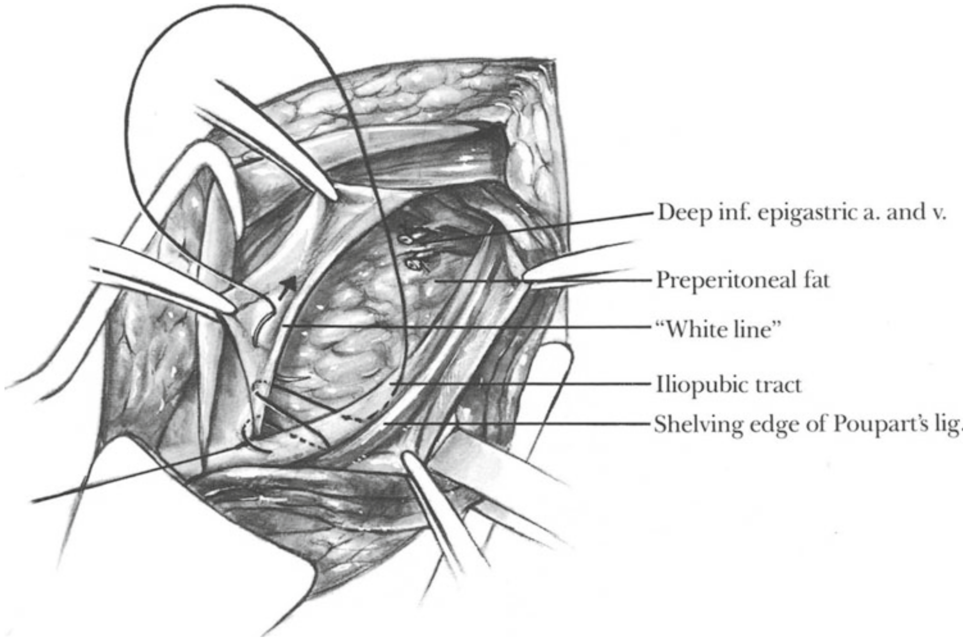

Fig. 100.12

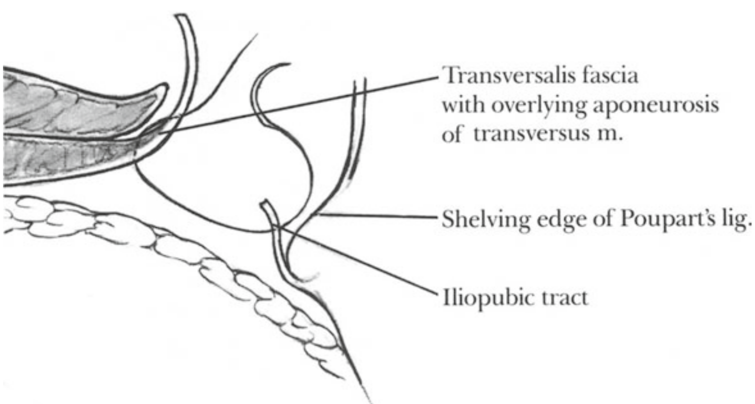

Fig. 100.13

internal ring has been closed snugly around the spermatic cord so only the tip of a Kelly hemostat fits loosely between the cord and the internal ring.

Layer 2

Excise the attenuated portion of the transversalis fascia and any fatty tissue adherent to the internal oblique muscle layer. Then use the same continuous strand of suture material as in layer 1 and sew the free cut edge of the medial leaflet of transversalis fascia with adjacent internal oblique muscle to the anterior aspect of the iliopubic tract. Include 2–3 mm of the shelving edge of the inguinal ligament in the continuous suture going medially (Figs. 100.14 and 100.15). Continue this suture to the pubic tubercle. Anchor the last stitch by inserting it into the pubic periosteum. At this point, terminate the suture by knotting it to its tail. A worthwhile modification of the Shouldice technique is to excise the lower 2 cm of the internal oblique muscle to expose the underlying aponeurosis of the transversus muscle. This step is in fact an integral part of McVay's method of hernia repair as shown in Fig. 101.1. After accomplishing this step, one can invert the sutures for Shouldice's layer 3 into the transversus aponeurosis instead of into the fleshy, internal oblique muscle.

Layer 3

Use a new strand of 3-0 Tevdek to begin layer 3. Take a bite of internal oblique muscle or "conjoined tendon" and another of the shelving edge of the inguinal ligament and tie the suture, beginning this time at the medial margin of the newly constructed internal ring. If the internal oblique muscle is flimsy, resect the muscle and sew to the underlying aponeurosis of the transversus muscle. Insert this suture continuously in a medial direction (Figs. 100.16 and 100.17) as far as the pubic tubercle. Do not leave any gap in the suture line near the pubic tubercle as this oversight is a common cause of recurrent hernia adjacent to the pubis.

Layer 4

Use the same continuous suture to create a fourth layer by taking first a bite of internal oblique muscle just cephalad to the previous layer and then a 4 mm bite of the undersurface of external oblique aponeurosis just anterior to the previously inserted layer (Figs. 100.18 and 100.19). Continue this suture until it approaches its point of origin at the internal ring, where the suture is terminated by being tied to its tail.

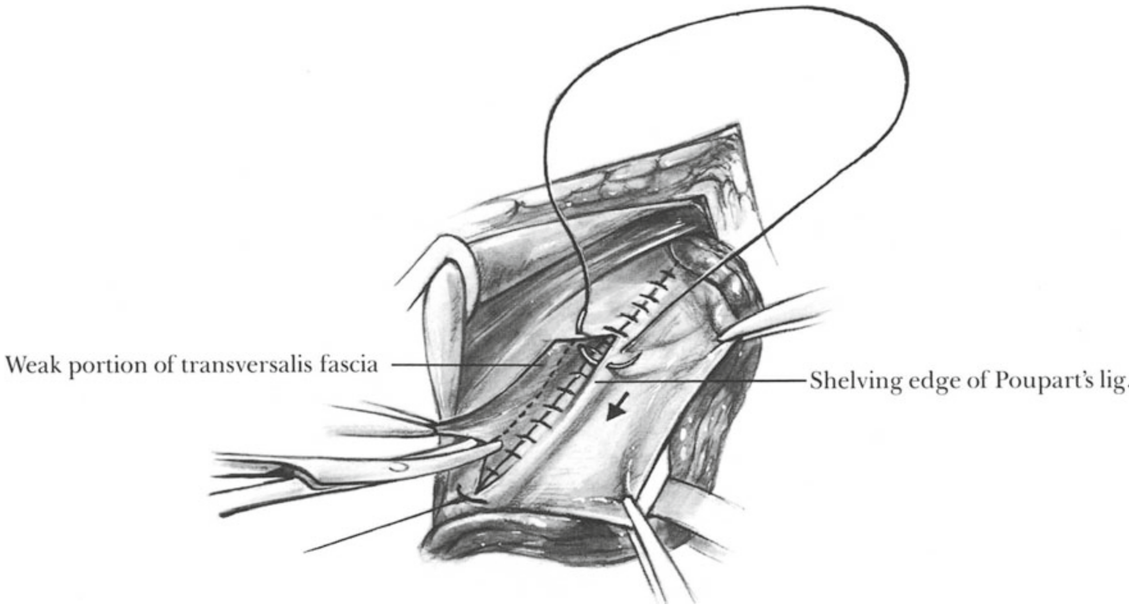

Fig. 100.14

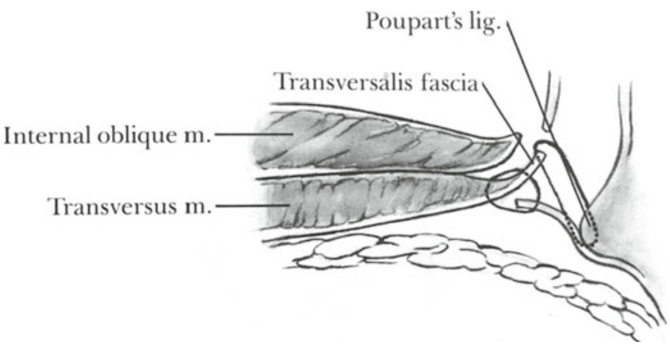

Fig. 100.15

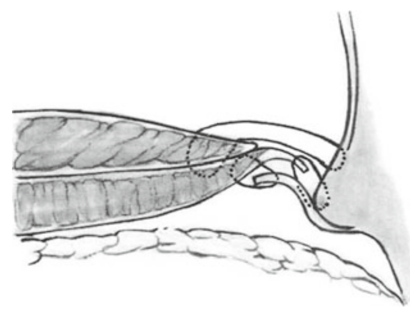

Fig. 100.17

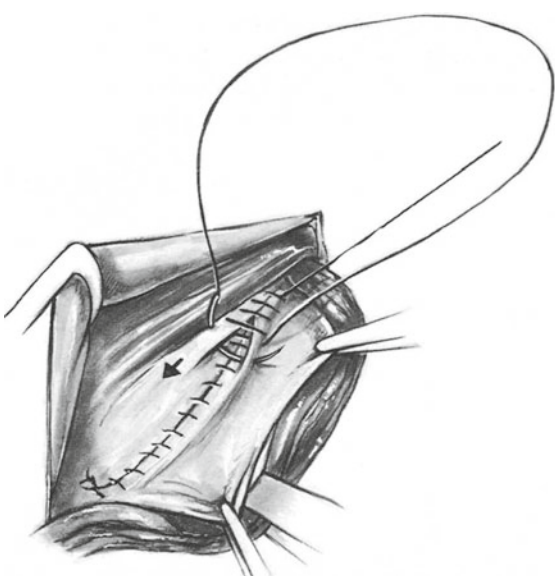

Fig. 100.16

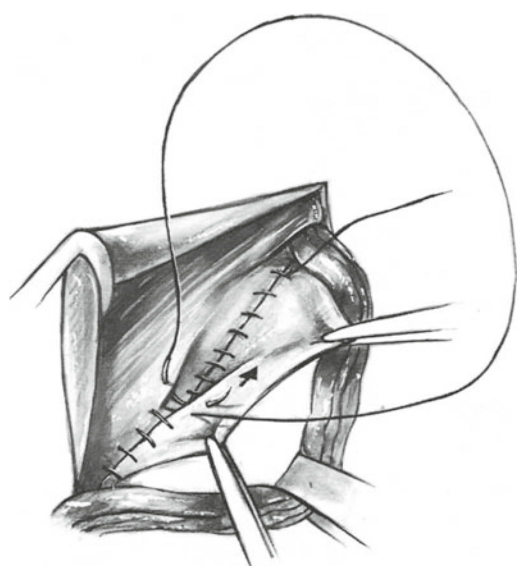

Fig. 100.18

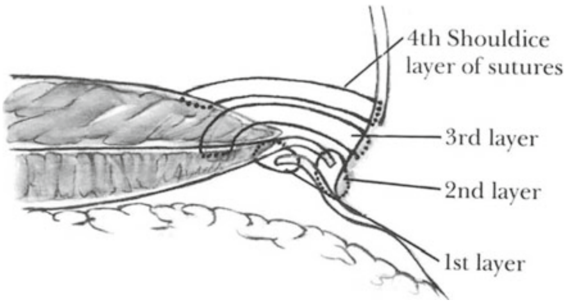

Fig. 100.19

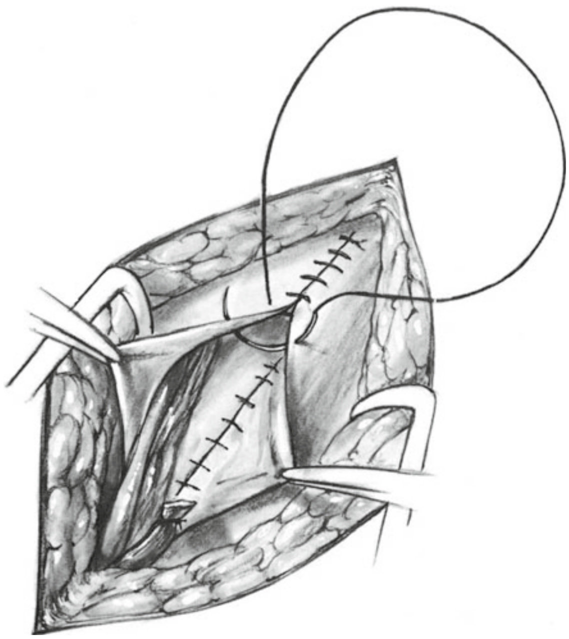

Fig. 100.20

Although the classic Shouldice repair calls for the four layers as described, we have frequently found that the width of available external oblique aponeurosis was inadequate to construct the fourth layer. Most often we do three layers and occasionally two layers. Berliner found no differences in the incidence of recurrence between the two-layer, three-layer, and four-layer Shouldice repairs.

Closure of External Oblique Aponeurosis

Meticulously inspect the cord and obtain complete hemostasis with a combination of fine ligatures and electrocoagulation. Replace the cord in the canal, which is now displaced slightly cephalad. Elevate the medial portion of the external oblique aponeurosis to provide adequate space for the spermatic cord. Close the two leaflets of the external oblique aponeurosis with a continuous 3-0 PG suture (Fig. 100.20). At the new external inguinal ring, include in the last bite of this suture the proximal cut edge of the cremaster muscle

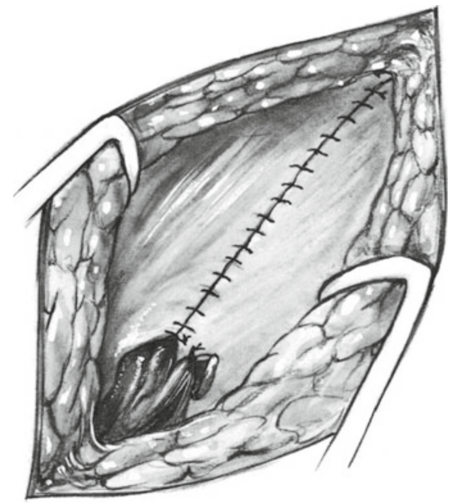

Fig. 100.21

(Fig. 100.21). This move prevents the testis from descending to an abnormally low point in the scrotum as a consequence of resecting the cremaster muscle. There is no virtue in creating a tight external ring. Rather, allow a 2 cm opening for the spermatic cord.

Approximate Scarpa's fascia with several 4-0 PG sutures. Close the skin with a continuous subcuticular suture of 4-0 PG or PDS supplemented by strips of sterile adhesive to the skin (Steri-Strips).

Postoperative Care

Begin active ambulation the afternoon of the operation. Terminate the intravenous infusion in patients who have undergone local anesthesia when they leave the recovery room. Laxatives may be given on the night of the first postoperative day to avoid patient discomfort at defecation. Generally the patient needs a prescription for pain medication for the first few days.

Complications

Systemic complications of a pulmonary, cardiac, or urologic nature are rare.

Wound infections are rare. Treat them promptly by opening the skin and subcutaneous tissues for adequate drainage and by prescribing appropriate antibiotics.

Hematomas may occur in the wound and are generally treated expectantly. Some degree of superficial ecchymosis may be secondary to injecting agents for local anesthesia.

Testicular swelling is generally due to venous obstruction. Although it is sometimes due to excessive constriction of the newly reconstructed internal ring, it is more often the result of trauma, hematoma, or inadvertent ligature of the internal spermatic veins in the inguinal canal. Although this complication may lead to testicular atrophy or necrosis, in most cases satisfactory results may be anticipated from expectant therapy.

Persistent pain in the area innervated by the ilioinguinal or genitofemoral nerves is a rare but disturbing complication of inguinal hernia repair. Starling and Harms reported on 19 patients with ilioinguinal neuralgia and 17 patients with genitofemoral neuralgia. Most of the pain followed inguinal hernia repair and was attributed to entrapment of the nerve in a stitch or scar tissue. These authors described the diagnostic studies they believed necessary to diagnosis nerve entrapment. In most but not all of their cases, relief of pain was achieved by reexploring the hernia incision and resecting the ilioinguinal nerve. In the case of the genitofemoral nerve, a retroperitoneal lumbar approach was used to transect the genital branch of the genitofemoral nerve.

Recurrent inguinal hernia is possible. See Chap. 104 for a discussion of the incidence, causes, and treatment of this problem.

Further Reading

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Cooper's Ligament (McVay) Repair of Inguinal Hernia

101

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Symptomatic direct or indirect inguinal hernia when use of prosthetic mesh is not desired
Femoral hernia

Operative Strategy

The McVay repair uses autogenous tissue to close the floor of the canal. Because the femoral canal is also closed, this is a good repair to use when an associated femoral hernia is found at repair of an inguinal hernia. This repair can succeed only if the fascia is strong. If exploration of the groin reveals tenuous fascia, a prosthetic mesh repair is required (see Chap. 102).

Documentation Basics

- Findings
- Presence or absence of incarceration
- Primary or recurrent

Operative Technique

Incision and Exposure

Make a skin incision over the region of the external inguinal ring and continue laterally to a point about 2 cm medial to the anterosuperior iliac spine. Open the external oblique aponeurosis with an incision along the line of its fibers from the external inguinal ring laterally for a distance of about 5–7 cm (see Fig. 100.3). Mobilize the spermatic cord. Excise the *entire* cremaster muscle from the area of the inguinal canal (see Fig. 100.4) and remove any lipomas of the cord. Explore the cord carefully for the presence of the indirect sac. If a sac is present, dissect it from the cord. Open the sac, explore it, close it at its neck with a suture-ligature, amputate it, and permit the stump to retract into the abdominal cavity. Identify the *external* spermatic vessels at the point where they emerge from the transversalis fascia (see Fig. 100.9). Divide and ligate them at this point and remove about 4–5 cm of the vessels; ligate them again at the pubic tubercle (see Fig. 100.10).

In patients with an indirect inguinal hernia, identify the margins of the transversalis fascia around the internal inguinal ring. If the internal inguinal ring is only slightly enlarged, close it with several sutures between the healthy transversalis fascia along its cephalad margin and the anterior femoral sheath at its caudal margin. If the hernia has eroded more than 2 cm of posterior inguinal wall, complete reconstruction is necessary. In this case, incise the transversalis fascia with a scalpel beginning at a point just medial to the pubic tubercle (see Fig. 100.11). Carry the incision laterally with a scalpel or Metzenbaum scissors, taking care not to injure the underlying deep inferior epigastric vessels. Continue the incision all the way to the internal inguinal ring. Sweep the preperitoneal fat away from the undersurface of the transversalis fascia. Free the deep inferior epigastric vessels so they may be retracted posteriorly together with the preperitoneal fat. A few small branches may have to be divided and ligated.

Excise the iliopubic tract adjacent to Cooper's ligament. Apply two identifying hemostats to the cephalad cut edge of the transversalis fascia and elevate to expose the aponeurosis of the transverses muscle. Excise the fleshy portion of the

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†Deceased

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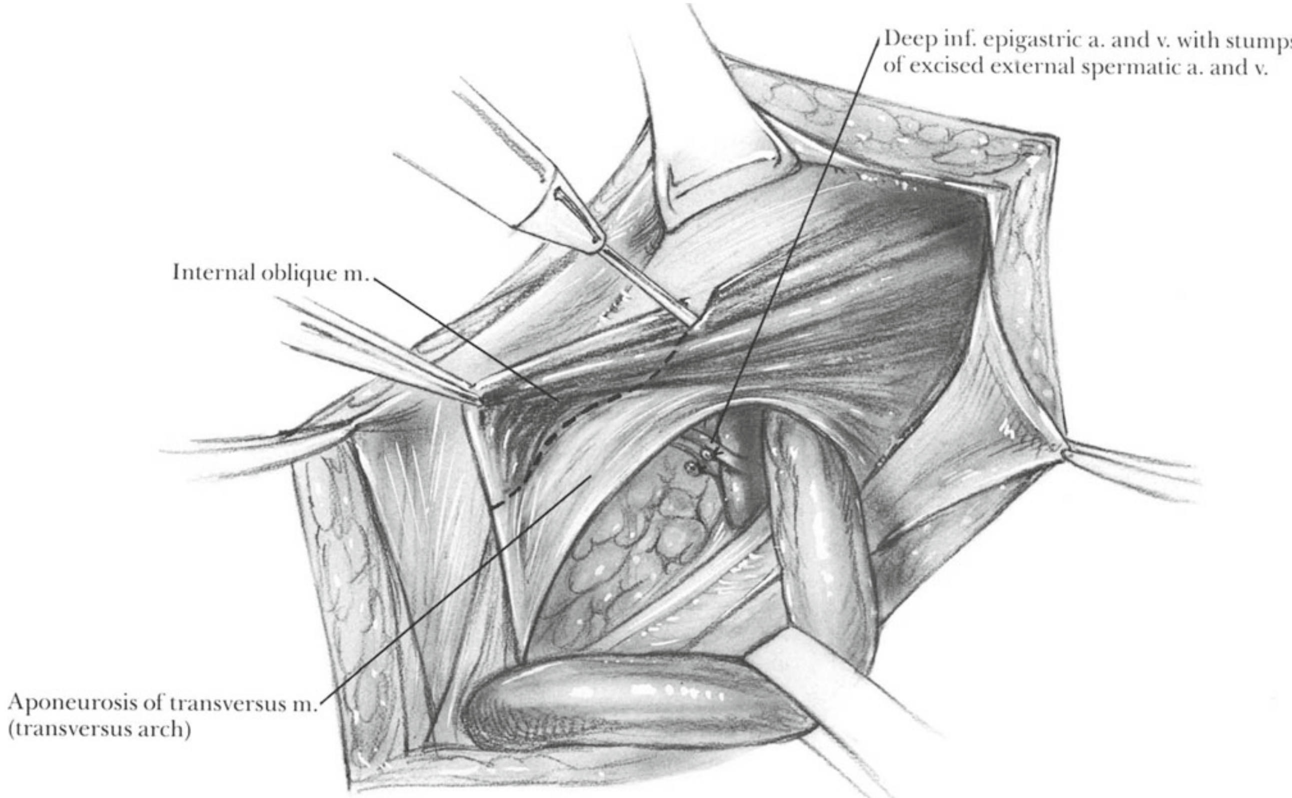

Fig. 101.1

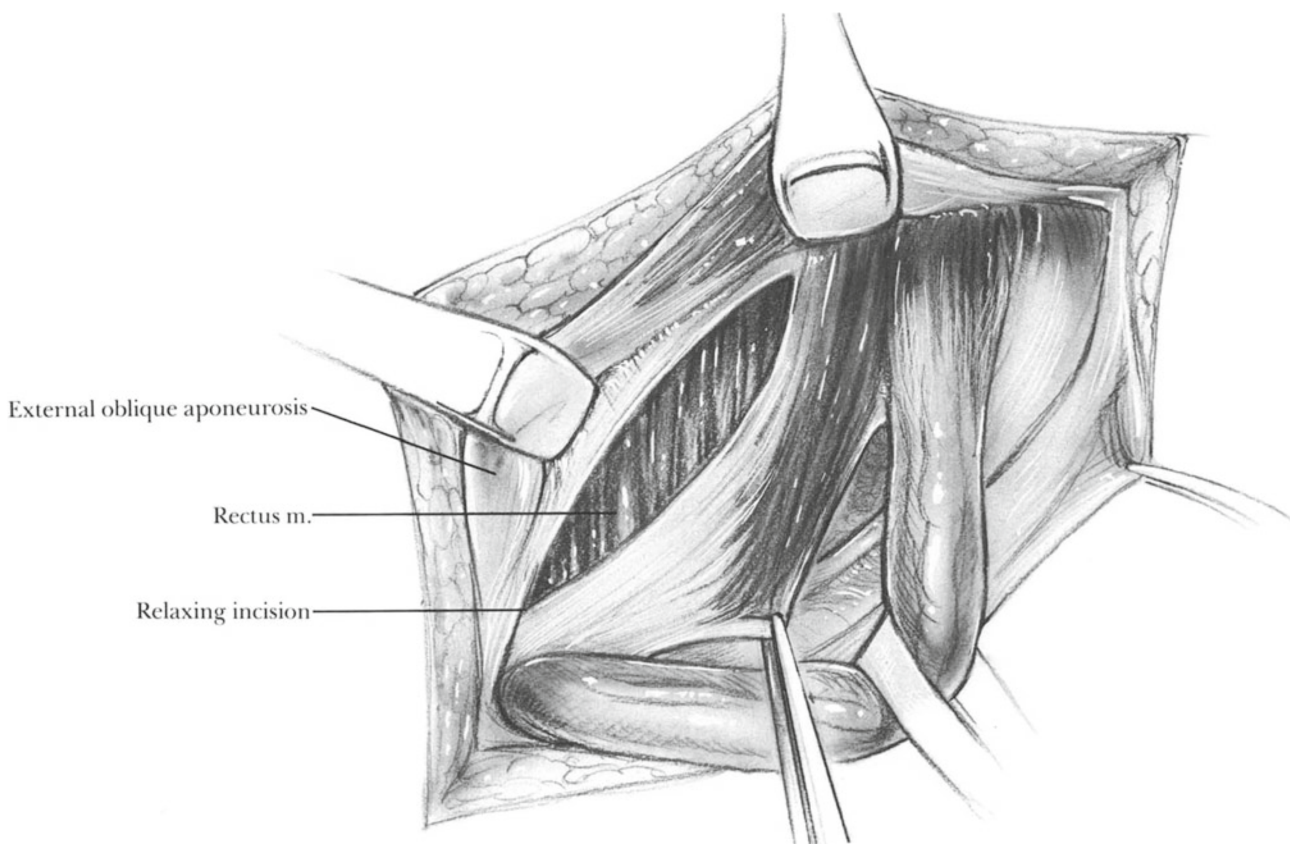

Fig. 101.2

internal oblique muscle overlying the fibrous transversus arch to improve the exposure (Fig. 101.1).

Identify the anterior femoral sheath by gently inserting the back of a scalpel handle between the shelving edge of Poupart's ligament and the femoral sheath overlying the external iliac artery and vein. Then identify the anterior surface of the external iliac vein and artery and retract them gently in a posterior direction with a peanut sponge dissector. This maneuver separates these vessels from the femoral sheath. To see the femoral sheath clearly, be certain to excise 100 % of the overlying cremaster muscle fibers.

Making the Relaxing Incision

A relaxing incision is essential to prevent tension on the suture line. Elevate the medial portion of the external oblique aponeurosis and dissect it bluntly away from the internal oblique muscle and from the anterior rectus sheath. Make a 7- to 8-cm incision in the anterior rectus sheath beginning about 1.5 cm above the pubic tubercle and continue the incision in a cephalad fashion just medial to the point where the external oblique aponeurosis fuses with the anterior rectus sheath. This constitutes a vertical line that curves as it continues in a superior direction. The anterior belly of the rectus muscle is exposed as downward traction is applied to the transversus arch (Fig. 101.2).

Inserting Cooper's Ligament Sutures

Suture the transversus arch to Cooper's ligament using atraumatic 2-0 silk or other nonabsorbable suture material (Fig. 101.3). Take substantial bites of both the transversus arch and Cooper's ligament and place the sutures no more than 5 mm apart. Do not tie the sutures until all are in place.

As the suture line progresses laterally, the external iliac vein is approached (Fig. 101.4). At this point insert a "transition suture" (Fig. 101.5) that penetrates the transversus arch, Cooper's ligament, and the anterior femoral sheath. Lateral to this suture, sew the transversus arch to the femoral sheath. In his description of Cooper's ligament repair, Rutledge advocated including a bite of the shelving edge of the inguinal ligament together with the anterior femoral

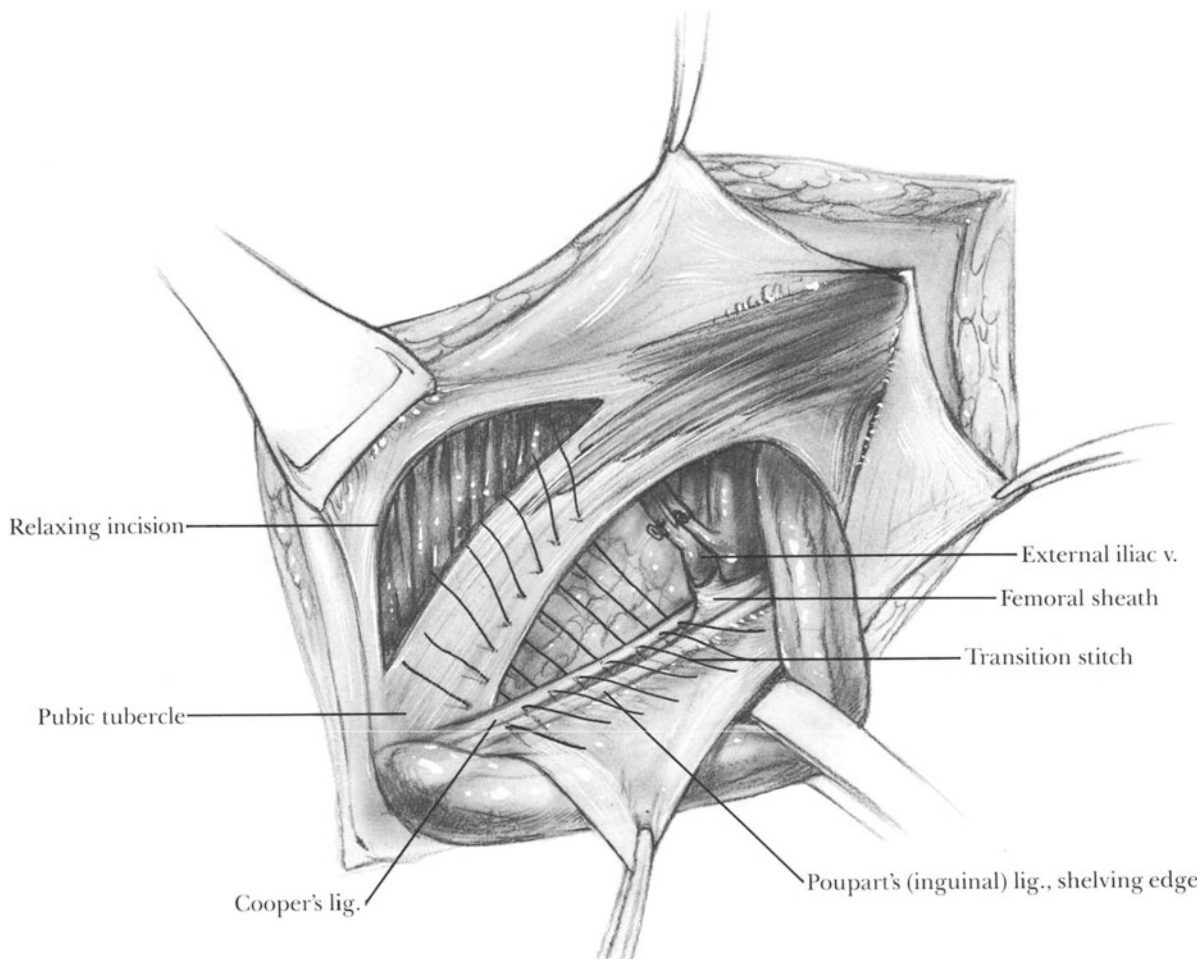

Fig. 101.3

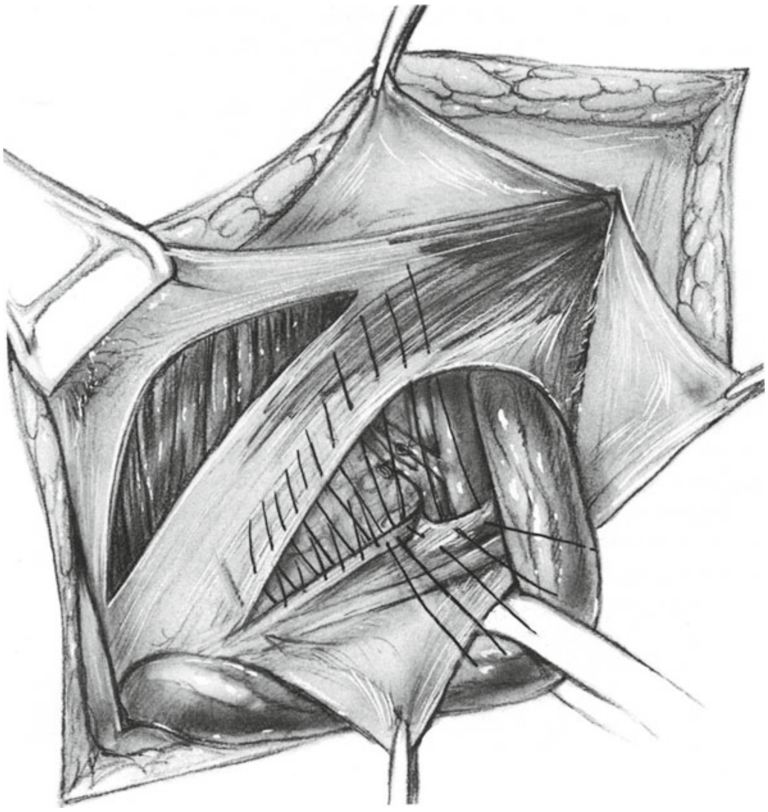

Fig. 101.4

sheath. Continue to insert sutures until the internal ring is sufficiently narrowed to admit only a Kelly hemostat alongside the spermatic cord (Fig. 101.6). Do not insert any sutures lateral to the cord. After all the sutures have been inserted, tie each suture proceeding from medial to lateral. Suture the incised anterior rectus sheath down to underlying muscle along the lateral aspect of the relaxing incision with a few 3-0 interrupted silk sutures.

Closing the External Oblique Aponeurosis

Replace the cord in the inguinal canal. Check to ensure complete hemostasis. Close the external oblique aponeurosis superficial to the cord and complete the wound closure as described in Chap. 100.

Postoperative Care

See Chap. 100.

Complications

See Chap. 100.

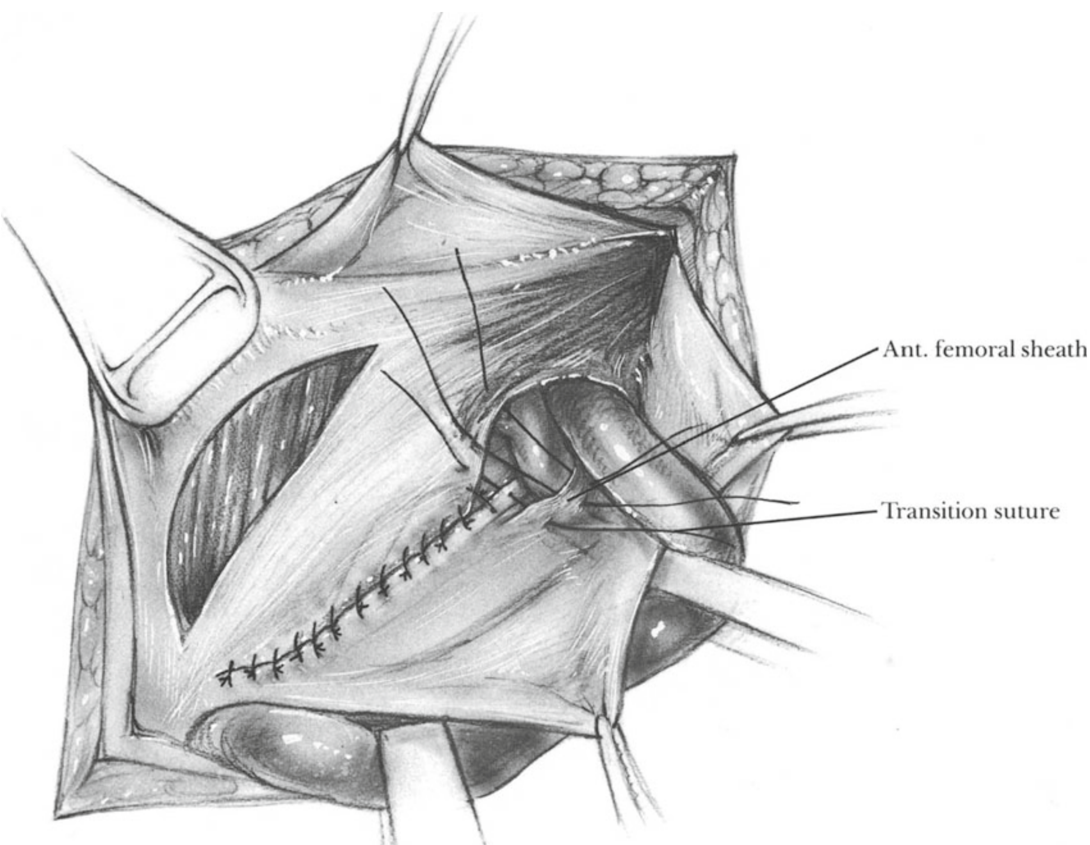

Fig. 101.5

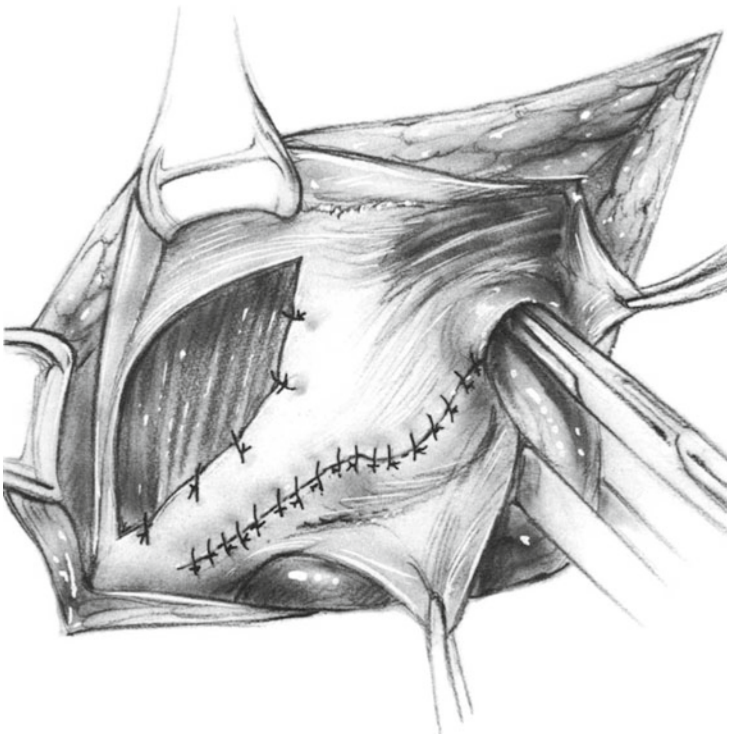

Fig. 101.6

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102 Mesh Repair of Inguinal Hernia

Carol E.H. Scott-Conner

Indications

Inadequate fascia for autogenous tissue repair of direct inguinal hernia.

Recurrent inguinal hernia repair. As discussed in Chap. 104, mesh is frequently used when a recurrent inguinal hernia is approached through the groin.

Prosthetic mesh repairs are used by some surgeons for virtually all inguinal hernias. Advocates of the repair shown here in a modified form cite speed, simplicity, and minimal dissection as major advantages to the surgeon; decreased pain and immediate return to normal activities are advantages to the patient. Current data support the use of a mesh repair for virtually all elective primary herniorrhaphies.

Preoperative Preparation

See Chap. 100.

Perioperative antibiotics.

Pitfalls and Danger Points

Failure to identify, reduce, and repair all hernias. A missed indirect hernial sac is a common cause of recurrence (see Chap. 104).

Failure to secure the mesh adequately. Mesh can curl or migrate. When this happens it may fail to produce the desired effect or may be palpable in the subcutaneous tissues of a slender patient.

Infection.

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Operative Strategy

This repair is performed through a short incision with minimal dissection. Direct and indirect sacs must be identified and reduced. Several kinds of mesh are available. This chapter describes the use of a preformed plug (PerFix, Davol Corporation) that is used to keep the hernia reduced as a kind of "internal truss." The plug is held in place by the edges of the fascial defect. Most indirect sacs are simply inverted, and the internal ring holds the plug in place. Direct hernial sacs are circumferentially incised to create the fascial ring that anchors the plug. The use of this plug is optional, and many surgeons simply reduce all hernias and place an onlay patch.

When a plug is used, it must be reinforced by an onlay patch. The procedure may be done under local or regional anesthesia.

Documentation Basics

- Findings
- Presence of incarceration
- Presence of strangulation
- Type of mesh used and exact details of placement and fixation

Operative Technique

Incision

Center a small skin line or nearly transverse incision over the medial third of the inguinal ligament and external inguinal ring (see Fig. 100.1a).

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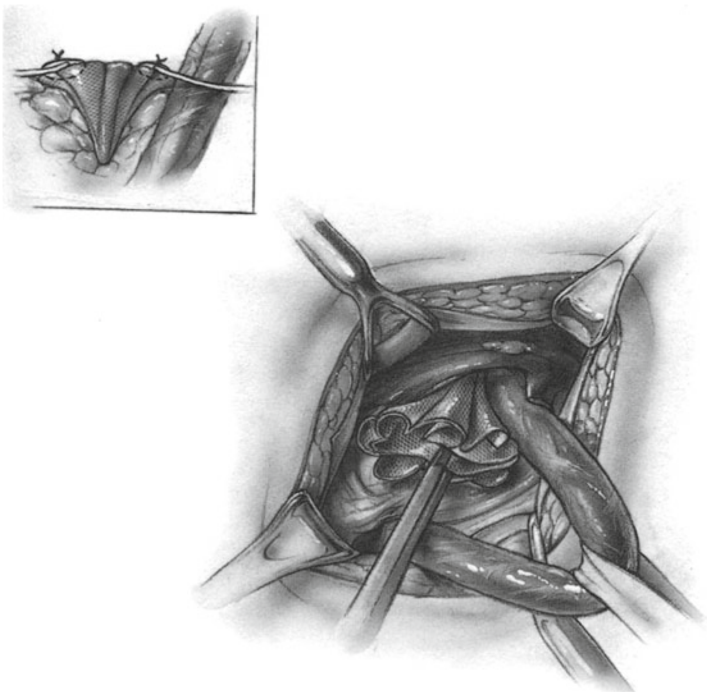

Fig. 102.1

Dissection and Identification of Direct and Indirect Sacs

The groin structures are exposed and the external oblique aponeurosis is identified as described in earlier chapters. Incise the external oblique aponeurosis in the direction of its fibers, preserving the ilioinguinal nerve (see Fig. 100.3). Encircle the cord and its posterior mesentery (which contains the genitofemoral nerve) (see Fig. 100.5). Perform just enough dissection to encircle the cord. Do not divide the cremaster muscle. Simply incise it in the direction of its fibers to allow careful inspection of the cord structures (see Fig. 100.4).

An indirect sac, if present, is found anteromedial to the cord structures. Trace the cord structures back to the internal ring, with the cord on traction to ensure that the leading edge of any indirect sac is seen. Visualization of the peritoneal lappet, a crescentic thickening of normal peritoneum created by traction on the cord, is positive proof that adequate dissection had been performed.

If an indirect hernia sac is found, separate it from the cord structures all the way to the internal ring. This high dissection allows the sac to be simply inverted into the peritoneum.

Assess the strength of the floor of the inguinal canal by palpation. If a direct hernial defect is present, circumferentially

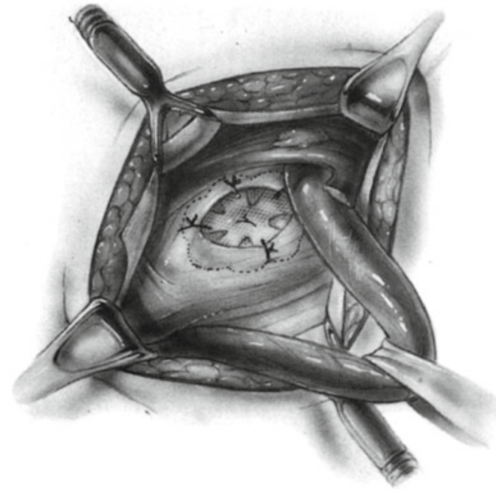

Fig. 102.2

incise the fascial defect with electrocautery and reduce the hernia with the attached portion of sac into the preperitoneal space.

Placement of Plug

Insert the preformed plug, pointed end first, into the internal ring of an indirect hernia or the fascial defect of a direct hernia so the petals unfold under the fascia and anchor it in place (Fig. 102.1). Occasionally, a direct hernial defect is so large two plugs, sutured together side by side, must be used to reduce it. Ask the patient to cough and assess the stability of the plug placement. Anchor the plug with three of four simple interrupted sutures of 3-0 PG placed to the inner aspects of the petals (Fig. 102.2), which allows the plug to expand behind the fascia and buttress the defect.

Placement of Onlay Patch

Insert the precut patch so it covers the floor of the canal with the cord coming through the hole and the incision and tails of the mesh extending lateral to the internal ring (Figs. 102.3 and 102.4). It should lie in a flat, stable position covering the floor of the inguinal canal and the plug (Fig. 102.5). Secure it in position with several interrupted sutures of 3-0 PG. Because the plug forms the primary strength layer of this repair, it is necessary to suture the patch in only a few places to ensure that it remains in the proper location until tissue ingrowth occurs. We tend to place sutures medially to the pubic tubercle, laterally to secure the two tails together and

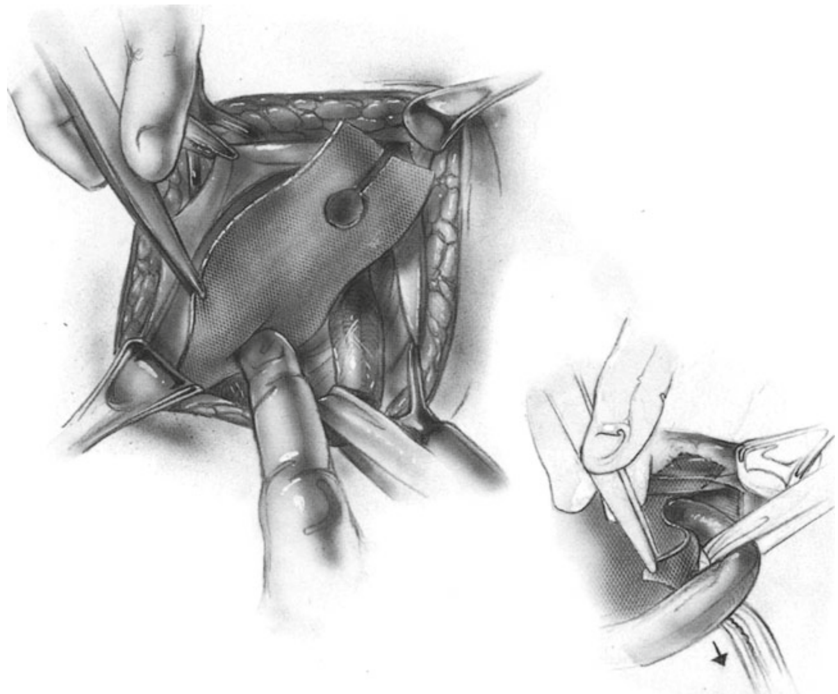

Fig. 102.3

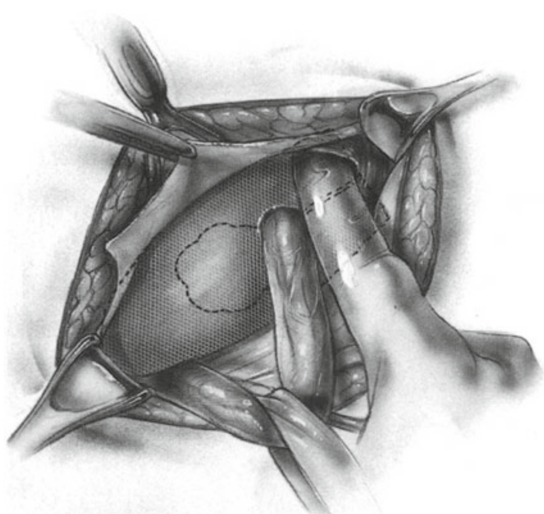

Fig. 102.4

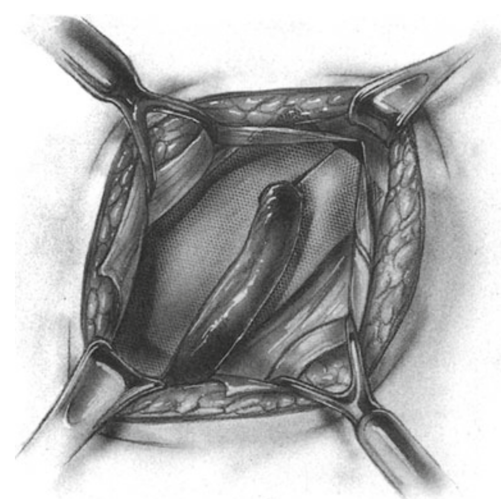

Fig. 102.5

tack the lateral part to the aponeurosis of the internal oblique muscle, inferiorly to the inguinal ligament, and superiorly to the conjoint tendon.

Closure

Close the external oblique and remaining layers in the usual fashion.

Postoperative Care

Patients are allowed to lift up to 25 lb immediately. They may resume heavy manual labor after 2 weeks.

Complications

Infection has been rare in most series.

Mesh migration into adjacent structures (femoral vein, spermatic cord), a theoretic concern, has not proven to be a significant problem. Rutkow and Robbins, in a 1998 review, were unable to find any documented cases.

Further Reading

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Laparoscopic Inguinal Hernia Repair: Transabdominal Preperitoneal (TAPP) and Totally Extraperitoneal (TEP) Repairs

103

Muhammed Ashraf Memon
and Robert J. Fitzgibbons Jr.

Indications

Inguinal hernia (see Chaps. 100, 101, and 102). Laparoscopic repair offers a significant advantage in these special situations:

Recurrent hernia (see Chap. 104). Laparoscopic repair is a logical choice because it avoids the previous surgical field and allows repair to be performed through healthy tissues with potentially better results.

Bilateral hernias. They can be repaired simultaneously without additional incisions or trocar sites.

Incidental herniorrhaphy during another laparoscopic surgery is only possible during TAPP procedure and if the patient is appropriately consented. Incidental herniorrhaphy is generally not recommended.

Preoperative Preparation

See Chaps. 9 and 100.

Insert a Foley catheter or perform immediate preoperative bladder decompression by voiding or inserting a straight catheter.

Prescribe perioperative antibiotics.

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Pitfalls and Danger Points

Missed hernia or inadequate mesh fixation resulting in hernia recurrence

Injury to bladder during the totally extraperitoneal approach

Nerve or major vessel injury

Documentation Basics

Document the type of repair (TEP or TAPP)

Findings at surgery

Type of hernia

Operative Strategy

There are two general approaches: transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP). TAPP is the logical choice when inguinal herniorrhaphy is performed after another laparoscopic procedure or when previous preperitoneal dissection limits access to the extraperitoneal space. It offers the additional advantage that the approach and anatomy are familiar to most surgeons, and hernias are readily identified as peritoneal outpouchings. The major disadvantage is penetration of the peritoneal cavity with associated potential for injury or adhesion formation.

The TEP approach avoids entry into the peritoneal cavity and hence minimizes these potential problems; but it requires dissection in the extraperitoneal plane and an excellent understanding of regional anatomy. The TEP approach is contraindicated when previous surgery or radiation therapy may have obliterated the retroperitoneal plane.

Crucial to the success of either approach is accurate identification of anatomy and hernias, accurate placement of mesh, and avoiding injury to adjacent structures. Figure 103.1

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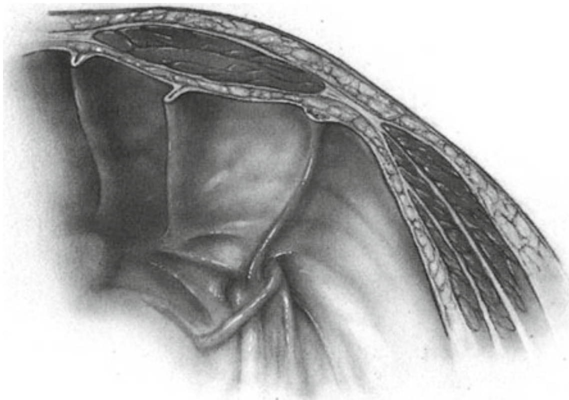


Fig. 103.1

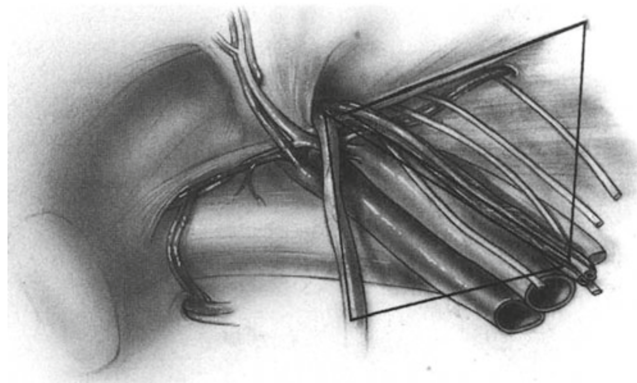


Fig. 103.2

shows the laparoscopic anatomy of the inguinal region. Figure 103.2 shows two danger areas—the triangle of pain and the triangle of doom—where staple fixation must be avoided. The single most important landmark is the iliopubic tract. If no staples are placed below this structure, major nerves and vessels can be avoided.

When laparoscopic herniorrhaphy follows an unrelated laparoscopic operation on the same patient under the same anesthesia, take the time to optimize the working environment for the second procedure. Additional trocars may be required, monitors moved, equipment procured, and other adjustments made. This is time well spent.

Operative Technique

Patient Position and Room Setup: TAPP or TEP

Position the patient supine with arms tucked at the side. Extending the arms on arm boards may not allow enough room for the surgeon to operate comfortably in the lower abdomen. The Trendelenburg position allows the bowel to fall away from the pelvis, providing excellent access. A single video monitor at the foot of the operating table adjusted to a comfortable viewing height serves both surgeon and assistants. The surgeon stands on the side opposite the hernia (Fig. 103.3).

Although a 30° angled laparoscope is preferred by some surgeons, it is certainly not a necessity. A 0° laparoscope can provide as good a view.

TAPP Approach

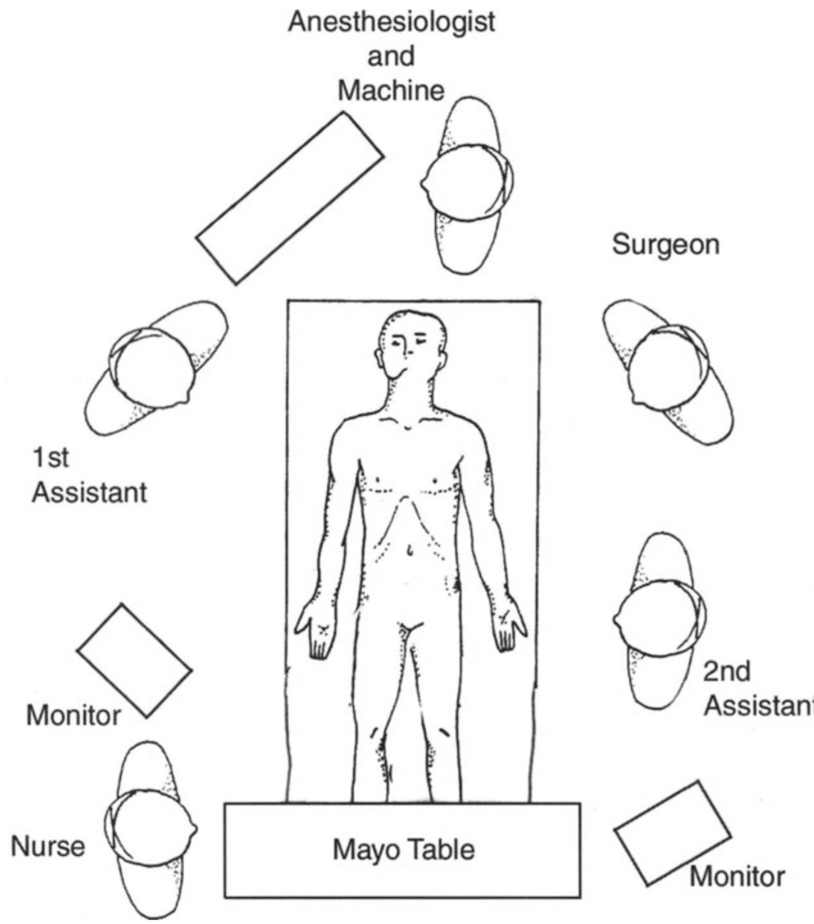
Place the first trocar (10–12 mm) at the umbilicus. Place two additional 10- to 12-mm trocars lateral to the rectus sheath on either side at the level of the umbilicus under direct vision (Fig. 103.4). Large trocars allow the laparoscope and stapler to be moved around for optimal dissection, depending on the anatomy. If 5-mm instruments are available, smaller trocars may be used. For a small, unilateral hernia a 5-mm cannula may be substituted for the 10- to 12-mm cannula on the ipsilateral side.

Inspect both inguinal regions. Identify the median umbilical ligament (remnant of the urachus), the medial umbilical ligament (remnant of the umbilical artery), and the lateral umbilical fold (peritoneal reflection over the inferior epigastric artery). If the median umbilical ligament appears to compromise exposure, divide it. A hernia is visible as an outpouching of the peritoneum (Fig. 103.5a, b).

Incise the peritoneum along a line approximately 2 cm above the superior edge of the hernial defect, extending from the median umbilical ligament to the anterosuperior iliac spine. Mobilize the peritoneal flap inferiorly using blunt and sharp dissection (Fig. 103.6). Some surgeons routinely inject local anesthetic (0. 5 % bupivacaine with epinephrine mixed in an equal amount of normal saline) under the peritoneum before opening it. This makes mobilization of the superior and inferior flaps of peritoneum much easier and provides excellent postoperative pain relief for at least 6 h.

Expose the inferior epigastric vessels and identify the pubic symphysis and lower portion of the rectus abdominis muscle. Dissect Cooper's ligament to its junction with the femoral vein. Identify the iliopubic tract. Continue the dissection inferiorly, with care to avoid an injury to the femoral branch of the genitofemoral nerve and the lateral femoral cutaneous nerve, which enter the lower extremity just below the iliopubic tract (Fig. 103.2). Complete the dissection by skeletonizing the cord structures. A small indirect hernial sac is easily mobilized from the cord and reduced back into the peritoneal cavity. A large sac may be difficult to mobilize because of dense adhesions between the sac and the cord structures due to the chronicity of the hernia. Undue trauma

Fig. 103.3



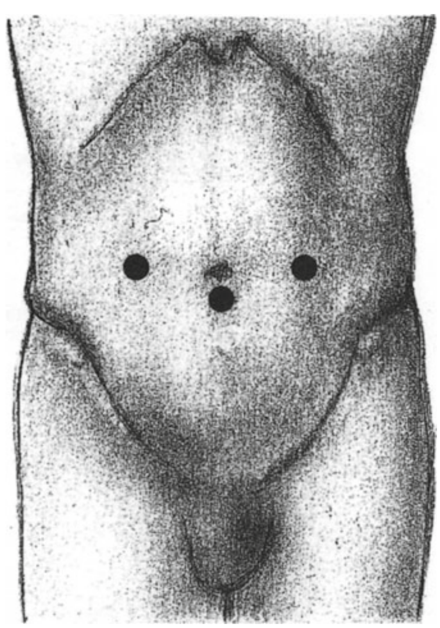


Fig. 103.4

to the cord may result if an attempt is made to remove the sac in its entirety. In this situation, divide the sac just distal to the internal ring, leaving the distal sac in situ. This is most easily accomplished by opening the sac on the side opposite the cord structures and completing the division from the inside. Dissect the proximal sac away from the cord structures. A direct hernia is easily managed by reducing the sac and preperitoneal fat from the hernial orifice by gentle traction (Fig. 103.7).

Placement of Mesh

Cut a piece of mesh at least 11 × 6 cm (unilateral); use one of the preformed mesh such as Bard 3D Max Mesh which comes in various sizes such as small, medium, and large. The mesh should be able to cover completely the direct, indirect, and femoral spaces. Do not cut a slit for the cord. We prefer to lay the mesh *over* the cord structures, rather than cutting a slit and wrapping the mesh *around* the cord structures. Recurrences have been reported through the orifice created around the new internal ring, even when the mesh has been closed around the cord. A large prosthesis

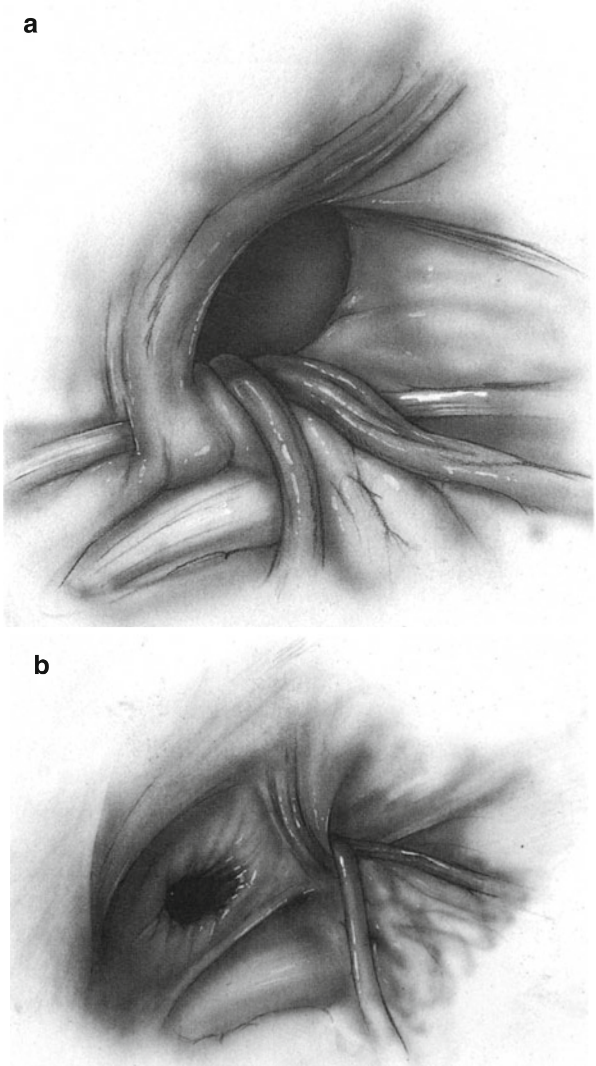


Fig. 103.5

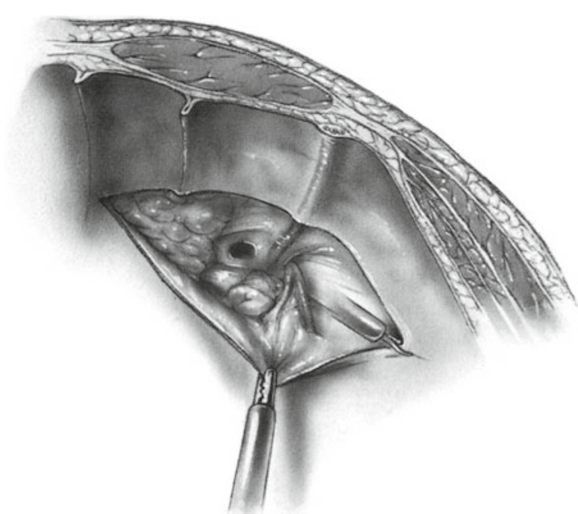


Fig. 103.6

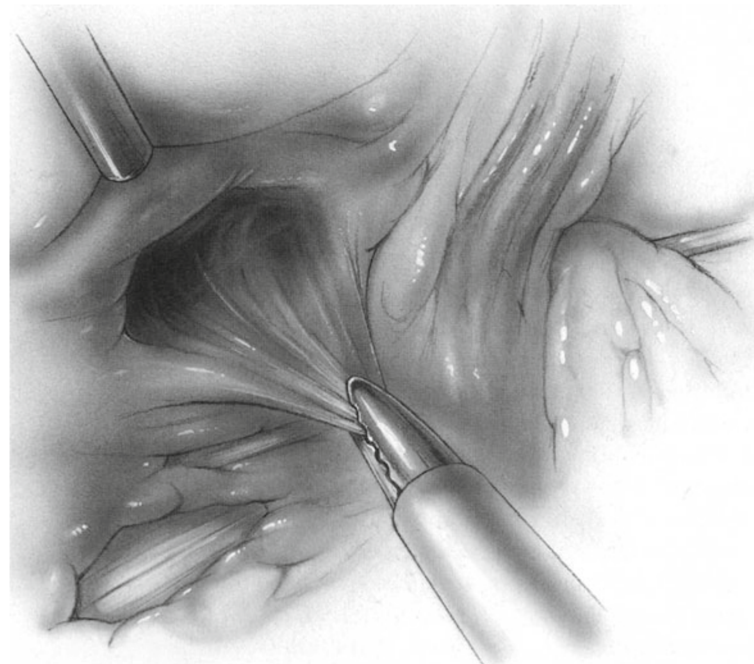


Fig. 103.7

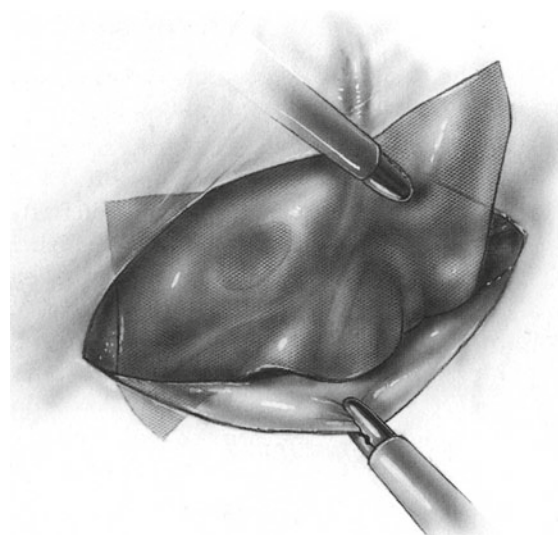


Fig. 103.8

allows intra-abdominal pressure to act uniformly over a large area, thereby preventing the mesh from conning out through the hernial defect. Roll the mesh longitudinally into a compact cylinder and pass it through one of the trocars. Some surgeons place temporary ties around the cylinder to facilitate handling.

Lie the cylinder at the inferior aspect of the working space and unroll it toward the anterior abdominal wall, smoothing it into place and tucking the corners underneath the peritoneal flap (Fig. 103.8). Take time to lay the mesh carefully

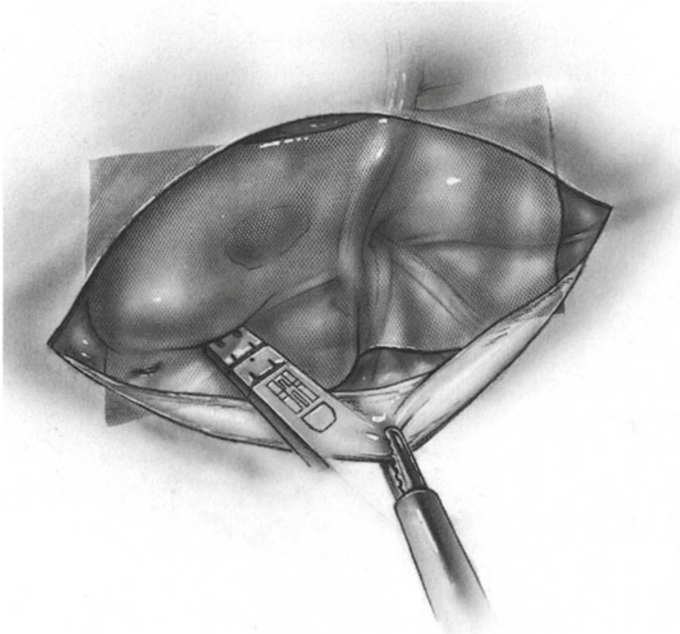


Fig. 103.9

over all hernial defects with good overlap. The mesh may be stapled or tacked in place or simply placed as an onlay graft. Both techniques are described here.

Stapling Technique

Staples or a hernia-tacking device may be used to affix the mesh. Begin stapling along the superior border of the prosthesis (Fig. 103.9) at the medial aspect of the contralateral pubic tubercle. Place the staples horizontally, progressing laterally along the superior border to the anterosuperior iliac spine. Horizontal staple placement minimizes the chance of injury to the deeper ilioinguinal or iliohypogastric nerves.

Staple the inferior border to Cooper's ligament medially using a horizontal or vertical orientation depending on the patient's characteristics (i.e., how the staples best attach). Again, the opposite pubic tubercle marks the area to begin placing staples for the inferior border, and stapling is continued over the area of the ipsilateral pubic tubercle to the femoral vein. Do not place staples directly into either pubic tubercle because chronic postoperative pain (osteitis pubis) can result. Always respect the triangles of doom and pain by not placing any staples below the iliopubic tract (Fig. 103.2).

Affix the medial and lateral borders using vertically placed staples, as this is the direction of the lateral cutaneous nerve of the thigh and the femoral branch of the genitofemoral nerve. Lateral to the internal spermatic vessels, place all staples above the iliopubic tract. This avoids neuralgia due to injury to the lateral cutaneous nerve of the thigh or the femoral branch of the genitofemoral nerve (Fig. 103.2).

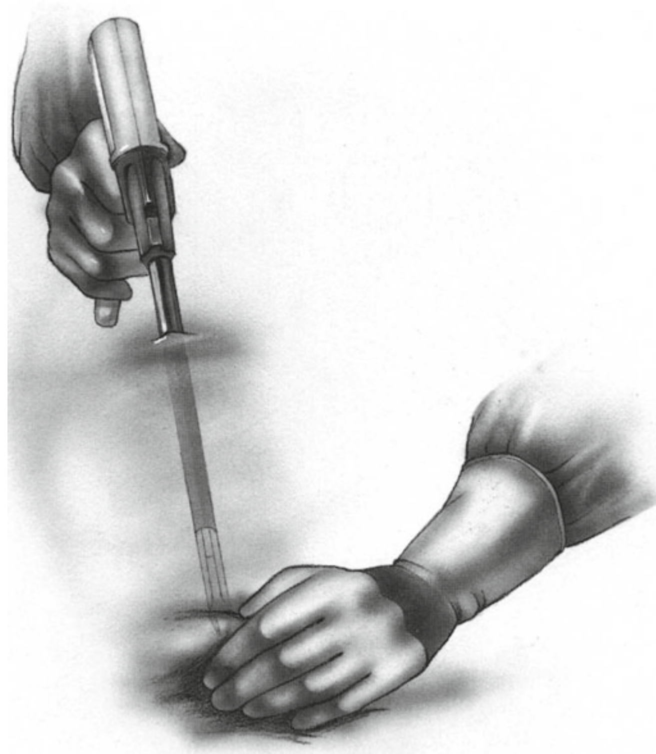


Fig. 103.10

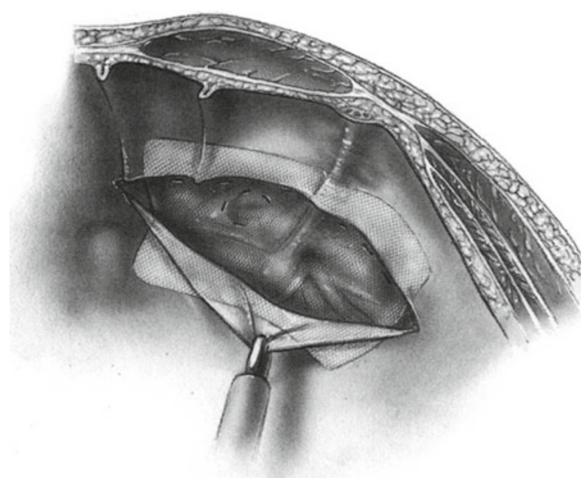


Fig. 103.11

It is useful to palpate the head of the stapler or tacker through the abdominal wall with the nondominant hand, ensuring that stapling is done above the iliopubic tract (Fig. 103.10). It also allows counterpressure to be applied, ensuring better purchase of the staples.

Excise any redundant mesh (Fig. 103.11) and close the peritoneal flap over the mesh with staples (Fig. 103.12). The

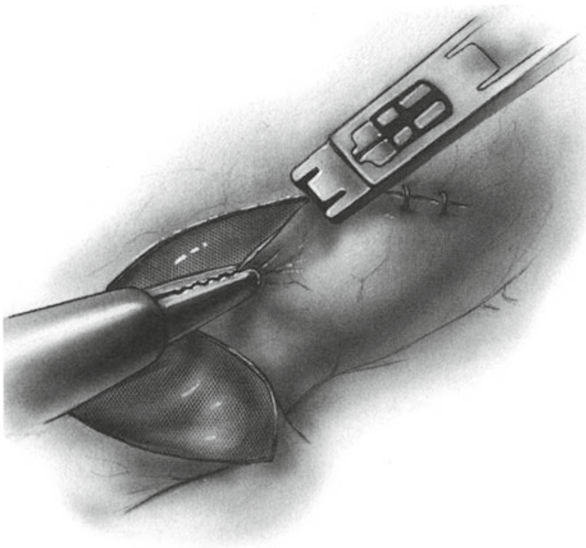


Fig. 103.12

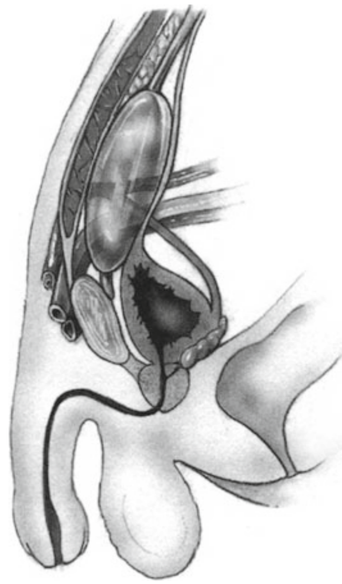


Fig. 103.13

goal is to isolate the mesh prosthesis from intra-abdominal viscera. Avoid excessive tension, which could tent the peritoneum over the mesh, creating a potential space into which bowel may herniate. It may be helpful to decrease the pneumoperitoneum before flap closure. Occasionally, it is necessary to simply cover the mesh with the inferior flap, leaving exposed transversalis fascia. Avoid excess gaps between staples, as bowel can herniate or adhere to the mesh through these defects. Inject a long-acting local anesthetic such as bupivacaine into the preperitoneal space before closure to decrease postoperative pain.

Onlay Graft (Nonstapled) Technique

Simply onlay the mesh in the preperitoneal space created earlier. Make sure the mesh lies perfectly flat with no rolled edges. Excise any redundant mesh and close the peritoneal flaps over the mesh with a continuous simple running intracorporeal suture of 3-0 PG. The goal is to isolate the mesh prosthesis from intra-abdominal viscera.

Bilateral Hernias

Bilateral hernias can be repaired using one long transverse peritoneal incision extending from one anterosuperior iliac spine to the other and a single large piece (30.0 × 7.5 cm) of mesh, or it can be done with two peritoneal incisions and two pieces of mesh. We favor the latter approach for the following reasons. First, it is easier to manipulate two small pieces of mesh and tailor them accurately to fit the preperitoneal spaces than a single large piece. Second, there is no potential for damage to a patent urachus if one exists. Finally, there is less concern about interfering with bladder function when two pieces of mesh are used.

TEP Approach

Make the skin incision for the first trocar (10–12 mm) at the umbilicus. Open the anterior rectus sheath on the ipsilateral side and retract the muscle laterally to expose the posterior rectus sheath. Following the incision of the anterior rectus sheath and retraction of the muscle laterally, insert a finger over the posterior rectus sheath and gently develop this space.

Insert a transparent balloon-tipped trocar into this space directed toward the pubic symphysis. Place the laparoscope in the trocar. Under direct vision, inflate the balloon to create an extraperitoneal tunnel or space (Fig. 103.13). Note that dissection in the correct plane mobilizes the bladder downward. This is followed by the insertion of a structural trocar which keeps the peritoneum pushed cranially.

Place two additional trocars in the midline under direct vision: one (5 mm) at the pubic symphysis and the other (10–12 mm) midway between the first and second (Fig. 103.14). Place these trocars by incising the skin with a scalpel.

Complete the dissection of the preperitoneal space, mesh placement, and stapling in a manner similar to that described for the TAPP procedure (Fig. 103.15). Bilateral hernias can be repaired with the use of a single large prosthesis or two pieces as previously discussed.

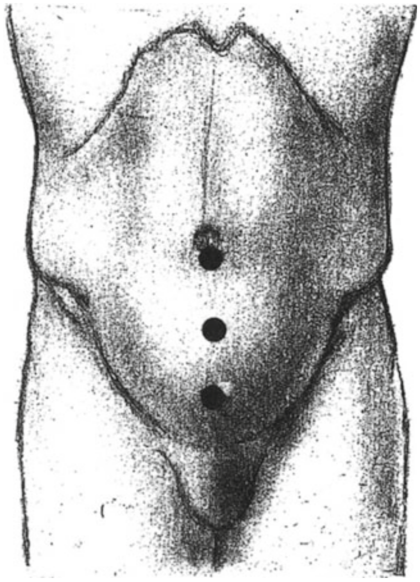


Fig. 103.14

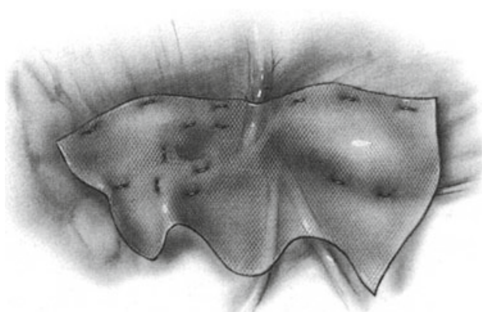


Fig. 103.15

Complications

Vascular injuries. Injury to the inferior epigastric and spermatic vessels is the most common vascular complication. Other vessels at risk include the external iliac, circumflex iliac profunda, and obturator vessels. Use of the open laparoscopic technique for inserting the initial cannula, meticulous dissection, and absolute identification of important landmarks are essential for preventing these injuries.

Urinary retention, *urinary infection*, *hematuria*. These are usually secondary to urinary catheterization, extensive preperitoneal dissection, general anesthesia, and administration of large volumes of intravenous fluids. These problems generally respond promptly to the usual treatments.

Bladder injury. This is one of the more common complications of laparoscopic herniorrhaphy. It is seen most commonly in patients with previous "space of Retzius" surgery. Previous surgery in this space (e.g., a prostate operation) should be considered a relative contraindication to laparoscopic hernia repair. If a bladder injury is recognized during hernia repair, it should be repaired immediately laparoscopically or via laparotomy if necessary. Repair the hernia by a conventional anterior approach to avoid placing a foreign body next to the bladder repair. A high index of suspicion is the key to the diagnosis of a missed urinary tract injury. Lower abdominal pain, a distended bladder, dysuria, and hematuria should be promptly investigated. Other signs may include azotemia, electrolyte abnormalities, and ascites. Indwelling catheter drainage alone may suffice for retroperitoneal bladder injuries, but intraperitoneal perforations are best closed laparoscopically or by laparotomy.

Nerve injury. The femoral branch of the genitofemoral nerve, the lateral cutaneous nerve of the thigh, and the intermediate cutaneous branch of the anterior branch of the femoral nerve are at risk of damage during laparoscopic herniorrhaphy because of (1) failure to appreciate the anatomy from the posterior aspect, (2) difficulty visualizing the nerves preperitoneally, (3) the variable course of the nerves in this region, (4) improper staple placement, or (5) extensive preperitoneal dissection. Symptoms of burning pain and numbness usually develop after a variable interval during the postoperative period. If neuralgia is present in the recovery room, immediate re-exploration is the best course of action. When the onset of the symptoms is delayed, the condition is usually self-limiting. In most cases nonsteroidal anti-inflammatory drugs (NSAIDs) are sufficient. Re-exploration and removal of the offending staple is occasionally required.

Vas deferens and testicular complications. Testicular pain may be the result of trauma to the genitofemoral nerve or to the sympathetic innervation of the testis during dissection around the cord structures or during separation of the peritoneum from the cord structures. Testicular swelling may be secondary to narrowing of the deep inguinal ring, ischemia, or interruption of lymphatic or venous vessels resulting from attempts at complete removal of a large indirect inguinal hernial sac. Pain and swelling are usually transient and self-limiting. Transection of the vas deferens and testicular atrophy are seen in about the same incidence as during conventional surgery. The risk of these complications may be significantly decreased if the surgeon avoids excessive tightening of the deep inguinal ring, gently dissects around the cord structures, and does not attempt complete removal of large indirect hernial sacs. Minor cord and testicular complications are treated by supportive care, such as testicular support, limitation of activities, and analgesics. If the vas deferens is transected, the cut ends should be repaired with fine, interrupted sutures unless fertility is not a consideration. There is no treatment for unilateral testicular atrophy. The hypogonadism produced by bilateral testicular atrophy is treated by supplemental testosterone.

Complications related to the mesh. Migration, infection, mass lesions representing palpable mesh, adhesion formation, and erosion of the mesh into intra-abdominal organs have been reported following laparoscopic herniorrhaphy. Fixation of the mesh prevents migration. Perioperative prophylactic antibiotics are recommended to prevent mesh infection. Adhesion formation is least likely to occur after the TEP procedure, as the mesh is never in contact with intra-abdominal organs unless there are unrecognized peritoneal perforations. Following the TAPP procedure, adequate closure of the peritoneum over the mesh is the most important factor in preventing complications such as bowel herniating through large gaps or becoming adherent to exposed mesh. Minimizing trauma, avoiding infection, sparing the blood supply, and avoiding exposed mesh decrease the incidence of adhesion formation. Mesh complications usually manifest weeks to years after the repair in the form of small bowel obstruction, abscess, or fistula. They may respond to conservative management or may require formal laparotomy.

Recurrence of the hernia. Potential mechanisms for recurrence include missed hernias or failure of the mesh to cover all hernial defects adequately. The latter may occur when the mesh rolls, migrates, is too small, or is improperly secured. We believe that thorough dissection of the preperitoneal space with identification of all the landmarks followed by fixation of a large piece of mesh that adequately covers and overlaps the entire myopectineal orifice without slitting or folding is the best way to avoid recurrence. A repeat laparoscopic repair or a conventional repair (see Chap. 104) is needed to correct the recurrence.

Osteitis. Pelvic or pubic osteitis results from staples placed directly into bone. Placing staples on the anterior and superior portion of Cooper's ligament or avoiding fixing mesh altogether prevents these complications. The diagnosis is essentially one of exclusion. NSAIDs may help.

Wound infection. This may be prevented by using meticulous sterile technique.

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104 Operations for Recurrent Inguinal Hernia

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Strangulation of recurrent hernia
Incarceration or recent history of incarceration of recurrent hernia
Symptomatic recurrent hernia in good-risk patients

Preoperative Preparation

If the patient suffers from chronic pulmonary disease, make every effort to achieve optimal improvement. Encourage all patients to stop smoking for at least a week before the operation.
Encourage the obese patient to lose weight.
Evaluate elderly male patients for potential prostatic obstruction.
Administer perioperative antibiotics if the use of mesh is anticipated.
Obtain consent for possible orchiectomy in elderly patients.

Pitfalls and Danger Points

Failing to identify all defects and to tailor the repair to the problem
Injuring internal spermatic artery and vein or iliac artery or vein
Injuring vas deferens
Injuring colon (rare)
Injuring bladder (rare)
Using weak tissues for repair

Operative Strategy

We note here the common causes of recurrence and their prevention. Thorough understanding of this material is essential for anatomic repair of recurrent hernias and helps the surgeon keep the primary recurrence rate low.

Internal Ring Left Too Large

At the conclusion of the repair, the internal ring should admit only the spermatic cord plus 2–3 mm (the tip of a Kelly hemostat). If closure is not adequate, the risk of recurrence is increased. Generally it requires removing both cremaster muscle and any lipomas from the spermatic cord as it passes through the internal ring.

Inadequate closure of the internal ring often follows repair of a large indirect hernia in adults. Simply removing the sac and performing a Bassini-type repair by suturing internal oblique muscle to the inguinal ligament often fail to produce adequate closure of the internal ring.

Defect at Pubic Tubercle

The second most common location of the hernial defect in a recurrent inguinal hernia is the most medial portion of Hesselbach's triangle adjacent to the pubic tubercle. This is often a localized defect measuring no more than 1–2 cm in diameter. The exact cause of this defect is not clear. It may result if the surgeon does not continue the suture line up to

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and including the pubic periosteum. Tying interrupted sutures (e.g., during a McVay repair) with excessive tension may play a part in the etiology of this type of defect.

Failure to Suture Transversalis Fascia or Transversus Arch

A Bassini repair is apt to fail if performed by suturing internal oblique muscle to the shelving edge of the inguinal ligament. Often these sutures fail to catch transversalis fascia or the aponeurosis of the transversus muscle (transversus arch), which are the strongest structures in the region. With traditional techniques of hernia repair, no attempt was made clearly to identify these structures prior to inserting sutures.

Failure to Excise Sac

Failure to remove the entire indirect sac is an important cause of recurrent hernia. Obviously, if the surgeon fails to remove the sac, hernia recurrence is probable. Even when an obvious direct hernia is found, always explore the cord and remove any indirect sac.

Use of Absorbable Sutures

It was demonstrated long ago that the use of catgut for repairing an inguinal hernia is followed by an excessive rate of recurrence. Nevertheless, a few surgeons persist in using absorbable suture material, which loses most of its tensile strength within several weeks, a length of time inadequate for solid healing of an inguinal hernia repair.

Subcutaneous Transplantation of Cord

A significant number of patients present with recurrent inguinal hernias following a Halsted repair in which the spermatic cord is transplanted into the subcutaneous plane by fashioning a new external ring directly superficial to the internal ring. The superimposition of one ring over the other results in a repair that is weaker than those that preserve the obliquity of the inguinal canal. Following the Halsted repair, a recurrent hernia presents at the point where the spermatic cord exits from the internal-external ring. Generally the two rings appear to have fused, and the hernia protrudes from this common orifice alongside the cord. It is important to recognize this before repairing the recurrence, as the cord is encountered early during the dissection and may be injured.

Femoral Recurrence Following Inguinal Hernia Repair

Several authors (McVay and Halverson 1980; Glassow 1970) have emphasized that following repair of an inguinal hernia, 1–3 % of patients later develop a femoral hernia on the same side. When operating to repair an inguinal hernia, the surgeon should inspect and palpate the cephalad opening of the femoral canal in search of a small femoral hernia. The normal femoral canal does not admit the surgeon's fingertip. The only circumstance in which this step might be omitted is when a young patient presents with a simple indirect hernia and no weakness of the floor of the inguinal canal.

If a femoral hernia is detected, it should be repaired simultaneously with the inguinal hernia repair. McVay's technique using Cooper's ligament automatically repairs any femoral defect by suturing the transversus arch to Cooper's ligament and the femoral sheath. Glassow recommended exposing the inferior opening of the femoral canal in the groin and repairing it with a few sutures from the lower approach. He then completed the inguinal repair by the Shouldice technique. A "plug" of Marlex mesh may be inserted into the femoral hernial ring from above or below to repair the femoral hernia.

Infection

Infection is rare in modern practice. When it occurs, the risk of subsequent recurrence may be as high as 40 %.

Recurrent Indirect Inguinal Hernia

For every repair of an indirect hernia, free the sac above the internal ring after excising the entire cremaster muscle. Remove it and carefully identify the margins of the internal ring. To do this, it is necessary to delineate the transversalis fascia, which forms the medial margin of the internal ring. It is also important to differentiate weak from strong transversalis fascia. After identifying the lateral edge of the transversalis fascia as it joins the internal ring, one can insert the index finger behind the transversalis layer and evaluate the strength of the inguinal canal's floor.

Although in infants and young children it is rarely necessary to reconstruct the internal ring following removal of the sac, in adults the indirect hernia has often reached sufficient width to erode the adjacent transversalis fascia and to leave an internal ring with a diameter of 2–4 cm. When this has occurred, we prefer to perform a Shouldice repair similar to that done for the direct inguinal hernia.

During both indirect and direct hernia repairs in the adult patient, remove all of the cremaster muscle and adipose tissue surrounding the spermatic cord. If the diameter of the spermatic cord is narrowed, the aperture of the internal inguinal ring can also be narrowed, leaving an insignificant defect in the floor of the inguinal canal for a possible recurrent hernia.

Direct Inguinal Hernia

Successful repair of a direct hernia requires meticulous dissection and exposure of the transversalis fascia, the aponeurosis of the transversus muscle, and the lateral condensation of the transversalis fascia near the inguinal ligament (iliopubic tract and femoral sheath) prior to suturing the transversus arch-transversalis fascia to the iliopubic tract and the inguinal ligament. Excellent results have been reported following appropriate use of the Shouldice and McVay repairs and for the various techniques utilizing prosthetic mesh. During any direct inguinal repair, the anatomic structures named above must be carefully dissected and evaluated for areas of weakness. Any weakened areas must be excised, and only strong tissues employed for suturing or for the floor must be replaced with prosthetic mesh.

Choice of Approach

A major decision required before surgery is whether to use an anterior (groin) approach or a preperitoneal (usually laparoscopic) approach. This choice determines the instruments, room setup, and choice of anesthesia. The preperitoneal approach described here as legacy material is occasionally useful if an anterior approach must be abandoned because of excessive scarring.

Anesthesia

Many groin operations for a recurrent inguinal hernia can be performed under local anesthesia without undue difficulty. Patients who have had previous operations for a recurrent hernia and have accumulated a great deal of scar tissue are preferably operated on with general anesthesia. General anesthesia is also needed for the preperitoneal (open or laparoscopic) approach.

Selecting the Optimal Technique for Repair of Recurrent Inguinal Hernia

There is no single best approach to a recurrent hernia. Obtain the previous operative record and determine what repair was done originally; then make an educated guess as to the probable mechanism and location of the recurrence. The occasional missed indirect inguinal hernia or the direct hernia with a virgin floor may be repaired in a manner similar to that used for primary repair. However, most recurrent hernias are more complex, with scarring and lack of good fascia to approximate without tension. The simplest, most secure way to repair these recurrent hernias is to bridge the gap with prosthetic mesh tailored to overlap good fascia by at least 3 cm and sutured in place. The repair must be individualized, and frequently the decision is made only after the anatomic defect has been exposed and identified.

A preperitoneal approach, whether open (as described by Nyhus (1995, 1989)) or laparoscopic, allows dissection in virgin planes. The defect is closed, again, after placing a large sheet of prosthetic mesh. This may be the best approach if mesh was placed at the primary operation.

Technique of Dissection

When the anterior inguinal approach has been selected, remember that the patient may have undergone the previous repair by the Halsted technique. Anticipate the possibility of encountering the spermatic cord in the subcutaneous layer of the dissection. Therefore soon after the skin incision is made, elevate the cephalad skin flap and direct the dissection so the anterior surface of the external oblique aponeurosis is exposed at a point 3–5 cm above the inguinal canal. This is virgin territory that has not been involved in previous surgery. Carefully direct the dissection in a manner that does not expose the external oblique aponeurosis inferiorly until the subcutaneous spermatic cord or the reconstructed external ring has been exposed. In the absence of a previous Halsted repair, continue the dissection beyond the previous suture line of the external oblique aponeurosis until the junction of the inguinal ligament and the upper thigh has been exposed. If one does encounter the spermatic cord in a subcutaneous location, meticulous dissection is necessary to preserve the fragile spermatic veins. In the absence of a previous Halsted repair, incise the external oblique aponeurosis with caution to avoid traumatizing the cord.

Avoiding Testicular Complications

In the elderly patient with a large recurrent hernia, the repair can be simplified if the patient is willing preoperatively to accept a simultaneous orchiectomy. In most series of recurrent hernia repairs, 10–15 % of patients undergo simultaneous orchiectomy. In younger patients and in those in whom the surgeon wishes to minimize the risk of having a testicular complication, the preperitoneal approach offers a sound alternative to dissection in a previous operative field.

Otherwise, take the time to perform meticulous dissection of the spermatic vessels and vas. Sometimes the spermatic veins have been spread apart by a large hernia, increasing their vulnerability to operative trauma.

When the anterior inguinal approach through the previous incision has been selected for repair of a recurrent hernia in a young man, occasionally preserving the spermatic cord seems impossible. In this situation it is advisable to abandon the anterior approach and to extend the skin incision so the medial skin flap can be elevated for a distance of 3–5 cm. Continue the operation by an incision through the abdominal wall using the preperitoneal approach of Nyhus. After dissecting the peritoneum and the sac away from the posterior abdominal wall in the inguinal region, insert a prosthetic mesh. This approach helps avoid testicular complications.

Documentation Basics

- Findings
- Presence of incarceration
- Presence of strangulation
- Use of mesh

Operative Technique

Inguinal Approach

Incision and Exposure

Enter the operative site through the old incision. It may be cosmetically advantageous to excise the previous scar. Then dissect the skin flap in a cephalad direction. Be aware of the possibility that at the previous operation the surgeon may have transplanted the spermatic cord into a subcutaneous location. Be careful not to injure the cord during this dissection. After the skin flap has been dissected for a distance of about 2–3 cm, carry the dissection down to the aponeurosis of the external oblique muscle. Accomplish this in an area that is superior to the region of the previous surgery. Now dissect all subcutaneous fat off the anterior surface of the aponeurosis, proceeding in an inferolateral direction until the inguinal ligament and the subcutaneous inguinal ring have been cleared.

Repairing Recurrent Hernia Following Previous Hoisted Operation Without Opening the Inguinal Canal

If the spermatic cord was transplanted into the subcutaneous plane at the previous operation, the subcutaneous and deep inguinal rings are now superimposed, one directly on the other. In this case the inguinal region is generally quite strong except for a single defect that represents an enlarged common external-internal ring through which the spermatic cord passes together with the hernial sac. In these patients it is often difficult to separate the external oblique aponeurosis from the deeper structures, a step that is necessary before accomplishing either a Shouldice or a McVay repair. Instead of incising the external oblique aponeurosis in the region between the hernial defect and the pubic tubercle in these patients, it may be more prudent to remove the hernial sac and then narrow the enlarged common ring with several heavy sutures.

To accomplish this, carefully identify and dissect the spermatic cord free from surrounding structures and isolate the hernial sac. Open it and insert the index finger to verify that the floor of the inguinal canal is indeed strong. Dissect the sac away from any attachments at its neck. Close the sac with a single suture-ligature of 2-0 PG. Alternatively, use a purse-string suture. Amputate the sac and permit the stump to retract into the abdominal cavity. Dissect areolar tissue, fat, and cremaster from the margins of the hernial defect. Close the defect medial to the point of exit of the spermatic cord using 2-0 Tevdek or Prolene on an atraumatic needle. In effect, the needle penetrates (at the medial margin of the ring) 5–6 mm of the external oblique aponeurosis, the underlying internal oblique, and the transversalis fascia. At the lateral margin of the repair the needle pierces the external oblique aponeurosis and the shelving edge of the inguinal ligament. Narrow the ring to the extent that a Kelly hemostat can be passed into the revised inguinal ring alongside the spermatic cord. Making the ring any smaller increases the risk of testicular complications.

Inevitably, these sutures must be tied with some tension, which threatens the success of any hernia repair. Therefore it is preferable when possible to insert an appropriately sized plug of Marlex mesh into the ring. Stabilize the plug with sutures as described in Fig. 105.7. This method obliterates the defect *with no tension* on the tissues. If the hernial defect is large (>3 cm in diameter), apply a patch consisting of a layer of Marlex or Prolene mesh to cover the defect. Suture the mesh to the edge of the hernial defect using large bites of interrupted or continuous 2-0 atraumatic Prolene. Leave an opening for exit of the spermatic cord along the medial margin of the repair.

Dissecting the Inguinal Canal

Most patients presenting with a recurrent inguinal hernia have had their previous repair performed with some variety of the Bassini technique; the spermatic cord thus remains in its normal location deep to the external oblique aponeurosis. In these cases, make an incision in the external oblique aponeurosis along the lines of its fibers aimed at the cephalad margin of the external inguinal ring, as described above. Perform a patient, meticulous dissection of the spermatic cord to avoid traumatizing the delicate spermatic veins. After mobilizing the spermatic cord, identify the hernial sac. In our experience the most common location of a recurrence is in the floor of Hesselbach's triangle medial to the deep inferior epigastric vessels. The previous surgeon probably did not identify the transversalis fascia and the aponeurosis of the transversus muscle. If this area is virgin territory, repair the recurrent hernia by the classic Shouldice technique described in Chap. 100. This repair is also suitable in patients who have a recurrence of an indirect nature, as these patients almost always have considerable weakness of the inguinal canal. Of course, the indirect sac must be excised.

Repairing a Localized Defect in the Inguinal Floor

A number of patients with recurrent hernia suffer from a relatively small (≤2 cm) defect in the inguinal canal floor just medial to the pubic tubercle. Simple suturing of this defect produces excessive tension and is doomed to failure. Standard repair calls for an incision through the floor of the inguinal canal followed by a definitive Shouldice or McVay reconstruction. Mesh repair is an excellent alternative that avoids an extensive dissection. A plug of Marlex mesh is placed in the defect and sutured in place with one or two stitches of 2-0 Prolene as described for repair of a femoral hernia (see Fig. 105.7).

Prosthetic Mesh Repair

In most cases of recurrent hernia, after dissection of the inguinal canal, the remaining tissues are simply not strong enough to ensure successful suturing of the hernial defect. By far the most common error made by surgeons repairing a recurrent hernia is to misjudge the strength of the tissues being sutured. Attenuated scar tissue sutured under tension *does not allow a successful long-term repair*. Do not hesitate to excise these weakened tissues. Make no attempt to close the defect by sutures; rather, insert prosthetic mesh, which can be inserted to replace the defect *without any tension at all*.

Complete the dissection of the inguinal canal through the layer of the transversalis fascia (see Figs. 100.3, 100.4, 100.5, 100.6, 100.7, 100.8, 100.9, 100.10, 100.11, and 100.12), so the peritoneum, Cooper's ligament, and the aponeurosis of the transversus muscle have all been exposed. Separate the peritoneum from the transversalis fascia for a distance of at least 3 cm around the perimeter of the inguinal defect. Trim away attenuated tissues. Now take a layer of Marlex or Prolene mesh and cut a patch in the shape of an ellipse whose diameter is 3–4 cm larger than that of the defect. Place the mesh behind the abdominal wall between the peritoneum and the transversalis fascia. Suture the mesh in place by means of 2-0 atraumatic Prolene stitches *through the entire abdominal wall* in a mattress fashion, as seen in Fig. 104.1a. Continue to insert these interrupted mattress sutures around the perimeter of the defect and to penetrate the external oblique, internal oblique, and transversus muscles and the transversalis fascia. Along the medial aspects of the hernial defect, the sutures penetrate the anterior rectus sheath, the rectus muscle, and the transversalis fascia. Along the lateral margin of the defect, suture the mesh to Cooper's ligament with interrupted or continuous 2-0 Prolene stitches going from the pubic tubercle laterally to the region of the femoral canal. Lateral to this point, suture the mesh to the femoral sheath and the shelving edge of Poupart's ligament. Cut a small section from the lateral portion of the mesh to avoid constricting the spermatic cord (Fig. 104.1b). *In most cases it is not possible to suture the layers of the abdominal wall together over the mesh without creating excessive tension*. After irrigating the operative area thoroughly with a dilute antibiotic solution, close Scarpa's fascia with 4-0 PG and close the skin with a continuous 4-0 PG subcuticular suture.

Abandoning the Anterior Approach

With rare recurrent inguinal hernias, it may be apparent during dissection of the spermatic cord that there is such dense fibrosis as to endanger preservation of the cord. When these conditions are encountered, especially in young patients, simply abandon the anterior approach. Elevate the cephalad skin flap and make an incision through the abdominal wall down to the peritoneum, as described below for the preperitoneal approach to the repair of a recurrent hernia. Dissecting peritoneum away from the posterior wall of the inguinal canal via the preperitoneal approach does not endanger the spermatic cord because this dissection is carried out in territory free of scar tissue.

Preperitoneal Approach Using Mesh Prosthesis (Surgical Legacy Technique)

The technique described below is derived in many aspects from the contributions of Nyhus. It is described as used for a large right recurrent inguinal hernia.

Incision and Exposure

Enter the abdominal cavity by making a transverse incision in the lower quadrant at a level at least 3 cm above the upper margin of the hernial defect. Start the skin incision near the abdominal midline approximately two fingerbreadths above the pubic symphysis and proceed laterally for a distance of about 10 cm, aiming at a point just above the anterosuperior spine of the ilium. Expose the external oblique aponeurosis and the artery. Figure 104.2 illustrates the anatomy of structures encountered during this preperitoneal dissection on the *right* side of the patient.

Suturing the Mesh

Cut a square of Marlex or Prolene mesh sufficiently large to provide a layer of prosthesis that reaches from the abdominal incision (cephalad) to Cooper's ligament and to the iliopsoas fascia (caudad) and from the mid-rectus region medially to the anterosuperior iliac spine laterally.

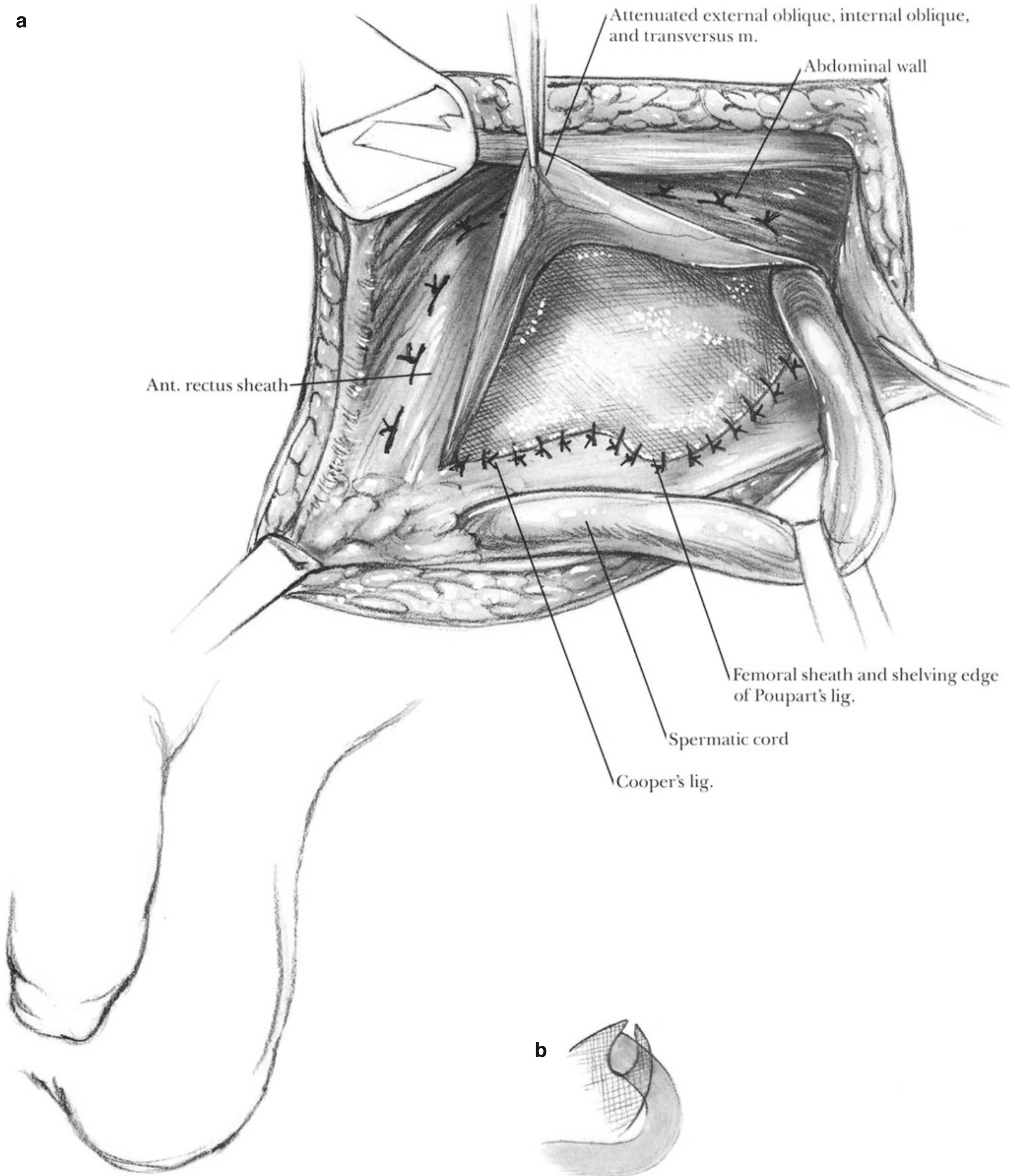

Fig. 104.1

For recurrent hernias repaired by this approach, do not attempt to close the hernial defect by suturing it because the tension would be excessive. Use 2-0 atraumatic Prolene swaged on a stout needle and take substantial bites of strong tissue to ensure that the mesh remains permanently in place. Do not expect that the ingrowth of fibrous tissue into the mesh will ensure fixation, as the polypropylene is relatively inert and substantial fibrous ingrowth does not *always* take place. Place the first suture in the ligamentous tissue adjacent to the pubic symphysis. Continue the suture line laterally, passing

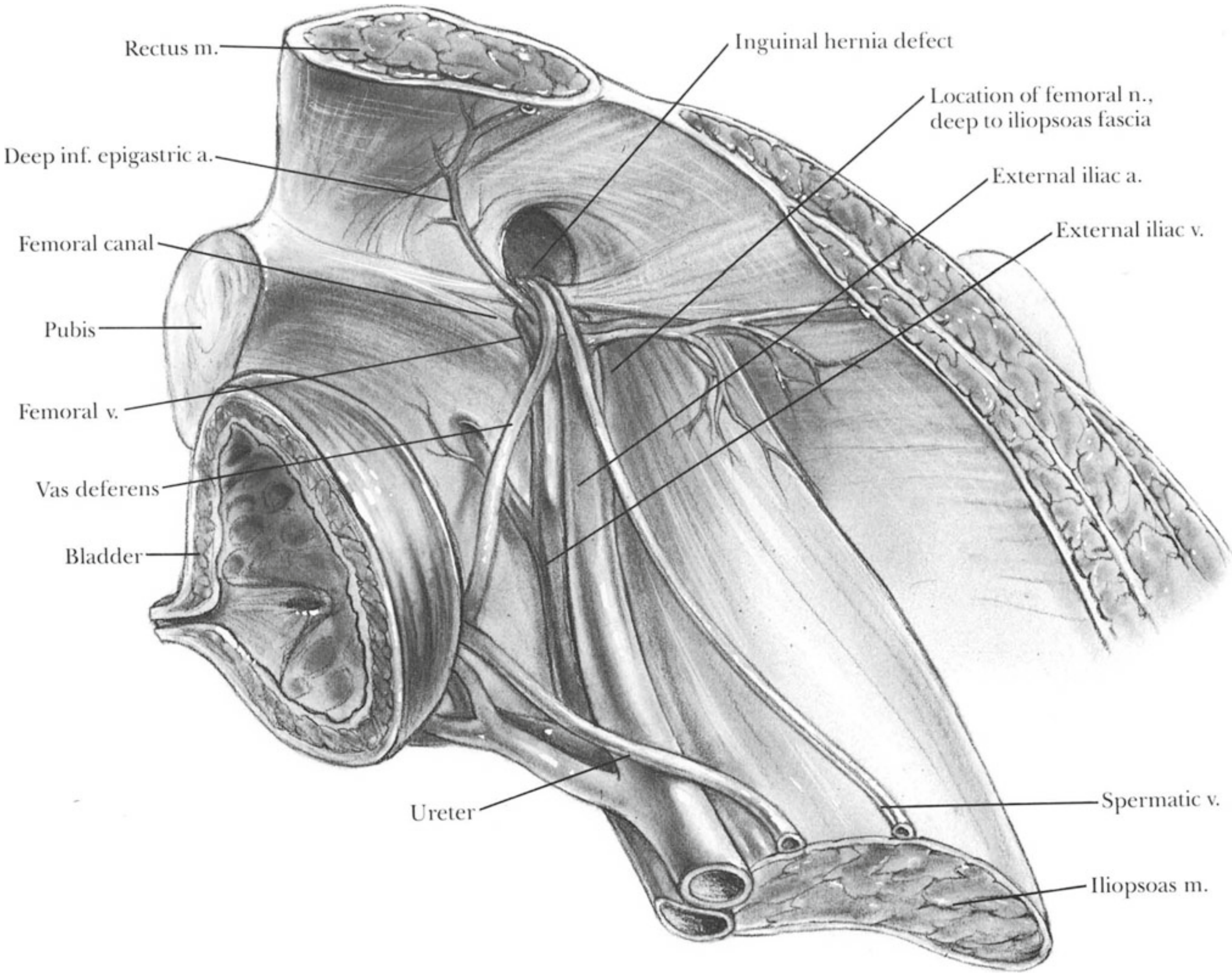

Fig. 104.2

interrupted 2-0 atraumatic Prolene sutures through the layer of mesh deep into Cooper's ligament along the pubic ramus. At the femoral ring, suture the mesh to the femoral sheath and the shelving edge of the inguinal ligament. When the internal inguinal ring is reached, leave a space for the spermatic cord to exit from the abdominal cavity in the male patient. Lateral to the external iliac artery, carry the suture line in a posterior direction and attach the mesh to the iliopsoas fascia proceeding laterally. Take deep bites into this fascia after identifying and protecting the femoral nerve, which runs just below the fascia. Continue the suture line in the iliopsoas fascia laterally toward the anterosuperior iliac spine until the lateral margin of the abdominal incision is reached. In the female patient, suturing the mesh to the femoral sheath and the iliopsoas fascia completely obliterates the internal inguinal ring, although this operation (using mesh to repair a large recurrent inguinal hernia) rarely is necessary in women.

Attach the medial margin of the layer of mesh to the medial portion of the rectus muscle by dissecting the subcutaneous fat off the anterior rectus sheath down to the pubis. Then insert 2-0 Prolene sutures by taking a bite first through the anterior rectus sheath, next through the body of the rectus muscle, and then through the layer of mesh in the abdomen. Return the same suture as a mattress suture by taking a bite through the mesh, the body of the rectus muscle, and finally the anterior rectus sheath. After tying the stitch, the knot is on the anterior rectus sheath. Continue this suture line up to the level of the transverse abdominal incision. Figure 104.3 depicts the appearance of the mesh sutured in place.

Intermittently during the operation irrigate the operative site with a dilute antibiotic solution. By this point in the operation, the mesh has been sutured into place medially, caudally, and laterally; only the cephalad margin is left unattached. Trim the mesh so this cephalad margin terminates evenly with the inferior margin of the transverse abdominal incision. Because of the irregular nature of the surface that has been covered by the flat patch of mesh, there is a surplus of mesh in the lateral portion of the incision. Correct this by making a vertical fold in the mesh, as necessary, to include the mesh in the closure of

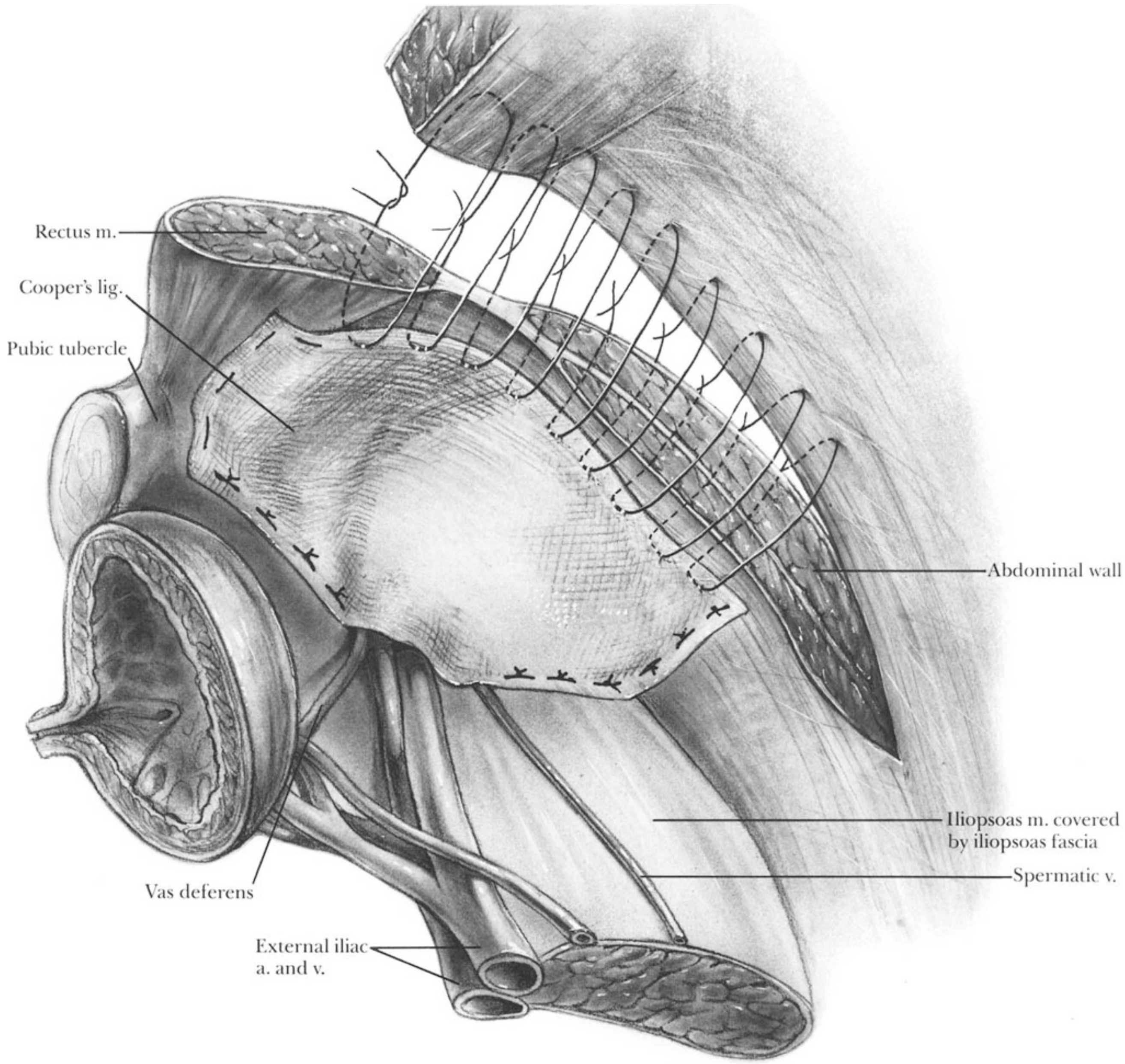

Fig. 104.3

the abdominal incision. Prior to inserting many of the sutures, it is necessary to ligate and divide or to coagulate a number of blood vessels in the region of Cooper's ligament and the femoral sheath so inserting the sutures does not produce bleeding.

Closing the Abdominal Incision

Close the anterior rectus sheath with interrupted nonabsorbable sutures. Lateral to the rectus muscle, close the abdominal incision using the Smead-Jones technique of interrupted 0 Prolene sutures that grasp a width of at least 1.5 cm of the abdominal wall including the external oblique aponeurosis, the internal oblique and transversus muscles, the transversalis fascia, and the *proximal edge of the mesh* in the caudal margin of the incision as well as the same layers on the cephalad margin except for the mesh. Close the skin with a continuous 4-0 PG subcuticular stitch. Figure 104.3 illustrates the completed incision suture line.

Postoperative Care

Ambulate the patient the day of the operation.

Complications

Testicular swelling and/or atrophy
Urinary retention in males
Recurrence of hernia
Wound hematoma
Wound sepsis. When infection develops in patients who have undergone insertion of a mesh prosthesis, it is not always necessary to remove this foreign body to remedy the infection, as the mesh is made up of monofilament fibers. In most patients wide drainage of the skin incision accompanied by parenteral antibiotics with perhaps local antibiotic irrigation may prove effective. We have had no experience managing a pelvic infection after insertion of a mesh prosthesis in the pelvis by the preperitoneal route. If we encountered this problem, we would subject the patient to a trial of conservative therapy after opening the incision to explore the pelvis and to insert indwelling irrigating catheters and sump-suction drains.

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Femoral Hernia Repair

105

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

As strangulation is common with femoral hernias, it is advisable to operate on all such patients unless their medical status is so precarious it contraindicates even an operation under local anesthesia.

Preoperative Preparation

If there are signs of intestinal obstruction, initiate nasogastric suction.

When a patient has symptoms suggestive of a femoral hernia but lacks definitive physical findings, request a sonogram of the groin. This study may reveal a small incarcerated femoral hernia. Sonography is also helpful for diagnosing symptomatic spigelian and other interstitial hernias of the abdominal wall.

Pitfalls and Danger Points

Injuring or constricting femoral vein
Transecting an aberrant obturator artery

Operative Strategy

Choose the operative approach (low groin, high inguinal, or preperitoneal) that best fits the situation. A low groin approach under local anesthesia is an excellent choice for the frail elderly patient (unless strangulated bowel is suspected). The preperitoneal approach offers the best access for bowel resection if strangulation has occurred. An inguinal approach allows any associated inguinal hernia to be repaired and gives adequate access for bowel resection, but it creates a defect in an otherwise intact inguinal floor. The low groin and preperitoneal approaches are described here.

Inguinal Approach

The inguinal approach is essentially identical to the McVay repair described in Chap. 101.

Low Groin Approach

For the low groin approach, after opening the sac and reducing its contents, amputate it. It is not necessary to close the neck of the sac with sutures (Ferguson). It is important, however, to clear the femoral canal of any fat or areolar tissue so the sutures can bring the inguinal ligament into direct contact with Cooper's ligament and the pectineus fascia. This maneuver obliterates the femoral canal but leaves an opening of 6–8 mm adjacent to the femoral vein. Equally good results can be obtained if the femoral canal is obliterated by inserting a plug of Marlex mesh. The technique avoids all tension on the suture line.

To reduce an incarcerated femoral hernia, an incision may be made to divide the constricting neck of the hernial sac. It should be done on the medial aspect of the hernial ring. Although we have never observed the phenomenon, a number of texts warn that an anomalous obturator artery may follow a course that brings it into contiguity with the neck of the hernial sac, making it vulnerable to injury when the constricted neck is incised. This accident *rarely* occurs

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if the neck of the sac is incised on its medial aspect. If hemorrhage is indeed encountered during this maneuver and the artery cannot be ligated from below, control the bleeding by finger pressure, and rapidly expose the inner aspect of the pelvis by the Henry approach, which involves a midline incision from the umbilicus to the pubis, after which the peritoneum is swept in a cephalad direction to expose the femoral canal from above. With this exposure a bleeding obturator artery can be easily ligated. It should be emphasized that this complication is so rare it does not constitute a significant disadvantage of the low approach to femoral herniorrhaphy.

If the sutures drawing the inguinal ligament down to Cooper's ligament must be tied under excessive tension, abandon this technique. Then insert a plug of nonabsorbable mesh to obliterate the femoral canal, as described below.

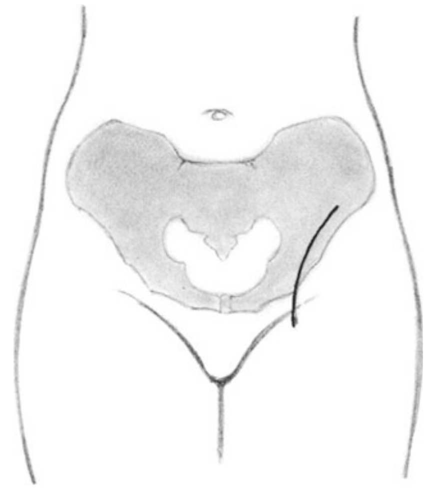

Fig. 105.1

Documentation Basics

- Findings
- Presence of incarceration or strangulation
- Primary or recurrent
- Type of repair
- Type of mesh used (if applicable)

Operative Technique

Low Groin Approach for Left Femoral Hernia

Make an oblique incision about 6 cm in length along the groin skin crease curving down over the femoral hernia (Fig. 105.1). Carry the incision down to the external oblique aponeurosis and the inferior aspect of the inguinal ligament. Identify the hernial sac as it emerges deep to the inguinal ligament in the space between the lacunar ligament and the common femoral vein (Fig. 105.2). Dissect the sac down to its neck using Metzenbaum scissors.

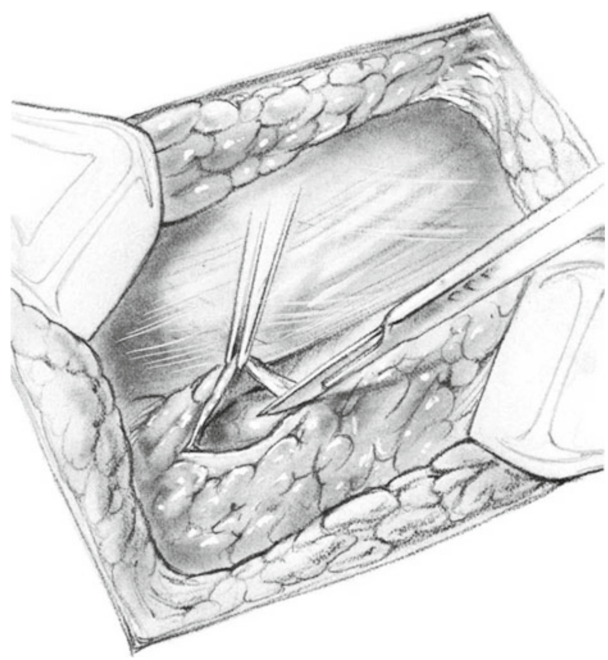

Fig. 105.2

Grasp the sac with two hemostats and incise with a scalpel. Often the peritoneum is covered by two or more layers of tissue, each of which may resemble a sac. They consist of preperitoneal tissues and fat. This situation is seen especially when intestine is incarcerated in the sac.

When the bowel or the omentum remains incarcerated after opening the sac, incise the hernial ring on its medial aspect by inserting a scalpel between the sac and the lacunar ligament (Figs. 105.3 and 105.4). After returning the bowel and the omentum to the abdominal cavity, amputate the sac at its neck. Although it is not necessary to ligate or suture the neck of the sac, this step may be performed if desired (Fig. 105.5). Using a peanut sponge, push any remaining preperitoneal fat into the abdominal cavity, thereby clearing the femoral canal of all extraneous tissues.

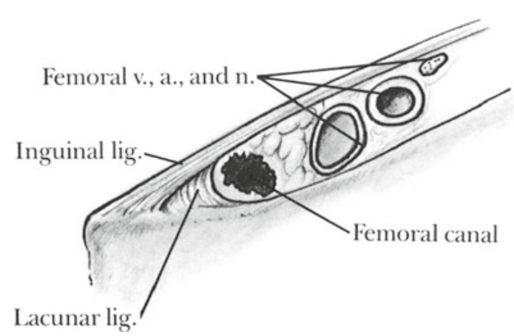

Fig. 105.3

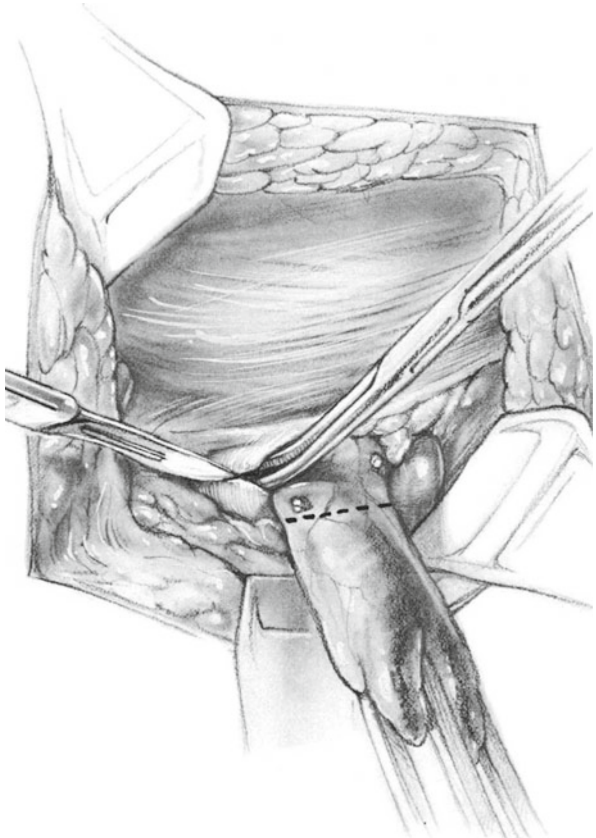

Fig. 105.4

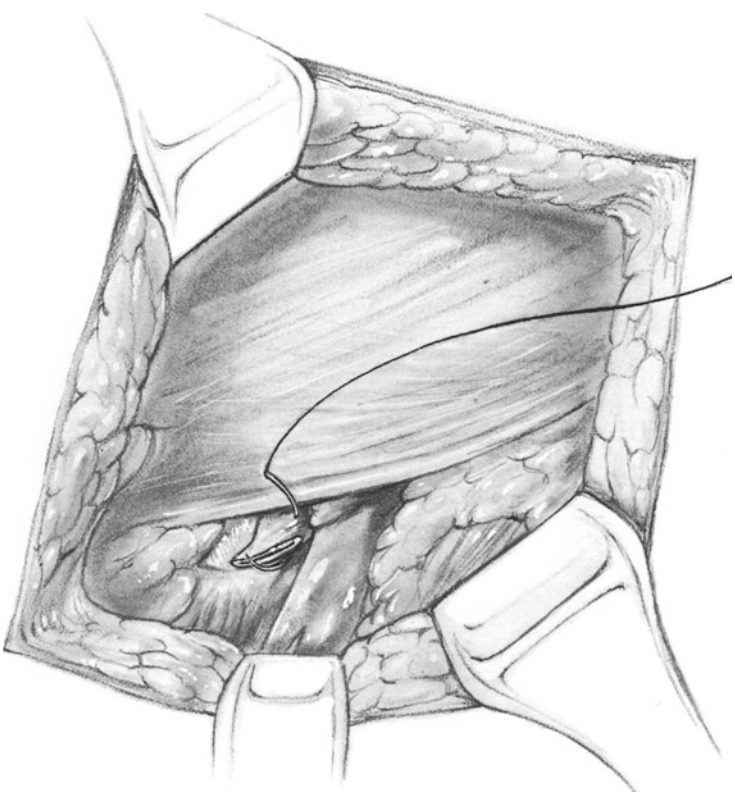

Fig.

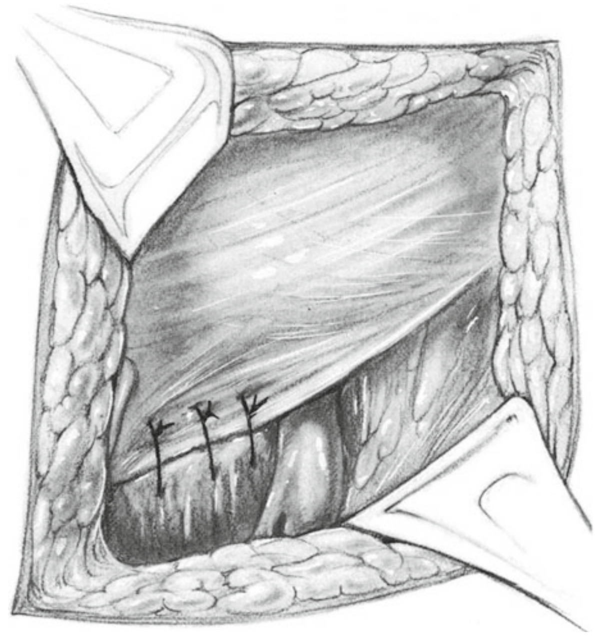

Fig. 105.6

Repair the hernial defect by suturing the inguinal ligament down to Cooper's ligament using interrupted 2-0 sutures of Prolene on a heavy Mayo needle. Often this can be accomplished if the inguinal ligament is pressed down and cephalad toward Cooper's ligament with the index finger. The needle is then passed through the inguinal ligament and through Cooper's ligament in one simultaneous motion. Cooper's ligament is indistinguishable from the periosteum overlying the cephalad aspect of the pubic ramus. An alternative method involves placing the stitch through the inguinal ligament and then positioning a narrow retractor in the femoral canal to take a bite of Cooper's ligament and pectineus fascia. No more than two or three sutures are generally necessary. Identify the common femoral vein where it emerges from underneath the inguinal ligament, and leave a gap of 4–6 mm between the femoral vein and the most lateral suture (Fig. 105.6). Close the skin of the groin incision with either continuous 4-0 PG subcuticular sutures or interrupted 4-0 nylon sutures.

If strangulated bowel requiring resection is encountered after opening the hernial sac, make a second incision in the midline between the umbilicus and the pubis. Separate the two rectus muscles and identify the peritoneum. Do not incise the peritoneum. Elevate the peritoneum from the pelvis by blunt dissection until the iliac vessels and the femoral hernial sac are identified. At this point, open the peritoneum just above the sac. Incise the constricting neck of the femoral canal on its medial aspect and reduce the strangulated bowel. After resecting the bowel, irrigate the femoral region with a dilute antibiotic solution, and repair the femoral ring from below as already described. Irrigate the abdomen and close the abdominal incision in routine fashion.

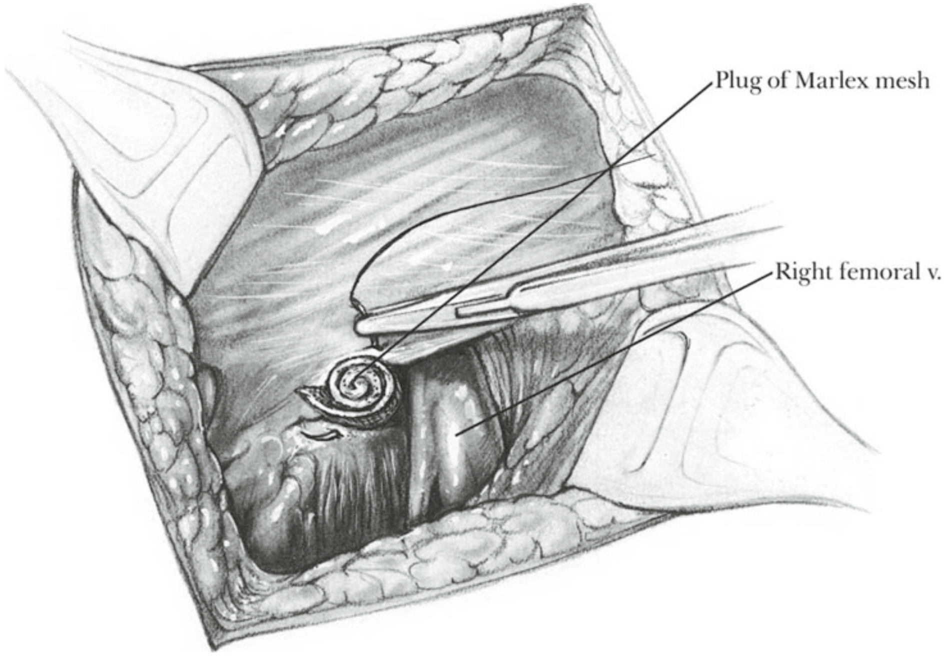

Fig. 105.7

Low Groin Approach Using Prosthetic Mesh "Plug"

Approximating the inguinal ligament to Cooper's ligament by sutures frequently requires excessive tension. Monro, who strongly favored the low groin approach, emphasized that the sutures should be tied loosely so they form a latticework of monofilament nylon. This technique serves to occlude the defect without producing tension.

The same end can be accomplished even more simply by inserting a rolled-up plug of Marlex mesh as advocated by Lichtenstein and Shore. *We believe this is the best method* for repairing a femoral hernia. Cut a strip of Marlex mesh about 2 × 10–12 cm. Roll the Marlex strip in the shape of a cigarette, 2 cm in length. After the hernial sac has been eliminated and all the fat has been cleared from the femoral canal, insert this Marlex plug into the femoral canal. The diameter of the plug may be adjusted by using a greater or lesser length of Marlex, as required. When the properly sized plug is snug in the femoral canal with about 0.3 cm of the plug protruding into the groin, fix the Marlex in place by inserting two sutures of 2-0 atraumatic Prolene (Fig. 105.7). Insert the needle first through the inguinal ligament, then through the Marlex plug, and finally into the pectineal fascia or Cooper's ligament. After the two sutures have been tied, the plug should fit securely in the canal. After irrigating the wound with a dilute antibiotic solution, check for complete hemostasis and then close the skin incision without drainage. If the patient accumulates serum in the incision postoperatively, aspirate the fluid occasionally with a needle.

Fig. 105.8

Preperitoneal Approach for Right Femoral Hernia (Nyhus)

Anesthesia

General or regional anesthesia with good muscle relaxation is required.

Incision

Start the skin incision at a point two fingerbreadths above the symphysis pubis (Fig. 105.8) and about 1.5 cm lateral to the abdominal midline. Carry the incision laterally for a distance of 8–10 cm, and expose the anterior rectus sheath and the external oblique aponeurosis. Elevate the caudal skin flap sufficiently to expose the external inguinal ring.

Make a transverse incision in the anterior rectus sheath about 1.5 cm cephalad to the upper margin of the external inguinal ring for a distance of about 5 cm in a direction parallel to the inguinal canal (Fig. 105.9). Retract the rectus muscle medially, and deepen the incision through the full thickness of the internal oblique and transversus abdominis muscles, exposing the transversalis fascia. Carefully make a transverse incision in this layer but do not incise the peritoneum.

Apply a Richardson retractor against the lateral margin of the incised abdominal wall. Use blunt dissection to elevate the peritoneum out of the pelvis.

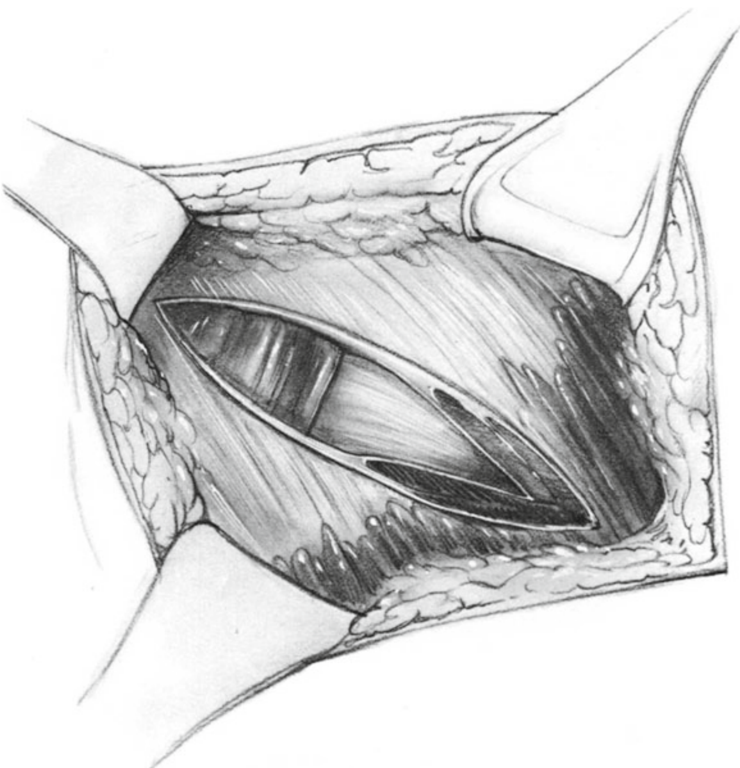

Fig. 105.9

Mobilizing the Hernial Sac

If the femoral hernia is incarcerated, it is possible to mobilize the entire pelvic peritoneum except for that portion incarcerated in the femoral canal (Fig. 105.10). If the hernia cannot be extracted by gentle blunt dissection around the femoral ring, incise the medial margin of the femoral ring, and extract the hernial sac by combining traction plus external pressure against the sac in the groin. Although the presence of an aberrant obturator artery along the medial margin of the femoral ring is a rarity, there may be one or two small venous branches that require suture-ligation prior to incising the medial margin of the ring.

Open the sac (Fig. 105.11). Evaluate the condition of the bowel. If strangulation mandates bowel resection, enlarge the incision enough so adequate exposure for a careful intestinal anastomosis may be guaranteed. If bowel has been resected, change gloves and instruments before initiating the repair. Irrigate the incision with a dilute antibiotic solution. Excise the peritoneal sac and close the peritoneal defect with continuous 3-0 PG.

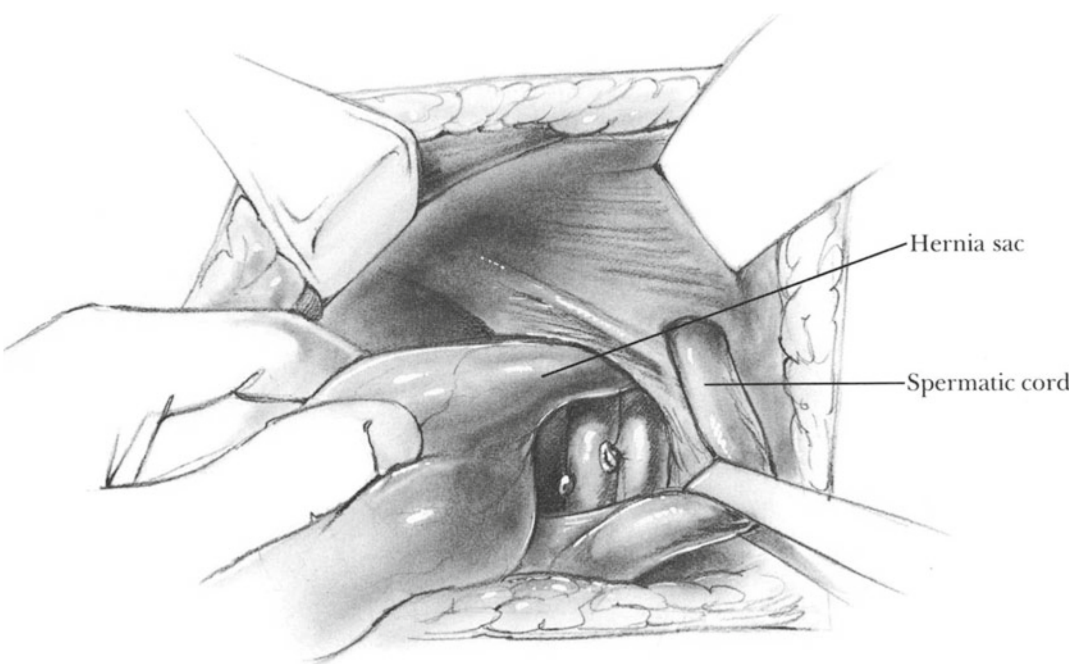

Fig. 105.10

Suturing the Hernial Ring

The superficial margin of the femoral ring consists of the iliopubic tract and the femoral sheath. These structures are just deep to the inguinal ligament. The deep margin of the femoral ring is Cooper's ligament, which represents the reinforced periosteum of the superior ramus of the pubis. When repairing the hernial defect, suture the strong tissue situated in the superficial margin of the femoral ring to Cooper's ligament with several interrupted sutures of 2-0 Tevdek or Prolene (Figs. 105.12 and 105.13). Whether the suture catching the superficial margin of the femoral ring contains only the iliopubic tract or it also catches a bite of inguinal ligament is immaterial so long as the tension is not excessive when the knot is tied. If closing the ring by approximating strong tissues would result in tension, it is preferable to suture a small "cigarette" of Marlex into the femoral ring from the cephalad approach.

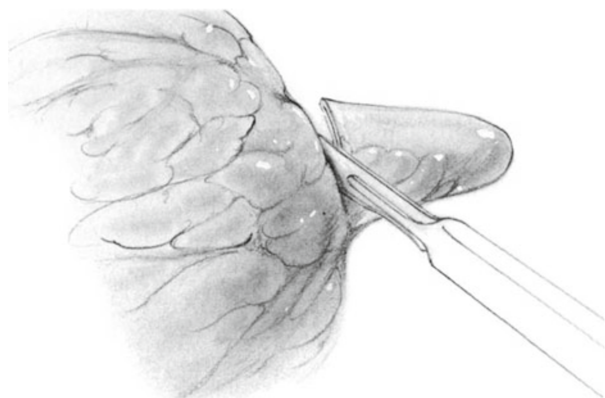

Fig. 105.11

Postoperative Care

Early ambulation

Perioperative antibiotics are employed in patients with intestinal obstruction or those who have had bowel resection for strangulation. Use nasogastric suction selectively in patients with intestinal obstruction or bowel resection.

Complications

Deep vein thrombosis has been reported secondary to constriction of the femoral vein by suturing.

Wound infections occur but are rare.

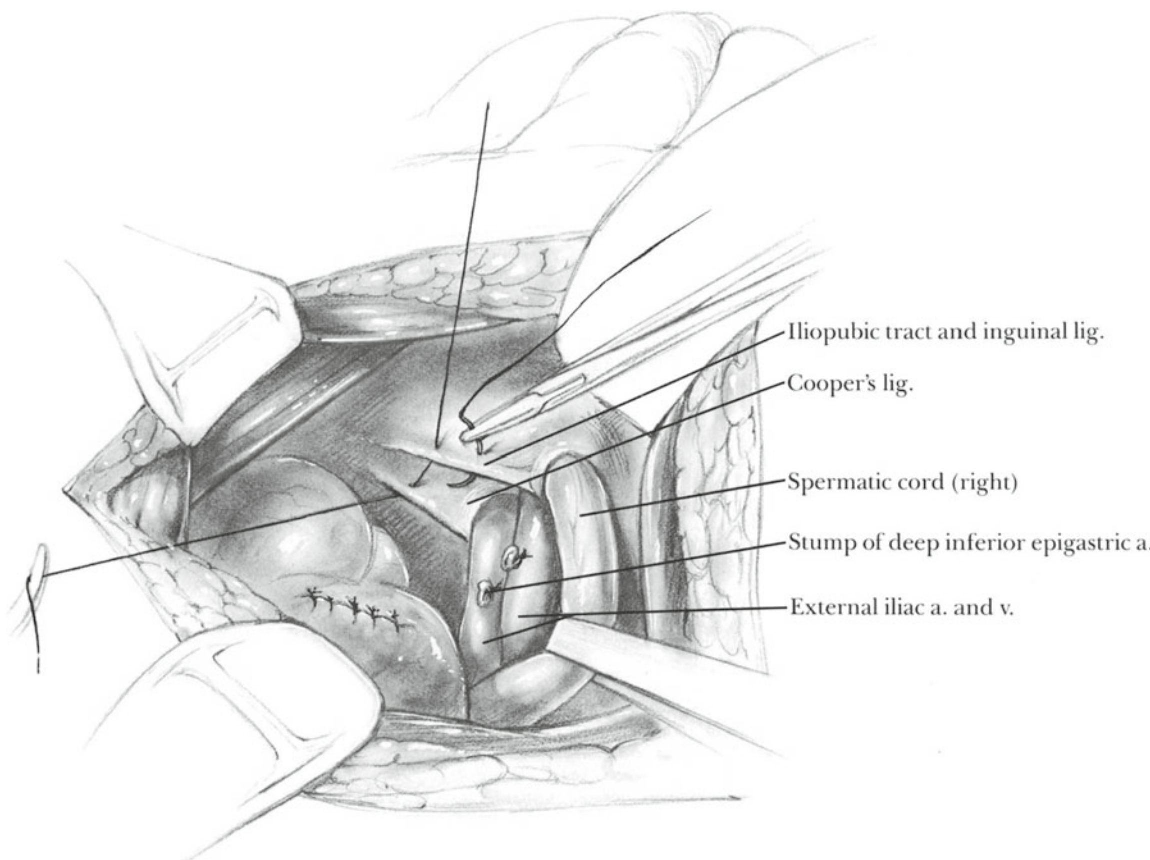

Fig. 105.12

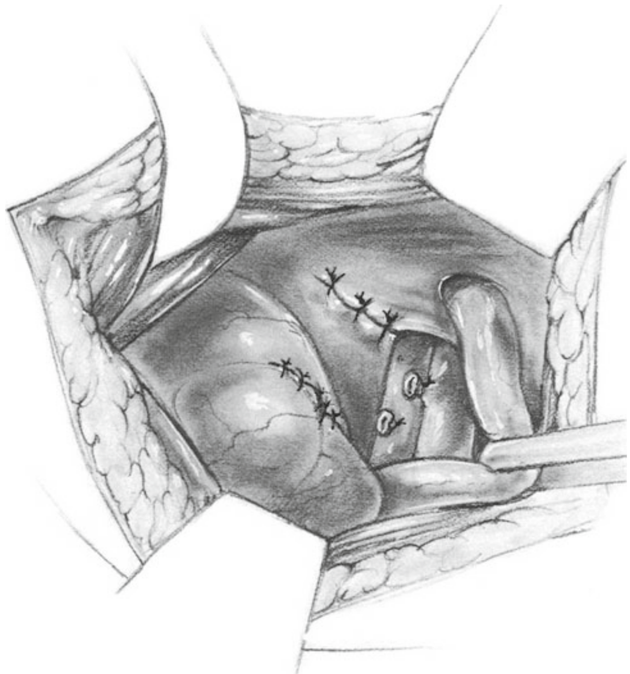

Fig. 105.13

Ventral hernia may follow the preperitoneal approach to femoral hernia repair.

Recurrence is rare, although in some series it has ranged from 1 to 3 %.

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Operations for Large Ventral Hernia

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Carol E.H. Scott-Conner and Jameson L. Chassin†

The multitude of repair techniques available for ventral (incisional) hernia repair attests to lack of satisfaction with any one method. At the time of this writing, more than ten kinds of prosthetic sheets (generically called "mesh," although not all are strictly speaking mesh) and five kinds of biologic implants were available for use in this application. Prosthetic materials differ in weight, resistance to infection, amount of tissue ingrowth, pore size, and elasticity, among other properties. Most surgeons will settle on one or two types of each. Problems associated with mesh repairs have led to a resurgence of interest in autologous tissue repairs. The most common type of autologous repair is called component separation. It involves wide mobilization of the musculoaponeurotic layers of the abdominal wall with appropriate relaxing incisions designed to preserve the neurovascular supply to the muscles. Component separation is particularly useful in contaminated fields. It may be combined with mesh placement. The classic component separation repair is described in this chapter, and references give further information on other techniques.

The choice of open or laparoscopic repair is based upon a number of factors including the size of the defect and the experience of the operating team. Laparoscopic repairs work well for smaller defects. In general, the large ventral hernias associated with open abdomen management (damage control laparotomy) require open repairs.

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Indications

Good-risk patients should undergo elective repair of a ventral hernia with any defect of more than 1–2 cm. Early repair of the small hernia is a simple procedure. Nonoperative therapy is almost always followed by gradual enlargement of the hernial ring over time. Not only does this make the repair more difficult, but there is a significant incidence of incarceration.

Repair is also indicated for incarceration, as with any hernia.

Preoperative Preparation

Nasogastric tube prior to operation for large hernias

Perioperative antibiotics in patients with hernias large enough to require prosthetic mesh

Weight loss in the obese is an admirable goal but difficult to achieve in practice. Consider whether the patient may be a candidate for bariatric surgery. If so, a possible strategy in refractory obesity is to refer the patient for laparoscopic bariatric surgery and then perform elective ventral hernia repair after weight loss has been achieved. Doing the ventral hernia first will not only increase the risk of hernia recurrence but may make laparoscopic bariatric surgery more difficult.

Smoking cessation

Pitfalls and Danger Points

Excessive tension on the suture line

Sewing tissues that are too weak to hold sutures

Postoperative infection

Failure to achieve complete hemostasis

†Deceased

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Operative Strategy

A thorough understanding of the factors that lead to incisional hernia formation is crucial. These same factors contribute to recurrence after repair.

Infection

Infection of the postoperative abdominal wound not uncommonly leads to an incisional hernia at a later date, especially if the infection was not detected and widely drained early during the course of its development. Strategies to minimize the incidence of wound infection during a contaminated abdominal operation are discussed in Chap. 7.

Occult Wound Dehiscence

When a large ventral hernia appears within the first few months after an abdominal operation, a likely cause of the hernia is contained dehiscence of the fascial and muscular layers of the abdominal wall during the early postoperative course in a patient whose skin incision has remained intact. Prevention of postoperative wound dehiscence is discussed in Chap. 3.

Making Too Large a Drain Wound

Postoperative hernias may occur at drain exit sites, particularly the large stab wounds used for Penrose drains. Generally, if the stab wound admits only one finger, a postoperative hernia is unlikely. When drainage of necrotic tissue (e.g., necrotizing pancreatitis) is required, large drainage wounds are appropriate, and the risk of subsequent hernia formation is accepted. Closed-suction drains require smaller incisions and rarely become sites of hernia formation.

Failure to Close Laparoscopic Trocar Sites Adequately

In general, close the fascial defect after inserting any trocar larger than 5 mm in diameter. Radially dilating trocars are designed to spread rather than cut fibers of the abdominal wall muscle and fascia. Larger radially dilating trocar sites may not require closure, therefore, because the spread fibers simply close. This is particularly true for lateral sites where overlapping muscle layers have fibers that cross at right angles providing a gridiron type of closure that may be more secure.

Transverse Versus Vertical Incision

As discussed in Chap. 3, we have not detected an increased incidence of incisional hernia or wound dehiscence when comparing the midline vertical incision with transverse or oblique subcostal incisions, provided the midline incision has been carefully closed. Long subcostal incisions may be associated with denervation of part of the abdominal wall. The resulting bulge must be differentiated from a true hernia. Ultrasound or other imaging modalities may help in this situation.

Suturing Technique

Type of Suture Material

Closure with catgut, Dexon, or Vicryl results in a large number of wound dehiscences and incisional hernias and is no longer recommended. Nonabsorbable monofilament suture does not dissolve but often results in suture sinus formation or painful bumps at sites of knots. As a compromise, PDS has been adopted by many surgeons for closure material. It maintains strength sufficiently long to allow secure healing but eventually dissolves, thus minimizing the tendency to form suture sinuses.

Size of Tissue Bites

The width of tissue included in each stitch is an important determinant of the incidence of wound dehiscence or incisional hernia, regardless of whether a continuous or interrupted technique is used. Sutures that contain small bites of tissue tend to cut through in response to muscle tension. We believe that *at least 2 cm* of musculofascial tissue on each side of the incision should be included in the stitch.

Tension with Which Suture Should Be Tied

When a stitch in an abdominal incision is tied with strangulating force, no matter how large a bite of tissue the stitch contains strangulation may cause the stitch to cut through the abdominal wall. This error manifests as a small hernia 1–2 cm lateral to the scar several months following operation. The hernial ring is often no more than 1.0–1.5 cm in diameter when first detected. This phenomenon is somewhat less likely to occur with synthetic monofilament sutures than with wire sutures because these sutures have a larger diameter than the equivalent-strength stainless steel suture.

It is easy to tie monofilament sutures too tightly because the knot has a tendency to slip. Resist the temptation to snug the knot down successively tighter with each throw. If the suture is tied with too much tension, it may cut through the necrotic tissue that results. Insist that the anesthesiologist provide adequate muscle relaxation at the time of closure, as it makes it easier to apply the proper tension to each suture.

Intercurrent Disease

Cirrhosis and ascites
Long-term high-dose steroid treatment
Marked obesity
Severe malnutrition
Abdominal wall defects secondary to tumor resection

Defects in the abdominal wall, secondary to resection for tumor, may be managed by inserting a prosthetic mesh as described below for ventral hernia repair provided adequate coverage of the mesh with viable skin and subcutaneous fat is possible. Otherwise, a full-thickness pedicle flap must be designed to cover the mesh.

Choice of Approach

This chapter describes several anterior approaches to large ventral hernias. They are applicable to virtually all incisional hernias. As noted above, an emerging experience with laparoscopic ventral hernia repair makes it a potentially attractive option, especially for small defects (see Chap. 107).

Identifying Strong Tissues

Each ventral hernia is characterized by a defect, small or large, in the tissue of the abdominal wall. In the hope of facilitating approximation of the edges of the defect, the surgeon is often tempted to preserve, and insert sutures into, weak scar tissue instead of carrying the dissection beyond the edge of the hernial ring to expose the normal musculoaponeurotic tissue of the abdominal wall. Depending on scar tissue to hold sutures for repair of a hernia leads to a high recurrence rate. It is best to carry the dissection 2–3 cm beyond the perimeter of the hernial ring on all sides and clearly expose the anterior surface of the muscle fascia.

Often an obvious incisional hernia is accompanied by additional smaller hernias 3–5 cm away from the major defect. These secondary hernias occur because more than one suture, inserted at the previous closure, has cut through the tissue, leaving additional small defects. If the additional defects are close to the large hernial ring, incise the tissue bridges and convert the several defects into one large hernial ring.

Some surgeons advocate separating the abdominal wall into its component layers—peritoneum, muscle, and fascia—and suture each layer separately. We believe that in most cases, it is preferable to insert the suture by taking a large bite of the entire abdominal wall in each stitch, following the principle of the Smead-Jones technique, rather than splitting the abdominal wall and closing each layer separately. By the same token, we have not used relaxing incisions through the aponeurosis of the external oblique layer to expedite hernial closure because we have observed subsequent herniation through the area of the relaxing incision. Other surgeons have advocated creating a flap from the anterior rectus sheath on each side and then bridging the hernial defect by suturing one fascial flap to the other. Our experience suggests that this technique does not successfully repair an incisional hernia larger than a few centimeters in diameter.

Avoiding Tension During the Repair

By far the most dangerous threat to long-term success with hernial repair is *excessive tension on the suture line*. Although all surgeons agree with this principle, there is a wide variation in each surgeon's perception of what comprises "excessive" tension. We believe that *any degree of tension is* "*excessive*" because this judgment is always made with the patient under anesthesia. Even local anesthesia produces muscle relaxation in the area of anesthesia, so any degree of tension is magnified when the effects of anesthesia have disappeared.

In the case of *small* ventral hernias (<3 cm in diameter), success may be anticipated if the weakened tissues are excised and the remaining defect in the abdominal wall is simply approximated with the Smead-Jones technique, just as one would close a primary abdominal incision (see Chap. 3). It is important to excise all of the attenuated tissues, but it is not necessary to remove the condensation of fibrous tissue that often forms a firm ring and separates the hernial defect from the normal tissues of the abdominal wall. Using the Smead-Jones stitch, simply insert the sutures 2–3 cm beyond the hernial ring through all layers of the abdominal wall including peritoneum. It may be preferable to close a circular defect in a transverse (rather than vertical) direction, but the main consideration is to select the direction that produces the least tension. Although it is sometimes possible to approximate abdominal wall defects 6–8 cm in width under anesthesia without appearing to have produced excessive tension, *many* of these patients return with recurrent hernias if they are followed 4–5 years or more.

Role of Prosthetic Mesh

If there is tension on the proposed suture line, do not close the defect at all. Rather, bridge the defect with one or two layers of a prosthetic mesh. No attempt is made to close the defect with this technique. The defect is thus *replaced* by the mesh, which is sutured in place by means of 2-0 or 0 Prolene mattress sutures that penetrate the full thickness of the abdominal wall.

The most serious complication following the use of prosthetic mesh arises when dense adhesions form between the small intestine and the fabric of the mesh. If intestinal obstruction in this situation requires subsequent laparotomy, it may prove impossible to separate the mesh from the bowel without extensive intestinal damage. Although this complication is uncommon, it is important to take the precaution of interposing omentum between the mesh and the intestines whenever possible. When omentum is not available for this purpose, preserve the hernial sac and interpose this tissue between the intestines and the mesh, which is then sutured as an onlay patch over the defect (as shown later in this chapter). Although using an onlay patch mechanically does not result in as strong a repair as inserting stitches through the entire abdominal wall to fasten the mesh, it may be preferable to risk producing excessive intestinal adhesions.

In contrast to the onlay patch technique, a sublay patch is placed deep to the fascia. The fascia may or may not be closed over the sublay patch. The major theoretical advantage of the sublay patch is that increased intra-abdominal pressure should push the patch against the abdominal wall. The disadvantage is that the prosthetic material may be in contact with viscera.

Types of Synthetic Prosthetic Material

There are three general types of synthetic prosthetic material in common use: absorbable PG mesh, monofilament polypropylene (or other nonabsorbable) mesh, and expanded polytetrafluoroethylene (ePTFE) sheets. True long-term follow-up data are not available for many of these prosthetic materials.

Absorbable PG mesh is suitable for temporary closure of abdominal wall defects, particularly in the infected abdomen. After granulation tissue forms, the defect is skin grafted. Because the mesh absorbs, subsequent incisional hernia formation is inevitable, and a delayed repair is needed when the patient has recovered from the initial problem and sufficient time (usually at least 6 months) has elapsed for the skin and hernia sac to "pinch" easily off underlying bowel. This technique has largely been superceded by use of bioprostheses or by component separation. Absorbable mesh is not suitable for permanent repair of ventral hernias as described in this chapter and will not be discussed further.

Monofilament nonabsorbable meshes from different manufacturers vary in chemical composition, stiffness (resistance to bending), and degree of stretch. As mentioned earlier, erosion into bowel and dense adhesion formation have been problems with these prosthetic materials. A major advantage of this mesh is its tolerance to infection. Because the mesh is composed of monofilament fibers, the patient often tolerates a wound infection without the need to remove the mesh. Opening the skin widely for drainage generally proves sufficient and in many cases avoids the need to remove the mesh.

Expanded PTFE sheets are soft and pliable. Adhesion to bowel is much less of a problem than with the previously described meshes. This material feels smooth to the touch and does not encourage tissue ingrowth. Currently available ePTFE mesh does not tolerate infection well and is recommended for use only during clean procedures. If the operative field becomes contaminated during dissection (e.g., by inadvertent enterotomy or exposure of a buried chronic suture abscess), this material is not a good choice.

Combination prostheses are available. These use a material such as ePTFE on one side (to be put next to the bowel) bonded to a material which enhances tissue ingrowth on the other side (to be put next to the fascia).

Bioprosthetic Materials

A variety of bioprosthetic materials, made of acellular collagen matrix, are available. The theoretical advantage of these materials is that they encourage tissue ingrowth and, in time, become incorporated into the abdominal wall. For this reason, many surgeons prefer these materials in repair of the contaminated abdomen. A recent meta-analysis (Bellows et al.) did not show definitive benefit associated with the use of these materials and called for randomized controlled clinical trials.

Myocutaneous Flap

Increased interest in the myocutaneous flap has resulted in the development of techniques that facilitate rotation of large flaps of muscle covered by skin and subcutaneous fat into full-thickness defects of the abdominal wall with retention of an excellent blood supply to the flap. The tensor fasciae latae muscle is one example of such a myocutaneous flap that can be used to bridge defects in the abdomen. The exact role of this modality is still being evaluated, but it is an important option to remember in complex situation.

Separation of Components

Separation of components was originally described by Ramirez as a way to obtain autologous tissue closure of moderate-sized abdominal wall defects with preservation of the neurovascular supply to the muscles. Techniques have been further developed that facilitate closure of even large defects by this method. The key elements are elevation of extensive flaps of skin and subcutaneous tissue to expose the external oblique aponeurosis above and below the hernia sac. A longitudinal incision in the external oblique aponeurosis, just lateral to the lateral edge of the rectus muscle, allows the muscles to slide medially. This slide is enhanced by separation of the external oblique from the underlying internal oblique muscle as far laterally as can be achieved. This allows the rectus and internal oblique muscles to slide medially and be closed without tension in the midline. Some surgeons will add a sublay prosthetic patch to provide further reinforcement.

Use of Drains

Because most all repairs result in elevation of large subcutaneous flaps, many surgeons place closed-suction drains in the space between the subcutaneous tissue and the fascia to decrease seroma formation. A recent meta-analysis of the limited number of randomized trials (Gurusamy) failed to demonstrate any difference in outcome associated with drain placement.

Operative Technique

Elective Ventral Hernia Repair

Dissecting the Hernial Sac

Make an elliptical incision in the skin along the axis of the hernial ring and carry the incision down to the sac (Figs. 106.1 and 106.2). Dissect the skin away from the sac on each side until the area of the hernial ring itself has been exposed in its entire circumference (Fig. 106.3). Retract the skin flap away from the sac and make a scalpel incision down to the anterior muscle fascia. Continue to dissect normal muscle fascia using a scalpel or Metzenbaum scissors until at least a 2 cm width of fascia has been exposed around the entire circumference of the hernial defect. This dissection generally leaves some residual subcutaneous fat attached to the area where the sac meets the hernial ring. Using scissors, remove this collar of fat from the base of the hernia. For small defects, the hernia sac is usually removed (as described here). For large ventral hernias, it may be possible to keep the dissection superficial to the hernia sac, preserving it as a protective layer between the bowel and any prosthetic material used.

Resecting the Hernial Sac

Make an incision along the apex of the hernial sac and divide all of the adhesions between the intestine and the sac (Figs. 106.4 and 106.5), reducing the intestines into the abdominal cavity after inspecting them for viability (Fig. 106.6). Expose the circumference of the hernial defect so the neck of the sac and a 2- to 3-cm width of peritoneum are freed of all adhesions around the entire circumference of the hernia. Irrigate the wound with a dilute antibiotic solution intermittently (Fig. 106.7).

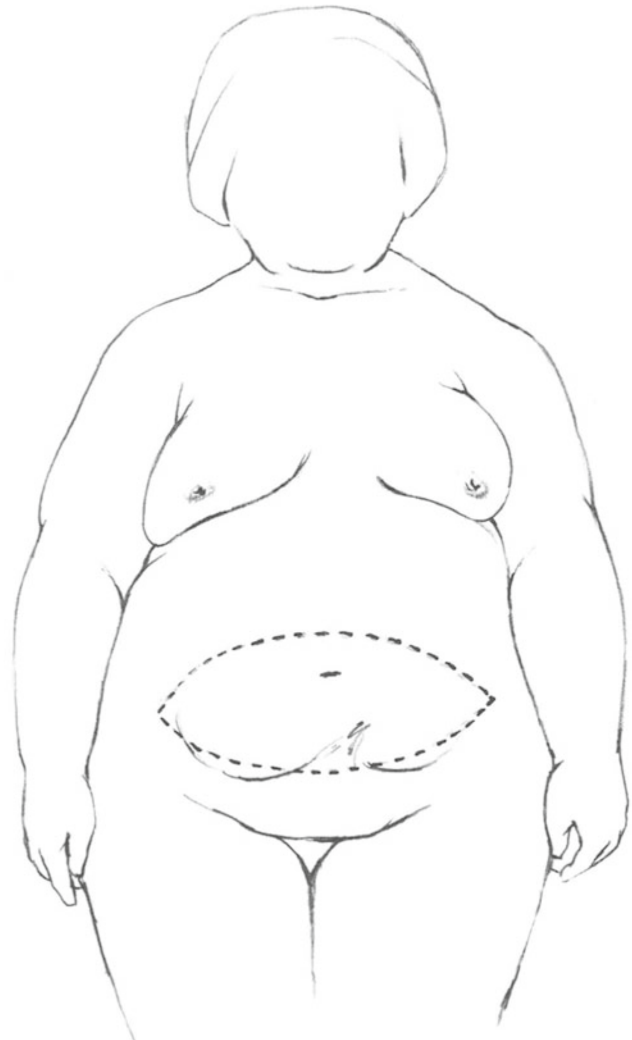

Fig. 106.1

Mesh Repair of Ventral Hernia

Sandwich Repair

The “sandwich repair” was first described by Usher. It combines what would now be called a sublay patch (deep to the fascia) and an onlay patch. Two identical sheets of mesh are cut from a large sheet. Each piece of mesh should be 2 cm larger than the hernial defect. One sheet is placed inside the abdominal cavity, and the other makes contact with the fascia around the hernial ring. The two sheets are held by sutures that go through the top sheet, then through the full thickness of the abdominal wall, and finally through the deep sheet of mesh. The stitch then returns as a mattress stitch

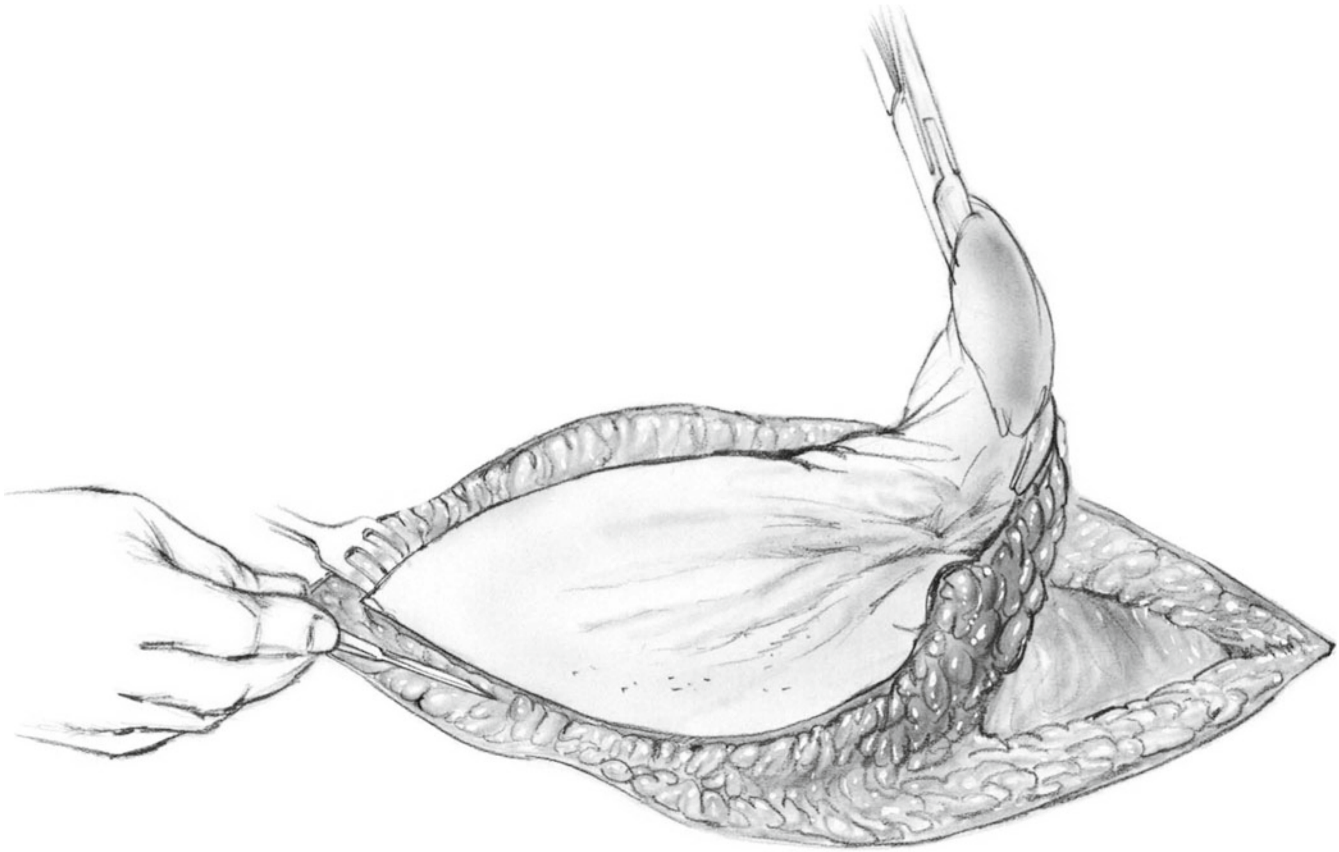

Fig. 106.2

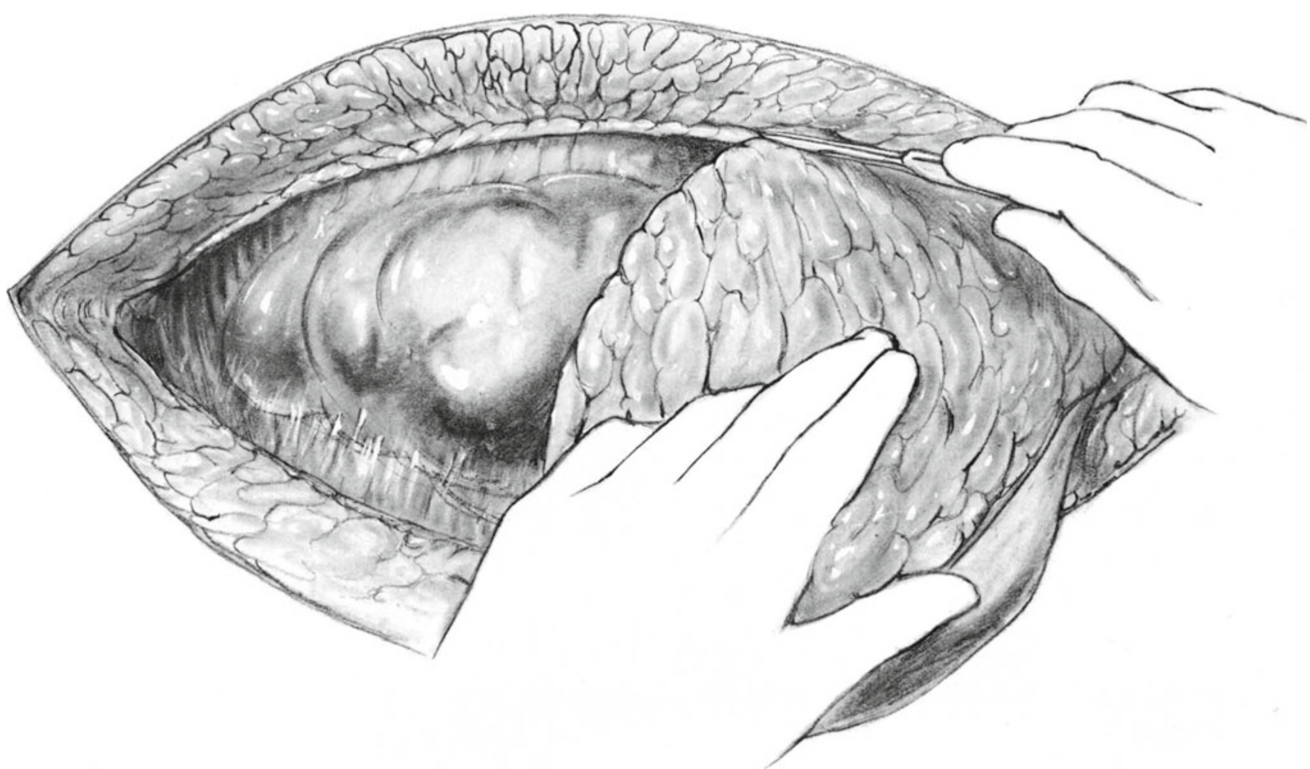

Fig. 106.3

penetrating the deep sheet of mesh, the full thickness of the abdominal wall, and finally the superficial sheet of mesh before being tied with a knot located in the subcutaneous layer (Fig. 106.8). The deep layer of mesh should be separated from the bowel by the omentum. In the absence of a satisfactory layer of omentum, it may be preferable to omit the intraperitoneal layer of mesh and to preserve enough hernial sac so the sac, after being trimmed and sutured closed, can be retained as a protective layer to separate the intestines from the mesh, which is now used as an onlay patch, as described in the next section (see Fig. 106.13).

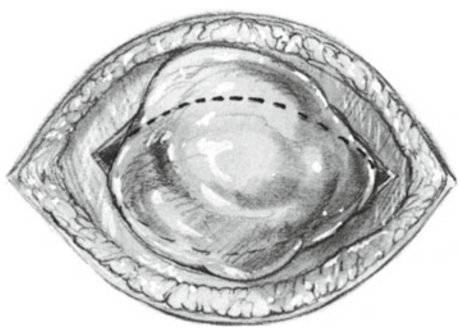

Fig. 106.4

Application of the sandwich technique to a large recurrent ventral hernia in an obese patient is illustrated beginning with Fig. 106.9. After the skin flaps have been elevated, which exposes healthy fascia around the entire circumference of the hernial defect, make certain there are no additional hernial defects above or below the major hernia. If there are additional hernias, combine them into one large defect by incising the bridge of tissue between them.

Excise the sac down to its point of attachment to the hernial ring and excise subcutaneous fat around the hernial ring. Then insert one sheet of mesh inside the abdominal cavity and the other over the rectus fascia. Place the mattress sutures through the mesh at a point about 2–3 cm away from the hernial ring to be certain the sutures engage normal abdominal muscle and aponeurosis. A horizontal mattress suture penetrates first the superficial layer of mesh, next the entire abdominal wall, and then the deep layer of mesh. When returning the suture, the width of the bite of mesh must be less than the width of the bite in the abdominal wall; otherwise, the mesh tends to bunch together when the stitch is tied rather than lying flat. Therefore, when returning the stitch through the deep layer of mesh, select a spot that encompasses only 7 mm of mesh while including a 1 cm width of abdominal wall. After penetrating the anterior rectus fascia,

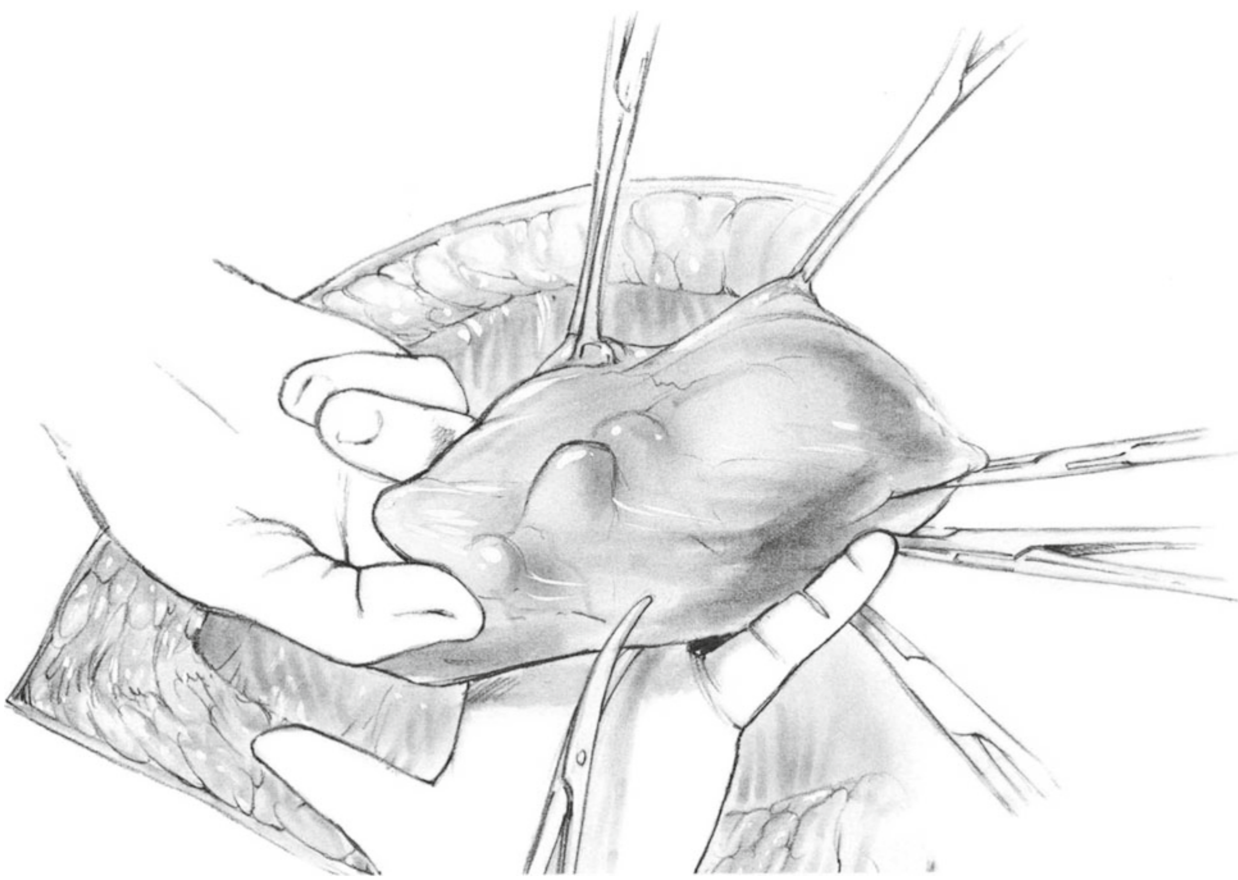

Fig. 106.5

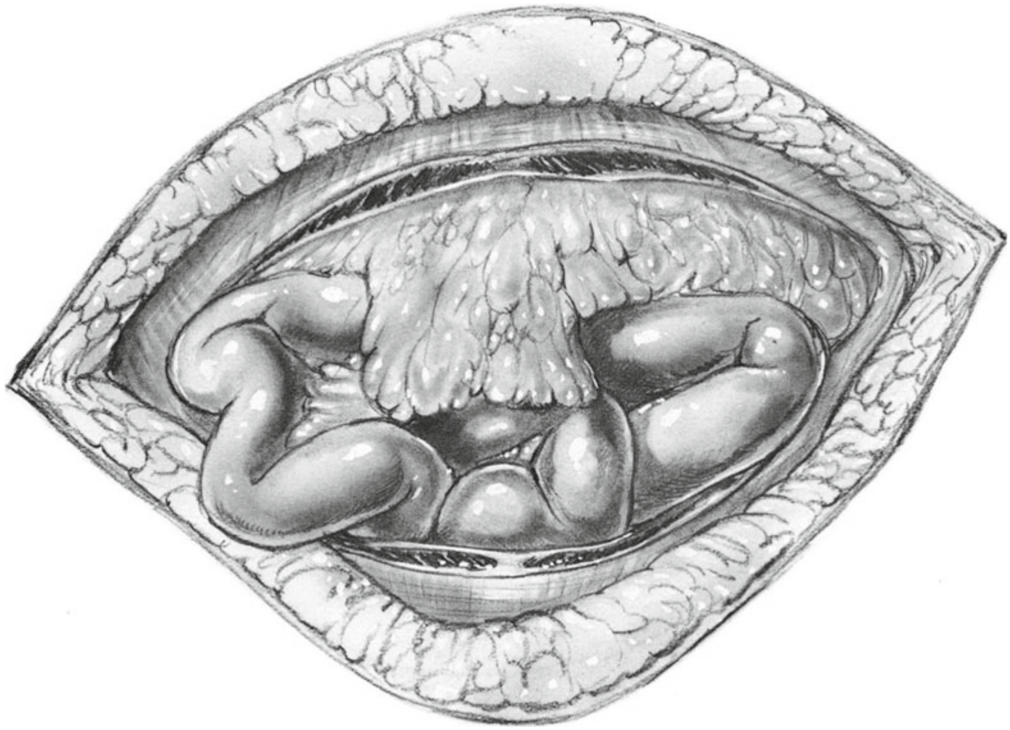

Fig. 106.6

Fig. 106.7

pass the needle through the anterior layer of mesh again at a point 7 mm away from the tail of the stitch. Tie the suture. We use the 3–1–2 knot (see Fig. 4.25), supplemented by a few additional throws. The suture material used is 2-0 Prolene on an atraumatic needle. Insert additional mattress sutures of the same material at intervals of about 1.0–1.5 cm until half of the sutures have been inserted and tied. Then insert the remaining sutures, but do not tie any of them until all have been properly inserted. After tying all the sutures, check for any possible defects in the repair (Figs. 106.10 and 106.11). When a hernial defect borders on the pubis, include the periosteum of the pubis in the sutures attaching the mesh to the margins of the defect.

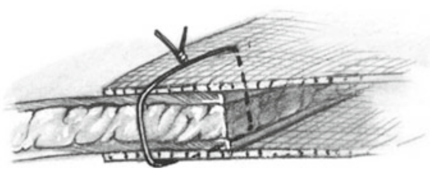

Fig. 106.8

Be certain to achieve complete hemostasis with electrocoagulation and fine PG ligatures. If a drain is desired, insert a multiperforated closed-suction catheter through a small puncture wound in the skin. Lead the catheter across the superficial layer of the mesh and attach it to a Jackson-Pratt closed-suction device. Approximate the skin with interrupted nylon sutures. Apply a sterile pressure dressing.

Onlay Patch Mesh Repair

As mentioned above, the onlay patch mesh repair is suitable when there is no layer of omentum available to be interposed between the intestines and the mesh. Here the hernial sac is preserved. Trim away the excess sac, leaving enough tissue so it can be closed without tension by a continuous 2-0 atraumatic PG suture (Fig. 106.12). This serves as a viable layer that hopefully will avoid the development of adhesions between the bowel and the mesh. The drawback to this technique is that its sutures, compared with those of the sandwich technique, are weaker because the bites of tissue are not equivalent to those of large mattress sutures, which penetrate the entire abdominal wall.

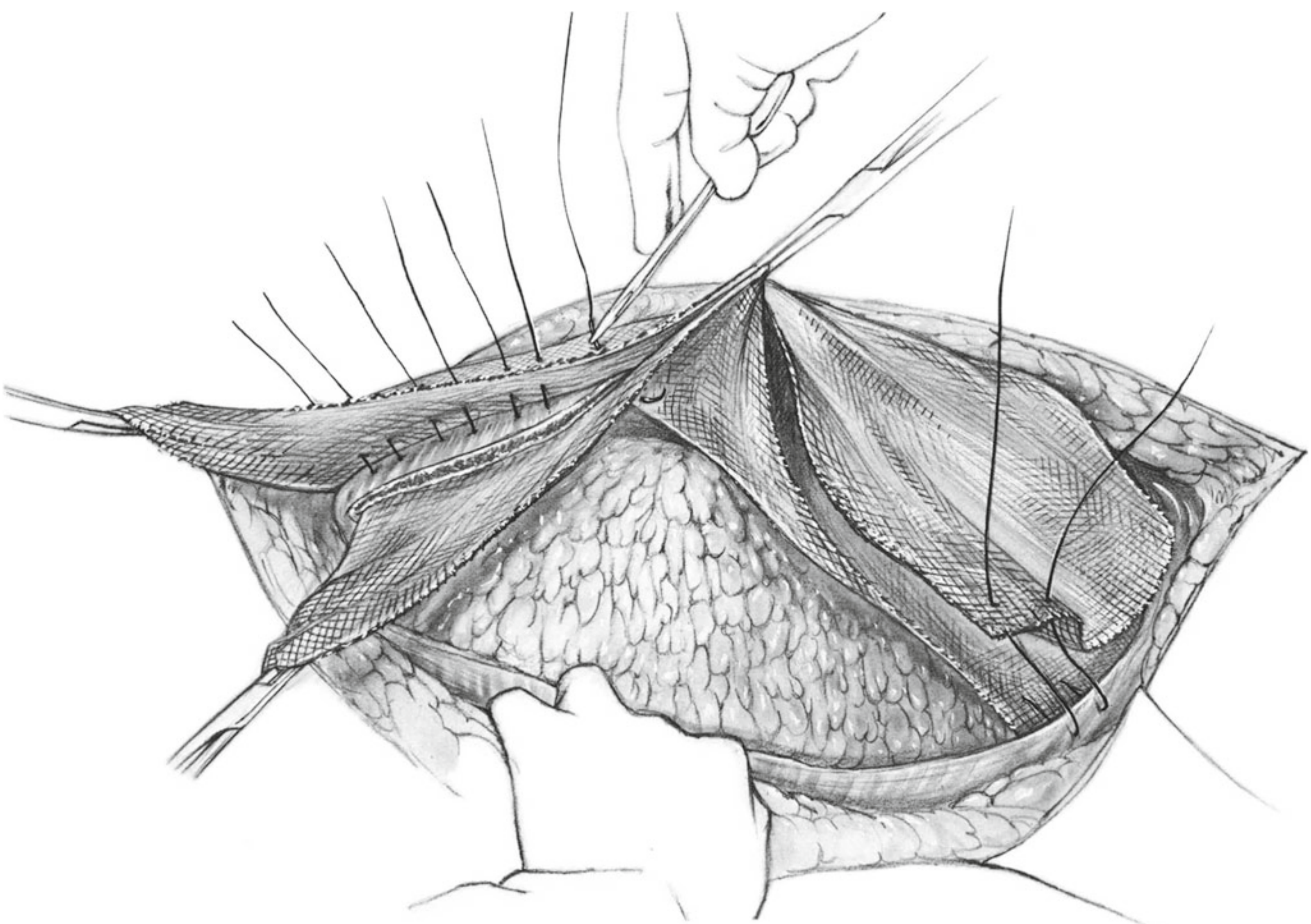

Fig. 106.9

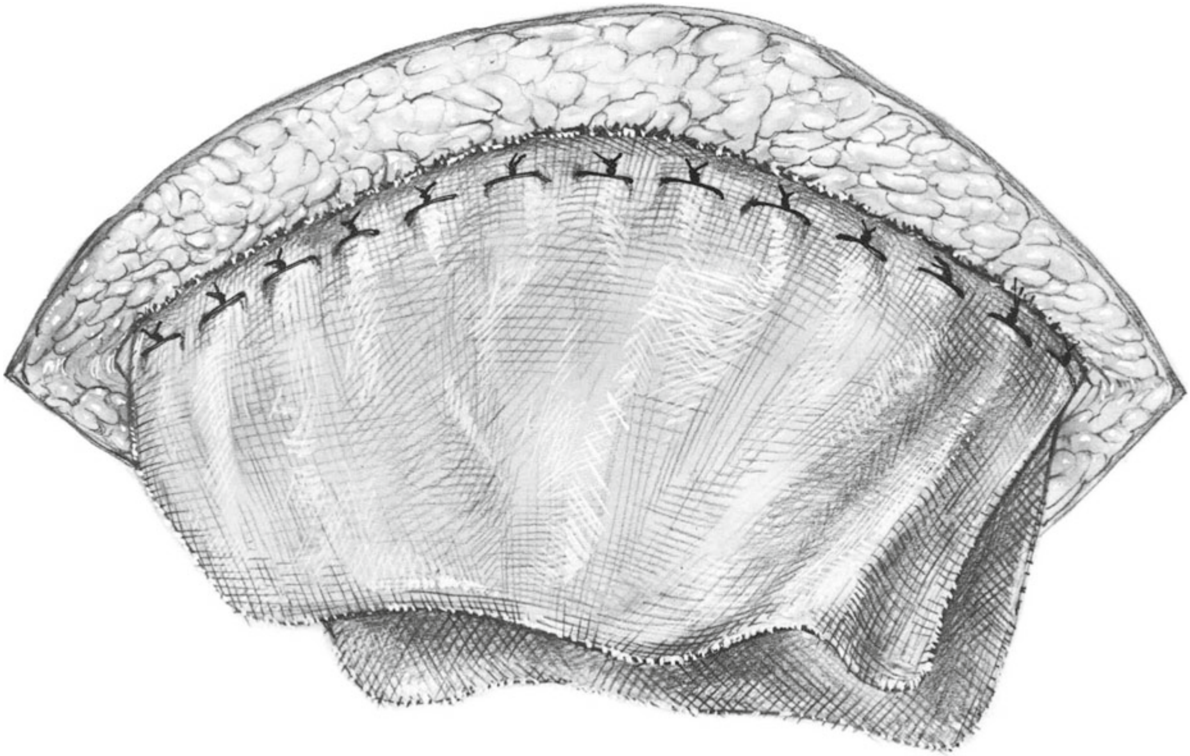

Fig. 106.10

Fig. 106.11

Only the peritoneum of the hernial sac is sutured to cover the defect with this method.

A piece of Prolene mesh is cut 2–3 cm larger on all sides than the diameter of the hernial defect. The first stitch of 0 Prolene starts at the caudal margin of the defect and catches the edge of the hernial ring. Tie the stitch and then proceed with a continuous stitch that fixes the mesh to the dense fibrous tissue at the margin of the hernial defect. When the cephalad edge of the hernial defect is reached, insert a second stitch and tie it. Anchor the first stitch by tying it to the

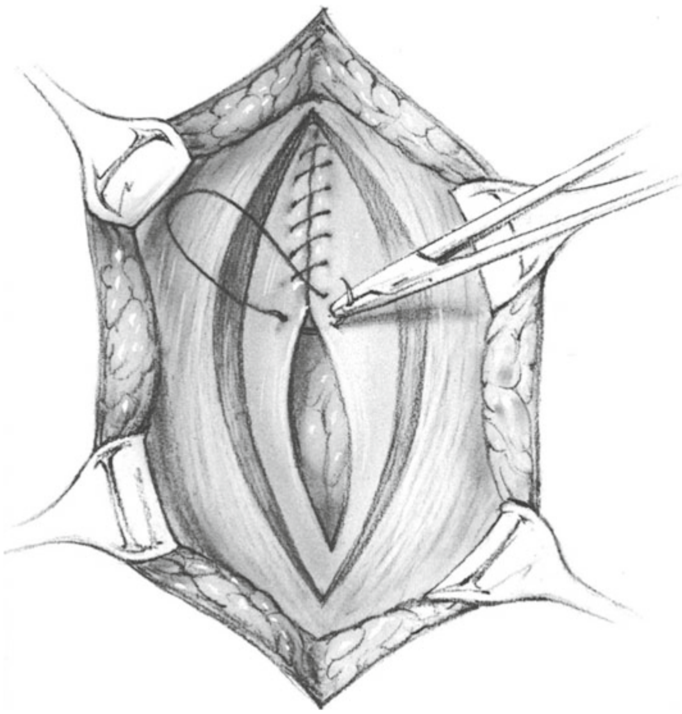

Fig. 106.12

tail of the second one. The second stitch runs in a continuous fashion along the opposite margin of the hernia and is terminated at the caudal edge of the hernial defect.

Using a similar technique, stitch the *edge* of the mesh to the anterior layer of muscle fascia in a continuous fashion using atraumatic 2-0 Prolene (Fig. 106.13a, b). Insert a closed-suction catheter through a puncture wound and close the skin in routine fashion.

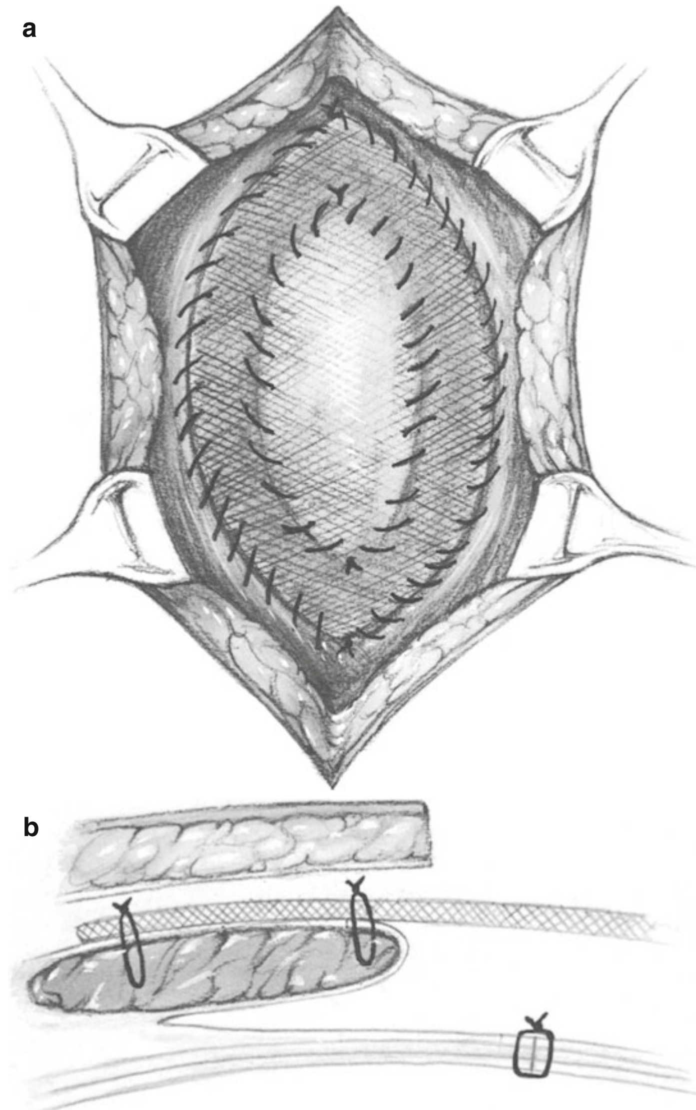

Fig. 106.13

Separation of Components

Make a long vertical incision and expose and dissect the hernia sac as previously described. Develop flaps at the level between subcutaneous fat and musculoaponeurotic layers as far laterally as possible. Identify the aponeurosis of the external oblique muscle just lateral to the lateral edge of the rectus abdominis muscle (Fig. 106.14).

Using electrocautery, incise the external oblique muscle along a line parallel to the lateral edge of the rectus muscle and approximately 2 cm lateral to that edge. Enter the plane deep to the external oblique and superficial to the internal oblique muscle. Note that the neurovascular structures pass deep to the internal oblique muscle and should be preserved if this dissection progresses in the correct plane. Use a finger or clamp to elevate the muscle and facilitate division of the external oblique for an ample distance above and below the cephalad and caudad extent of the hernia sac. This may require continuing the division up over the costal margin in some cases.

Gently undermine the resulting flap of external oblique muscle so that the muscle can retract laterally as the midline is approximated. Pull the midline together and assess tension, keeping in mind that muscle relaxation under general anesthesia makes it easy to underestimate the tension on the repair under normal physiologic conditions. This dissection allows the components to separate and slide, so that the resulting flap of internal oblique muscle, transversus abdominis muscle, and rectus will slide medially and can be approximated in the midline without tension.

Suture the fascia together in the midline. The new arrangement of abdominal wall muscles is shown in Fig. 106.15. If desired, a sublay patch (usually a bioprosthesis) can be placed before closing the fascia. Then recheck hemostasis and close the subcutaneous tissues and skin as previously described.

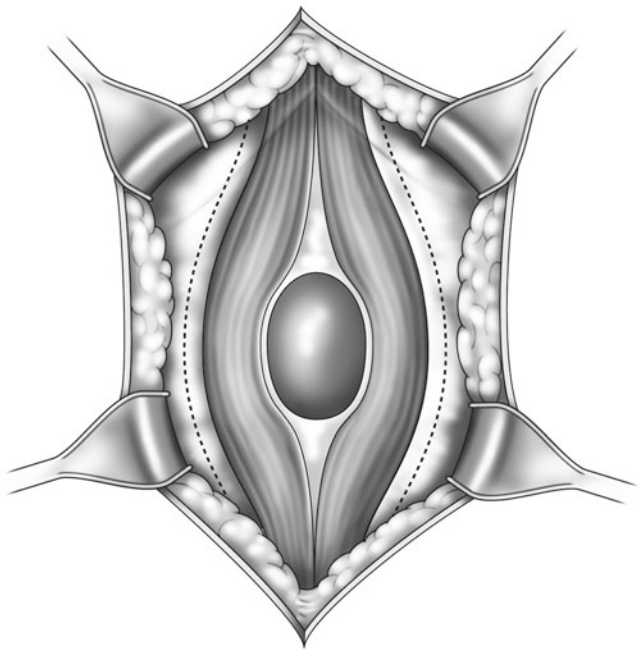

Fig. 106.14

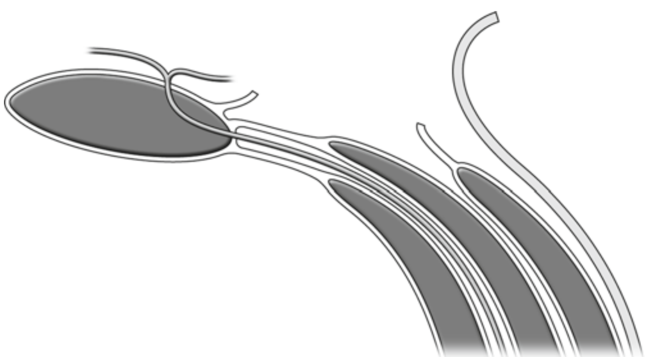

Fig. 106.15

Postoperative Care

Remove the suction drains (if used) 5–7 days following operation.

Give perioperative antibiotics.

Institute early ambulation promptly on recovery from anesthesia.

Complications

Wound Infection. With proper precautions, wound infection should be rare following elective repair of a ventral hernia. If an infection of the subcutaneous wound does occur, it is not generally necessary to remove the mesh. Because of its monofilament nature, polypropylene mesh with monofilament Prolene sutures resists infection if the skin incision is promptly opened widely for drainage. Change the moist gauze packing daily until clean granulations have formed over the mesh. Then permit the skin to heal by secondary intention.

Hematoma. Most hematomas, unless large, can be treated expectantly.

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107 Laparoscopic Ventral Hernia Repair

Carol E.H. Scott-Conner

Indications

The indications for laparoscopic ventral hernia repair are basically the same as those for open repair, that is, symptomatic ventral hernias. Specific indications for each procedure are still under development, and there is considerable overlap. Laparoscopic repair is best undertaken by an experienced laparoscopic team. It is particularly useful for small defects. It may be a better approach for elderly or obese individuals, in whom the morbidity associated with open surgery can be avoided. Conversely, the presence of dense adhesions, particularly adhesions to previous mesh placement, renders the laparoscopic approach more difficult, and generally an open approach is preferred.

Preoperative Preparation

See Chap. 106, Ventral Hernia Repair.

Pitfalls and Danger Points

Injury to bowel
Inadequate mesh fixation leading to recurrent hernia formation
Chronic pain associated with mesh fixation

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Operative Strategy

The patient is positioned supine with arms tucked. Initial entry into the abdomen is usually made with a Hasson cannula to avoid bowel injury. Usually four ports are placed. The laparoscopic approach provides excellent visibility of adhesions of omentum or bowel to hernia sac. Gentle traction and countertraction with judicious use of sharp dissection are necessary to avoid bowel injury. If the bowel is entered, placement of mesh is generally contraindicated. All adhesions to anterior abdominal wall must be reduced so that all defects can be visualized.

Usually the patch is placed in an intraperitoneal onlay position. No attempt is made to cover it with peritoneum. Composite mesh is used. This mesh has two surfaces. One surface, designed to be placed against the abdominal wall, encourages tissue ingrowth. The other surface is smooth and is meant to be placed against the viscera, to minimize adhesion formation. It is crucial to be familiar with the particular mesh that you are using and to identify and maintain the correct orientation.

The hernia defect or defects are mapped out on the anterior abdominal wall, and a patch is cut sufficiently large to overall defects by at least 4–5 cm in all directions. The mesh is prepared by marking one side for orientation and placing four corner sutures, tied and with tails left on. The mesh is then rolled up and passed into the abdomen.

The four corner ties are pulled out with a suture passer and tied deep to the subcutaneous tissues but superficial to the fascia, and these anchor the mesh. Tacks or sutures are then placed to securely anchor the perimeter of the mesh. It is crucial that the mesh span the gap securely with sufficient overlap, and it is important to realize that when the pneumoperitoneum is released, the mesh may buckle. A variety of techniques have been described to avoid this potential pitfall.

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Operative Technique

Exposure and Preparation of the Defect

Position the patient supine with arms tucked. Choose an entry site remote from incisions and away from the hernia. Often, an entry into the left upper quadrant (left subcostal) either with a Veress needle and optical trocar or with a Hasson cannula is the safest approach. Place three more trocars in such a manner as to span the perimeter of the defect, sufficiently far apart and far from the hernia defect to allow a comfortable working distance. If the hernia is in the upper abdomen, position instruments and laparoscope along an arc in the lower and lateral abdomen (Fig. 107.1). Conversely, if the hernia is in the lower abdomen, position the trocars as shown in Fig. 107.2.

First, inspect the abdomen. Sometimes the contents of the hernia sac will reduce as the abdominal wall expands with pneumoperitoneum, but often adhesions between omentum or bowel and the hernia defect persist, particularly around the edges of the defect. Gently reduce these adhesions into the abdomen. Use energy modalities sparingly; usually the adhesions are avascular, and simple blunt or sharp dissection suffices. Bleeding is usually minimal. It is crucial to perform this dissection with care, as inadvertent enterotomy produces a contaminated field not favorable to mesh placement.

If such enterotomy occurs, carefully repair the bowel and consider a staged repair of the hernia. Do not place mesh.

Once all adhesions are lysed, identify all defects. A missed defect is a common cause of recurrence, and it is only when the entire abdominal wall can be visualized laparoscopically that you can be certain no defects remain.

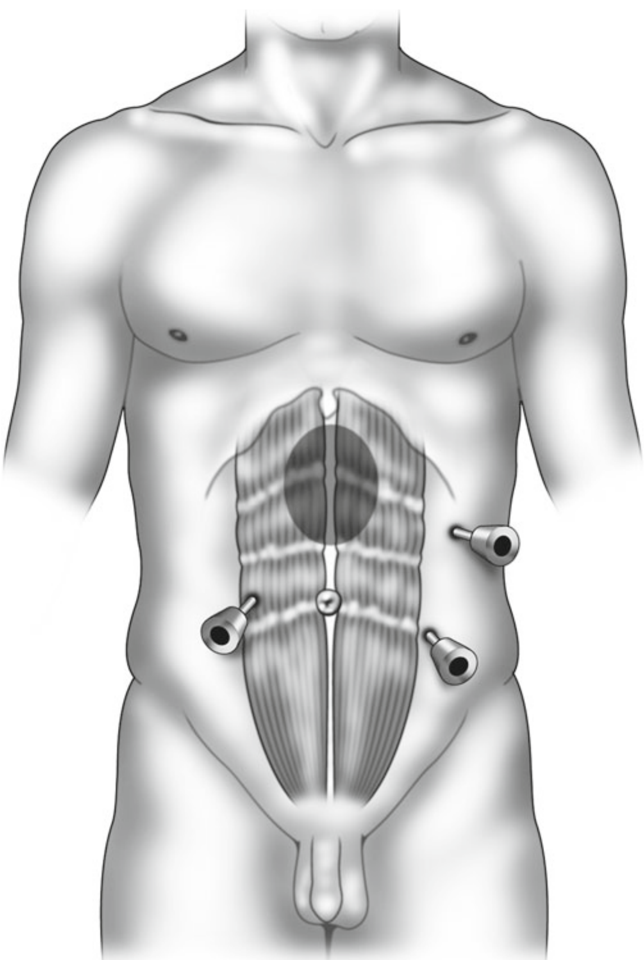

Fig. 107.1

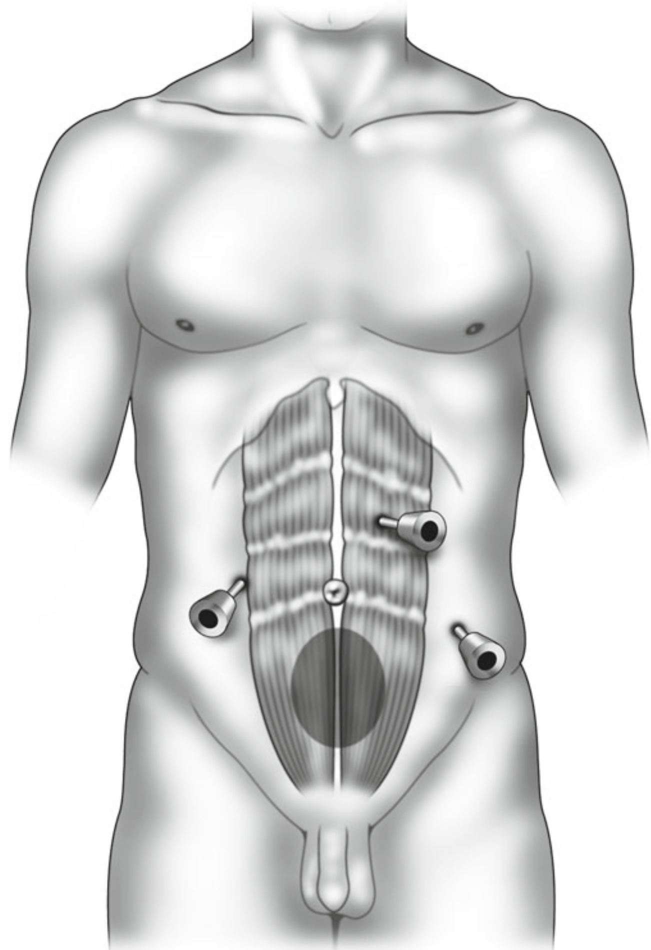

Fig. 107.2

Sizing the Mesh

Map the extent of the area that must be covered with a 22 gauge spinal needle. Pass the needle directly into the abdomen under laparoscopic visualization at the upper aspect of the most cephalad defect. Pass a second needle directly into the abdomen at the lower aspect of the most caudal defect.

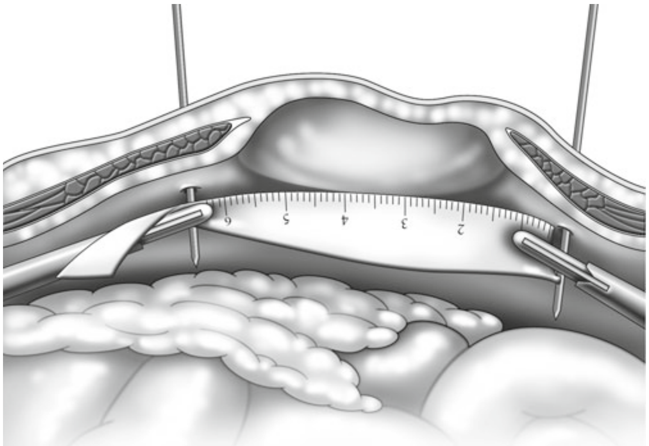

Fig. 107.3

Pass a measuring tape into the abdomen and measure the distance between the two spinal needles (Fig. 107.3). Add 10 cm to this distance, to allow a 5 cm overlap at each end. This measurement tells you the long axis of the patch. Mark the skin at the entry site of these needles.

Repeat this maneuver with the farthest lateral aspects of the defect or defects on each side. This distance (with an additional 10 cm for overlap) gives you the width of the patch. Remove the measuring tape from the abdomen.

Cut the patch to size. Mark the side that is to face the viscera. Draw lines marking the midline of the vertical and horizontal axes. The mesh will be anchored with four corner sutures. These can be placed before the mesh is introduced into the abdomen or after. Here, we show the method used when the sutures are placed before introducing the mesh. Place these four corner sutures near the end of each marked axis such that the long tails are on the "out" or superficial side of the mesh (mnemonic, "out-to-in, then in-to-out") and leave the tails long (Fig. 107.4).

Roll the mesh up into a tight cylinder and pass it into the abdomen. Unfurl it so that the marked side is made to face the viscera and separate the sutures into four bundles corresponding to the four corners.

Proper orientation of the mesh so that it is centered over the defect with adequate overlap is absolutely crucial. The mesh must also be placed with sufficient tautness to span the gap. We prefer to place all four sutures and pull them tight before tying all of them in order to ascertain that these crucial sutures place the mesh with sufficient tautness and accurately span the defect.

For each suture, make a small incision in the skin. Pass a suture passer with a nonabsorbable suture (needle attached) into the abdomen, grasp one end of the preplaced corner suture, and pull it out through the fascia. Take care not to pull the other end out of the mesh, anchoring it as needed with a grasper. Then replace the suture passer through a slightly different point in the fascia and grasp and retrieve the other end. Place a hemostat on this suture (Fig. 107.5). Similarly place all four sutures and test the mesh by pulling up on all four simultaneously. Some surgeons will partially desufflate the abdomen at this point to more nearly approximate normal anatomy and verify that the mesh does not gape. If the mesh spans the defect nicely, tie these deep to the subcutaneous tissues (Fig. 107.6). Take care not to catch any subcutaneous tissue in the tie, as this may cause unsightly dimpling.

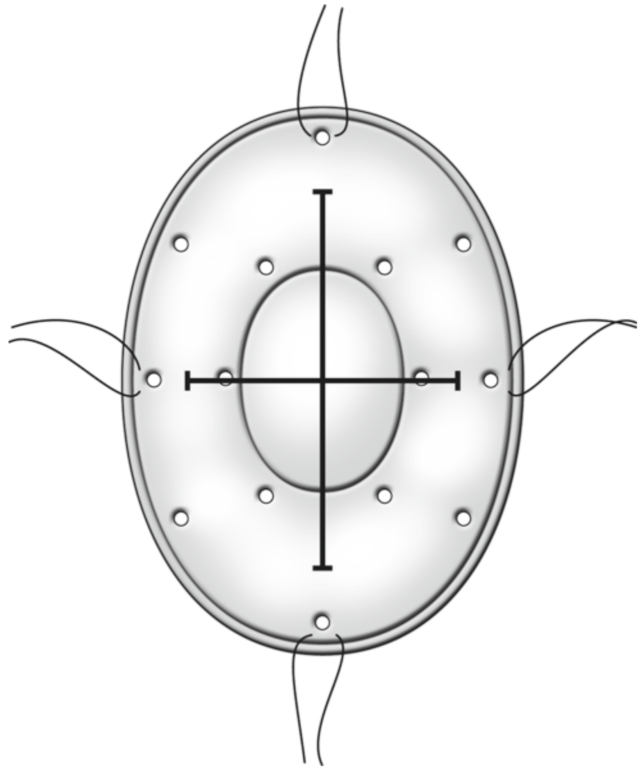

Fig. 107.4

It is now relatively simple to secure the perimeter of the mesh with a hernia tacker or with sutures (Fig. 107.7). Again, check by partially desufflating the abdomen to ensure that the mesh does not gape anywhere.

Check hemostasis. If omentum is available, bring it down to lie under the mesh.

Inject trocar sites with local anesthesia. Remove the trocars and close sites as usual.

Postoperative Care

Postoperative care is routine. These procedures are typically done on an outpatient basis. Seroma formation is virtually universal, and the patient must understand that this is a normal finding and not a recurrence of the hernia. Many surgeons advise wearing an abdominal binder to minimize seroma formation during the first few weeks.

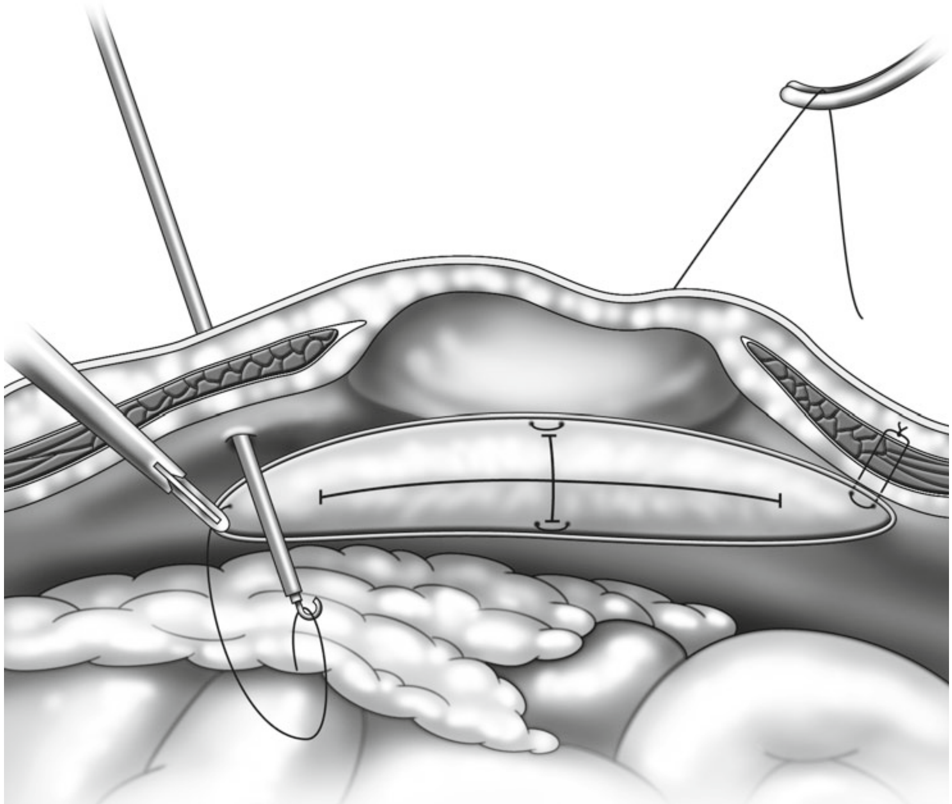

Fig. 107.5

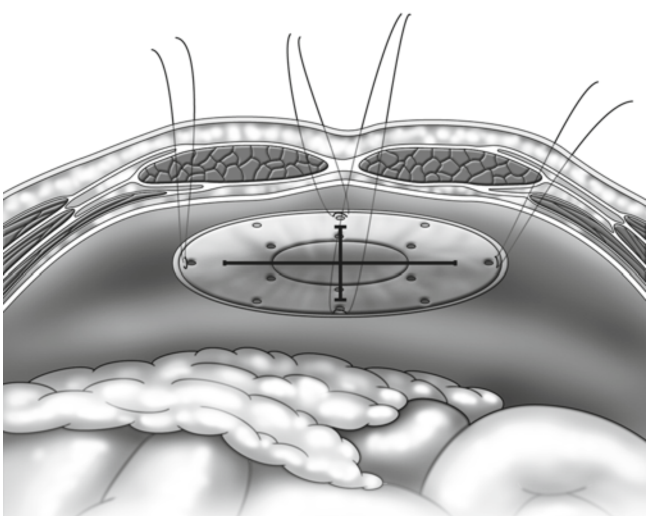

Fig. 107.6

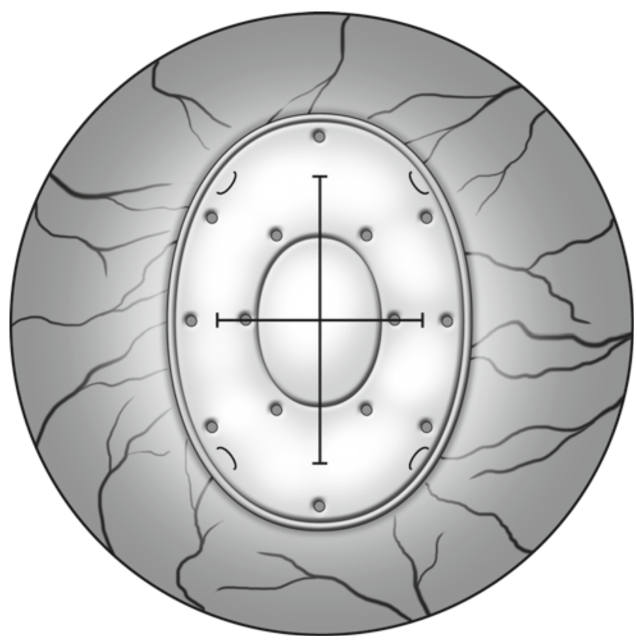

Fig. 107.7

Complications

Missed enterotomy is the most feared complication of this procedure. Take extreme care during adhesiolysis, and carefully inspect the bowel several times. If an enterotomy occurs, repair it and do not place mesh. Mesh placement in this situation is almost always destined to fail.

Recurrent hernia can occur. Minimize the risk of this by carefully identifying all defects and by sizing the mesh appropriately (sufficient overlap). As with all mesh repairs, most recurrences occur at the interface between mesh and fascia.

Pain due to sutures traversing the richly innervated parietal peritoneum can also occur.

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108 Operations for Infected Abdominal Wound Dehiscence, Necrotizing Fasciitis, and Intra-abdominal Abscesses

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Spreading infection of the anterior abdominal wall

Infected dehiscence, with or without evisceration

Prompt drainage of a subphrenic abscess is indicated when it is diagnosed.

Only about two-thirds of patients with subphrenic abscesses demonstrate the typical clinical picture of fever, localized pain or tenderness, leukocytosis, and ipsilateral pleural effusion on the chest radiograph. Few of these manifestations may be present during the *early* stages. Consequently, recent advances in radiographic and other types of body imaging have been most welcome.

Although sonography has value for identifying subphrenic sepsis, computed tomography (CT) is by far the most accurate method for identifying an abdominal abscess. The accuracy of CT is so impressive; it is cost-effective to perform this study on any patient who has an unexplained persistent fever following abdominal surgery.

Percutaneous drainage may be performed by the interventional radiologist if there is a well-established fluid collection with a safe percutaneous access route. Occasionally, a safe route cannot be planned, and operative drainage is required. Operative drainage is also needed when there are multiple abscesses or associated intra-abdominal pathology that requires correction or when percutaneous drainage fails to eradicate the infection.

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Preoperative Preparation

Administer therapeutic doses of systemic intravenous antibiotics effective against gram-negative rods, enterococci, and anaerobes, including clostridia, until definitive bacterial cultures and sensitivity studies are available. This requires an aminoglycoside, ampicillin or penicillin, and clindamycin (or metronidazole or chloramphenicol). Third- and fourth-generation cephalosporins may also prove effective in these cases.

Because intra-abdominal sepsis is a frequent companion, if not the cause, of the necrotizing infection, many of these patients require total parenteral nutrition.

Perform abdominal computed tomography (CT) to identify any abdominal sepsis.

Establish nasogastric suction.

Insert a Foley catheter.

In the elderly and the critically ill patient, monitor fluid requirements and cardiorespiratory function by means of pulmonary arterial pressure measurements, cardiac output determinations, and frequent blood gas determinations.

Pitfalls and Danger Points

Inadequate débridement of devitalized tissue

Failure to identify and drain intra-abdominal abscesses, including loculations and multiple abscesses

Failure to identify an associated gastrointestinal fistula

Injuring the spleen, liver, or a hollow viscus

†Deceased

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Operative Strategy: Infected Abdominal Wall and Dehiscence

Wide Débridement

Unhesitatingly cut away all devitalized tissue and continue the scalpel dissection until bleeding is encountered from the cut edge of the tissue. If even a small remnant of devitalized fat or other tissue is left, it is a haven in which bacteria can proliferate and destroy more of the abdominal wall.

Managing the Abdominal Wall Defect

Closure of even small abdominal wall defects in the setting of necrotizing infection is doomed to failure. The strategy that has evolved accepts the trade-off of a possible incisional hernia for a better chance of patient survival. Small defects (<4–6 cm in diameter) may be managed by Adaptic gauze covered with moist gauze packing. Larger defects may be managed by application of a vacuum dressing or closure with absorbable mesh (inserted by a rapid suture technique). Dressing changes and subsequent granulation tissue formation ultimately result in a surface that can be covered with a split-thickness skin graft. Generally, the large resulting incisional hernia is managed by delayed repair, possibly involving a musculocutaneous flap, at a time remote from the life-threatening illness.

Repeat Laparotomy for Recurrence of Abdominal Sepsis

Always anticipate the potential need for repeat exploration. If re-exploration is likely, use a vacuum dressing. Sometimes, after successfully débriding an infected abdominal incision and repairing the defect with mesh, subsequent clinical observation may disclose the need to re-explore the abdomen for recurrent sepsis between the loops of small bowel, the pelvis, the subhepatic or subphrenic spaces, or elsewhere. If may be simpler to make an incision through the mesh, perform the abdominal exploration, and then repair the mesh with a continuous 2-0 Prolene suture than to attempt to remove the mesh.

Management of Intestinal Stomas and Fistulas

When a patient who is taken to the operating room for débridement of an infected abdominal incision also requires exteriorization of an intestinal fistula or requires a colostomy, avoid loop colostomy or enterostomy creation. This type of stoma is difficult to control, and secretions continuously contaminate the open abdominal wound. If possible, create matured end stomas of the small bowel or colon and bring them out at sites well away from the open abdominal wound.

Marsupialization and Open Abdomen Management

When complex collections with multiple loculations and necrotic tissue are encountered, the probability of recurrence is high. In the critically ill patient, consider leaving the abdomen open (and applying a vacuum dressing) so that daily explorations, débridements, irrigation, and packing can be done in the intensive care unit. Closure (generally using mesh) is performed once sepsis has been controlled.

Intra-abdominal Abscesses: Classification of Spaces of the Upper Abdomen

For purposes of this discussion, we have adopted the classification of Boyd (for spaces of the upper abdomen) with a slight modification. On the right side, there is a single suprahepatic subphrenic space and a right infrahepatic space. On the left, there is a subphrenic space and a left infrahepatic space that can be divided into two spaces: (1) the posterior infrahepatic space, which constitutes the lesser sac, and (2) the left anterior infrahepatic space, which is situated anterior to the stomach.

Operative Approaches to Abscess Drainage

Lateral and Subcostal Extraperitoneal Approach

DeCosse and associates modified the subcostal extraperitoneal approach by extending it in a lateral direction as far as the tip of the eleventh rib. The layers of the abdominal wall are divided down to the peritoneum. The surgeon's hand then dissects the peritoneum away from the diaphragm until the abscess is reached. The lateral extraperitoneal approach may also be used to treat a right posterior intrahepatic abscess. DeCosse and associates were successful in draining left subphrenic and left posterior infrahepatic abscesses in the lesser sac through the subcostal or lateral extraperitoneal approach. The lesser sac abscesses were reached by dissecting the peritoneum away from the upper pole of the kidney. The right suprahepatic subphrenic abscess is easily approached through an anterior (subcostal) extraperitoneal approach. An abscess in the left anterior infrahepatic space is best approached by performing a laparotomy.

Laparotomy

Although it is true that, thanks to modern antibiotics, there is no great risk of spreading the infection by draining an abscess transperitoneally instead of extraserously, no one can doubt that exploring the abdomen 2–3 weeks after major surgery is more difficult and more hazardous than is draining the abscess by an extraserous route. Before high-resolution CT scanning, there was a considerable risk that the patient might have an abscess in more than one location. Under these conditions, an extraperitoneal operation might overlook the second or third abscess.

When a CT scan demonstrates a *solitary* right or left subphrenic abscess or a right posterior infrahepatic abscess, we prefer to attempt drainage by the extraserous approach because the operation is safe and relatively simple. If this procedure fails to eliminate the signs of sepsis, a laparotomy should be performed. However, this discussion may be hypothetic because almost all of the subphrenic abscesses in accessible locations such as the above are effectively managed by inserting percutaneous drainage catheters with CT guidance. Laparotomy is mandatory in patients suspected of having a lesser sac abscess, a peripancreatic or a left anterior infrahepatic abscess, or an anastomotic leak with multiple intermesenteric abscesses.

When the transperitoneal approach has been elected, we prefer a midline incision, especially if there is suspicion of an anastomotic leak or an abscess located within the folds or the small bowel mesentery. If exploration of the subphrenic, subhepatic, and lesser sac spaces does not reveal the source of the patient's sepsis, it may be necessary to free the entire small bowel and the pelvis to rule out an abdominal abscess.

Extraserous Approach

Dissection in the extraserous preperitoneal or retroperitoneal plane is generally simple if the surgeon enters the proper plane by incising the transversalis fascia but not the peritoneum. The incision should be made long enough to admit the surgeon's hand. Blunt dissection then separates the peritoneum from the undersurface of the diaphragm until an area of induration is reached. This represents the abscess. Generally, blunt dissection with a finger permits entry into the abscess. Intraoperative ultrasonography or aspiration with a long spinal needle helps establish the location with certainty in difficult cases. Although it is possible to drain abscesses in the posterior right subhepatic space and in the lesser sac by the extraserous approach, we usually prefer a laparotomy to drain these two spaces.

When an extraserous approach has failed to reveal an abscess, it is generally simple to lengthen the incision in the abdominal wall transversely, converting it to a subcostal incision. Then incise the peritoneum and continue the exploration for the abscess transperitoneally. Alternatively, make a second vertical midline incision for further exploration.

Operative Technique

During surgery for large abdominal defects that remain after wide débridement of infected abdominal incisions, we recommend using the simplest possible closure technique in critically ill patients. For most, this will be a simple vacuum dressing. This is fast, controls leakage, and allows easy

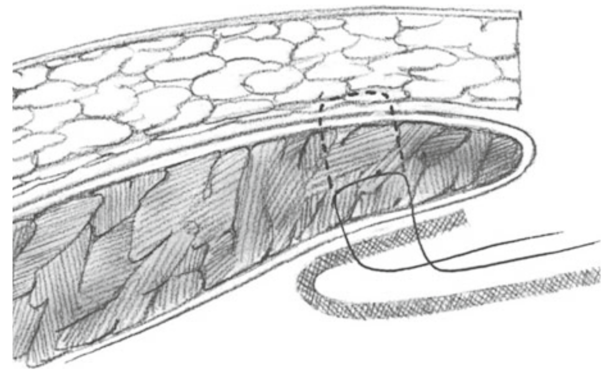

Fig. 108.1

re-exploration in the operating room or intensive care unit. It has the disadvantage of allowing the fascia and muscles to retract, making subsequent closure more difficult.

If the patient is sufficiently stable and reoperation is not likely, simple closure of the fascia with absorbable mesh is preferred. Cut the mesh so it is only 1 cm larger than the abdominal defect. Be certain that all intra-abdominal abscesses have been evacuated. Attempt to place a layer of omentum between the mesh and the underlying bowel. In no case should a bowel *anastomosis* ever be left in contact with synthetic mesh. Then use atraumatic sutures of 2-0 Prolene to attach the cut end of the mesh to the undersurface of the abdominal wall. In most cases, continuous sutures are employed. The technique described by either Markgraf (Fig. 108.1) or Boyd (Fig. 108.2) may be used. For both techniques, take a larger bite of the abdominal wall than of the mesh; otherwise, the mesh wrinkles. Apply slight tension to the mesh when inserting these sutures so it lies as flat as possible. Markgraf recommended that when inserting sutures into the abdominal wall below the semicircular line, it is helpful to insert the suture through the entire thickness of the rectus muscle including the *anterior* rectus fascia; otherwise, the muscle and peritoneum may have inadequate holding power.

After the mesh has been sutured in place, apply gauze packing moistened with isotonic saline. In some cases, it is appropriate to moisten the gauze with an antibiotic solution for the first 24 h after débriding the wound.

Extraserous Subcostal Drainage of Right Subphrenic Abscess (Surgical Legacy Technique)

Incision and Exposure

Make a 10- to 12-cm incision, beginning near the tip of the right eleventh rib and continue medially parallel to the costal margin. Carry the incision through the external oblique muscle and aponeurosis (Fig. 108.3). Generally, the internal oblique muscle (Fig. 108.4) can be separated along the line of its fibers. It is usually necessary to divide the ninth

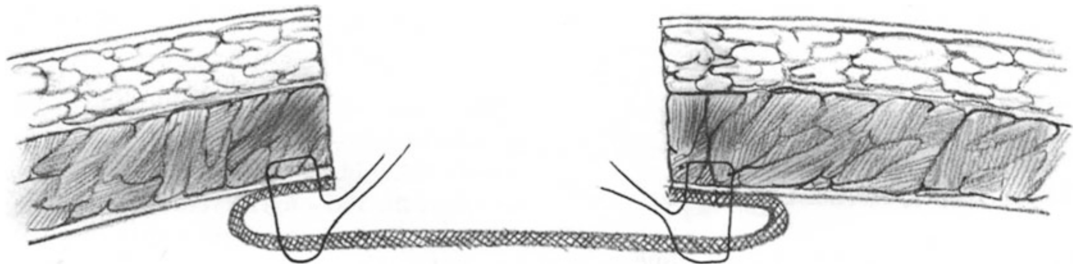

Fig. 108.2

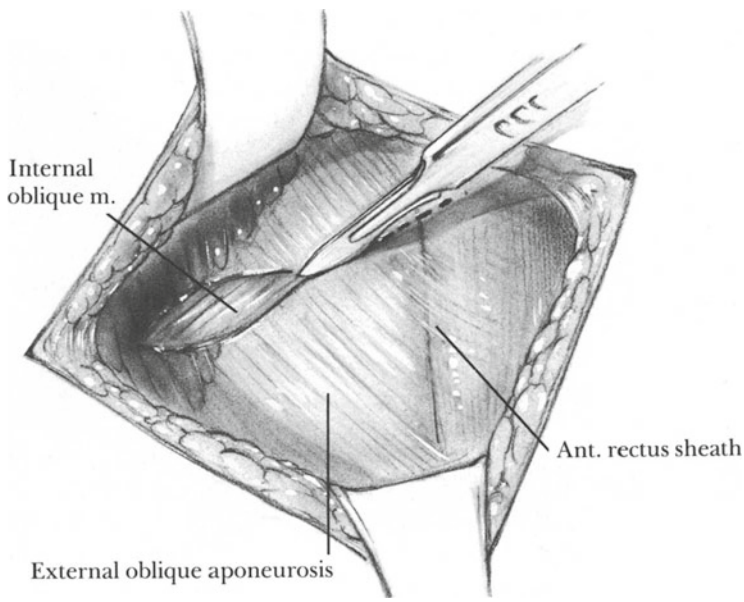

Fig. 108.3

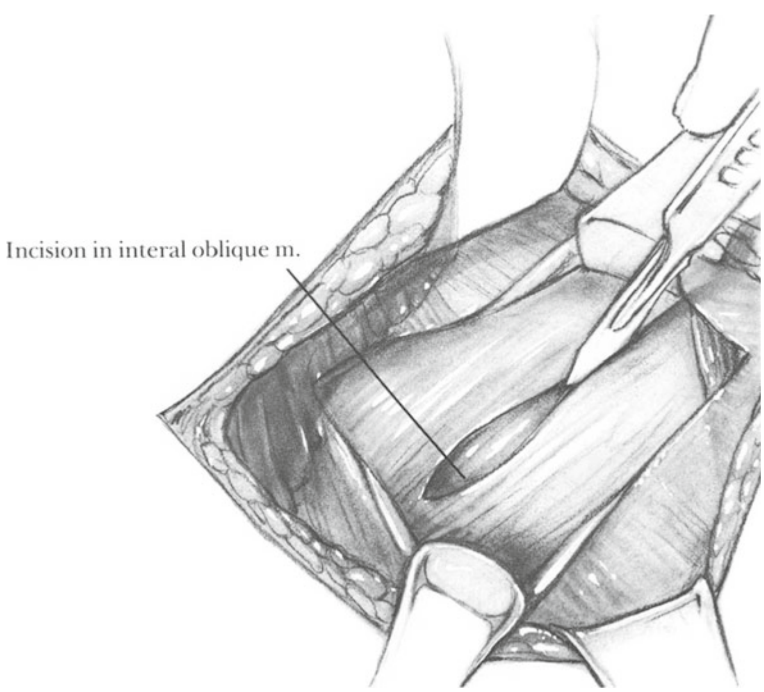

Fig. 108.4

intercostal nerve. Then transect the transversus muscle with electrocautery. If necessary, continue the incision through the lateral one-fourth of the rectus muscle.

Identify the transversalis fascia and carefully divide it with a scalpel (Fig. 108.5), revealing the underlying peritoneal membrane. Use a gauze sponge on a sponge holder to dissect the peritoneum away from the transversalis fascia. Continue the dissection upward by inserting the hand to separate the peritoneum further from the undersurface of the diaphragm until the dome of the liver is reached (Fig. 108.6).

A right posterior infrahepatic abscess can be reached by the extraserous approach if the peritoneum is dissected laterally (Fig. 108.7) until the fat overlying Gerota's fascia is encountered, which is swept away from the posterolateral peritoneal envelope. The abscess is then encountered medial and superior to the upper pole of the right kidney. On the left side, a posterior infrahepatic or lesser sac abscess can be approached in a similar fashion by dissecting the posterolateral peritoneum away from the fat over Gerota's capsule. The abscess is then encountered medial to the upper pole of the left kidney.

Drainage and Closure

After exposing an area of induration in one of the subphrenic spaces, enter the abscess by inserting a fingertip or the tip of a blunt Kelly hemostat. Open the abscess cavity widely and irrigate out the purulent material after obtaining a sample for routine and anaerobic cultures (Fig. 108.8).

If an abscess has been drained in its early stages, before its walls have become rigid, evacuating the pus permits the abscess cavity to collapse and disappear. In cases of this type, it is necessary to insert only a single suction drain and a single large latex drain. These drains may be brought out through the incision (Fig. 108.9) (or through a stab wound). Close the remainder of the abdominal wall incision so one finger can be inserted into the abdominal cavity alongside the drains. Although many surgeons prefer to sew the skin closed after this operation, we believe that the skin and the subcutaneous tissue should be lightly packed with a strip of moistened gauze and left open. Several untied interrupted nylon skin sutures may be inserted, in anticipation of a

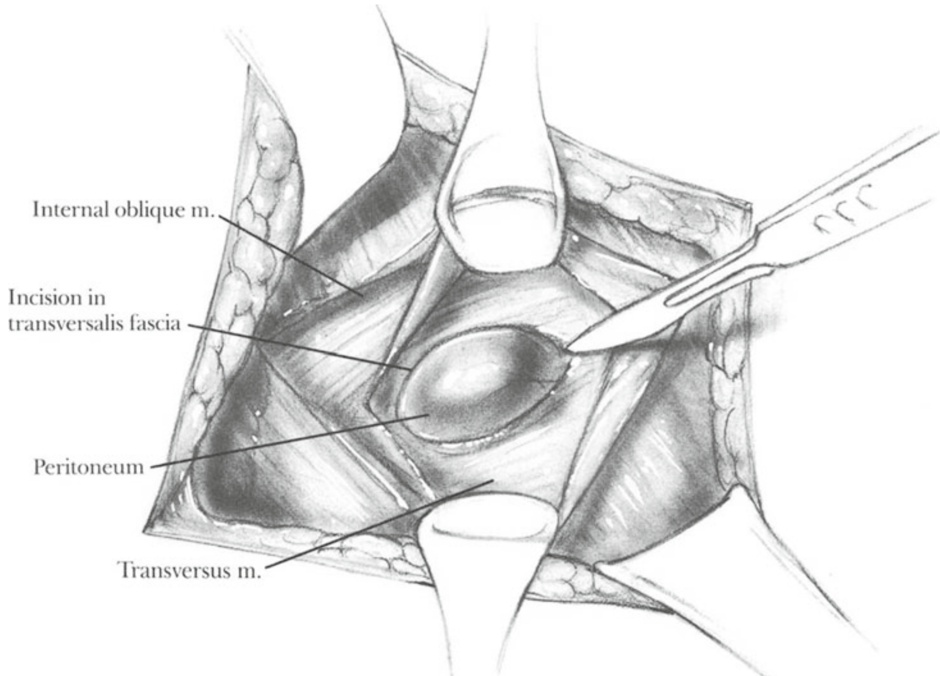

Fig. 108.5

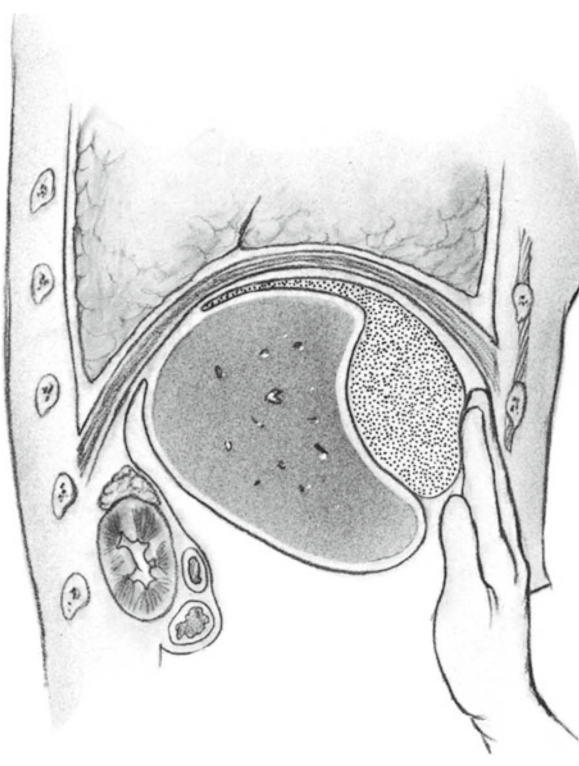

Fig. 108.6

Fig. 108.7

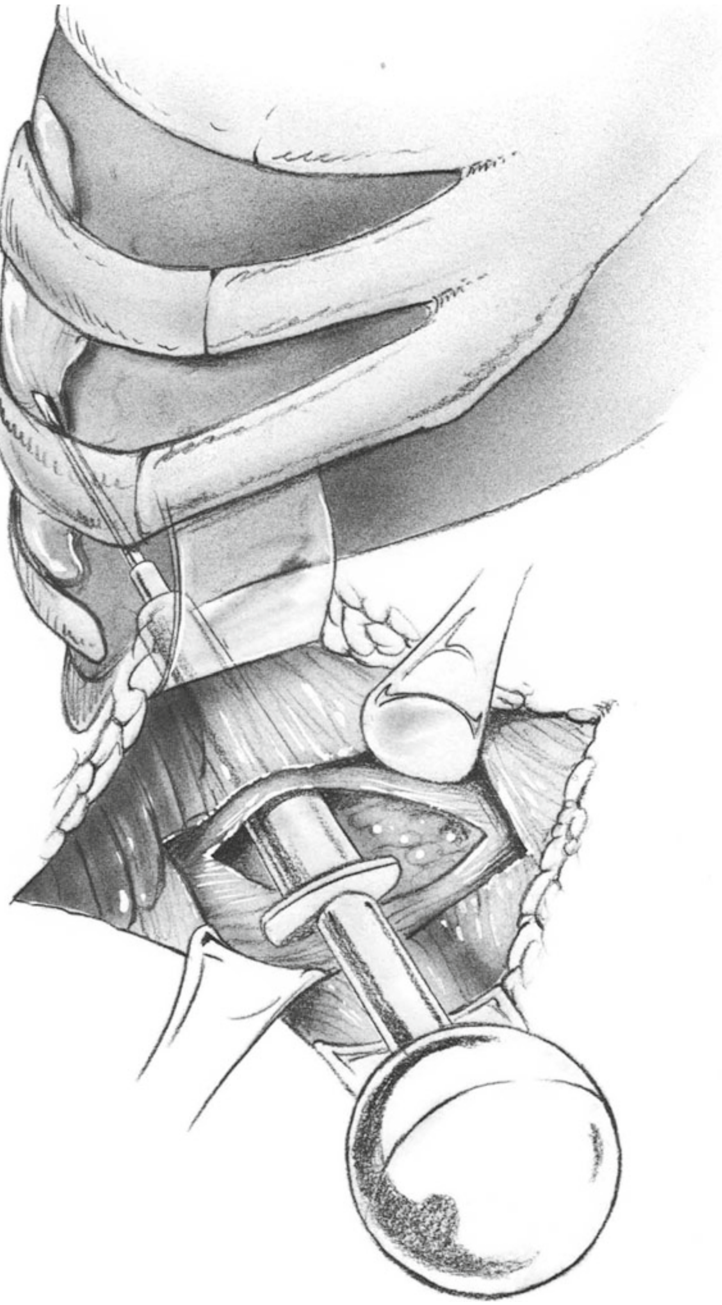

Fig. 108.8

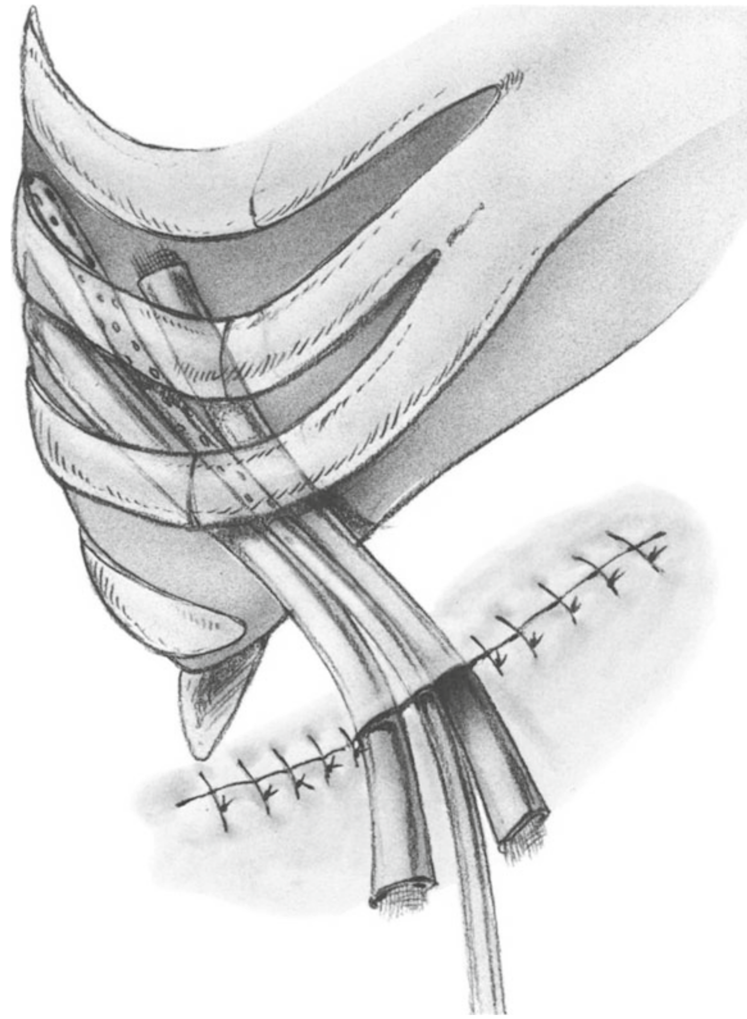

Fig. 108.9

delayed secondary closure at the bedside 4–7 days following operation. If the patient has a large subphrenic abscess with rigid walls that do not collapse after evacuating the pus, insert two suction drains and three or four large latex drains, anticipating that the drains may have to be left in for a number of weeks before the abscess cavity collapses or fills with granulation tissue.

Laparotomy for Subphrenic and Abdominal Abscesses

Incision and Exposure

When draining an accurately localized right infrahepatic abscess, a right lateral subcostal incision is suitable. Left anterior infrahepatic and lesser sac abscesses, suprahepatic abscesses, and most other abdominal abscesses are better drained through midline incisions. If the patient has had a recent operation through a midline incision, try to enter the abdomen by extending the previous midline incision into a virginal area of the abdominal wall to minimize the chance of injuring densely adherent bowel. After the abdomen is opened, identify the falciform ligament and peritoneum. Dissect these two structures away from all the underlying bowel and omentum, first on the right side and then on the left. Then pass a hand over the liver to explore the suprahepatic and then the infrahepatic spaces.

Divide the avascular portion of the gastrohepatic ligament and enter the lesser sac behind the lesser curvature of the stomach. If this approach has been obliterated by previous surgery or adhesions, enter the lesser sac by dividing the omentum along the greater curvature and expose the posterior wall of the stomach and the anterior surface of the pancreas. Identify the right and left paracolic spaces and expose the pelvic cavity, as both are likely abscess sites, especially in patients suffering ruptured appendicitis or diverticulitis. Finally, if it is necessary to rule out the possibility of an interloop abscess, the surgeon must patiently free the entire length of small intestine and its mesentery. Perform a needle catheter jejunostomy in all patients not likely to resume oral nutrition early in the postoperative course.

Drainage and Closure

When a long midline incision has been used, bring drains out through suitable stab wounds. Although large sump drains are suitable for subphrenic abscesses, there is considerable risk of creating a colocutaneous or enterocutaneous fistula if a large plastic drain remains in contact with a segment of bowel for more than 2 weeks. Consequently, it may be preferable to use soft Silastic sump drains or latex Penrose drains rather than a more rigid drain.

Postoperative Care

Continue therapeutic dosages of appropriate antibiotics.

Change the gauze packing over the mesh every 8–12 h until it is ascertained there has been no extension of the necrotizing infection. Thereafter, inspect the wound and change the dressing daily.

If a vacuum dressing has been applied, change as per protocol.

Observe the patient carefully for recurrent abdominal sepsis and take appropriate diagnostic, therapeutic, and surgical measures to correct this sepsis.

After the wound is cleaned and granulation has formed, if the defect is small, it is possible that epithelialization may proceed spontaneously. In most cases, as abdominal distension disappears, wrinkling of the mesh precludes spontaneous healing. In these cases, remove the mesh when the wound is clean and the patient's condition has stabilized, preferably around the 20th postoperative day. Then apply a split-thickness graft over the granulations covering the intestinal viscera. Delay definitive repair of a large abdominal hernia until a later date.

Abscess Drainage

If the abscess cavity was not rigid and its walls collapsed after the pus was evacuated, remove the drains after 10–14 days. If there is any question about a residual cavity, inject sterile Hypaque or other iodinated aqueous contrast medium through the sump drain to obtain a radiographic sinogram or CT scan. Leave at least one of the drains in place until the cavity has been eliminated.

If the patient has a large abscess cavity with rigid walls and thick pus, consider the advantages of irrigating the abscess daily through one of the sump catheters with a dilute antibiotic solution.

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Part XI

Breast and Melanoma

Concepts in Breast and Melanoma Surgery

109

Lyndsay A. Gutierrez, Sartaj S. Sanghera,
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Breast Surgery

Surgeons provide key services for diagnosis and treatment of benign and malignant breast disease and are often the coordinating provider for breast care. Surgeons must also be familiar with all aspects of breast care to assure that application of surgical interventions is properly coordinated with other components of care.

Screening for Breast Cancer

Breast cancer is the most common cancer and cause of cancer death among women with over 200,000 cases in the United States annually (SEER Cancer Statistics Review 2011). Though there is still debate on the appropriate age to start screening mammography, most organizations recommend that all women begin annual screening mammography at age 40 (Smith et al. 2011). Those at marked increased risk, usually by virtue of a strong family history, should begin screening at an earlier age. Breast ultrasound is not useful in screening though it is a key adjunct to other imaging in evaluation of breast lesions. Magnetic resonance imaging (MRI) may be useful in screening women at marked increased breast cancer risk. Its increased sensitivity for cancer must be balanced against a high false-positive rate (Saslow et al. 2007). Findings of breast imaging are coded using the BI-RADS system with a score of 0–6 (Eberl et al. 2006). If a breast lesion seen on imaging is predicted to have a greater than 2 % chance of malignancy (BI-RADS 4 or 5), biopsy is warranted.

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Breast Biopsy: Obtaining a Tissue Diagnosis

Lesions deemed suspicious on imaging or clinical examination require biopsy. Needle biopsy (core needle biopsy, CNB, or fine-needle aspiration, FNA) is preferred over surgical biopsy. Surgical excision should not be performed as the initial biopsy unless needle biopsy cannot be done (about 10 % of cases) or if pathology obtained from FNA or CNB is not concordant with imaging. Core biopsy is preferred over FNA because FNA provides just cytology and has a significant false-negative rate. CNB provides histologic information on tissue architecture and allows easier biomarker determination (hormone receptors and HER2/neu).

Biopsies of calcifications or small masses seen only on mammogram require image guidance (stereotactic mammographic, ultrasound, or MRI). A metallic biopsy marker should always be deployed in the lesion at the time of CNB to guide a possible subsequent surgical excision. CNB can be performed without image guidance for palpable lesions.

Management of Common Benign Breast Lesions

Many benign breast lesions require evaluation and management by the breast surgeon. *Breast abscesses* are lactational (puerperal) or non-lactational (nonpuerperal). Abscesses are typically caused by *Staphylococcus aureus*, *streptococci*, and *Staphylococcus epidermidis*. Lactational abscesses should be drained, preferably by aspiration with at least a 21 gauge needle under ultrasound guidance to allow for more complete drainage. The syringe can be changed and the abscess cavity irrigated. Repeated aspirations may be required for complete resolution. Open drainage procedure may be needed if the skin overlying the abscess is thinned or necrotic (Dixon and Khan 2011).

Non-lactational breast abscesses occur primarily in the subareolar or periareolar area of the breast but may be in the periphery of the breast. They are more likely in smokers and those with nipple piercing (Gollapalli et al. 2010). Treatment

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is drainage by aspiration of the abscess with antibiotics. This may require repeated aspiration. If this fails, open drainage should be performed. After the infection is resolved, breast imaging should be performed for cancer screening. In those with recurrent infections, central duct excision may be warranted (Li et al. 2006).

Breast cysts are very common and generally of no significance and do not warrant intervention. Ultrasound distinguishes whether a mass seen on mammogram or a hard palpable mass is solid or a cyst. Simple cysts require no intervention but may be aspirated if symptomatic or psychologically worrisome to the patient. Complex cysts have fluid levels, solid components, septations, or irregular borders. Complex cysts should be aspirated and any solid component biopsied to rule out a malignancy (Chang et al. 2007).

Benign Lesions on CNB That Require Excision

Most lesions that undergo CNB are benign and do not require excision. A few benign lesions found on CNB are associated with a nearby cancer in a few cases and should be surgically excised. The most common of these is atypical ductal hyperplasia (ADH). With ADH on CNB, up to 20 % harbor cancer, most often ductal carcinoma in situ (DCIS), found at excision. Other lesions where excision is generally performed include atypical lobular hyperplasia (ALH) and lobular carcinoma in situ (LCIS) though the likelihood of cancer may be lower (Karabakhtsian et al. 2007).

Management of Breast Cancer

Surgery remains a mainstay of breast cancer treatment. Previously, mastectomy was the only treatment available. However, a series of clinical trials over the last four decades provide clear evidence that in most cases mastectomy is not necessary. Outcomes for women treated with breast-conserving therapy (BCT) measured in both survival and in many situations in breast (local) recurrence are the same for both treatments (Fisher et al. 2002). However, surgical therapy must be coordinated with adjuvant radiation therapy and with adjuvant systemic therapy that may be administered prior to surgery. Surgery to determine lymph node involvement is also an integral part of treatment.

Ductal carcinoma in situ (DCIS) is characterized by the absence of invasion of the ductal basement membrane and no potential for developing metastatic disease. Mastectomy for DCIS is curative for almost 100 % of patients. However, the long-term survival with BCT is equal to that with mastectomy, and BCT is feasible in most cases. Those with extensive DCIS or multiple distinct foci of DCIS widely separated in the breast still require mastectomy.

BCT generally includes surgical resection of the DCIS followed by radiation. Resection usually requires image localization to define the area to be removed. Using the imaging and surgical experience, the surgeon removes a margin of normal tissue around the DCIS. Postoperative margin assessment will reveal close or positive margins in 10–20 % of cases requiring re-excisional surgery. For this reason, the surgeon must orient the initial surgical specimen for the pathologist to define the specific close or involved margin and allow re-excision directed at that margin(s) only. The pathologist reports the closest margin(s) and the distance in millimeters from that margin. Margins less than 2 mm generally require re-excision (with the exception of anterior skin margins and posterior margins where the muscle fascia was resected). Prior to re-excision, mammography is important to ascertain if there are residual calcifications. In cases where re-excision would leave an unacceptable appearance, mastectomy is an option.

Though long-term outcome is the same with BCT and mastectomy for DCIS, there is a risk of recurrence in the breast ("local recurrence") of which about 1/3 are invasive and 2/3 are DCIS. Post-lumpectomy adjuvant radiation reduces the local recurrence rate by about 50 % (Fisher et al. 2002). Local recurrence rates without radiation are reported as high as 40 % but may be much lower in those with small areas of DCIS and/or low-grade DCIS. However, among women treated on randomized trials of radiation in DCIS, there have been no subgroups identified that do not benefit from radiation therapy. All women who have undergone lumpectomy for DCIS should be considered for adjuvant radiation therapy.

Lymph node staging is not indicated with DCIS (unless mastectomy is performed, see below). When sentinel lymph node biopsy (SLNB) is performed with DCIS, the incidence of sentinel lymph node metastasis is 5 % or lower, and most are micrometastases or isolated tumor cells. These generally mean that there is an invasive component of the tumor (Allegra et al. 2010). It is important to note that invasive cancer is identified at final excision in some cases where CNB shows DCIS. SLNB can usually be performed as a second operation and should not be performed with BCT. Lymph node staging is warranted in cases where the imaging shows a mass highly suspicious for invasive cancer even if the CNB only shows DCIS. SLNB is also warranted with mastectomy for DCIS because the anatomic disruption of lymphatics with mastectomy makes subsequent SLNB impossible.

Women treated with BCT may further reduce the risk of local recurrence by taking the selective estrogen receptor modulator tamoxifen for 5 years (Fisher et al. 1999). The benefit must be weighed against the toxicity, which is higher among postmenopausal women. Clinical trials of aromatase inhibitors for reducing the risk of local recurrence with DCIS are under way and may be reported soon.

Invasive Cancer

Most cancers of the breast invade the investing basement membrane and have the potential to spread to other organs and overwhelm the host. Invasive cancers are classified histologically by the apparent origin in the ductal components (invasive ductal cancer – IDC) or lobular components (invasive lobular cancer – ILC). IDC is most common along with IDC variants such as tubular and mucinous.

Treatment for invasive breast cancer must address both control in the breast and the potential for distant spread with the consideration of adjuvant systemic therapy. The need for systemic therapy is based on the risk of developing distant metastases and dying from breast cancer estimated from key prognostic factors including tumor size, lymph node status, and tumor grade supplemented by information on biomarkers including hormone receptors and HER2/neu. Systemic therapies include endocrine therapy for virtually all women with hormone receptor-positive cancer with some of them also requiring chemotherapy and chemotherapy for those with hormone receptor-negative cancer except those with very small cancers (well under 1 cm). A full discussion of adjuvant therapy is beyond this chapter, but surgeons must be aware of the key issues in systemic therapy including the situations where systemic therapy should precede surgery – the so-called neoadjuvant endocrine and/or chemotherapy. A key reference is the practice guideline of the National Comprehensive Cancer Network (NCCN) (available at www.nccn.org).

As with DCIS, local therapy involves either BCT or mastectomy. With invasive cancer, lymph node surgery is warranted in virtually all cases to inform the decisions regarding systemic therapy with sentinel lymph node biopsy (SLNB) and/or complete axillary lymph node dissection (CLND). Local therapy with BCT generally also includes radiation therapy. Radiation may also be warranted with mastectomy because of the risk of local chest wall and nodal recurrence. Radiation is used after mastectomy in the case of large cancers (T3, >5 cm), with lymph node involvement or with positive surgical margins.

The decision between BCT and mastectomy involves both medical and personal considerations. Medical indications for mastectomy include multicentric disease (synchronous foci of cancer located more than 5 cm apart in the breast), inflammatory breast cancer, prior therapeutic radiation to the breast region, and local recurrence after BCT with prior radiation. Women with large cancers may be treated with neoadjuvant systemic therapy to shrink the cancer, and if BCT is possible following this, evidence shows that outcomes including local recurrence risk are equivalent to mastectomy (Bear 2010; Kaufmann et al. 2010).

Mastectomy may also be performed for personal reasons of the affected woman. The most common reason for choosing mastectomy when BCT is possible is a high risk of a subsequent second cancer. This most often occurs because of real or perceived inherited susceptibility based on strong family history and/or the presence of a mutation in genes associated with breast cancer risk. Some of these women ask to have prophylactic contralateral mastectomy as well. Recent evidence points to an increase in the number of women having this approach. These decisions are complicated and often require multiple visits as well as consultation with other specialists including genetics professionals, psychologists, and other oncology disciplines.

Women considering mastectomy should also be counseled on the options for breast reconstruction. This can often be performed at the time of the primary mastectomy or at a later date using tissue expander/implant techniques or autologous tissue transfer flaps. Many factors influence the choice of reconstruction and reconstructive techniques. The use of postmastectomy radiation may affect the risk and outcome of reconstruction, and the need for radiation is not known before surgery in many cases. Once again, multidisciplinary consultation and care counseling are needed in considering reconstruction at the time of mastectomy.

Mastectomy is performed through elliptical incision encompassing the nipple areolar complex and some surrounding skin. With immediate reconstruction, a skin-sparing approach which leaves the breast skin envelope provides a better cosmetic appearance. The nipple may be spared in highly select cases of small peripheral tumors. Frozen section of the subareolar tissue may help select these cases to avoid leaving tumor in the nipple (Brachtel et al. 2009).

Skin flaps are made superiorly to the level of the clavicle, inferiorly to the rectus abdominis muscle, laterally to the latissimus muscle, and medially to the sternal border. The breast along with the pectoral fascia is taken off the pectoralis major muscle. Axillary surgery is performed through the same incision or through a separate incision if limited skin-sparing incisions provide insufficient access to the axilla.

Breast-conserving surgery is generally performed through two incisions – one for the lumpectomy and the other for the axilla unless the tumor is located in the axillary tail and both are easily done through one incision. Non-palpable tumors require image guidance. This is not needed if the tumor is readily palpable. The most common image guidance technique is needle localization, first described by Dodd in 1966. This is done by placing a needle that has a flexible hook wire inside directly to the cancer. After placement, the needle is removed leaving the wire in place. This may be guided by with ultrasound, mammography, or MRI. A technique adopted by some surgeons is placement of a radioactive seed in the tumor with intraoperative localization with a gamma probe.

Surgery may be done with local or general anesthesia. The incision is generally placed directly over the cancer in a curvilinear fashion along the lines of Langer. The incision placement should be fashioned in case a mastectomy is warranted at some point in the future so that the previous scar may be incorporated into the mastectomy incision. Based on the localizing films or the palpable tumor, the surgeon excises tissue around the lesion often removing the underlying fascia except in cases with superficial tumors. The surgeon must orient the surgical specimen by a clear means such as stitches or clips placed on the surface of the specimen and/or inking the tumor with multiple colors of ink. For image-guided excisions, the lumpectomy specimen should be imaged to confirm the presence of the cancer. Recently, there is increased interest in procedures to improve the cosmetic appearance of the lumpectomy result using oncoplastic techniques to move tissue. This may be done for larger cancers often in collaboration with a plastic surgeon.

As with DCIS, the goal is a negative surgical margin. The risk of local recurrence is higher with close or positive margins. About 10–15 % of cases require re-excision. This can be directed only at the close margin as defined by the orientation of the initial excision specimen.

Radiation is a key component of BCT. Early studies showed a local recurrence rate of 40 % without radiation (Fisher et al. 2002). With current surgery, pathology, and radiation practices and with appropriate application of adjuvant systemic therapy, this risk is likely much lower. However, with radiation, many series report local recurrence rates with radiation as low as 2 %. The standard for radiation is treatment of the whole breast. However, because most recurrences occur in close proximity to the lumpectomy site, there is intense interest in techniques that administer radiation to just the site of the lumpectomy – the so-called partial breast irradiation. This may be delivered in as little as 5 days or possibly even in one dose at surgery (intraoperative radiation). Long-term data on the efficacy of partial breast radiation are still lacking, but it is likely this will prove effective. These developments highlight the need for surgeons to work closely with radiation oncologists in program planning and individual case treatment planning.

Lymph Node Staging

Lymph node spread of breast cancer is a key prognostic factor and may affect the need for and choice of adjuvant systemic therapy. Surgical resection is the only accurate technique for defining node involvement. Until the 1990s, this required complete axillary lymph node dissection (CLND). However, as with melanoma described in this chapter, mapping lymphatic drainage with colloidal tracers identifies the same few nodes to which the cancer may spread. The hypothesis is that lymphatic vessels draining a breast cancer will first drain to these sentinel lymph nodes and if these are negative for tumor, the likelihood of other node involvement is very low and CLND is not necessary. SLNB is appropriate for women with clinically negative nodes. With clinically positive nodes, CLND should be performed.

Until recently, any case with a positive sentinel node had CLND because of the presumed need to know the number of positive nodes and to prevent axillary disease progression/recurrence. Recent clinical trial data demonstrates that CLND is not needed for women with 1 or 2 positive nodes who will be treated with radiation and systemic therapy after BCT (Giuliano et al. 2011). This has affected practice significantly with far fewer women requiring axillary dissection. This and other studies have also affected the techniques used for lymph node pathological evaluation. Intraoperative evaluation was standard but is now not frequently performed. Further, studies clearly demonstrate that micrometastases and isolated tumor cell clusters have minimal or no clinical significance so that cytokeratin immunohistochemistry analysis of nodes is not necessary (Weaver et al. 2011). Though this practice may change in the future, CLND remains standard when mastectomy is performed and a sentinel node is positive. Therefore, intraoperative evaluation of the sentinel node is warranted with mastectomy.

SLNB involves circumareolar intradermal or subareolar injection of a colloidal material. The most widely used is technetium-99m-labeled sulfur colloid, often supplemented by isosulfan blue or methylene blue dye. The radioactive tracer may be injected hours before surgery, but recent evidence shows that it is equally accurate and effective to inject in the operating room. Unlike melanoma, there is no added value to preoperative lymphoscintigraphy. The vital dyes should be injected in the operating room. After injection, the breast is massaged for 5 min and the gamma probe used to search for the sentinel node(s). An incision is made in a curvilinear fashion below the hair-bearing area of the armpit. Any blue lymphatics are traced to their draining lymph nodes, and the handheld gamma probe is used to identify tracer uptake. The "blue" and "hot" lymph nodes are removed. The average number of nodes identified is 3. SLNB is highly accurate. Data from the early studies showed a false-negative rate of SLNB of about 10 % (Krag et al. 2007).

Axillary dissection is reserved for those with clinically positive nodes or those with extensive lymph node involvement. Axillary dissection is performed through the same incision as mastectomy or through a separate incision with BCT. Standard dissection includes those nodes lateral to the pectoralis muscle to the latissimus muscle and to the medial border of the pectoralis minor muscle (levels I and II). If there is gross node involvement in level II, the pectoralis minor muscle insertion on the coracoid process is divided to remove nodes medially to the thoracic inlet (level III).

Patients with multiple involved lymph nodes require radiation to the supraclavicular region in addition to the breast or mastectomy site. Though not fully supported by high-level evidence, many also receive radiation to the internal mammary lymph nodes.

Treatment of Local Recurrence

Standard treatment for a breast cancer recurrence following BCT is mastectomy. For those with local recurrence after mastectomy, local excision should be done if possible followed by chest wall and extended nodal radiation. Isolated axillary recurrence is uncommon. Resection and radiation are the mainstay of treatment to prevent progression to the brachial plexus. Because local recurrence can be a harbinger of metastatic disease, screening imaging for metastases is warranted. The value of additional systemic therapy is unproven, but this should be considered.

Metastatic Disease

The role of surgery in women with metastatic disease is limited (Gnerlich et al. 2007; Neuman et al. 2010; Rashaan et al. 2012). Retrospective registry data suggests a survival advantage for those women with metastatic disease at initial presentation (stage IV), but this is likely a selection bias of who received surgery. Palliative surgery for an advanced lesion in the breast in a woman with metastatic disease may be considered to prevent progression to painful open wounds. Resection of liver, lung, and brain metastases does not improve overall survival in breast cancer and should only be done in highly select circumstances.

Melanoma Surgery

Melanoma is the sixth leading cause of cancer death in the United States. The incidence of melanoma is rising, and it is estimated that there will be 70,230 new cases of melanoma diagnosed in 2011 (National Cancer Institute 2011). Surgery is the most effective treatment available as it can achieve a cure, particularly in early-stage melanoma. It is imperative that surgeons involved in the treatment of melanoma be familiar with the oncological principles of diagnosis, definitive therapy of the cutaneous primary, management of the drainage nodal basin(s), the use of adjuvant therapies, and management of distant metastases.

Biopsy of a Suspicious Lesion

The mnemonic “ABCD” is frequently used to recall the high-risk features of a cutaneous lesion suspicious for melanoma. “ABCD” stands for *a*symmetry, irregular *b*orders, variegated *c*olors, and *d*iameter >6 mm. The addition of an “E” to indicate any kind of *e*volution or change over time is one of the most important features to interrogate. The presence of any of these features alone or in combination warrants biopsy.

Excisional biopsy is the best choice for evaluation whenever possible. The biopsy should include the full thickness of skin and some amount of subcutaneous fat to facilitate a thorough evaluation. The depth of the primary lesion is one of the most important prognostic factors in melanoma and is most accurately assessed after complete excision. In circumstances where an excisional biopsy is not feasible (e.g., large lesion and/or location on the head and neck), a full-thickness punch biopsy or an incisional biopsy may be performed directed at the most suspicious part of the lesion (e.g., palpable irregularity, deep pigmentation, and thickest visible part). A shave biopsy of a melanoma is never acceptable and should be reserved for situations where the suspicion of a melanoma is low. No attempt should be made to include wide margins in the initial biopsy. The width of needed definitive margins is dictated by the microscopic pathological features of diagnostic biopsy. However, the initial biopsy should always account for the potential need for a wide local excision after definitive diagnosis and should be oriented so that it may be easily incorporated into any subsequently planned wide excision. A critically important example of proactive planning is to orient the incision along the long axis of the limb when performing an extremity biopsy, which may be overlooked due to misguided concerns for cosmesis.

The correct pathological interpretation of a melanoma biopsy is paramount to proper staging and treatment recommendations. Whenever doubt exists about a diagnosis or microscopic feature(s), it is preferable to have the slides reviewed by an experienced dermatopathologist.

Primary Lesion: Wide Local Excision

Wide local excision is the established standard for the treatment of primary cutaneous melanomas. The first step in planning excision is defining the required width of the resection margin. Margins are measured circumferentially around the lesion from the farthest visible edge of the pigmented lesion. In cases where an excisional biopsy has been previously performed, the distance is measured from the outer edge of the resulting scar. The excision must be carried down to the level of the fascia covering of the underlying muscle, without including the fascia in the specimen. Although the margins of excision are measured circumferentially, an elliptical incision is usually made incorporating this circle so as to avoid unsightly “dog ears” at the edges. A rule of thumb is to make the ellipse 2.5–3 times as long as it is wide. On extremities, the incision is oriented longitudinally so as to incorporate maximal possible length of the lymphatics draining in line with the lesion. Theoretically, this approach may also reduce the risk of postoperative lymphedema in the treated extremity by minimizing the disruption of parallel lymphatic channels. Despite wide local excision with the recommended margins, local relapse can occur. This may be related to radial subclinical proliferation of melanoma cells beyond the resection margins. The spread of melanoma cells through lymphatic channels and/or the phenomenon of "neurotropism" wherein there is neural sheath invasion may also account for local recurrence.

Historically, melanomas were excised with 5 cm margins, resulting in disfiguring defects, the need for extensive reconstructive procedures, and unnecessary morbidity. The optimal margin to be used for wide local excision has now been extensively studied and evidence-based guidelines formulated. The depth of invasion is one of the most important prognostic features and determines the resection margins needed to minimize the risk of local recurrence. Thin melanomas (≤1.0 mm thick) can be safely excised with 1 cm margins, and melanomas 2.0 mm or thicker require 2 cm margins. The optimal margin width is less definitively established for melanomas between 1.00 and 2.00 mm as published guidelines recommend a margin of "1–2 cm." Where cosmetic considerations are not significant, a 2 cm margin may be preferable. In circumstances where there may be a significant impact on function and/or appearance (e.g., on the face), a 1 cm margin is appropriate and does not compromise survival though it may incur a higher potential for local recurrence (Thomas et al. 2004; Veronesi et al. 1988; Cohn-Cedermark et al. 2000; Balch et al. 2001; Khayat et al. 2003).

Primary closure of the wound is possible in the vast majority of cases. When not feasible, grafts or more complex reconstructions can be employed. Full- or partial-thickness skin grafts may be used. Full-thickness grafts include all the components of the dermis and therefore better retain all the characteristics of normal skin and heal with less contracture. They are often used on the visible areas of the face, on the hands, and over joints. The donor site is chosen so as to offer the best match for color and texture to the surrounding skin at the recipient site. Full-thickness skin graft is usually harvested from areas that are easily concealed, like the postauricular scalp and groin crease. Partial-thickness skin grafts include the epidermis and a variable thickness of the dermis. Although they do not offer equivalent cosmetic results, they can be used to cover a wider defect and have a very low failure rate, even in difficult locations. The usual donor site for partial-thickness skin grafts is the lateral thigh, abdomen, or back. Skin harvesting should never be performed from the treated extremity so that surveillance and any potential future surgical interventions are not compromised.

More complex reconstructions are not commonly needed. When necessary, useful techniques include the Z-plasty and the V-Y advancement flap. Consultation with a plastic surgeon may be valuable for the more complex reconstructions and should be sought liberally. It is never justifiable to compromise on the minimum recommended margin width solely for cosmetic purposes.

Evaluation and Treatment of Regional Nodes

Lymph node status is the single most important prognostic factor in melanoma patients with clinically localized disease (Balch et al. 2009). Evaluation and appropriate treatment of nodal spread are therefore essential components of the treatment of melanoma. Historically, elective lymph node dissection (ELND) of the drainage basin was used for any primary melanoma with high-risk features. The introduction of the sentinel lymph node biopsy (SLNB) is perhaps the single most significant advance in the staging of melanoma in the last century as it allows definition of the lymph node status without the morbidity of ELND. The technique, introduced by Morton and colleagues in 1992, identifies the lymph nodes to which cancer may drain – termed the sentinel node – by mapping the drainage of a colloidal material injected at or around the site of the primary melanoma. The status of the sentinel node(s) accurately defines if the nodal basin has metastatic disease. SLNB has been rigorously studied and validated and is the standard of care in melanoma and other malignancies, including breast cancer (Giuliano et al. 1994; Morton et al. 2006, 1999, 1992).

SLNB has saved innumerable patients from an ELND and its significant morbidity. CLND is only necessary for those with a positive sentinel node, and the role of CLND is itself the subject of ongoing investigation. Critics point to the lack of a demonstrable survival benefit, whereas proponents have highlighted that the studies were not adequately powered to demonstrate a difference (McMasters et al. 2001). Both because the number of lymph nodes involved provides important prognostic information and because of the potential impact on local recurrence, CLND remains the standard of care for those with a positive sentinel node.

Indications

Any primary melanoma with a thickness of ≥ 1.0 mm, ulceration, or a mitotic index of >1 without clinically evident nodal disease should be evaluated for the presence of lymph node metastases using SLNB. This recommendation is strongest for intermediate-thickness melanomas (between 1 and 4 mm thick) where the risk of node involvement is highest without a very high risk of distant metastases. The risk of lymph node metastases in thin melanomas (<1.0 mm) without ulceration or with a mitotic index of <1 is considered too low to warrant SLNB. Although the overall risk of lymph node involvement in this group has been quoted at 1–2 %, the risk for the subset of patients with melanomas that are 0.76–1.00 mm deep is in the range of 5–6 % (Andtbacka and Gershenwald 2009). There is increasing agreement among experts treating melanoma that this subset of patients may derive benefit from SLNB (Clinical Practice Guidelines 2011). This is especially true for those with other factors associated with node involvement including young age, Clark's level IV or V, the presence of a vertical growth phase, evidence of regression, and an incomplete biopsy.

SLNB in thick melanomas (>4 mm) may be less valuable. The risk of lymph node metastases in these lesions is 50–60 %, with an approximately equal risk for the presence of distant metastatic disease. The current recommendation is to perform SLNB to guide prognosis in the absence of clinically evident distant metastatic disease. SLNB should not be performed in the setting of clinically evident nodal disease, where a therapeutic lymph node dissection (TLND) is recommended.

Preoperative Considerations

When positioning the patient, it is frequently possible to do so in order to allow access to both the primary site and the drainage basin at the same time. If this is not possible, the patient can be repositioned following completion of the wide local excision, to afford better access to the nodal region to be dissected. Although most wide local excisions can be performed under local anesthesia, SLNB and/or CLND usually requires general or regional anesthesia.

SLNB

Reliable and accurate identification of the sentinel node requires teamwork and coordination between the surgeon and the radiologist. Preoperative lymphoscintigraphy is an absolute requirement to definitively identify the draining nodal basins for melanoma. The lymph from primary lesions can follow variable drainage patterns and may drain to multiple nodal basins. Nodes may also be found in unusual locations between the primary site and the drainage basin ("interval nodes"). Prior excisional biopsy of the lesion does not impair the ability to perform SLNB, but the surgeon must reliably indicate the site of the primary lesion to the radiologist to ensure accurate injection for lymphoscintigraphy. Unlike breast cancer where lymphoscintigraphy is not needed, lymphoscintigraphy is a key step in SLNB in melanoma. It is usually performed a few hours prior to surgery and must evaluate all the ectopic drainage basins including the epitrochlear region, the popliteal fossa and the muscular triangle of the neck.

The injection for SLNB is performed by injecting a small dose (usually 0.5 mCi) of a radiolabelled colloid intradermally around the primary lesion followed by scintigraphy scanning 5–10 min later. The most commonly agent used in the United States is filtered sulfur colloid tagged with technetium-99 m. The injection can be performed proximal to the lesion if the lesion is on an extremity. For melanomas located on the trunk, the intradermal injection is performed circumferentially around the lesion. Identification of the nodes on lymphoscintigraphy may take up to 1 h. Their location is marked on the skin, and the lymphoscintigraphy films are sent to the OR with the patient's outline clearly marked on the films. It is important that the lymphatic channels feeding the sentinel lymph node and any interval lymph nodes be identified as well. The films are reviewed by the surgeon prior to beginning the procedure. In the operating room, a handheld, collimated radioactivity probe is used to confirm the location of the sentinel node(s) and to check for location of interval nodes beyond the limits of the "diffusion zone" created by the injection around the primary lesion. Ideally, SLNB should be performed no later than 4–6 h after injection of the radiolabelled colloid, as this is the time of peak accumulation in the lymphoid tissue.

At the time of surgery, intradermal injection of 1–2 cc of a colored colloidal dye (isosulfan blue or methylene blue) may also be performed in a similar fashion around the primary lesion approximately 5–10 min prior to beginning SLNB to facilitate sentinel node identification. The area of the lesion may be gently massaged to aid in the lymphatic distribution. The incision for SLNB is made directly over the suspected location of the sentinel node(s) as defined by lymphoscintigraphy and confirmed real time with the use of the radioactivity probe. The incision should be in line with any potential future CLND incision where it can be easily ellipsed with the specimen. The node with the highest count ("hot spot") is identified and dissected free from the surrounding connective tissue. Extreme care should be taken to avoid disrupting the lymph node capsule as micrometastatic melanoma deposits may be strictly isolated to the subcapsular space. Usually, the sentinel lymph node is both hot on interrogation with the gamma probe and stained with blue dye if used. There may be more than one sentinel node, and it is important to remove all sentinel nodes. These can present as additional "hot" nodes, blue nodes that do not have increased radioactivity counts and all nodes being clearly fed by a blue lymphatic channel, even though the node itself may not be blue. Generally, all nodes with a radioactive count of more than 10 % of the sentinel node with the highest counts are considered "sentinel" and should be removed. Any palpable abnormal nodes should also be removed regardless of colloid concentration. During dissection, clips should be placed on all visible lymphatic channels to avoid subsequent seroma formation. Ex vivo counts of all nodes are recorded and the node is inspected for any evidence of gross involvement by melanoma (black or pigmented lymph node).

When performed properly by experienced surgeons, SLNB has a low false-negative rate of 1–2 %. The false-negative rate is higher for lesions on the head and neck, approaching 10 %. Accuracy is increased with the simultaneous use of both the radiolabelled colloid and the blue dye, and therefore routine use of the dual modality has been recommended (Morton et al. 2005). An exception may be made on the face, where the blue dye injection may be omitted to avoid visible permanent tattoos. Prior nodal surgery is not a contraindication to performance of SLNB, and accurate identification of a sentinel node has been demonstrated in this setting.

SLNB is a safe procedure with few complications. Reaction to the colored dye occurs in about 1 % of cases and can be serious, including life-threatening anaphylaxis. Wound complications occur in 5–10 % of cases with seroma formation being the most common complication (3–5 %). Although lymphedema is much less common when compared to complete lymph node dissection, it occurs in 1 % of cases of SLNB (Morton et al. 2005; Wrightson et al. 2003). Wound infection increases the risk of long-term lymphedema. SLNB can be performed safely in pregnancy using the radiolabelled colloid as the dose of radiation delivered is extremely small. There is increasing evidence that it is not deleterious to the fetus (Pandit-Taskar et al. 2006). However, the use of blue dyes is contraindicated as these are class C drugs not tested in pregnancy.

Intraoperative evaluation of the sentinel node by frozen section or cytology in melanoma is notoriously unreliable and should not be done. Complete pathological evaluation includes examination of multiple sections and staining to include routine hematoxylin and eosin (H&E) as well as immunohistochemical (IHC) stains using S100, HMB45, and MART-1. The latest AJCC staging manual does not differentiate between H&E positivity and IHC positivity, nor does it distinguish size of the deposit of tumor cells (micrometastasis vs. macrometastasis) in the evaluation of N staging (Balch et al. 2009).

CLND

CLND remains the standard of care for patients with melanoma and positive sentinel lymph nodes. Although no clear survival benefit for CLND has been established, the potential for improved local control, decreased lymphedema, and decreased need for adjuvant radiation therapy has been attributed to early CLND. Currently, a proportion of stage III melanoma patients, even those with bulky disease, can still be cured surgically by a CLND, and it should be performed whenever possible.

However, only one in five patients with positive SLNB will have additional nodes involved with metastatic disease on CLND. Therefore, four of five patients are subjected to a morbid operation and derive no benefit. The need for CLND compared to ultrasound observation alone in patients with a positive sentinel node is the subject of an ongoing large randomized trial (MSLT II trial).

When performing CLND, thin skin flaps must be raised to minimize the risk of local recurrence. In general, all lymphatic tissue should be taken. This involves stripping the major vascular bundles and resection of the muscular fascia in continuity to remove all potential deposits of disease. Seroma formation and wound infection are the most common complications. These are minimized by the use of closed suction drains. Small sensory nerves are frequently sacrificed, especially in the axillary and groin dissections, and it is therefore advisable that the patient be counseled regarding the possibility of postoperative paresthesias and hypoesthesia. Equally important is the discussion of postoperative lymphedema, which can be disabling in rare circumstances. A protocol for the institution of graded range of motion training after recovery is essential to preserve muscle strength and function while minimizing the development of lymphedema. The minimum number of lymph nodes to be removed from particular nodal basins has been standardized and serves as a measure of quality (Spillane et al. 2009).

In-Transit Disease

Melanoma has a pattern of regional spread unique to melanoma wherein tumor deposits in the skin or subcutaneous tissue are found en route from the primary lesion to the draining lymph node basin – termed “in-transit” disease. When a small number of lesions are detected, they may be treated surgically with wide local excision. Often, however, the burden of disease precludes surgical resection, and regional therapy is the only option.

First described in 1958 by Creech et al, isolated limb perfusion (ILP) is a technique that allows regional delivery of chemotherapeutic agents at concentrations several times those that can be administered by systemic administration. This can also be combined with increased temperature that may increase effectiveness. ILP requires surgical exposure, vascular control of the arterial inflow and venous outflow to the affected extremity, and isolation of the treatment area with a tourniquet. A less invasive alternative, developed in Australia in the 1990s, involves percutaneous cannulation of the extremity vasculature without outflow obstruction and is referred to as isolated limb infusion (ILI) (Thompson et al. 1998).

Although both these methods have the benefit of avoiding systemic toxicity, they have significant associated local morbidity. Appropriate patient selection is key, and disease confined to an extremity with the confirmed absence of distant metastatic spread is a prerequisite for consideration of ILP/ILI for in-transit disease. Response rates associated with these modalities are quite high, and in select cases, regional therapies may be curative.

Metastatic Disease

The role of surgery in metastatic disease is somewhat limited. Surgical resection is considered appropriate in circumstances where a long expected overall survival justifies resection. One example is small bowel metastases in the absence of other distant metastases. Single isolated metastases are associated with the best prognosis. Before embarking on surgery for melanoma metastases, staging workup should be completed including a CT chest, abdomen, and pelvis; brain MRI; and/or PET scan. Consideration of the disease-free interval between the time of primary melanoma excision and the appearance of metastatic disease may also influence surgical management. Patients amenable to metastasectomy with long disease-free intervals tend to have a better survival than those with short disease-free intervals and may be better candidates for an aggressive approach.

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Excision of Benign Palpable Breast Mass

110

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

See Chap. 109.

Fibroadenoma. Operation is indicated when a fibroadenoma enlarges or when the diagnosis is in doubt. Most fibroadenomas are small, round, freely movable, and well-encapsulated nodules that are easily diagnosed on physical examination. In particular, it is sometimes difficult to differentiate a fibroadenoma from a low-grade phyllodes tumor on core biopsy or fine-needle aspiration. Occasionally, carcinoma masquerades as a fibroadenoma, but generally this should be easily differentiated by core needle biopsy or fine-needle aspiration.

Other well-circumscribed benign palpable lesions

Preoperative Preparation

Preoperative evaluation may include ultrasonography, fine-needle aspiration cytology, or mammography as individually appropriate. Although several techniques have been described for percutaneous management of these lesions (see references at the end), most are treated by either observation or surgical removal.

Operative Strategy

Most fibroadenomas are completely surrounded by a smooth fibrous capsule surrounded by a thin areolar rim; the plane is not always well defined between the fibroadenoma and surrounding breast. Whenever this is the case, include a narrow rim of normal adjacent breast in the specimen being excised; otherwise, local recurrence of the tumor is possible. The strategy for biopsy or excision (lumpectomy) of a presumed malignant lesion is different (see Chap. 112). Current guidelines emphasize the use of needle biopsy (rather than surgical biopsy) for initial diagnosis of breast masses. This allows surgery to be tailored to the particular circumstances, either a simple excision in the case of benign masses or a lumpectomy with sentinel node biopsy in the case of breast cancer.

Among the errors encountered during surgery for a palpable mass is failure to locate the lesion. This can occur when a deep-seated tumor is being excised under local anesthesia. Unless the tumor is easily palpable and superficial, it may not be easy to palpate, especially when the operation is being performed through a cosmetic circumareolar incision at a distance from the lesion. Ultrasound is a useful adjunct, and it is always important to palpate the inside of the cavity after removing the lesion.

A more important consideration, especially with large fibroadenomas, is the possibility of a phyllodes tumor, which resembles a large fibroadenoma on physical examination. The most important characteristic of both benign and malignant phyllodes tumors is a strong predilection for local recurrence. It is not always possible to confirm or exclude phyllodes tumor on needle biopsy. Therefore, always include a 1 cm rim of normal breast tissue when excising a large fibroadenoma (>4–5 cm in diameter) or one that has grown rapidly.

Consider an oncoplastic approach, incorporating breast reduction techniques, whenever a large fibroadenoma has enlarged and distorted the breast. These techniques are referenced at the end of Chap. 112.

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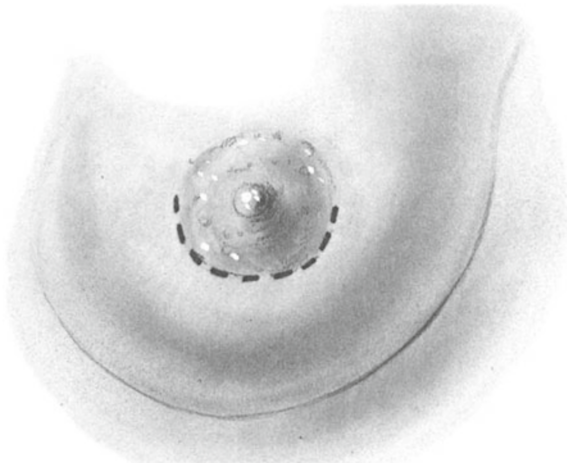

Fig. 110.1

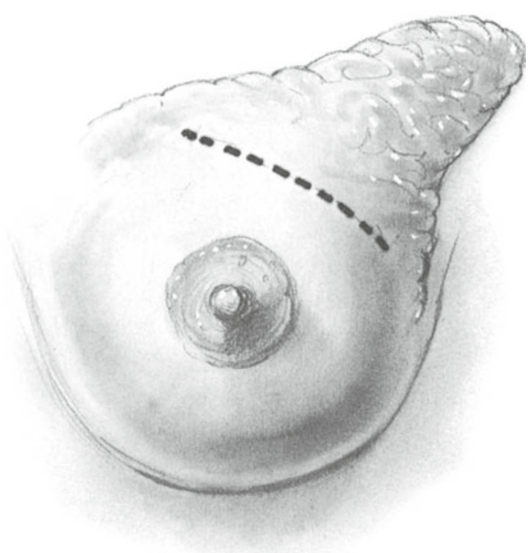

Fig. 110.2

Operative Technique

Choice of Incision

Superior cosmetic results follow the use of a circumareolar incision (Fig. 110.1) or an incision made in the inframammary crease. However, it is not advisable to dissect through a large distance of breast when trying to extract a fibroadenoma via one of these incisions. For tumors more than a few centimeters away from the areola, make an incision in the line of Langer directly over the tumor (Fig. 110.2). These lines are essentially circular in nature in the skin overlying the breast, each circle being concentric with the areola.

Local Anesthesia

Raise a skin wheal along the line of the proposed incision using 1 % Xylocaine without epinephrine. (Epinephrine causes vasoconstriction, and delayed bleeding may result when the vasospasm relaxes). Infiltrate laterally in a fanlike pattern on all sides of the skin incision to anesthetize the skin and subcutaneous regions of the breast thoroughly. Do not inject directly into the area containing the mass; rather, inject in a circumferential manner *around* it. It may be necessary to inject *underneath* the mass as dissection progresses. Allow sufficient time for the anesthetic to work and use gentle technique. Sharp dissection is frequently better tolerated than electrocautery. Mild sedation may be beneficial.

Dissection

After opening the skin, use a scalpel to carry the incision through the subcutaneous fat down to breast tissue; then incise the breast tissue down to the lesion. Push the lesion down toward your field as you work. Palpate to verify the location of the lesion as the dissection progresses. Electrocoagulate each bleeding point so the field remains bloodless. Self-retaining retractors are helpful. We prefer Gelpi retractors (placed as a pair, at right angles to each other) because they have a very low profile.

If you are approaching the mass from a circumareolar incision, it may be helpful to maintain gentle pressure behind the mass in such a fashion as to push it down into the incision. With practice, this can be done with the fully extended little finger of the nondominant hand.

Unless the lesion is quite superficial and the dissection is easy, a traction stitch facilitates subsequent dissection. Use 2-0 silk on a curved cutting needle to transfix the lesion or deep breast tissue just superficial to the mass (Fig. 110.3). Place a figure-of-eight suture for security and use it to elevate and manipulate the lesion (Fig. 110.4).

When the capsule of the fibroadenoma appears, incise it with a scalpel. If the fibroadenoma then shells out with no further attachment, the capsule may be left behind. If there are any attachments between the fibroadenoma and the surrounding tissue, excise the capsule and a small rim of breast tissue with it.

Repair

Make no attempt to resuture the defect in the breast, as these sutures often create a mass at the site of the repair. During the months and years following surgery, evaluation of the patient's breast on physical examination can be made extremely difficult by the presence of a firm mass at the site of the previous excision. The defect in the breast will fill with

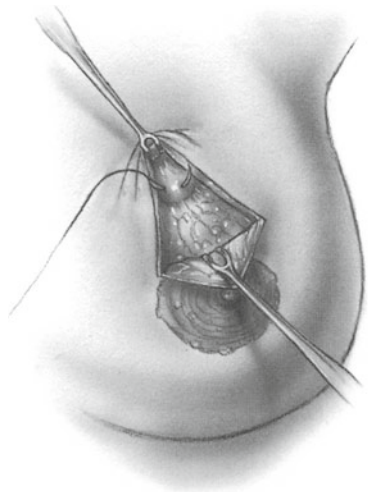

Fig. 110.3 Adapted from Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 1993. with permission

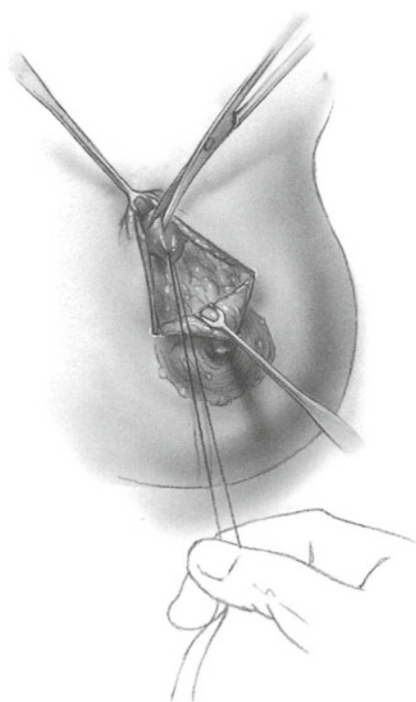

Fig. 110.4 Adapted from Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 1993. with permission

fluid and serum and gradually be replaced by normal tissue. Because these masses tend to displace rather than replace surrounding breast tissue, even large benign fibroadenomas may be removed without creating a defect in the breast.

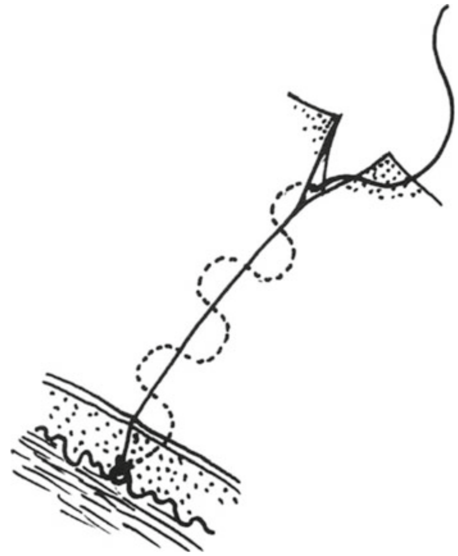

Fig. 110.5 Adapted from Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 1993. with permission

Place several interrupted 3-0 PG sutures to approximate the subcutaneous layer just under the skin. Then close the skin with interrupted sutures of 5-0 nylon or a running subcuticular suture of 5-0 PDS (Fig. 110.5). No drain is used.

Postoperative Care

To apply even pressure on the operative site, request that the patient wear a supportive brassiere over a bulky gauze dressing continuously for the first postoperative week.

Complications

Hematoma
Infection
Inadequate excision (missed lesion)

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Excision of Ducts, Operations for Breast Abscess

111

Carol E.H. Scott-Conner and Jameson L. Chassin[†]

Excision of Ducts

Indications

Single duct discharge with or without palpable mass
Recurrent subareolar abscesses with or without associated mammary fistula

Preoperative Preparation

Always perform a complete imaging workup, with mammography and ultrasound as appropriate.
If single (rather than total) ductal excision is planned, localize the involved duct by the following methods:

Physical Examination

Apply finger pressure at varying points along the outer margin of the areola to determine which segment of the breast contains the offending duct (the finger pressure induces discharge from this duct). If this is not accomplished at initial examination, apply collodion or skin glue to the surface of the nipple to occlude all of the ducts temporarily and prevent any discharge. At subsequent examination a week later, remove the collodion and repeat the attempt to localize the offending duct. Also, collodion may be applied to the surface of the nipple 1 week prior to operation to cause distension of the diseased duct.

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Ductography

Ductography may be performed by inserting a tiny catheter into the duct orifice and injecting a small amount of aqueous radiopaque medium.

Ductal Endoscopy

This technique, if available, may prove useful in identifying the site of underlying pathology.

Operative Strategy

Single Duct Excision Versus Total Duct Excision

When the indication for surgery is a bloody nipple discharge, the diagnosis is generally an intraductal papilloma. In very rare cases, carcinoma or DCIS may be the cause. Careful localization to a single duct allows precise excision, which is diagnostic in the case of carcinoma and therapeutic in the case of an intraductal papilloma. Single duct excision also provides better preservation of sensation in the nipple-areolar complex and may permit breast feeding once healing has occurred. Multiple papillomas or ductal ectasia with recurrent subareolar abscesses generally requires complete ductal excision.

Prevention of Skin Necrosis with Ductal Excision

Total excision of the mammary ducts requires elevation of the entire areola. Most surgeons use a circumareolar incision, which is almost invisible when fully healed. It is important not to include more than 40–50 % of the circumference of the areola in order to avoid skin necrosis. Handle this skin flap delicately to avoid unnecessary trauma. A radially oriented

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incision confined to the skin of the areola is an excellent alternative, particularly in women with large areolae.

Strategic Approach to Breast Abscesses

Many breast abscesses respond to aspiration and antibiotics and do not require incision and drainage. When an abscess requires incision and drainage, first consider the location in the breast. Abscesses that are located close to the nipple-areolar complex are often associated with pathology in the terminal ducts. It is important to warn the patient that recurrence of the abscess and/or formation of a chronic draining fistula is a common sequela. Drain abscesses in this location through a radial incision to facilitate excision of any resulting fistula at the time of secondary ductal excision (Figs. 111.6, 111.7, and 111.8).

Abscesses that are located peripherally, away from the nipple-areolar complex, are not as prone to recurrence and fistula formation. Adequate incision and drainage, biopsy of the wall of the abscess, and packing and application of vacuum dressing to facilitate closure generally suffice. In these cases, the location and direction of the incision used for drainage may be tailored to the individual situation and particular anatomic cosmetic considerations.

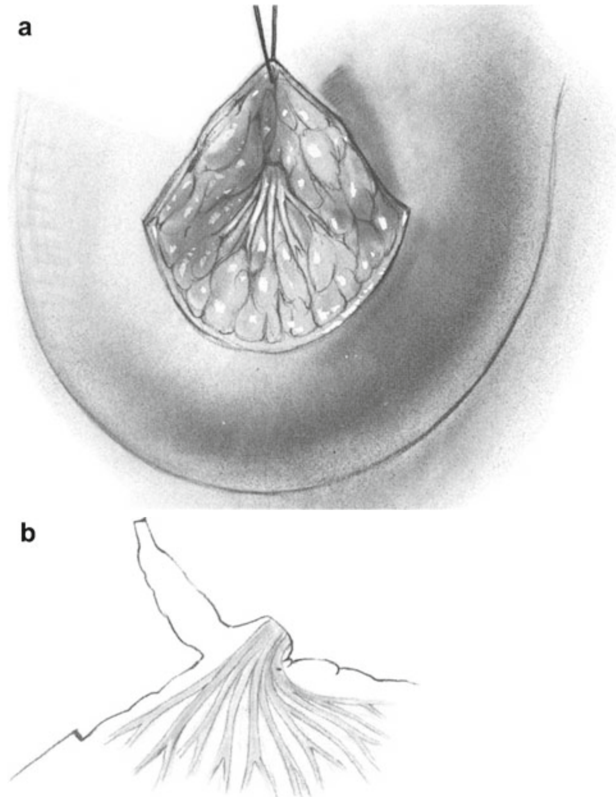

Fig. 111.1

Documentation Basics

- Findings
- Selective or complete ductal excision

Operative Technique

Single Duct Excision

Incision

A single duct may be excised through a radial incision or an incision around the circumference of the areola. Use a sharp scalpel and obtain hemostasis with accurate electrocoagulation.

Identification and Excision

If a discharge is visible, cannulate the duct with a lacrimal duct probe and use it to guide dissection. Some surgeons cannulate the duct with a small caliber venous catheter and inject methylene blue to dye the duct and surrounding tissues.

If collodion has been used to occlude the surface of the nipple for a week prior to surgery, the diseased duct is by now distended. A duct containing bloody or serosanguinous discharge will generally appear bluish. Gently dissect the duct from surrounding tissue. Divide it between hemostats at its junction with the nipple and dissect it out to a point about 1–2 cm beyond the circumareolar incision. Submit it for histologic examination.

If the duct cannot be clearly identified, excise an area of the ductal system beginning at the nipple and proceeding in a peripheral direction. Here, it is important to have accurate information from the initial physical examination so that if, for example, the discharge was observed to come from a duct at 10 o'clock, the ducts appropriate to that quadrant can be excised. Have the pathologist examine the specimen to ascertain that the pathology has indeed been excised. If the woman is past childbearing, conversion to total ductal excision may be the best course of action.

Closure

In many cases, it is necessary only to close the skin incision with interrupted 5-0 nylon sutures or a running subcuticular suture of 5-0 PDS. In some cases, a few PG sutures may be placed if there is a significant defect in the underlying breast. If hemostasis is good, drainage is not necessary.

Total Duct Excision

Incision

Make an incision along the circumference of the areola at the exact margin between the areola and skin (see Fig. 110.1). The length of the incision should encompass no more than

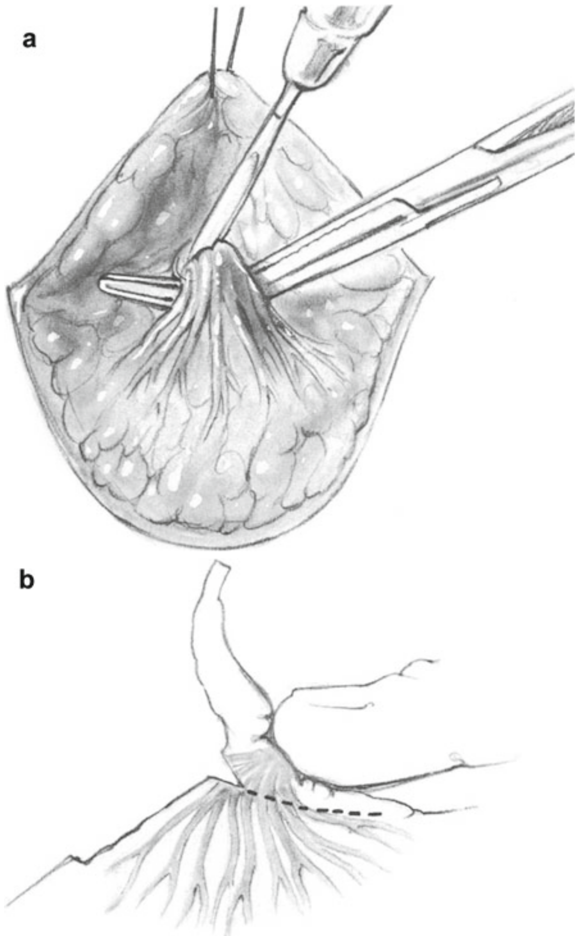

Fig. 111.2

50 % of the areola's circumference. Insert sutures in the edge of the incised areola temporarily and apply a hemostat to each suture. These are used to apply traction while the areola is being dissected off the breast (Fig. 111.1a, b). Skin hooks are an alternative. Use scalpel or scissor dissection to elevate the areola with a thin layer of fat and contained vessels. Continue this dissection beyond the nipple so the entire skin of the areola has been elevated. Do not detach the nipple from its ducts at this stage of the operation.

Excising the Ductal System

After the skin has been elevated, note that the approximately 12 terminal ducts constitute the only attachment between the nipple and the underlying breast. Apply a ligature to these ducts and make an incision that detaches them flush with the nipple (Fig. 111.2a, b).

Dissect the ducts for a distance of 3–5 cm. Using electrocautery, excise the circle of ducts and breast tissue (Fig. 111.3a, b). The circular mass of tissue has a radius of 3–5 cm and a thickness of 1–2 cm. If any of the diseased ducts is dilated and extends beyond 5 cm, follow this duct and remove a further section until it disappears into the breast tissue. Occasionally, a diseased duct involves a section

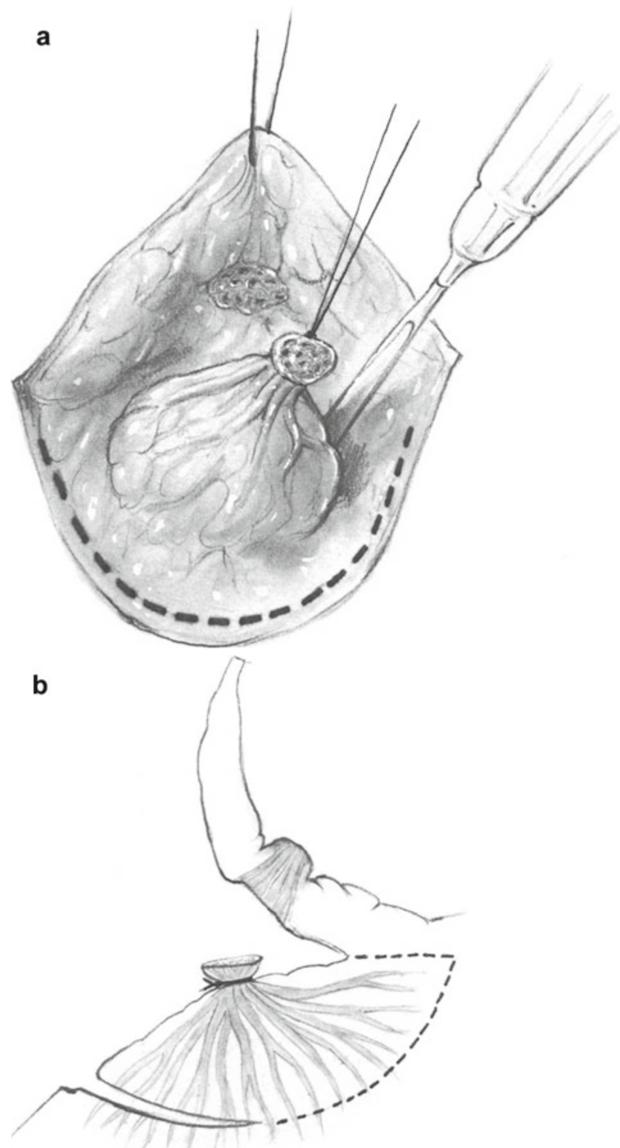

Fig. 111.3

of the nipple, which then appears inverted. In this case, a tiny segment of nipple may be removed. Obtain complete hemostasis with electrocautery.

Reconstruction

In the patient with a large breast, the resulting defect may be relatively shallow so the reconstructed areola rests on a solid base of breast tissue. In this case, no further reconstruction is necessary. In many cases, however, there is a significant defect underneath the areola. Because the blood supply of the areola is somewhat tenuous, it requires a firm base of breast tissue for optimal healing. In this case, close the defect in the breast in layers with interrupted small sutures of PG material.

If detaching the areola results in a tendency for the nipple to invert, corrective measures must be taken. Before closing the skin incision, insert a 5-0 PG purse-string suture in

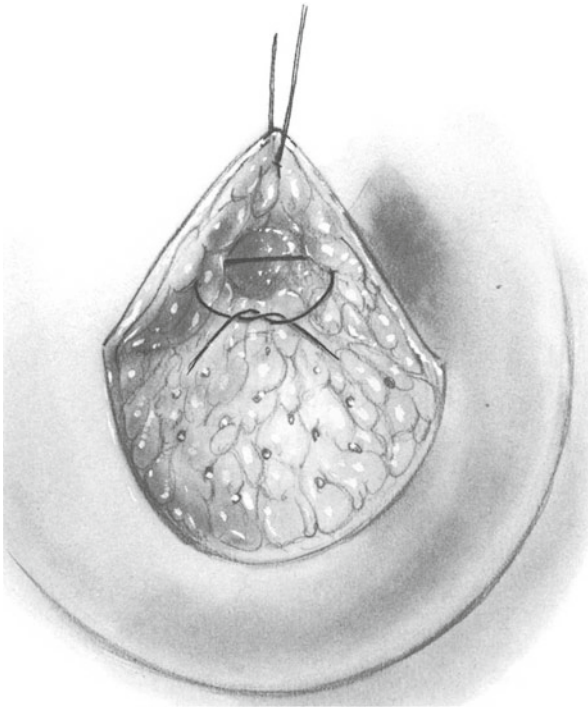

Fig. 111.4

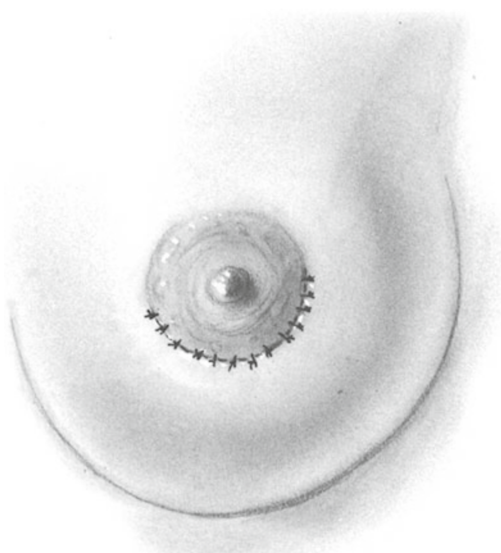

Fig. 111.5

the subcuticular tissues at the base of the nipple to maintain it in the erect position (Fig. 111.4). Then close the skin incision with interrupted 5-0 nylon sutures (Fig. 111.5) or a subcuticular suture of 5-0 PDS.

Postoperative Care

Instruct the patient to wear a supportive brassiere over a moderately bulky dressing to apply even pressure for the first 7 days and nights after surgery.

Complications

Hematoma may appear.

Occasionally, following total duct excision, elevation of the entire areola in a plane too close to the subcutis results in an area of *skin necrosis*. Generally, this will resolve with local wound care but may result in scarring and distortion of the nipple-areolar complex with a suboptimal cosmetic result.

Breast Abscess

Breast abscesses are most often seen in nursing mothers. They are generally the result of bacteria being introduced via a break in the skin of the nipple. Often these lactational abscesses respond to antibiotics and aspiration.

In the nonlactacting woman, an abscess may appear with little surrounding inflammation and induration. In some of these cases, aspiration of pus under local anesthesia and treatment with antibiotics lead to rapid resolution. If pus is not obtained on aspiration or the abscess does not respond promptly, perform operative drainage with biopsy of the abscess wall. Evacuate the pus, obtain cultures, and loosely insert a gauze pack. Conversion to a vacuum wound dressing may speed closure of the resulting cavity.

Para-areolar Abscess or Fistula

An abscess in the region of the areola or just adjacent to the areola often originates in an obstructed mammary duct, generally from duct ectasia. There is a strong association with smoking. Nipple piercing can cause a similar kind of abscess. This underlying pathology may result in a recurring abscess at the same location or in a chronic draining fistula. Drain an abscess in this location through a radial incision, to facilitate any second procedure that may be required.

Recurrent abscesses should be rendered quiescent by antibiotics and drainage or aspiration and elective surgery performed when the infection has subsided. Similarly, chronic

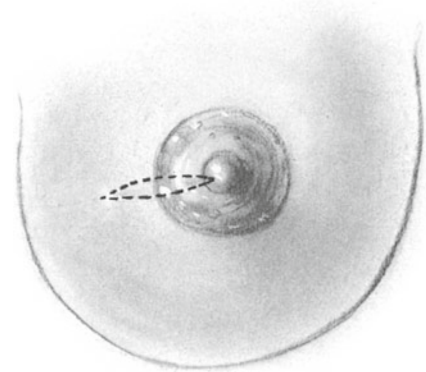

Fig. 111.6

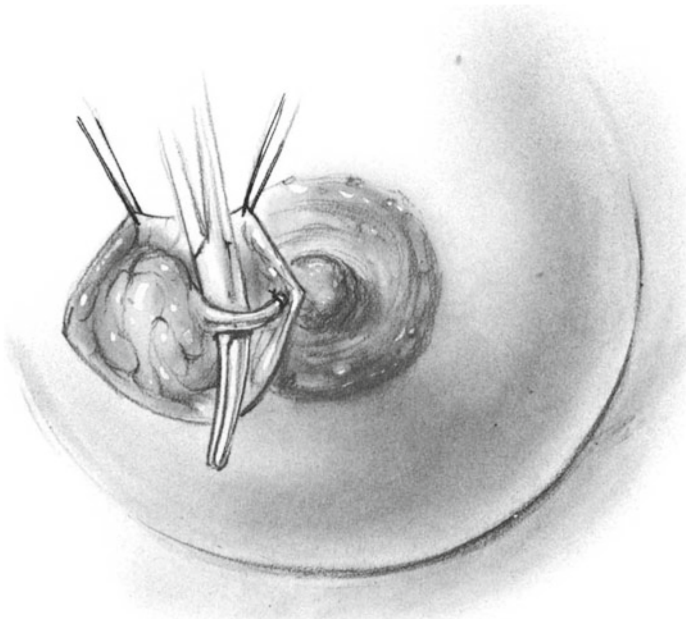

Fig. 111.7

draining fistulae may require surgery. In either case, proper treatment requires a radial elliptical incision (Fig. 111.6) overlying the duct, which can usually be palpated as a thickened cord running from the nipple toward the periphery of the breast. Remove a small ellipse of skin and surrounding breast tissue. Identify the duct (Fig. 111.7) and excise it together with the diseased tissue (Fig. 111.8).

If the incision has not been greatly contaminated, close the skin loosely around a drain. If the area *is* grossly contaminated, it may be wiser to insert skin sutures for delayed primary closure 4–6 days later. If the diseased duct is not removed, the abscess or fistula recurs. Recurrence may occur even with adequate ductal excision, particularly in smokers, and it is important to warn patients of this possibility.

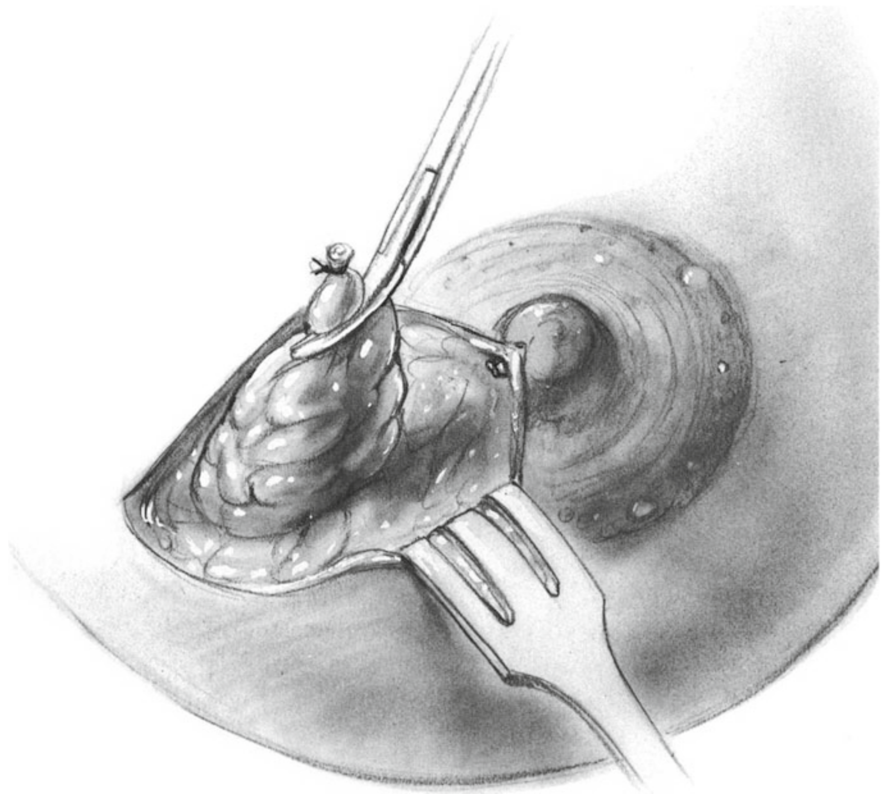

Fig. 111.8

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Lumpectomy for Breast Cancer

112

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Palpation of a suspicious breast mass or "dominant lump" even if the mammogram is normal
Detection of a suspicious shadow on mammography even if not palpable
Ductal carcinoma in situ (see Chap. 109) in conjunction with postoperative radiation therapy
Early-stage breast cancer, generally with axillary staging (see Chap. 103), as part of breast conservation. This is usually followed by radiation therapy.

Pitfalls and Danger Points

Failure to include pathologic tissue in the biopsy specimen
Failure to achieve clean margins

Operative Strategy

Biopsy/Lumpectomy of Palpable Mass

In most cases, a diagnosis has been made by fine-needle aspiration (FNA) or core biopsy. Make the incision directly over the mass and use the index finger of the nondominant hand to palpate the mass, retract it, and guide the dissection. In a thin-breasted woman, a well-localized mass is easily felt and removed. When the area is ill defined, particularly if located in the axillary tail, it may be simpler to excise a segment of breast extending from the subcutaneous fat down to the pectoral fascia to be sure the cancer has been adequately resected. Always carefully orient the mass before sending it to pathology. It is important to get a clear margin of normal tissue in all directions. If the margin is inadequate, the care that you have taken orienting the specimen will help guide your subsequent reexcision. Intraoperative pathologic examination may help reduce the need for reexcision.

Biopsy or Lumpectomy of Nonpalpable Breast Lesions

Image-guided excision of nonpalpable lesions is required during two general circumstances, and the surgical approach is tailored accordingly. The primary difference between the two procedures is the amount of tissue excised and the care used to attain clean margins. Close communication with surgeon and radiologist is essential to the successful performance of these procedures.

Image-Guided Biopsy

This is used when mammography, ultrasound, or MRI demonstrates a suspicious lesion, but image-guided core biopsy has failed or proven technically impossible. In this case, the surgeon's role is to obtain a diagnosis, and a relatively conservative excision is performed. The goal is to strike a balance between adequate surgery and cosmesis. Additional surgery may be needed if the biopsy returns malignant. If the target is a small well-localized cluster of microcalcifications, excision with attempt at obtaining adequate margins is appropriate and may avoid a second procedure. When the target is a large area of microcalcifications, a more limited procedure sufficient to assure an accurate diagnosis is generally appropriate.

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Image-Guided Lumpectomy

This is performed when a diagnosis has been obtained by core biopsy and excision is required. In most cases, this will be for ductal carcinoma in situ (DCIS) or invasive breast cancer. Careful excision with care to obtain adequate margins is crucial. Sometimes lumpectomy is performed for borderline lesions such as lobular carcinoma in situ or for precursor lesions such as atypical ductal hyperplasia.

Localizing Technique

When mammography, ultrasound, or breast MRI detects a suspicious finding in a breast where no mass is palpable, preoperative localization must be used to mark the lesion. In most of these cases, image-guided core biopsy has provided a tissue diagnosis, and excision is then guided by the clip placed during biopsy, by the residual hematoma, or by any residual tumor mass. A Kopans hooked guidewire inside a needle is placed in or close to the radiographically suspicious lesion by the radiologist, and the surgeon's task is then to locate and excise a mass of breast tissue around the tip of the wire.

Because most of these nonpalpable lesions are relatively small, we endeavor to excise the lesion completely together with normal breast tissue whenever possible. If no palpable lesion is encountered, we excise a liberal portion of breast from the area indicated by the needle. This is feasible because many patients with nonpalpable lesions have reasonably large breasts.

Take great care during dissection lest the wire be broken or dislodged. If the wire breaks, it is necessary to find and retrieve the broken end, a tedious process that may require the use of a metal detector. Standard wires are unlikely to break if a scalpel or cutting cautery (rather than scissors) and gentle technique are used for the dissection. The localizing wires placed under MRI guidance are particularly fragile. Do not use cautery near an MRI-placed wire as some of these wires are easily divided with cautery.

Extent of Excision, Marking the Specimen, Closure

An adequate lumpectomy removes the cancer with a rim of surrounding normal tissue. Preserve the orientation of the specimen so positive margins can be identified and reexcised if necessary. We prefer to use commercially available sets of metallic markers. These come in packets of six. We place four of these with the specimen still in situ and place the last four (usually the deep and the final attachment site) after excision. Other surgeons ink the margins in the OR. If none of these are available, it is always possible to orient the specimen with two marking sutures, using the mnemonic "*s*hort stitch = superior margin, *l*ong stitch = *l*ateral margin."

After excising a segment of breast, we do not attempt to close the defect by suturing the parenchyma of the breast together, as it would distort the shape of the breast and produce a mass lesion. Postoperatively, palpating a gap in the continuity of the breast tissue is easier to interpret than palpating a mass. Oncoplastic techniques involving the development of flaps and rearrangement of tissue may be used for larger defects (see references at the end).

Documentation Basics

- Findings
- Extent of excision (biopsy versus lumpectomy)
- Any additional margins
- Wire localization?
- Ultrasound performed?

Operative Technique

Lumpectomy for Palpable Mass

Incision

When performing a biopsy for a palpable mass, make the incision directly over the mass. The incision is made in the lines of Langer, which represent the natural skin creases and can be seen to run in a circular fashion, roughly parallel to the perimeter of the areola (see Fig. 110.2) or in a radial fashion. For lesions located at the medial aspect of the breast, a horizontal incision along the 9 o'clock axis of the breast is acceptable. Try to keep the incision below the "bra line" so that it is hidden by clothes. Always remember that a mastectomy may be indicated subsequent to the biopsy. The biopsy site is preferably in a location that can be easily encompassed by the mastectomy incision or, alternatively, reexcised as part of a skin-sparing pattern.

The incision should be long enough to facilitate removal of the entire mass with a 1 cm shell of normal surrounding breast tissue without requiring excessive retraction of skin flaps. Local anesthesia may be used if concurrent axillary staging is not planned. If so, infiltrate as described in Chap. 110. Make the incision along the previous ink mark down into the subcutaneous layer using a scalpel. Elevate the skin flaps as necessary in the subcutaneous plane (Fig. 112.1).

With the left index finger palpating the mass, carry the incision along one side of the tumor deep enough to palpate the deep aspect of the tumor. We prefer to use sharp dissection (or cutting electrocautery), avoiding the use of coagulating cautery to preserve the margins for histologic analysis.

Do not apply a tenaculum or other clamp to the tumor mass, as it would only make it more difficult to ascertain the outer margins of the tumor by tensing the tissues. Sometimes an accurately placed figure-of-eight suture in the tumor mass for retraction is of some benefit. We prefer to use gentle retraction with the finger or a small handheld retractor.

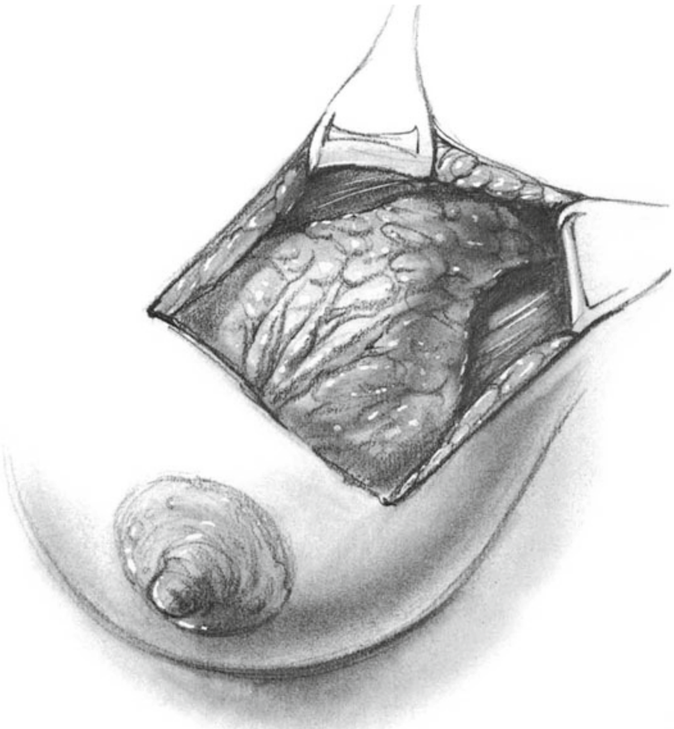

Fig. 112.1

Initiate the dissection on the opposite side of the mass and carry the dissection down to a level of the breast deep to the mass, leaving a margin of normal breast tissue on the deep layer. Often it is best to go down to the fascia of the pectoral muscle where there is a natural plane between the breast and the fascia (Fig. 112.2). Elevate the breast tissue from the pectoralis major muscle by blunt dissection, and then continue the excision. Under guidance of the index finger, excise the tumor. Obtain meticulous hemostasis utilizing the coagulating current of electrocautery. Because there will be a tissue defect in the breast, even minor bleeding produces a large postoperative hematoma, so hemostasis must be complete.

Closure

Do not attempt to close the defect in the breast parenchyma, and do not place a drain. Close the subcutaneous layer with three or four 3-0 PG sutures. Close the skin with a continuous subcuticular suture of 5-0 PDS.

Nonpalpable Lesion: Wire Localization

In the case of nonpalpable lesions, the patient is transferred from the radiography suite to the operating room with a

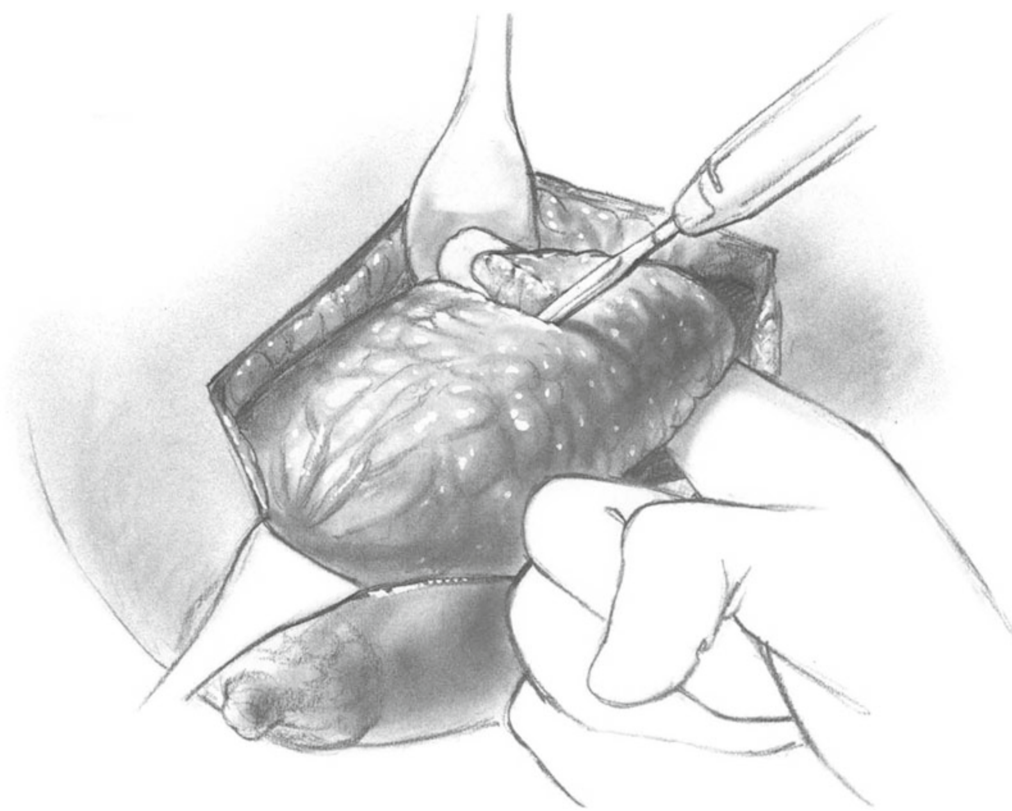

Fig. 112.2

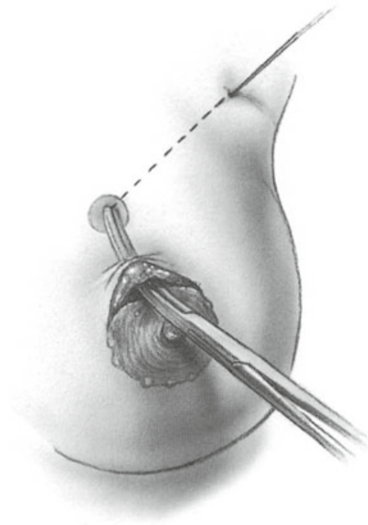

Fig. 112.3 (Adapted from Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 2009, with permission)

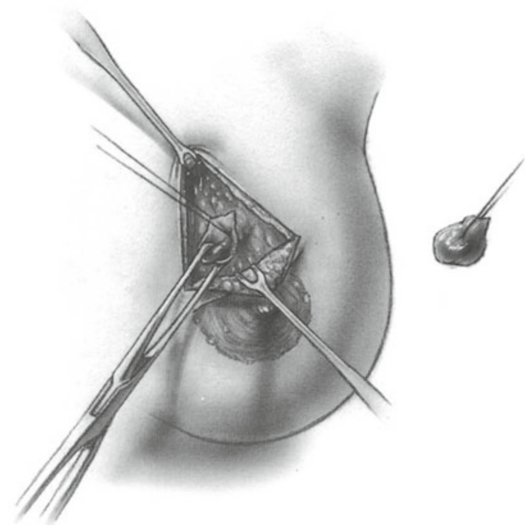

Fig. 112.4 (Adapted from Scott-Conner CEH, Dawson DL. Operative anatomy. Philadelphia: Lippincott; 2009, with permission)

Kopans hooked wire and needle inserted in the breast close to the suspicious radiographic shadow. Compare the localization radiographs with the original mammogram. Mentally extrapolate from the direction of the wire and its length and estimate the probable location of the tip. Gently palpate the breast in the region where the tip is thought to lie. Frequently, the free end of the wire bobs when the tip is palpated, confirming the location.

If the area at the tip of the needle can be palpated or otherwise identified, make a curved incision in the skin crease overlying the tip of the needle and excise the breast tissue in that vicinity (Fig. 112.3). If the tip is a considerable distance from the skin entry site, it may be preferable to place the incision halfway between the two. At a convenient time, gently draw the wire into the incision so it can be removed with the mass (Fig. 112.4).

Unless the patient has a small breast, do not hesitate to excise a liberal quantity of tissue around the tip of the wire, perhaps 5×3×2 cm. Orient the specimen, preferably with the six radio-opaque markers previously described. Submit the tissue with the wire in place to the radiography department where specimen mammography is performed and compared with the original studies to confirm that the lesion has been excised. We prefer to view these images personally with the radiologist to ascertain not only target acquisition but proximity of any residual microcalcifications or mass to any of the margins.

Do not close the wound until confirmation that the suspicious shadow is located on the specimen mammogram and that margins are adequate (if lumpectomy rather than biopsy is the goal). In the extremely rare situation where the radiographic shadow was not included in the specimen, carefully palpate the entire area of dissection for any suspicious lesions. Excise any such additional tissue and submit it for another specimen mammogram. If again no pathology can be detected, terminate the operation and subject the patient to a repeat mammogram in 2–3 months. If a suspicious lesion remains in the breast, perform another biopsy using the Kopans localizing procedure.

In cases where the tip of the Kopans device cannot be accurately localized, make the incision at the point where the needle enters the skin of the breast or midway along the estimated trajectory, as mentioned above. By measuring the wire external to the skin, calculate the length of wire that remains in the breast tissue. Dissect along the shaft of the wire. Remove a cylinder of breast tissue about 2 cm in diameter at the level of the incision and increase the diameter of the cylinder to 3–4 cm as one approaches the tip of the wire. Periodically palpate the tissue to ascertain that the wire has not been exposed during the dissection. When the proper depth has been reached, transect the cylinder of tissue and remove it together with the wire. Again, achieve complete hemostasis with electrocautery. Close the incision in two layers, with absorbable Vicryl sutures on the subcutaneous layer and a fine running subcuticular skin closure.

Ultrasound-Guided Lumpectomy

If you are facile with breast ultrasound and if the lesion or biopsy cavity and clip are visible on ultrasound, this is an excellent way to guide excision. We position the patient and perform ultrasound before prepping and draping. Take note of distance to skin and distance to deep fascia, and use this information to help you decide whether or not to excise a skin ellipse or additional deep margin. If necessary, drape the ultrasound transducer into the sterile field and use it as an aid during dissection. We prefer to orient the specimen and then obtain specimen radiographs as previously described, because there are often additional microcalcifications (or other clues as to extent of disease) best seen on radiograph. See the references at the end for further details on this procedure.

Lumpectomy Following Previous Biopsy

The term "lumpectomy" refers to excision of a primary carcinoma of the breast with histologic confirmation that the entire malignancy has been enclosed in an envelope of normal breast tissue on all sides. In patients whose diagnosis of cancer has been confirmed by a needle biopsy, a lumpectomy is essentially the same procedure as that described above for excising a palpable mass.

In patients whose initial surgical biopsy resulted in histologic confirmation of the diagnosis of cancer but in whom no attempt was made at complete excision, a second operation for lumpectomy is indicated. In these cases, make an elliptical incision around the previous biopsy scar, with a 1 cm margin of normal skin on both sides. Thereafter, use the scalpel to incise the breast tissue so the entire previous cavity left by the biopsy procedure is excised en bloc. If the deep margin of the biopsy cavity is close to the pectoral fascia, excise the pectoral fascia in this location together with the specimen. If excision of the amount of breast tissue required for lumpectomy produces a poor cosmetic result, lumpectomy is contraindicated and mastectomy followed by reconstruction of the breast is preferable.

If a nearly complete excision was made, but one or more margins are inadequate, it is often possible to reopen the previous incision and excise the appropriate margins.

Achieve complete hemostasis with electrocoagulation and ligatures as necessary. After hemostasis is complete, close the incision without drainage utilizing 4-0 Vicryl sutures to the subcutaneous fat and a subcuticular stitch of 4-0 PDS. Apply a gauze pressure dressing.

Postoperative Care

Apply a bulky gauze dressing over the area of dissection. Instruct the patient to wear her brassiere day and night for 7–10 days following surgery. The gauze dressing should be large enough that continuous pressure is applied to the defect created by the biopsy excision. This practice inhibits venous bleeding and controls the volume of serum that accumulates in this tissue defect.

Complications

Retained fragment of wire
Failure to identify and excise pathologic tissue in patients who have a breast cancer
Hematoma
Infection (should be seen in no more than 1–2 % of patients)

Further Reading

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Sentinel Lymph Node Biopsy and Axillary Staging for Breast Cancer

113

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Sentinel lymph node (SLN) biopsy is used to detect axillary metastases in clinically node-negative women with invasive breast cancer.

SLN biopsy is used when mastectomy is performed for DCIS, because of the possibility of a small occult invasive component.

Axillary node dissection is used for node-positive women. In highly selected women with otherwise early stage disease, *who will be treated with both radiation and systemic therapy*, completion axillary node dissection may be omitted.

Contraindications

Axillary staging is generally not performed for DCIS unless total mastectomy is planned.

Sentinel node biopsy is not used when the axilla has been proven positive by ultrasound-guided FNAC or core biopsy. In these cases, axillary node dissection is generally performed.

Allergy to blue dye contraindicates the use of this tracer.

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Preoperative Preparation

If needle localization is required for lumpectomy, schedule this first.

Allow sufficient time for injection of radioisotope and migration to sentinel node (generally around 1 h). This may be done the afternoon before.

If blue dye is to be used, inject this after induction of anesthesia.

Operative Strategy

Sentinel Lymph Node Biopsy

Sentinel lymph node biopsy relies upon a tracer (or, more commonly, two tracers) – substances that will accurately travel to the first node or nodes to which tumor cells would localize. Conceptually, then, examination of that node or nodes will accurately predict the involvement of the nodal basin and can be used to guide subsequent treatment decisions. References at the end of this chapter detail the evidence behind this approach and the learning curve. SLN biopsy has essentially replaced axillary node dissection for clinically node-negative patients with breast cancer.

Most surgeons use both a colloidal suspension of radioisotope (technetium-99m) and a blue dye. Some experienced surgeons may choose to omit the dye. This chapter describes the use of both indicators. The radioisotope may be injected the morning of surgery or the day before. The physicochemical characteristics of the colloid are such that the tracer will go to the SLN and not continue to travel up the chain. Some institutions use lymphoscintigraphy to document progression to an axillary node or nodes, many do not. We feel that it is helpful as it not only confirms good localization but will occasionally show drainage through two separate lymphatic

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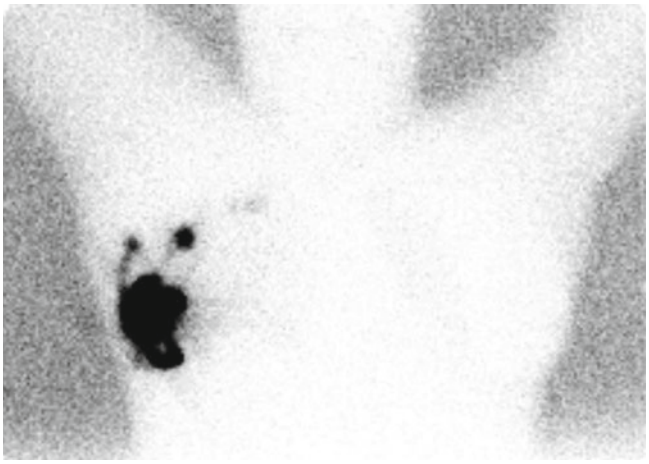

Fig. 113.1 (Courtesy of Michael Graham, Professor, Department of Radiology, Nuclear Medicine, University of Iowa Carver College of Medicine, Iowa City, IA)

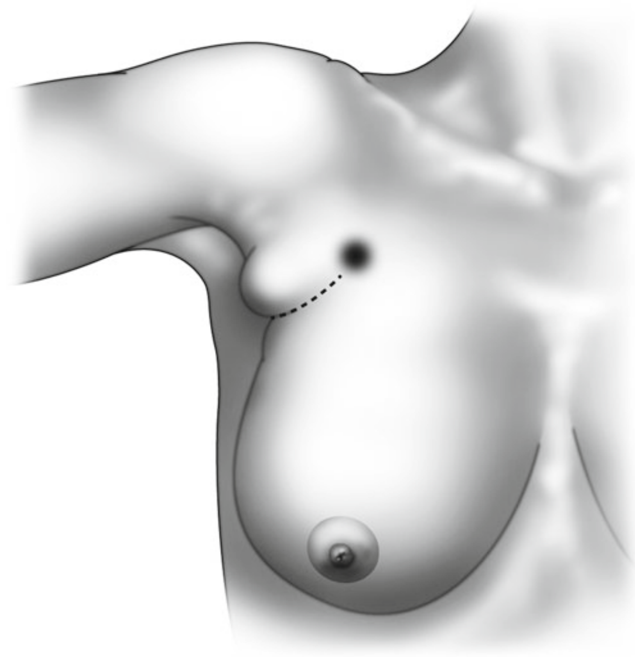

Fig. 113.2

pathways to two separate SLNs (Fig. 113.1). In this situation, it is important to seek and recover both.

The isotope will very rarely localize to an internal mammary node; these nodes are not, in current practice, pursued. This is rare with modern injection techniques.

In the operating room, after the patient is positioned and asleep, blue dye is injected. Two kinds of blue dye are in common use. Lymphazurin blue dye is nontoxic to the tissues but can occasionally cause anaphylactic reactions. Methylene blue dye is much cheaper and less likely to cause allergic reactions but can cause local tissue necrosis. To minimize this possibility, we prefer to dilute methylene blue dye 1:10 with sterile normal saline before injection. Always inform the patient that the breast will typically be stained blue (and in some cases, this is permanent), and the patient may pass green urine for a few days after the procedure. Always tell the anesthesia team that you are injecting a substance into the patient, and inform them of the possibility of an anaphylactic reaction if you are using Lymphazurin blue dye. These reactions may be minimized by premedication (see references).

Although sentinel node biopsy may be performed as an isolated procedure, it is most commonly combined with lumpectomy or mastectomy. Sometimes it is possible to do the sentinel lymph node biopsy through a (non-skin-sparing) mastectomy incision, but for most situations, a separate incision is required.

The gamma probe, set for the appropriate energy window (technetium-99m), is draped into the sterile field and used to locate the incision and then to identify the node. Test the probe by interrogating the injection site and axilla before prepping and draping the field. If you do not obtain a strong signal, verify that the probe is set for the correct isotope. In obese patients, the best incision will almost always lie in the natural skin line between the axillary fat pad and the breast (Fig. 113.2). Plan your incision so that it can be extended to perform a full axillary node dissection if necessary. In some slender patients, an oblique incision just behind the lateral border of the pectoralis major muscle may give better access to the hot node.

Always palpate the axillary space before dissecting nodes so as not to miss a node full of tumor (which might not take up the tracer substances). Use both the gamma probe (now draped into the sterile field) and any blue lymphatics to find the sentinel node or nodes.

Take a 10 s ex vivo count on the node after you remove it. Take time and obtain a strong signal from the node before taking this count, so as to maximize signal-to-noise ratio. The background count should be less than 10 % of the hottest node. Obtain careful hemostasis and lymph stasis before closing the incision.

Axillary Node Dissection

Axillary node dissection for breast cancer is generally confined to the level I and II lymph nodes (Fig. 113.3). Either a transverse skin crease incision below the axillary hair line (and usually in the crease between the axillary fat pad and the fat of the breast in the obese patient, as noted above) or an oblique incision just posterior and parallel to the lateral border of the pectoralis major muscle will work well.

When performing axillary node dissection after sentinel node biopsy, try to avoid the sentinel node dissection cavity by initiating dissection along the lateral border of the pectoralis major muscle. Continue the dissection along the underside of the pectoralis major muscle, sweeping the fascia and node-bearing tissue down. Often this will allow

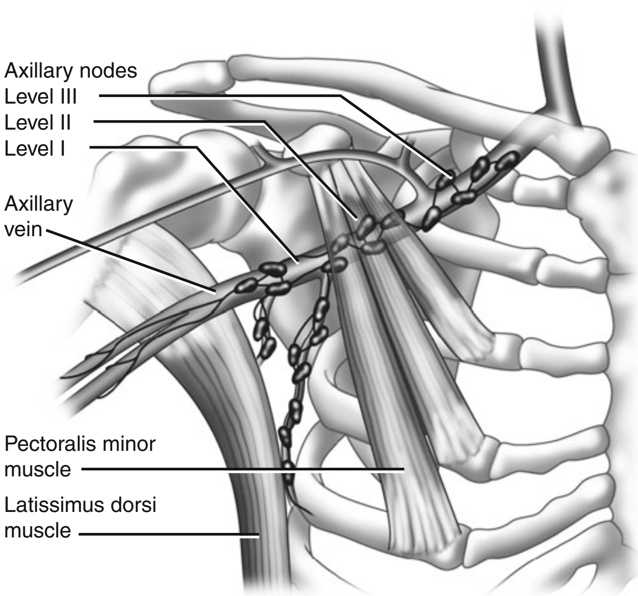

Fig. 113.3

dissection to progress in a virgin plane, facilitating the identification of important landmarks.

The crucial landmarks for axillary node dissection are the neurovascular bundle to the pectoralis major muscle (which should be preserved by gently sweeping it medial and cephalad), the long thoracic and thoracodorsal nerves, the axillary vein, and the intercostobrachial nerve. Neuropathic pain syndromes after axillary surgery are almost always related to injuries of the intercostobrachial nerve and other smaller sensory nerves in the region. It is unclear whether it is better to divide these nerves cleanly or to preserve them. Some advocate preserving the intercostobrachial nerve, but most surgeons sacrifice it (see references at the end of the chapter).

Pitfalls and Danger Points

Failure to identify a positive sentinel node due to technical failure of the procedure or poor localization
Allergic reaction to blue dye (Lymphazurin blue)
Injury to intercostobrachial nerves causing numbness and/or neuropathic pain syndromes
Injury to median pectoral nerve causing atrophy of pectoralis major muscle
Injury to long thoracic or thoracodorsal nerves

Documentation Basics

- Sentinel node biopsy
  – Blue dye injected? How much? Where?
  – Findings (number of nodes, counts, appearance)
- Axillary node dissection
  – Nerves and axillary vein identified and preserved

Operative Technique

Sentinel Lymph Node Biopsy

Position the patient supine, with the ipsilateral arm out on an arm board. We do not drape the arm free or place a roll under the ipsilateral shoulder. Interrogate the injection site and the axilla with the gamma probe. Confirm that the gamma probe is working properly. If no signal is obtained, check the battery pack and verify that the isotope is correctly set to technetium-99m. Familiarize yourself with the various settings on the gamma probe device that is in use in your operating room and know how to optimize it for your purpose.

If blue dye is to be used, have it ready to inject as soon as the patient is stable under anesthesia. Always tell the anesthesiologist what you are about to do. We use 3–5 ml of Lymphazurin blue dye. An equivalent amount of diluted methylene blue dye can also be used (always dilute the methylene blue 1:10 with normal saline to avoid local tissue toxicity). We inject the subareolar region through a single stick and fan out to inject the entire amount in the subcutaneous plane to access the subareolar lymphatic plexus.

If there is a previous lumpectomy site, consider whether or not this excision may have disrupted the lymphatic channels between this subareolar plexus and the axilla. Simply visualize a line from nipple to axilla – if the excision site is in the upper outer quadrant, it falls on this line and the lymphatics may be disrupted. In this situation, inject the blue dye at the axillary end of the lumpectomy site. Verify that the dye is actually going into the breast (rather than into the seroma cavity) by aspirating before injection. Massage the dye gently into the tissues for a few minutes. We generally inject the dye before prepping and draping the breast, to maximize the amount of time for the dye to migrate to the nodes.

Prep and drape the breast and axilla in the usual fashion. Secure the drapes laterally so that, if necessary, the breast can be retracted medially without losing adhesion of the drape to the skin. If the breast tends to fall laterally and obscure the field, have the anesthesiologist "airplane" the table. Additional retraction may be obtained by placing a sterile adhesive plastic drape over the breast in such a manner as to provide medial and caudad retraction. This drape can then be released after the axillary procedure is completed, if further surgery (e.g., lumpectomy) is to be performed.

Drape the gamma probe into the sterile field. Some gamma probe devices have foot pedals that allow you to control the various functions, but most require some assistance from a person who is not gowned and gloved. Spend a few moments instructing this person in exactly what you will need them to do to assist you.

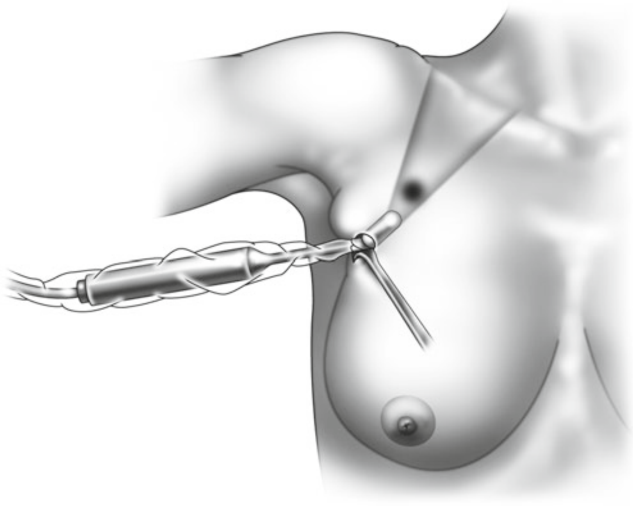

Fig. 113.4

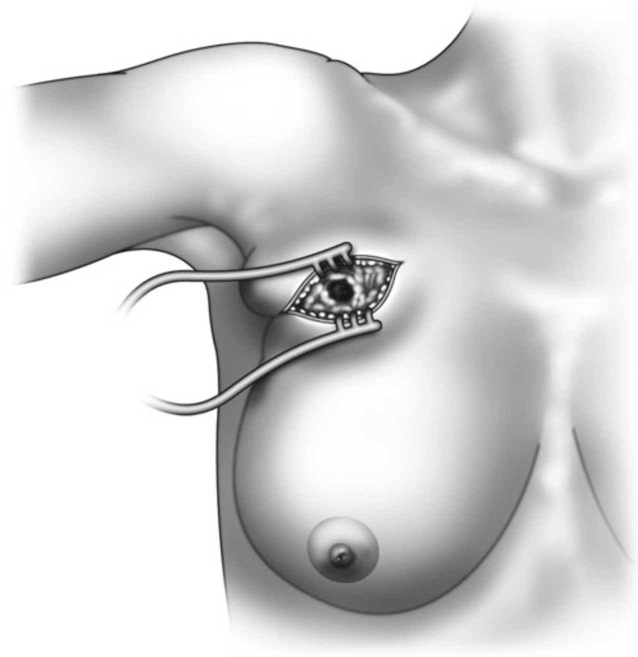

Fig. 113.5

Use the gamma probe to identify the hot spot in the axilla. If the injection site is in the upper outer quadrant, make sure you can separate the high activity in the injection site from the fainter but nearby signal from the axillary node. Retracting the breast laterally, as described above, increases the distance between these two points and will make this separation more apparent. Always take advantage of the collimation afforded by the probe tip construction (Fig. 113.4). Basically, the probe "looks" preferentially in the direction in which it is pointed. Pointing the probe toward the axilla and away from the injection site, then accessing the axilla by pressing down with the probe (maintaining the orientation) as shown help considerably.

Plan an incision that can be extended for a completion axillary node dissection, if necessary. There are two excellent incisions for AND – the skin crease incision shown in Fig. 113.2 and an oblique incision along and just posterior to the lateral border of the pectoralis major muscle. This oblique incision sometimes works better in slender muscular women but may produce a more obvious scar. In either case, always keep the incision lateral to the pectoralis major muscle so that it will be hidden behind this muscle. In a slender woman, a 1 cm incision may suffice to extract a single sentinel node. In an obese woman, do not hesitate to make a 2–3 cm incision to provide sufficient exposure.

Continue the incision through the subcutaneous fat and into the axillary fascia. Generally, the axillary fat is smoother, more like visceral fat, than the lumpy-bumpy subcutaneous fat. The axillary fascia is often palpable as a smooth barrier. Once this fascia is opened, it becomes possible to palpate the structures in the axilla and to pass the palpating finger without difficulty. Place fixed retractors to hold the incision open. Watch for blue lymphatics. Carefully preserve these by dissecting along their superficial aspect and working laterally. Most commonly, the blue lymphatic trunk will eventually dive deep and medially, leading you to a blue node. If it is necessary to divide a lymphatic trunk, use clips or ties to avoid subsequent seroma formation.

Always palpate and inspect for abnormal nodes first, before dissection distorts the anatomy. Remove any palpably abnormal nodes and submit them for pathologic analysis; always remember that a node may be too full of tumor cells to take up either of the tracer substances.

If no abnormal nodes are palpated, next use the sterile gamma probe to identify the area of greatest radioactivity. Gently grasp this fat and elevate it into the field. Confirm that the hot spot is contained within this fat. Next, dissect through the fat seeking a node. The node will be either blue (if dye was used and if it localized) or shiny and pinkish (Fig. 113.5). It will be slightly firmer than surrounding fat. Confirm that it is radioactive with the gamma probe.

Carefully dissect the node from surrounding fat, clipping or ligating any lymphatics, until it is hanging from its hilar vessels. These vessels typically enter deep and medial. Place a clamp across the hilum and remove the node. We leave this clamp in situ rather than immediately tying the pedicle, because if there is residual radioactivity it is most likely in the fat contained in this pedicle. The clamp provides a handy way to rapidly return to the region of interest.

Cup the node in your nondominant hand, turn away from the field (to avoid stray counts from the injection site), and face the display panel of the gamma counter. Probe the node with the gamma counter until you find the hottest region. Identify this by the highest counts-per-second number as well as the louder audio signal. You will need to hold the probe solidly against this hot spot for 10 s to get an accurate count; therefore, it is important that you stand comfortably and well braced. Take a 10 s count. It should be about 10× the counts-per-second number. If it is low, count again. Use the higher count.

Next, check the bed from which the node was removed. If no major hot spots are found, do a 10 s count. This count should be less than 10 % of your hottest node.

On rare occasions, it may seem difficult if not impossible to obtain a sufficiently low background count. If you are confident that you have obtained the nodes with the strongest signals, it is acceptable to terminate the dissection after four or five nodes (or, at most, six) have been harvested. Be wary, however, because occasionally the true sentinel (hottest) node has not yet been found.

If the lymphoscintigram showed two channels leading to two nodes as shown in Fig. 113.1, always seek the second node. If the lymphoscintigram demonstrated progression to an internal mammary node or a supraclavicular node, these are generally not biopsied.

In addition, remove any blue nodes. There is generally excellent concordance between the two tracers.

Irrigate the wound and obtain hemostasis and lymph stasis. If an immediate examination of the nodes (touch prep or frozen section) is being performed, it is efficient to proceed to any other part of the surgery (lumpectomy, mastectomy) as it may take 20–30 min or more to obtain the results. If this is the case, simply pack the wound and proceed with additional surgery.

If no further axillary surgery is planned, close this small incision in layers without any drains.

Axillary Node Dissection

Ensure that any neuromuscular blockade used during induction of anesthesia has been allowed to wear off (or has been reversed) so that motor nerves can be identified and tested, if necessary, with a nerve stimulator. Position, prep, and drape the patient as described above. As with sentinel node biopsy, two incisions are in common use. For most patients, a transverse skin crease incision in the line between breast and axillary fat pad provides excellent exposure and an optimal cosmetic result. Keep this incision below the hair-bearing part of the axilla. Curve the two ends of the incision upward, if necessary, to create a sufficiently long incision while keeping it within the axilla. Raise flaps in the subcutaneous plane and identify the lateral border of the pectoralis major muscle.

The alternate incision parallels the lateral border of the pectoralis major muscle. This incision is particularly useful in lean, muscular women. Take care to make the incision behind the border of the pectoralis major muscle so that the resulting scar will disappear behind the muscle. Only a lateral (posterior) flap needs to be developed with this incision.

Incise the fascia along the lateral border of the pectoralis major muscle. Place retractors to provide exposure. Progress along the underside of the pectoralis major muscle, sweeping all fatty node-bearing tissue laterally and down off the muscle. Be alert to the neurovascular bundle supplying the pectoral muscles. This contains the medial pectoral nerve. If this nerve is divided, the lateral portion of the pectoral muscle will atrophy and become a fibrous cord, producing significant cosmetic deformity and some functional disability. Sweep this neurovascular bundle medially and cephalad and continue to pull the fat down out of the axilla (Fig. 113.6).

Identify the lateral border of the pectoralis minor muscle. Incise the fascia lateral to this muscle. Elevate the muscle with a retractor and continue to dissect under it. Generally, only a small amount of fatty tissue will remain, and this can be swept laterally.

Next, clear the fatty tissue off the lateral chest wall and seek the long thoracic nerve. It may be necessary to carefully incise the fascia to free the nerve. Gently push it back along the chest wall where it belongs.

The next structure to identify is the axillary vein. In a morbidly obese patient, it may be helpful to palpate the arm under the drapes and mentally visualize the level at which this structure is likely to be found. Then bluntly dissect down through the fat until the bluish structure is located. Often the fat will "cleave" (with some lobules of fat easily being pushed cephalad and some caudad) right over the vein. If your dissection brings you down over a firm whitish structure, you are too far cephalad, over the brachial plexus. Minimize trauma to the brachial plexus by abandoning this plane of dissection and working 1–2 cm inferior to the plexus. Palpating for the pulse of the axillary artery may help. The vein will be found inferior and superficial to the artery.

Once the axillary vein is found, continue dissection medially and laterally in the anterior adventitial plane of the vein over its superficial aspect (Fig. 113.7). Any structure that crosses over the vein can be divided (all motor nerves lie deep to the vein). Use clips or ligatures liberally to avoid bleeding. Small branches entering the inferior aspect of the axillary vein can be clipped or ligated and divided. Sweep the fatty tissue downward and seek the thoracodorsal vein, a sizeable tributary that heads deep and inferior several centimeters lateral to the chest wall. The thoracodorsal artery and nerve lie about 1 cm deep to the vein. Generally, there is a small tributary to the specimen from the thoracodorsal vessels – it is best to find and secure this little twig with clips before it is avulsed. If it is avulsed, it tends to retract along the nerve where it can be surprisingly difficult to gain control.

The intercostobrachial nerve and other smaller sensory nerves pass from the chest wall directly lateral into the specimen. We divide these cleanly as needed to extract the specimen.

Now, all major structures have been identified (Fig. 113.8). All that remains is to sweep the fatty node-bearing tissue out

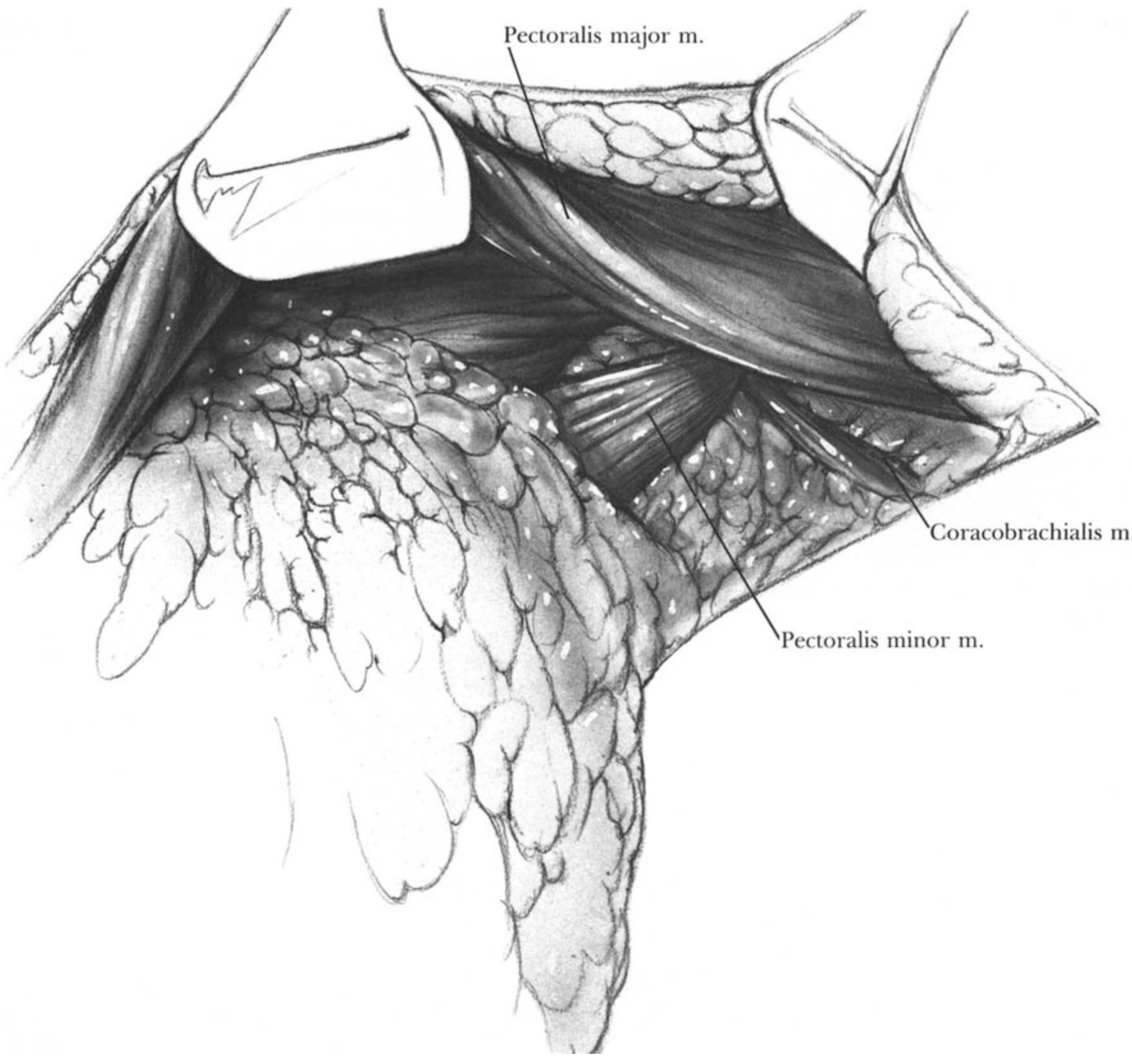

Fig. 113.6

of the axillary space, securing any small vessels with clips or ligatures. Irrigate the space and obtain careful hemostasis and lymph stasis. Place one or two closed suction drains in the space, bring these out through separate stab wounds inferior to the incision, and secure them in place. We prefer channel or Blake-type drains, which slide out easily and atraumatically. Close the incision in layers with interrupted 3-0 Vicryl and a running subcuticular stitch. Place fluffs into the axillary and apply firm but gentle pressure to smoothly reapproximate the skin to the deeper structures.

Postoperative Care

Remove the drains when output is less than 40 ml/24 h or after a specified period of time. The earlier the drains are removed, the more likely a postoperative seroma will form. Conversely, the longer the drains stay in situ, the less likely a seroma, but the risk of drain tract infection (particularly in obese women) may be increased.

Encourage early mobilization. Gentle exercises designed to preserve mobility help avoid a "frozen shoulder." If the patient has limited mobility at first postoperative visit (in about 2 weeks), prescribe physical therapy.

Complications

Bleeding, seroma, and infection are all possible complications. Seromas are managed by serial aspiration. Persistent seromas may require placement of a small closed suction drain such as a SeromaCath®.

Lymphedema may occur after either procedure but is more common after axillary node dissection. Early treatment helps limit progression. Referral to a lymphedema therapist is essential.

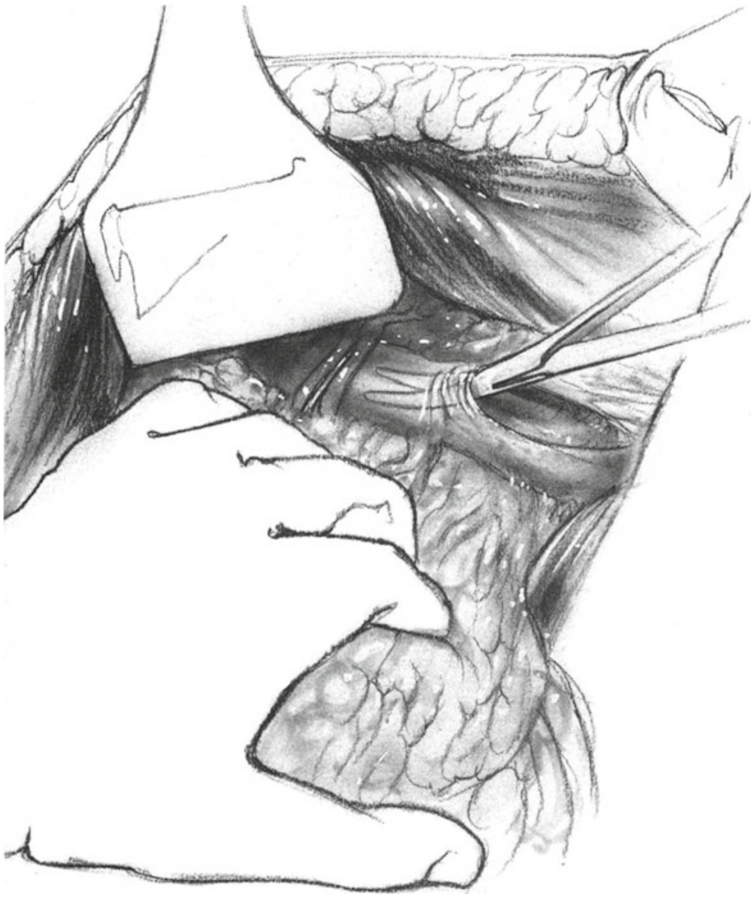

Fig. 113.7

Injury to one of the motor nerves results in decreased mobility of the shoulder.

Trauma to the intercostobrachial nerve or one of the other sensory nerves commonly results in a patch of insensate skin on the medial aspect of the upper arm. Some women will develop a neuropathic pain syndrome.

Axillary web syndrome is characterized by a palpable cord-like structure right under the axillary skin. It is more noticeable in slender women. This rarely limits mobility but may be of cosmetic concern.

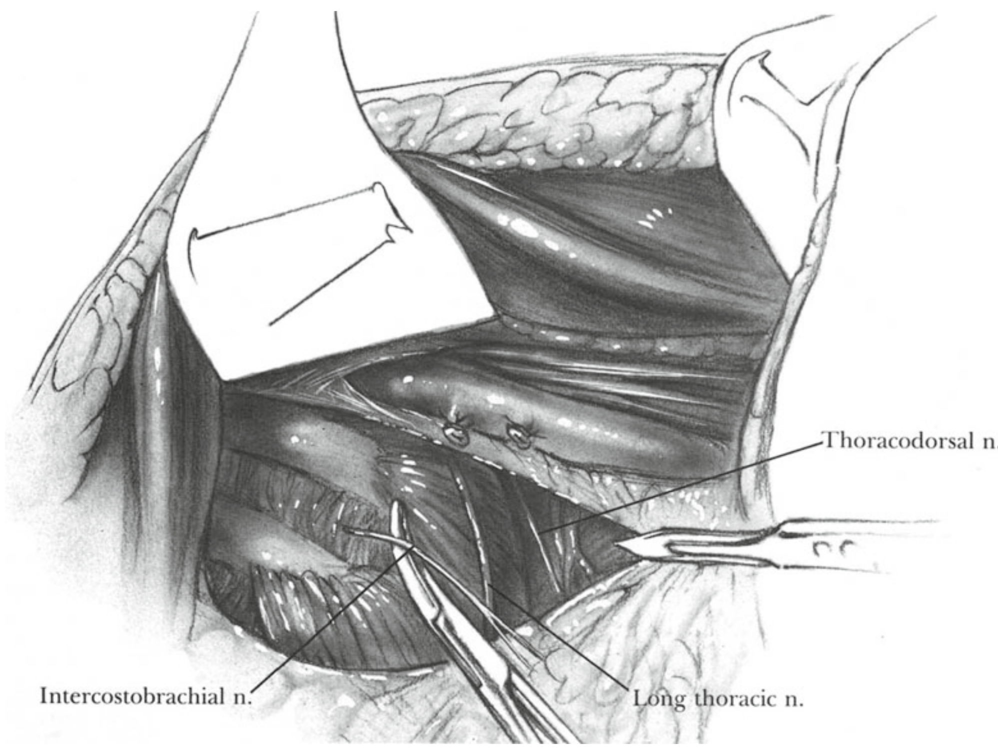

Fig. 113.8

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Modified Radical Mastectomy, Simple (Total) Mastectomy

114

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Modified radical mastectomy is the operation of choice for patients with lymph node-positive invasive carcinoma of the breast who are not eligible for breast conservation.

Simple (total) mastectomy is used for patients with ductal carcinoma in situ or clinically node-negative invasive breast cancer who are not candidates for breast conservation. In this setting, sentinel lymph node biopsy is performed.

Simple mastectomy is occasionally performed as a salvage procedure when breast conservation fails.

Preoperative Preparation

Mammography

Additional staging studies guided by protocols and extent of disease

Pitfalls and Danger Points

Ischemia of skin flaps

Injury to axillary vein or artery

Injury to brachial plexus

Injury to long thoracic or thoracodorsal nerve

Injury to lateral pectoral nerve resulting in atrophy of the major pectoral muscle

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Operative Strategy

Simple (Total) Versus Modified Radical Mastectomy

Simple mastectomy is used when axillary lymphadenectomy is not required. It can frequently be done through a small skin incision. Skin flaps are created in the same manner, and the dissection is terminated when the lateral border of the breast is reached. It is not uncommon for one or more lymph nodes to be included in the adipose tissue surrounding the axillary tail, but no effort is made to perform a lymphadenectomy.

Frequently, sentinel lymph node biopsy is performed as the first phase of this procedure, and the procedure is converted to a modified radical mastectomy if a positive sentinel node is encountered.

Modified Radical Mastectomy

The term modified radical mastectomy as used currently is synonymous with total mastectomy and axillary node dissection. As originally described, modified radical mastectomy removed all of the breast tissue together with the underlying fascia of the major pectoral muscle in continuity with a total axillary lymphadenectomy. The minor pectoral muscle also was excised. Most surgeons currently simply retract the minor pectoral muscle, and some divide it. Removal of the muscle is rarely needed.

Axillary Lymph Node Anatomy for Breast Cancer Surgeons

Breast cancer surgeons conventionally divide the axillary lymph nodes into three levels. The minor pectoral muscle is the anatomic landmark that delimits the three levels. Level I

†Deceased

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nodes lie along the chest wall and under the lateral portion of the axillary neurovascular bundle. They include the external mammary group, the subscapular group, and the axillary vein group. The lateral border of the minor pectoral muscle forms the upper border of this node group. Level II nodes lie directly underneath (deep to) the minor pectoral muscle. Level III muscles are superomedial to the minor pectoral muscle. Thus the minor pectoral muscle, crossing the axillary neurovascular bundle, must be retracted, divided, or removed to perform a complete lymphadenectomy. Additional nodes, termed Rotter's nodes, are found between the major and minor pectoral muscles. Although most surgeons no longer divide or excise the minor pectoral muscle, there should be no hesitancy in doing so if exposure is poor.

Incision and Skin Flaps

Thickness of Skin Flap

The extremely thin skin flaps advocated as an integral part of the classic Halsted radical mastectomy were necessitated by the advanced stage of cancer common at that time. Furthermore, even thin flaps can be shown to harbor islands of glandular breast tissue.

How thin to make the skin flap depends on how much subcutaneous fat exists between the skin and the breast. There is frequently a relatively avascular cleavage plane between this fat and the fat of the breast. Obese patients may have 1–2 cm of subcutaneous fat, whereas thin patients may have only a few millimeters of fat in this location. The important strategy is to remove all of the grossly obvious breast tissue. Leaving behind a layer of subcutaneous fat on the skin flap helps ensure the viability of the flap and facilitates reconstruction of the breast at a subsequent operation for those patients who desire this procedure. It does not increase the risk of local recurrence. Cooper's ligaments extend from the breast to the subcutis and form a discontinuous layer of thin white fibrous tissue, visible against the background of yellow fat. Incising this fibrous layer where it joins the subcutaneous fat is a good method for ensuring complete removal of the breast tissue while at the same time preserving an even layer of subcutaneous fat. This technique is described below.

Alternative Incisions for Mastectomy

If immediate or delayed reconstruction is planned, allow the reconstructive surgeon to have input into the location, direction, and size of the scar. Large-breasted women may be candidates for modified breast reduction-pattern incisions, which allow the reconstructive surgeon to reshape the breast. References at the end of the chapter describe skin-sparing mastectomy, an option for many women. Similarly, nipple-sparing techniques are used in selected circumstances and are described at the end.

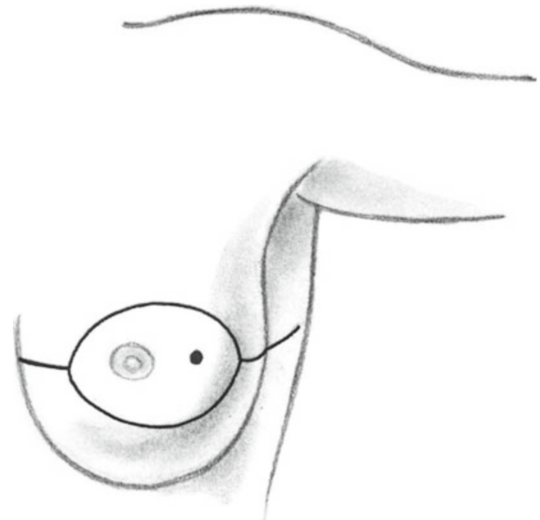

Fig. 114.1

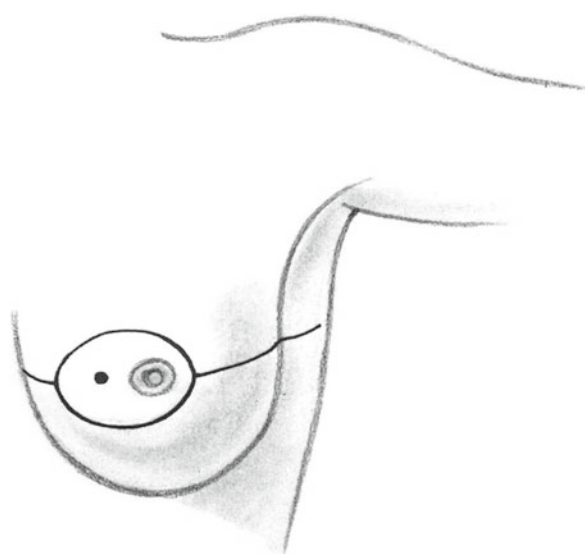

Fig. 114.2

In general, placing the incision in a gently oblique (low medial to high lateral) or horizontal direction gives the best cosmetic result because the scar is not visible when the patient wears clothing with a low-cut neckline. Although this incision is easy to apply to tumors in the 3 and 9 o'clock positions (Figs. 114.1 and 114.2), some modifications are necessary for tumors in the upper or lower portions of the breast. A good basic approach is to draw a circle around the tumor or biopsy incision, leaving a 3 cm margin on all sides. Plan the remainder of the incision so the entire areola is included in the specimen. If possible, accomplish this in an oblique or horizontal direction. After having drawn the circle around the tumor, preserve as much of the remaining skin as possible, as it avoids tension on the skin suture line. Excise

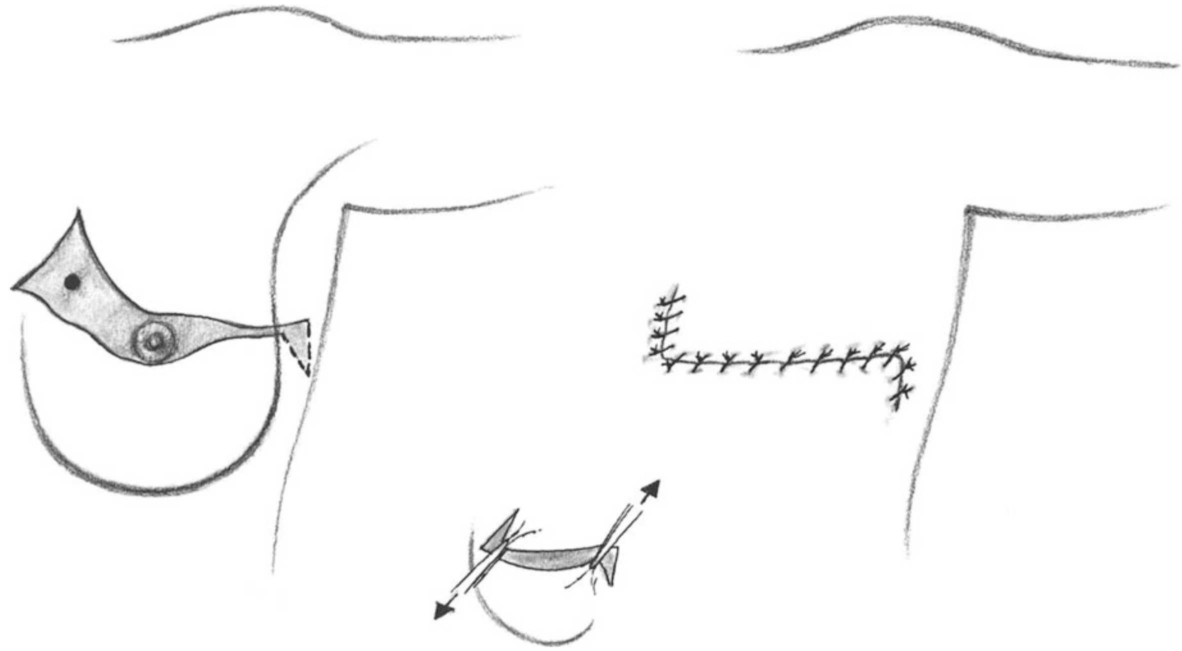

Fig. 114.3

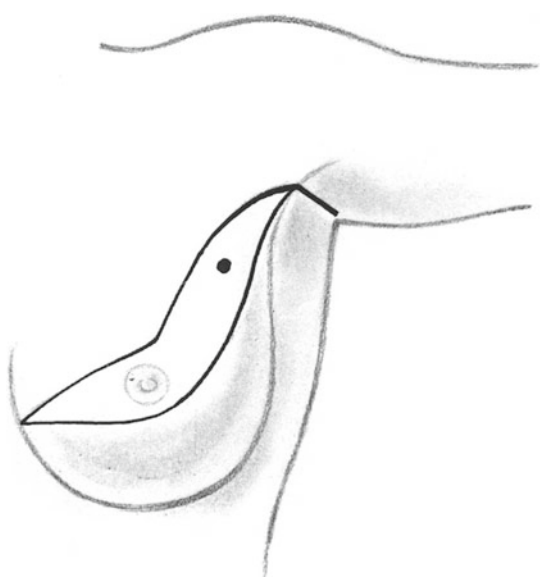

Fig. 114.4

the redundant skin after the specimen has been removed or leave it in situ if subsequent reconstruction is planned.

There are a number of alternative incisions for tumors in various locations of the breast. Figure 114.3 illustrates an incision tailored to encompass a lesion at 10 o'clock. Similarly, Fig. 114.4 shows an incision that accommodates a tumor in the upper outer quadrant of the breast yet is low medially where it is most likely to be visible.

Another cosmetic defect that should be avoided is the "dog-ear" deformity that can result at either end of the incision following mastectomy. This bunching together of skin is interpreted by many women as a residual tumor and is a cause for great anxiety. It is easily prevented by excising an additional triangle of skin until the incision lies flat on the chest wall (Fig. 114.5).

Documentation Basics

- Findings
- Sentinel lymph node biopsy?
- Axillary lymph node dissection?
- Reconstruction?

Operative Technique

Incision and Elevation of Skin Flaps

Position the patient so the arm is abducted 90° on an arm board and place a folded sheet, about 5 cm thick, underneath the patient's scapula and posterior hemithorax. Prepare the area of the breast, upper abdomen, shoulder, and upper arm with an iodophor solution. Enclose the entire arm in a double layer of sterile orthopedic stockinette to maintain sterility of the entire extremity in case the arm must be flexed to facilitate dissection of the upper axilla. We prefer to place a sterile Mayo instrument stand over the patient's head. It is used for extra hemostats and gauze pads for the assistant, and it supports the patient's arm during the period of the operation that requires it to be flexed.

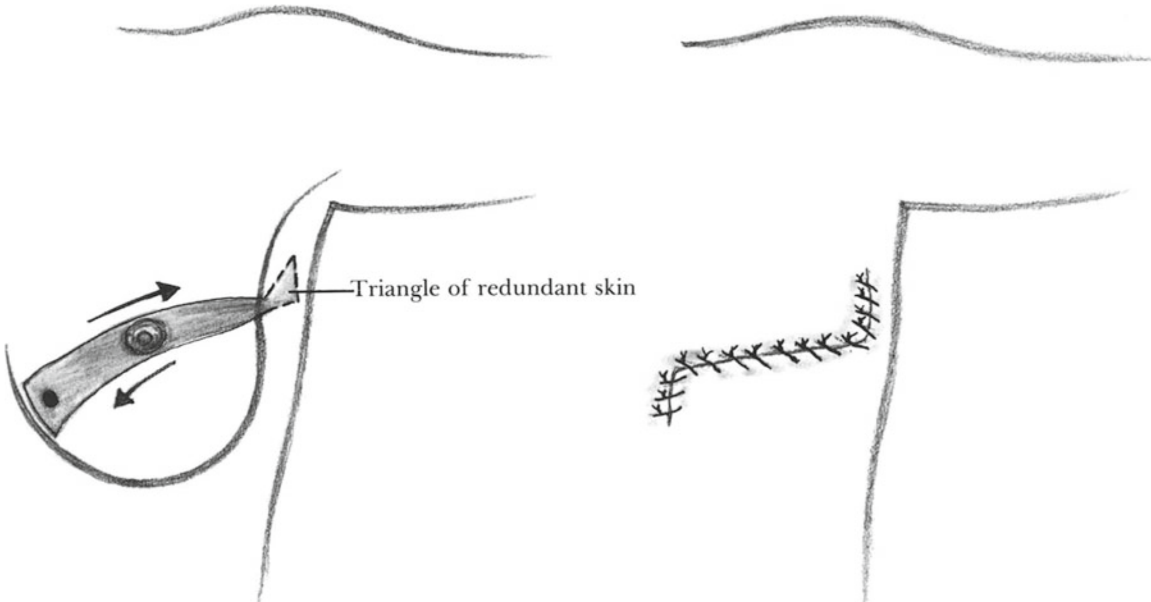

Fig. 114.5

Fig. 114.6

Using a sterile marking pen, draw a circle 3 cm away from the perimeter of the primary tumor. Depending on the location of the tumor, mark the medial and lateral extensions of the incision as discussed above. In addition to the area of skin outlined by the circle drawn around the tumor, include the entire areola and nipple in the patch of skin left on the specimen (Fig. 114.1). If there is little or no risk of requiring a skin graft, make an elliptical incision (Fig. 114.6). Then

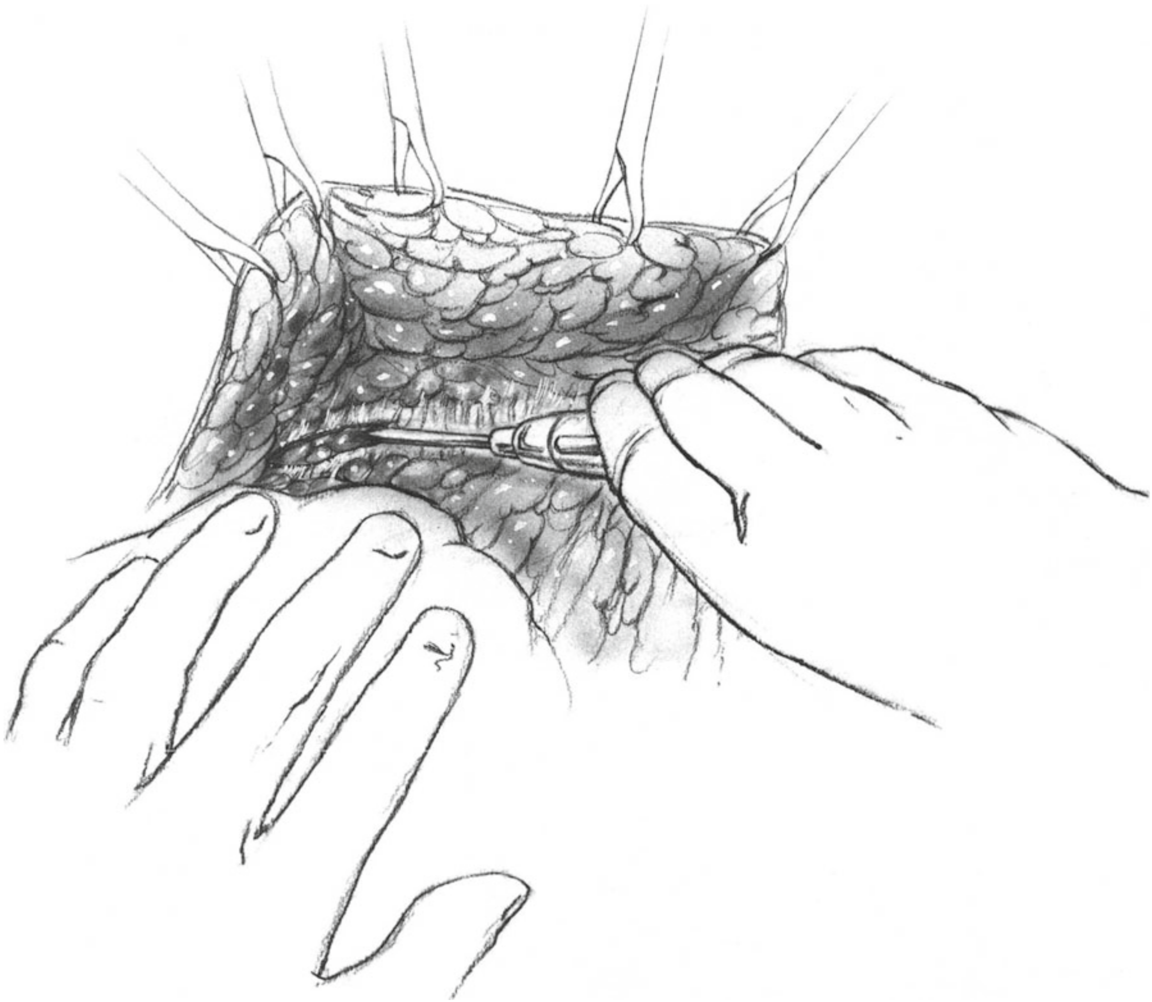

Fig. 114.7

use a scalpel to make the incision through all layers of the skin. Attain hemostasis by applying electrocoagulation to each bleeding point.

Apply Adair clamps or rake retractors, about 2–3 cm apart, to the cut edge of the skin on the lower flap. Have the assistant elevate the skin flap by drawing the Adair clamps in an anterior direction. Apply countertraction by depressing the breast posteriorly. Then use the electrocautery set on a medium cutting current to incise Cooper's ligaments, which attach the subcutaneous tissues to the surface of the breast (Fig. 114.7). Leave no visible breast tissue on the skin flap. When significant bleeding is encountered, simply switch to coagulating current to control the bleeding. This technique facilitates performing a mastectomy with minimal trauma and excellent hemostasis. Continue elevating the inferior skin flap until the dissection is beyond the breast. The medial margin for the dissection is the sternum. At the medial aspect, perforating vessels from the internal thoracic artery will be encountered. Preserve these, if possible, to protect viability of the skin flaps.

The lateral margin is the anterior border of the latissimus dorsi muscle, which is exposed for the first time during this phase of the operation. Apply a moist gauze pad to the operative site. Remove the Adair clamps from the lower skin flap and apply them now to the upper skin flap. Use the same technique to elevate the upper skin flap to a point about 3 cm below the clavicle. Whichever skin incision has been selected, it should permit wide exposure of the axillary contents from the clavicle to the point where the axillary vein crosses over the latissimus muscle. The final step in achieving exposure consists of clearing the fat from the anterior border of the latissimus muscle with a scalpel so the entire lateral margin of the dissection has been identified.

Clearing the Pectoral Fascia

After checking to ascertain that complete hemostasis has been achieved, use a scalpel to incise the fascia overlying the major pectoral muscle. Begin near the medial margin of this

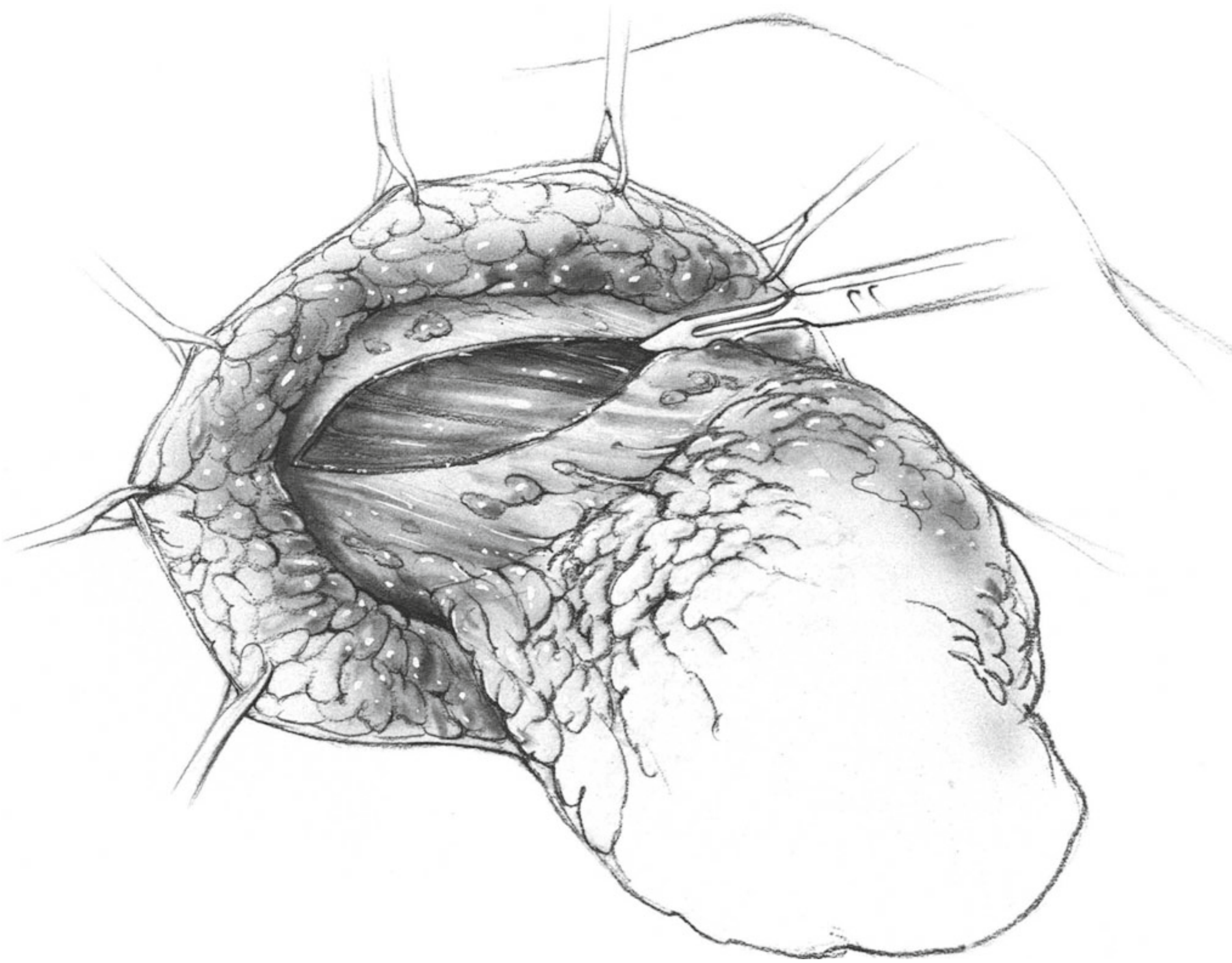

Fig. 114.8

muscle and proceed with scalpel or electrocautery to dissect the fascia off the anterior surface of the major pectoral muscle from the sternum to the lateral margin (Fig. 114.8). Simultaneous hemostasis is achieved if the first assistant electrocoagulates each of the branches of the mammary vessels as they are exposed or divided by the dissection. Whether using electrocautery or hemostats, exercise caution when pursuing a vessel that has retracted into the chest wall after being divided. We have on occasion, especially in thin patients, observed pneumothorax following this step. When the vessel is not easily controlled by electrocautery or a hemostat, simply apply a suture-ligature to control it.

When the lateral margin of the major pectoral muscle has been reached, use a combination of blunt and sharp dissection to elevate the edge of the pectoral muscle from its investing fascia. This maneuver maintains continuity between the breast, the pectoral fascia, and the lymph nodes of the axilla. If simple mastectomy is planned, terminate the dissection after removing the axillary tail of Spence.

Unroofing the Axillary Vein

Use a Richardson retractor to elevate the major pectoral muscle. Identify the minor pectoral muscle (Fig. 114.9). Branches of the medial pectoral nerve are seen lateral to the origin of the minor pectoral muscle. They may be divided without serious consequence, but be sure to identify and preserve the major branch of the lateral pectoral nerve that emerges just *medial* to the origin of the minor pectoral muscle and travels along the undersurface of the major pectoral muscle. Division of this nerve may result in atrophy and contraction of the major pectoral muscle. Dissect the fat and fascia off the anteroinferior edge of the coracobrachialis muscle using a scalpel. Directly inferior to this muscle is the brachial plexus and the axillary vessels. Continuing the dissection of the inferior border of the coracobrachialis in a medial direction leads to the coracoid process, upon which the minor pectoral muscle inserts. Elevate this muscle with a Richardson retractor and continue dissection underneath

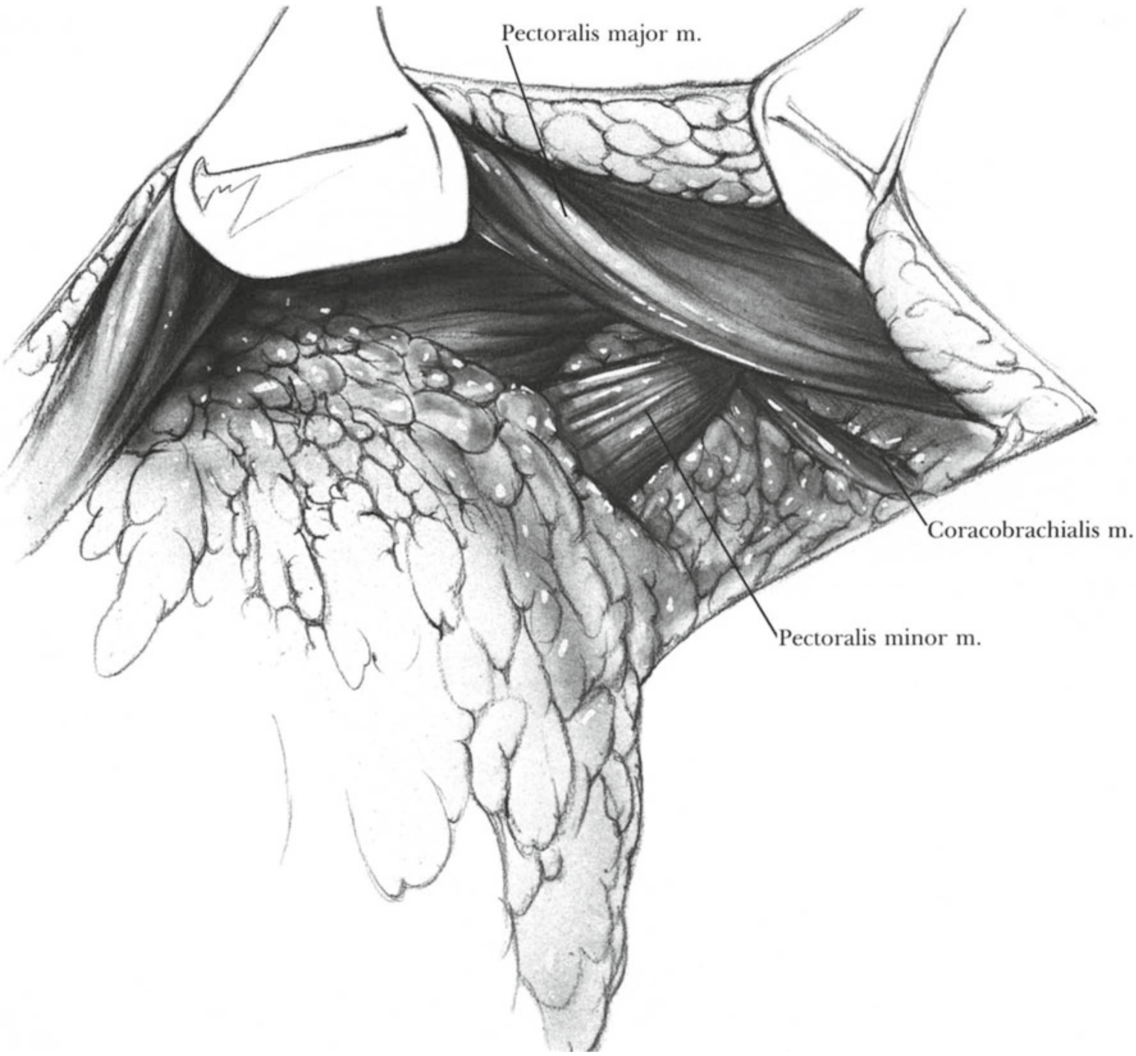

Fig. 114.9

it. If it is necessary to divide the muscle, use coagulating current to divide this muscle near its insertion (Fig. 114.10) and then free up enough of the divided muscle to provide complete exposure of the axillary vein. Deep to the minor pectoral muscle that was divided is a well-defined fat pad overlying the junction of the cephalic and axillary veins. Gentle blunt dissection generally succeeds in elevating this fat pad and drawing it in a caudal direction to expose the anterior surface of the axillary vein.

Now incise the adventitial sheath of the axillary vein (Fig. 114.11). Although light dissection with the belly of the scalpel can accomplish this, most surgeons prefer to use Metzenbaum scissors. A few branches of the lateral anterior thoracic artery, vein, and nerve cross over the anterior wall of the axillary vein. Divide these branches between hemostatic clips. To complete division of the sheath of the axillary vein from the region of the latissimus muscle to the clavicle, it is necessary to flex the upper arm. This relaxes the major pectoral muscle, which is then elevated with a Richardson retractor.

Axillary Vein Dissection

Axillary lymphadenectomy aims at removing all of the lymph glands inferior to the axillary vein (levels I–III). Only when these glands are replaced by metastases does tumor spread to the nodes cephalad to the axillary vein and to the neck. Not only is it unnecessary to strip all of the fat from the brachial plexus, this maneuver produces lifelong painful neuritis in some patients.

Identify all the branches entering the axillary vein from below. Clear each of the branches of adventitia and divide each between hemoclips (Fig. 114.12). Do not divide the subscapular vein, which enters the axillary vein from behind.

Fig. 114.10

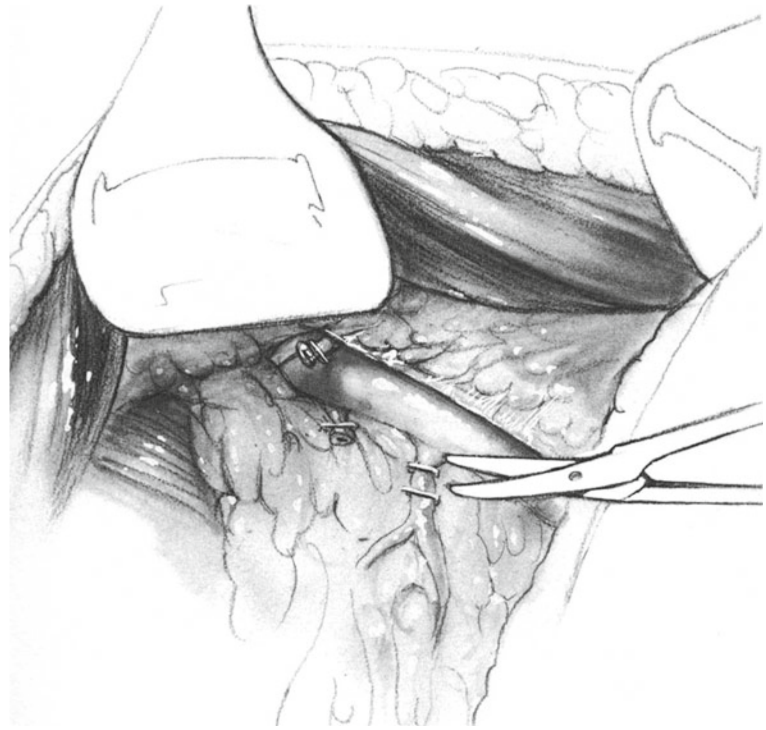

Fig. 114.12

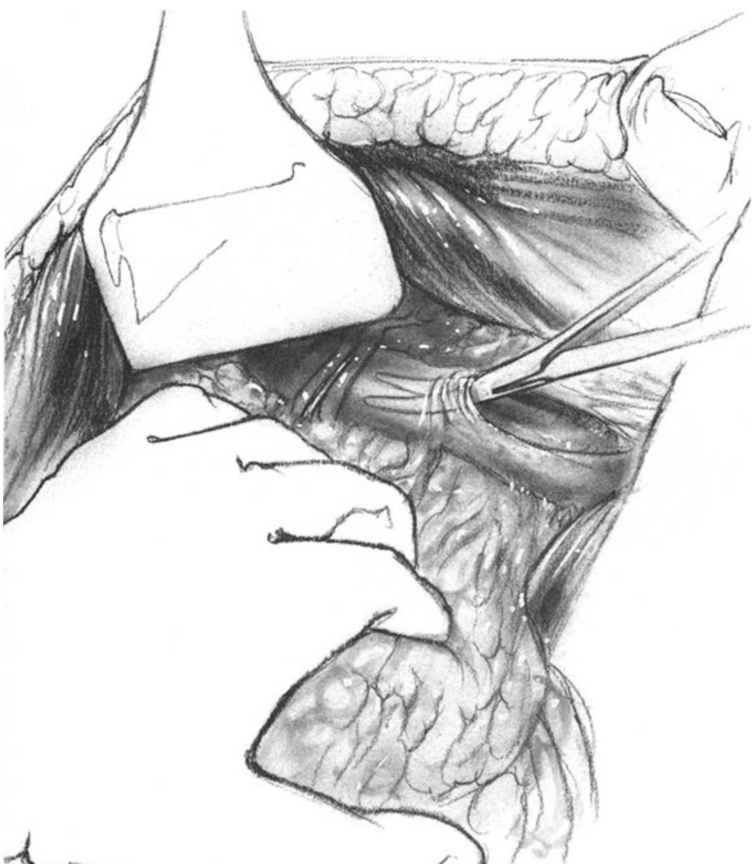

Fig. 114.11

At this point, it is essential to label the apex and the lateral margin of the axillary specimen. Many pathologists prefer that a third label be attached at the point where the minor pectoral muscle crosses the axillary specimen.

The upper boundary of the axillary dissection is the crossing of the clavicle over the axillary vein. Detach the lymphatic and areolar tissue at this point with the electrocoagulator. Now make a scalpel incision in the clavipectoral fascia on a line parallel to and 1 cm below the axillary vein. Do not retract the axillary vein in a cephalad direction, as it might expose the underlying axillary artery to injury during this step. If suspicious nodal tissue is identified cephalad to the axillary neurovascular bundle, biopsy it to document the extent of disease.

Dissect the areolar and lymphatic tissues off the intercostal muscles and ribs going from medial to lateral. When the minor pectoral muscle is encountered, divide it 2–3 cm from its origin with the electrocoagulator (Fig. 114.13) and leave the excised muscle attached to the specimen. If this muscle was not divided earlier in the operation, it is not necessary to resect it. Restore the arm to its previous position of 90° abduction. As the chest wall is cleared laterally, one or two intercostobrachial nerves are seen emerging from the intercostal muscle on their way to innervate the skin of the upper inner arm. Because these nerves penetrate the specimen, divide them even though it results in a sensory deficit in the upper inner arm (Fig. 114.14). Use a sterile gauze pad to wipe the loose fat out of the subscapular

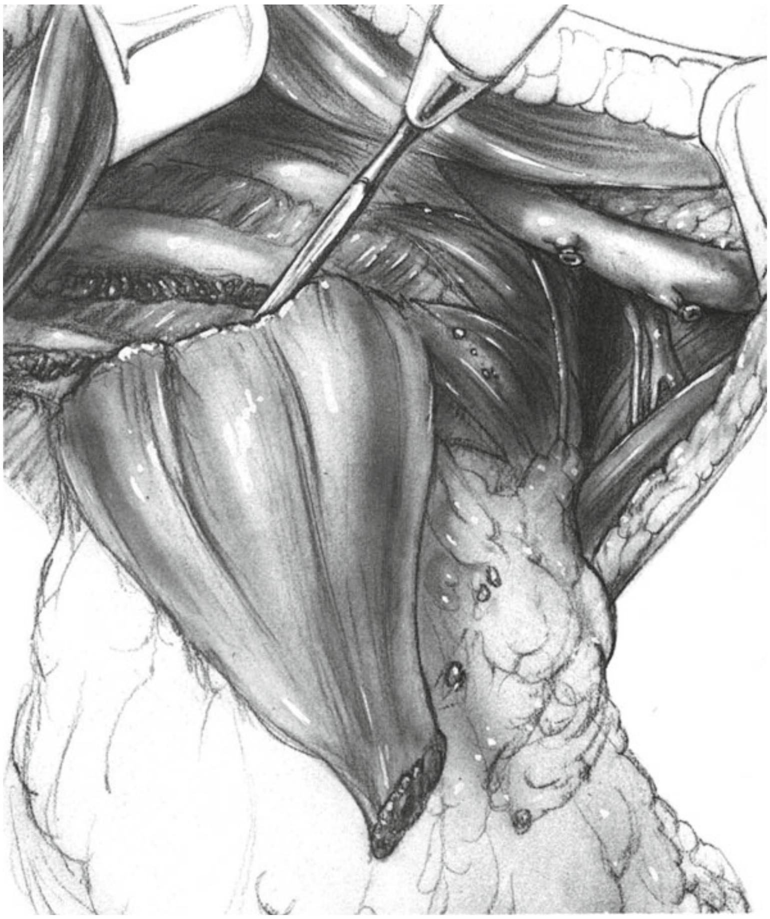

Fig. 114.13

space going from above downward. This maneuver exposes the long thoracic nerve that runs along the rib cage in the anterior axillary line in a vertical direction from above downward to innervate the anterior serratus muscle. The thoracodorsal nerve can be identified as it leaves the area of the subscapular vein and runs both laterally and downward together with the thoracodorsal artery and vein to innervate the latissimus dorsi muscle. Because these two nerves run close to the peripheral boundary of the dissection, they should be preserved when no metastatic lymph nodes are seen in their vicinity.

Detach the lymphatic tissue inferior to the portion of the axillary vein that crosses over the latissimus muscle. Preserving the long thoracic nerve is complicated by the fact that a number of small veins cross over the nerve in its distal portion. Circumvent this difficulty by moving the partly detached breast in a medial direction so it rests on the patient's chest after freeing the specimen from the anterior border of the latissimus muscle. Then make an incision in the fascia of the serratus muscle 1 cm medial to the long thoracic nerve. Dissecting this fascia a few centimeters in a medial direction detaches the entire specimen from the chest wall (Fig. 114.15).

Irrigation and Closure

Thoroughly irrigate the operative field. We use sterile water, which lyses not only clot and blood, making it easier to spot

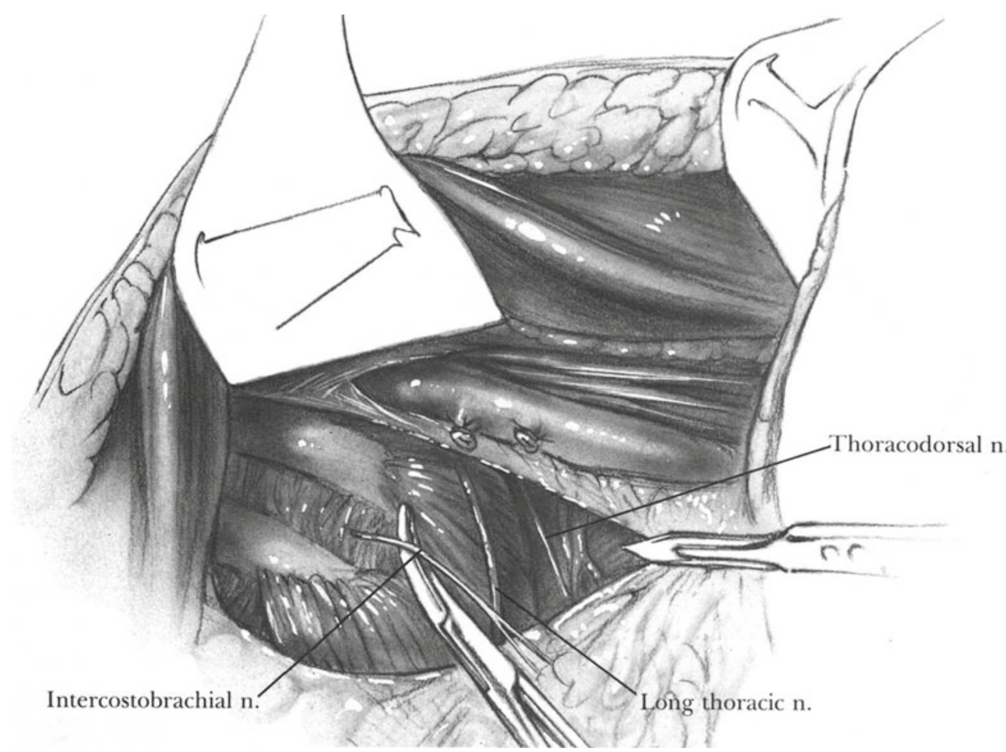

Fig. 114.14

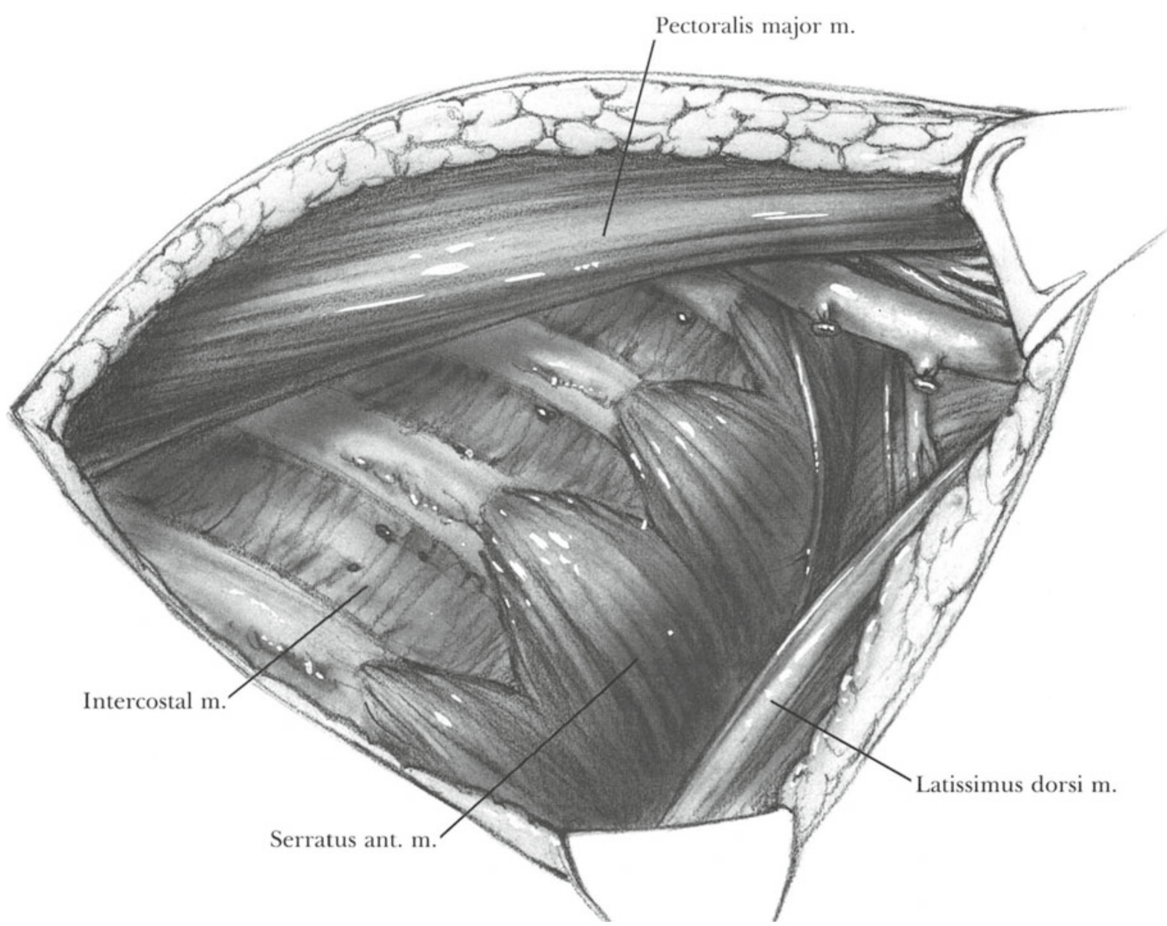

Fig. 114.15

small bleeders, but also any spilled tumor cells that may have been dispersed into the operative field. Check the entire field to be sure *complete* hemostasis has been achieved.

Insert two large closed suction drains through puncture wounds into the lower axilla. Bring one catheter deep to the axillary vein and the other catheter across the thoracic wall from the puncture wound to the region of the sternum. Suture each catheter to the skin at the site of the puncture wounds and attach to closed suction drainage (Fig. 114.16).

Close the skin with subcuticular PDS, interrupted fine nylon sutures, or skin staples. Be certain there is no significant tension on the incision; otherwise, postoperative necrosis of the skin flap may be anticipated. Often shifting the skin flaps in a medial or lateral direction relieves tension. Do not permit either of the skin flaps at the lateral margin of the incision to become bunched up in such a fashion that a "dog-ear" forms. Many patients are convinced that this represents residual tumor. The "dog-ear" deformity can be eliminated by excising a triangular wedge of skin as noted in Figs. 114.3 and 114.5. When closed suction drainage is used postoperatively, it is not necessary to apply a bulky pressure dressing.

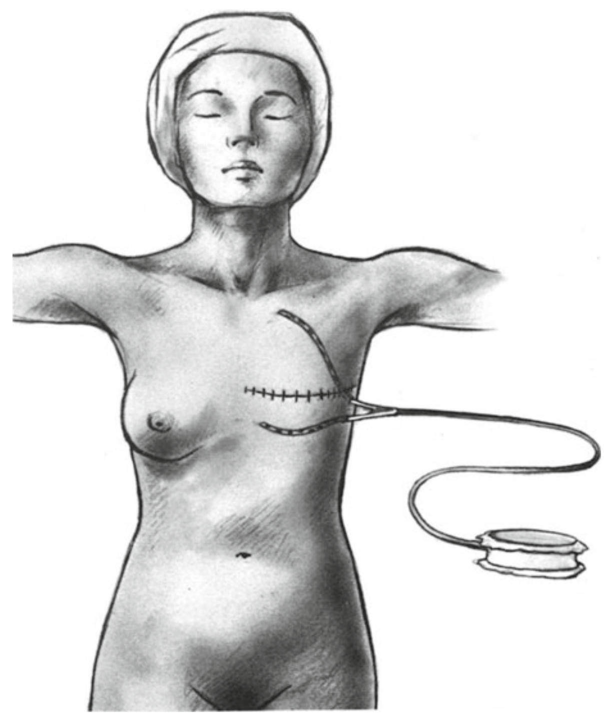

Fig. 114.16

Postoperative Care

Leave the two closed suction drainage catheters in place until the daily drainage diminishes to 30–40 ml/day or about 7 days.

Encourage early ambulation, but do not permit the patient to abduct the arm on the side of the operation for 5–7 days, as this activity prevents the skin flaps from adhering to the chest wall and encourages prolonged drainage of serum. Permit the patient to use this arm for ordinary activities not requiring abduction. We use a standardized series of graded physical exercises to ensure that the woman regains full mobility. Physical therapy is helpful in some cases.

Take appropriate steps throughout postoperative treatment to ensure the patient's emotional and physical rehabilitation.

If skin staples or sutures were used, do not remove them for 2 weeks because the operation has separated the skin flaps from much of their blood supply, slowing the rate of healing.

Aspirate any significant collections of serum underneath the skin flaps with a sterile syringe and needle as necessary.

Refer the patient for adjuvant chemotherapy or for participation in one of many clinical trials.

Follow the patient for local recurrence or the development of cancer in the opposite breast.

Once the initial period of close follow-up is completed, we follow these patients annually for life.

Carefully inspect the arm for the development of lymphedema, which can become a disabling complication if not detected and treated early. Warn the patient to avoid trauma, including sunburn, to the arm and forearm of the operated side. If at any time the hand is traumatized or there is any evidence of infection in the hand or arm, prompt treatment with antibiotics for 7–10 days, followed by application of a specially fitted elastic sleeve of the Jobst type, may prevent the development of permanent arm edema.

Postoperative Complications

Ischemia of Skin Flap

This is a serious, partially preventable complication. Minimize its risk by avoiding tension on the suture line and excessive devascularization of the skin flaps. When ischemia is permitted to develop into gangrene of the skin, a process that takes 2 weeks or more, some degree of cellulitis invariably follows. This process occludes many residual collateral lymphatic channels through which the lymph fluid from the arm manages to return to the general circulation. Blocking these channels increases the incidence and severity of permanent lymphedema of the arm. Consequently, skin necrosis should be anticipated when purple discoloration appears in the skin flap on the fifth or sixth day following mastectomy. If this purple discoloration cannot be blanched by finger pressure, it represents devitalization of the skin; it is not cyanosis.

Once this skin change has been observed, the patient should be returned promptly to the operating room. With local anesthesia, excise the devitalized skin and replace it with a skin graft. At this early date, infection has not yet ensued, and primary healing of the skin graft may be anticipated. This prompt action eliminates damage to the collateral lymphatic channels and weeks of morbidity. It is, of course, far preferable to prevent skin necrosis in the first place by utilizing a skin graft during the primary operation whenever excessive tension is observed during skin closure.

Wound Infection

Wound infection is uncommon in the absence of skin necrosis.

Seromas

Collections of serum underneath the skin flap, seromas occur during the first few weeks following mastectomy when the skin flap has failed to adhere to the chest wall. This problem appears more commonly in obese patients. Treatment consists of aspirating the serum every 3–5 days. On rare occasions, this process continues for several months. In such a case, it is preferable to make an incision under local anesthesia and insert a drain. Repeated aspiration over many weeks may result in infection of the seroma.

Lymphedema

Lymphedema of the arm is more common in obese patients, in those who have undergone axillary radiotherapy, and in those who have experienced skin necrosis, wound infection, or cellulitis of the arm. Treat cellulitis of the arm promptly with antibiotics. Lymphedema in the absence of any sign of infection is treated as soon as it is detected by applying a Jobst elastic sleeve, which applies a pressure of 50 mmHg to the forearm and arm. These sleeves should be changed whenever they lose their elasticity, generally after 6 weeks. This treatment should be instituted whenever one detects an increase in circumference of the arm of 2 cm or more. Generally, elastic compression keeps the condition under control if it has not been long neglected. Once the edema has been permitted to remain for many months, subcutaneous fibrosis replaces the edema and makes it irreversible. Intermittent pneumatic compression has been recommended, but few patients tolerate the intermittent compression for the many hours a day necessary before significant progress is demonstrated with long-standing edema. Prompt treatment of the hand or arm with antibiotics and early application of elastic compression are helpful for preventing and controlling edema.

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Radical Mastectomy: Surgical Legacy Technique

115

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Radical mastectomy is occasionally useful in highly selected patients for local control of advanced disease.

Preoperative Preparation

Same as for modified radical mastectomy (see Chap. 114)

Pitfalls and Danger Points

These include those listed for the modified radical mastectomy operation (see Chap. 114).

Pneumothorax may be produced by perforation in the chest cavity during attempts to control branches of the internal mammary artery.

Operative Strategy

After elevating the skin flaps by the usual technique, radical mastectomy can be accomplished in one of two sequences. With the technique described below, axillary lymphadenectomy precedes removal of the breast from the chest wall. It is also feasible to remove the breast and the major pectoral muscle from the chest wall prior to doing the axillary dissection, as described for modified radical mastectomy. When the breast is removed proceeding from medial to lateral, gravity provides sufficient retraction and facilitates exposure. No data are available comparing these two sequences, so the choice is based on personal preference.

Operative Technique

Incision

The principles underlying the choice of incision for radical mastectomy (Fig. 115.1) are the same as those for modified

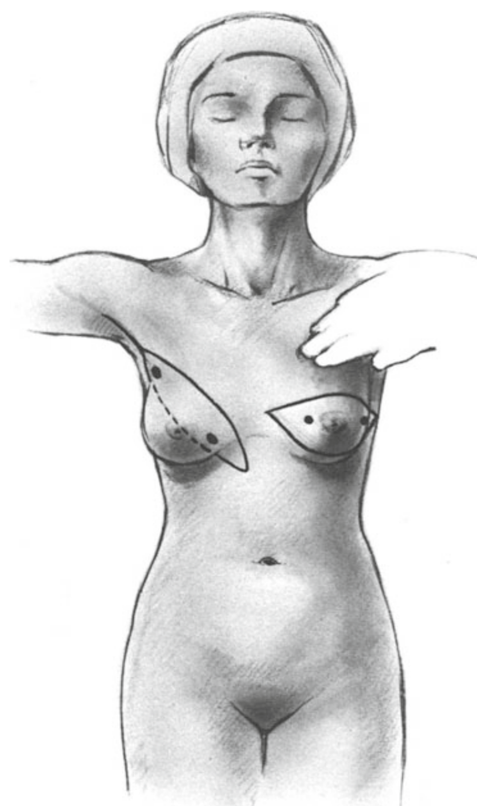

Fig. 115.1

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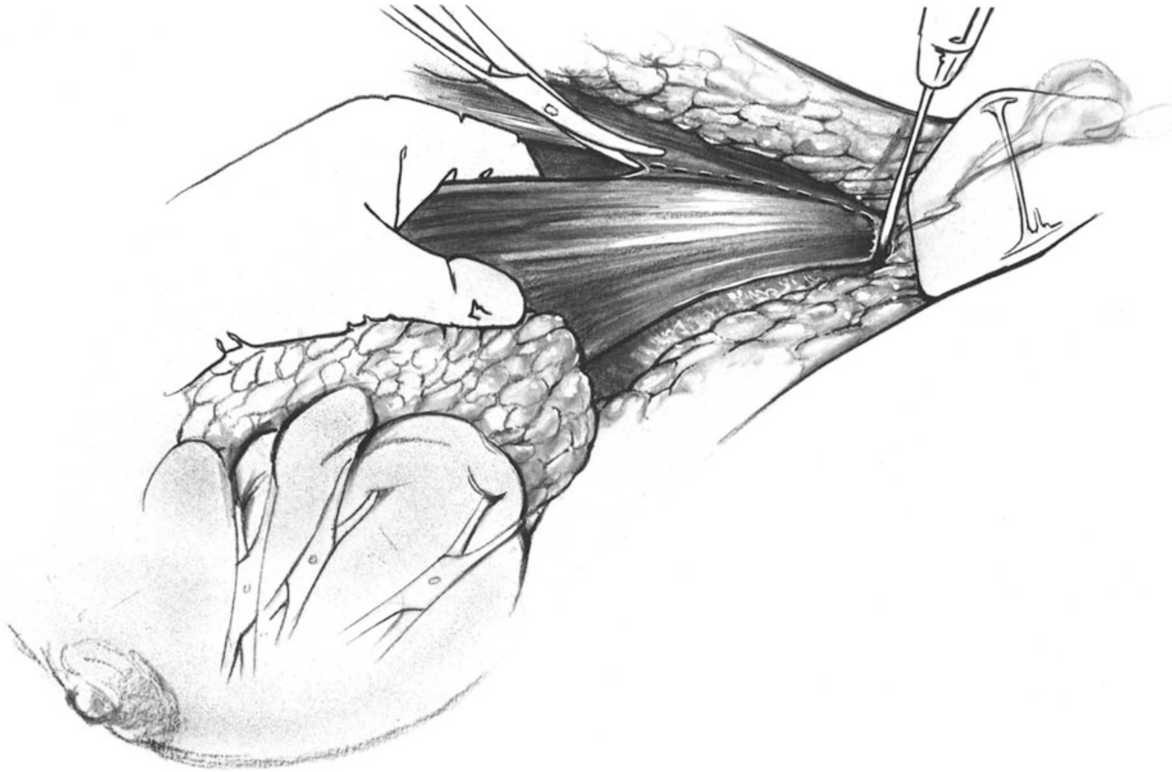

Fig. 115.2

radical mastectomy. Adequate excision of advanced disease may necessitate that considerable skin be excised and the resulting defect closed by a split-thickness skin graft or a local full-thickness flap (usually based upon the latissimus dorsi).

Elevation of Skin Flaps

The same technique as for modified radical mastectomy is used to elevate the skin flaps (see Chap. 114).

Exposing the Axilla

To perform a complete axillary lymphadenectomy, it is not necessary to remove the portion of the major pectoral muscle that arises from the clavicle. Preservation of the clavicular head of this muscle improves the cosmetic appearance of the upper chest wall. Consequently, develop a line of separation by blunt dissection between the sternal and clavicular heads of the pectoral muscle. Continue this separation to the point where the major pectoral muscle inserts on the humerus. Place the left index finger underneath the sternal head of the muscle near its insertion and divide the muscle from its insertion with electrocoagulating current (Fig. 115.2). Complete the line of division between the two heads of the muscle proceeding in a medial direction until the sternum is reached. A number of lateral anterior thoracic arteries, veins, and nerves are divided between hemoclips during this dissection. Also detach the upper 2–3 cm of the major pectoral muscle from the upper sternum.

Incise the areolar tissue and fascia over the surface of the coracobrachial muscle and continue in a medial direction until the coracoid process is reached. This move exposes the junction between the coracobrachial muscle and the insertion of the minor pectoral muscle (Fig. 115.3). Just caudal to the coracobrachial muscle are the structures contained in the axilla: the brachial plexus and the axillary artery and vein. They are covered not only by fat and lymphatic tissue but by a thin layer of costocoracoid fascia. Clearing the fascia away from the inferior border of the coracobrachial muscle serves to unroof the axilla and expose the insertion of the minor pectoral muscle. Detach this muscle from its insertion after isolating it by encircling it with the index finger; use the coagulating current to divide the muscle near the coracoid process (Fig. 115.3). A pad of fat overlying the axillary vein near the entrance of the cephalic branch can be swept downward by blunt dissection, exposing the axillary vein.

Dissecting the Axillary Vein

It is not necessary to clean the fat off the brachial plexus or to remove tissue cephalad to the axillary vein. Pick up the sheath of the axillary vein with Brown-Adson or DeBakey forceps and use Metzenbaum scissors to separate the

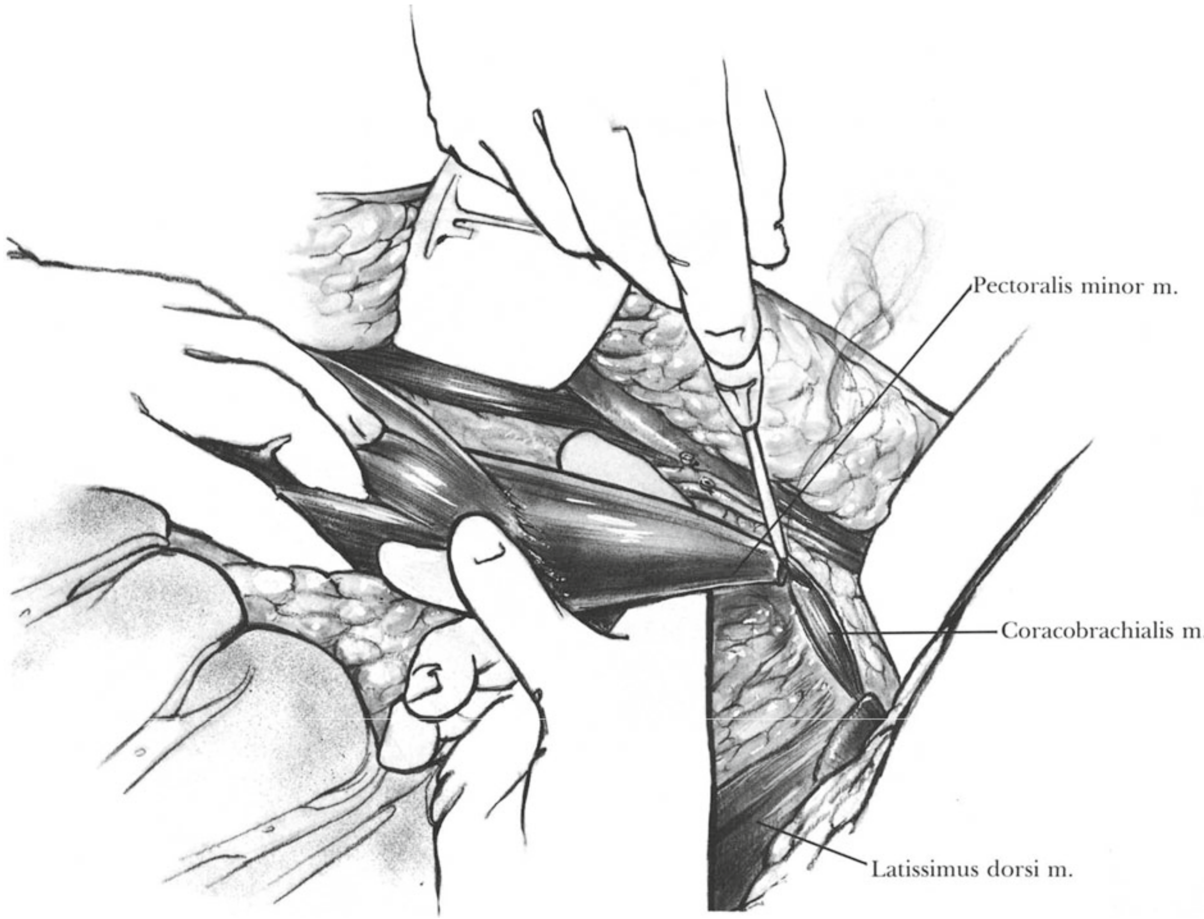

Fig. 115.3

adventitia from the underlying vein (Fig. 115.4). Once the unopened scissors have been inserted underneath the adventitia to establish the plane, remove the scissors and insert one blade of the scissors under this tissue. Close the scissors, dividing the adventitia. Continue this dissection along the anterior wall of the axillary vein from the region of the latissimus muscle to the clavicle. The only structures crossing anterior to the axillary vein are some thoracoacromial, lateral anterior thoracic, and pectoral blood vessels and nerves. Divide these structures between ligatures or hemoclips. At the conclusion of this step, the branches of the axillary vein have been fairly well skeletonized. Now divide each of the branches of the axillary vein that comes from below using hemoclips or 3-0 PG ligatures (Fig. 115.5). At this point, use silk sutures to apply labels to mark the apex and the lateral portion of the lymphadenectomy specimen.

Dissecting the Chest Wall

Make a scalpel incision through the clavipectoral fascia just inferior to the medial portion of the axillary vein (Fig. 115.6). This maneuver clears fat and lymphatic tissue from the upper chest wall. Continue this dissection laterally until the subscapular space has been reached; then clear the areolar tissue from the subscapular space using a gauze pad, bluntly dissecting from above downward. This maneuver reveals the location of the long thoracic nerve descending from the brachial plexus in apposition to the lateral aspect of the thoracic cage. Preserve this nerve. Identify the thoracodorsal nerve that crosses the subscapular vein and travels 2–3 cm laterally together with the artery and vein supplying the latissimus dorsi muscle (Fig. 115.7). In the absence of obvious lymph node metastases in this area, dissect out the thoracodorsal nerve down to its junction with the latissimus dorsi muscle.

If the anterior border of the latissimus muscle has not yet been thoroughly exposed, complete this maneuver now. The entire lymphadenectomy specimen should be freed from the axillary vein, the upper anterior chest wall, and the anterior border of the latissimus muscle.

Detaching the Specimen

Keeping the long thoracic nerve in view, make an incision in the fascia of the anterior serratus muscle on a line parallel to

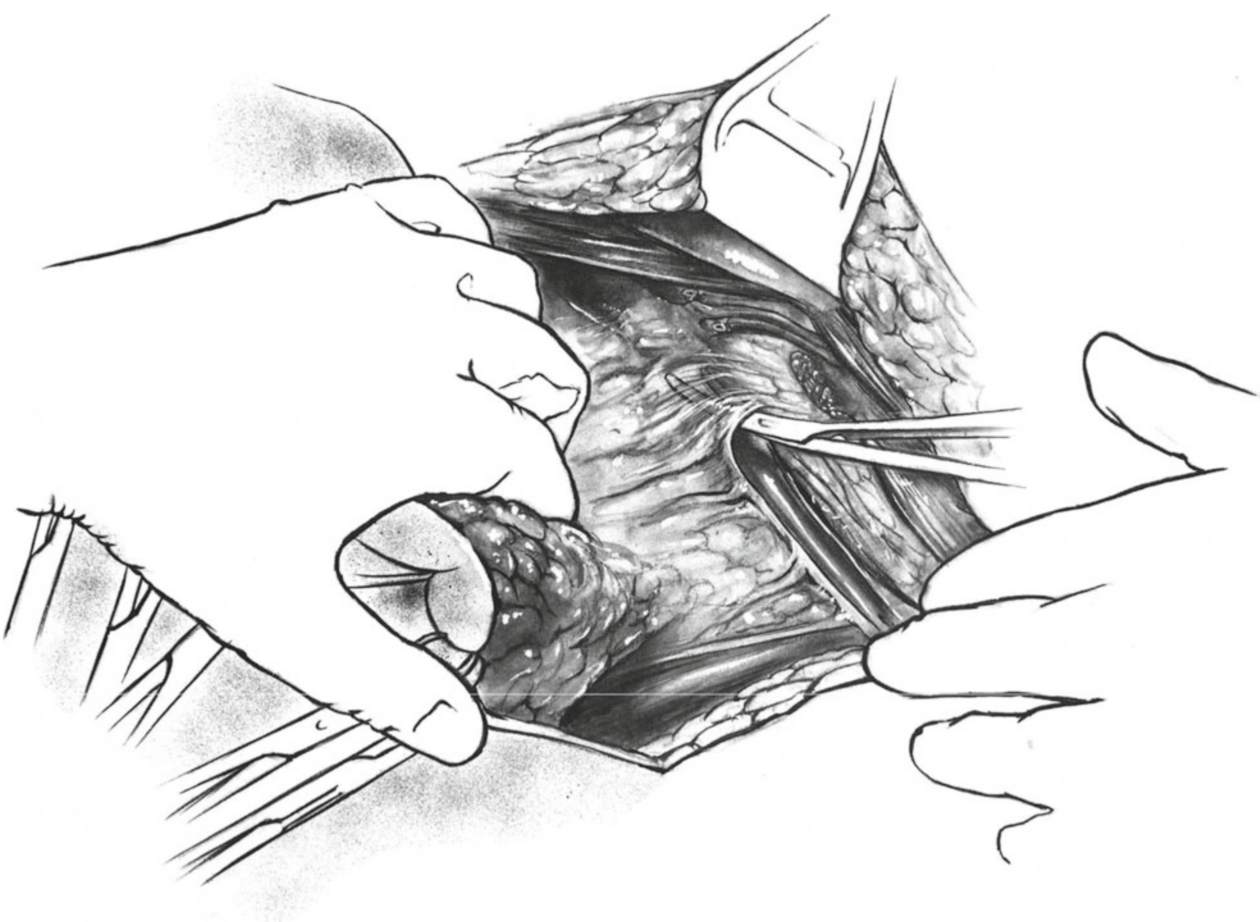

Fig. 115.4

and 1 cm medial to this nerve. Elevate the fascia by dissecting in a medial direction, exposing the underlying muscle until the interdigitations of the pectoral muscles are encountered (Fig. 115.8). Detach the pectoral muscles from their points of origin with electrocautery. Apply a small hemostat to each bleeding vessel. Try to avoid including any extraneous tissue in the hemostat other than the blood vessel. If this is accomplished, each of the blood vessels on the chest wall may be occluded by applying the coagulating current to each hemostat at the conclusion of the dissection. As the pectoral muscles are divided, leave about 0.5 cm of muscle tissue on the rib cage, as it facilitates applying hemostats to the perforating branches of the internal mammary vessel. If these are divided flush with their point of emergence from the chest wall, they often retract into the chest, which makes hemostasis difficult and increases the risk of pneumothorax.

Continue the retraction medially in the direction of the pectoral muscles and the attached breast, proceeding until all of the internal mammary branches have been clamped and divided and the dissection has been completed at the border of the sternum. Remove the specimen and electrocoagulate each of the vessels. Ascertain that hemostasis is complete. Irrigate the entire operative field with sterile water in an attempt to wash out detached tissue and malignant cells (Fig. 115.9).

Closure of Incision and Insertion of Drains

Closure and drainage procedures are the same as for other kinds of mastectomy (Fig. 115.10).

Full-Thickness Skin Graft

If an area of excessive tension is encountered while closing the skin wound by suturing, leave this portion of the incision unsutured. Typically, this will be an ellipse of skin in the midportion of the incision. Measure the defect and determine if there is sufficient redundant skin in other areas of the skin flaps that may be excised, defatted, and transplanted into the defect. To expedite the defatting of skin to be grafted, it is helpful to pin one edge of the skin patch down to a sterile board. Then grasp the fat with the forceps and use a large scalpel blade to dissect all of the fat off the skin. Sometimes a few remaining bits of fat are excised with

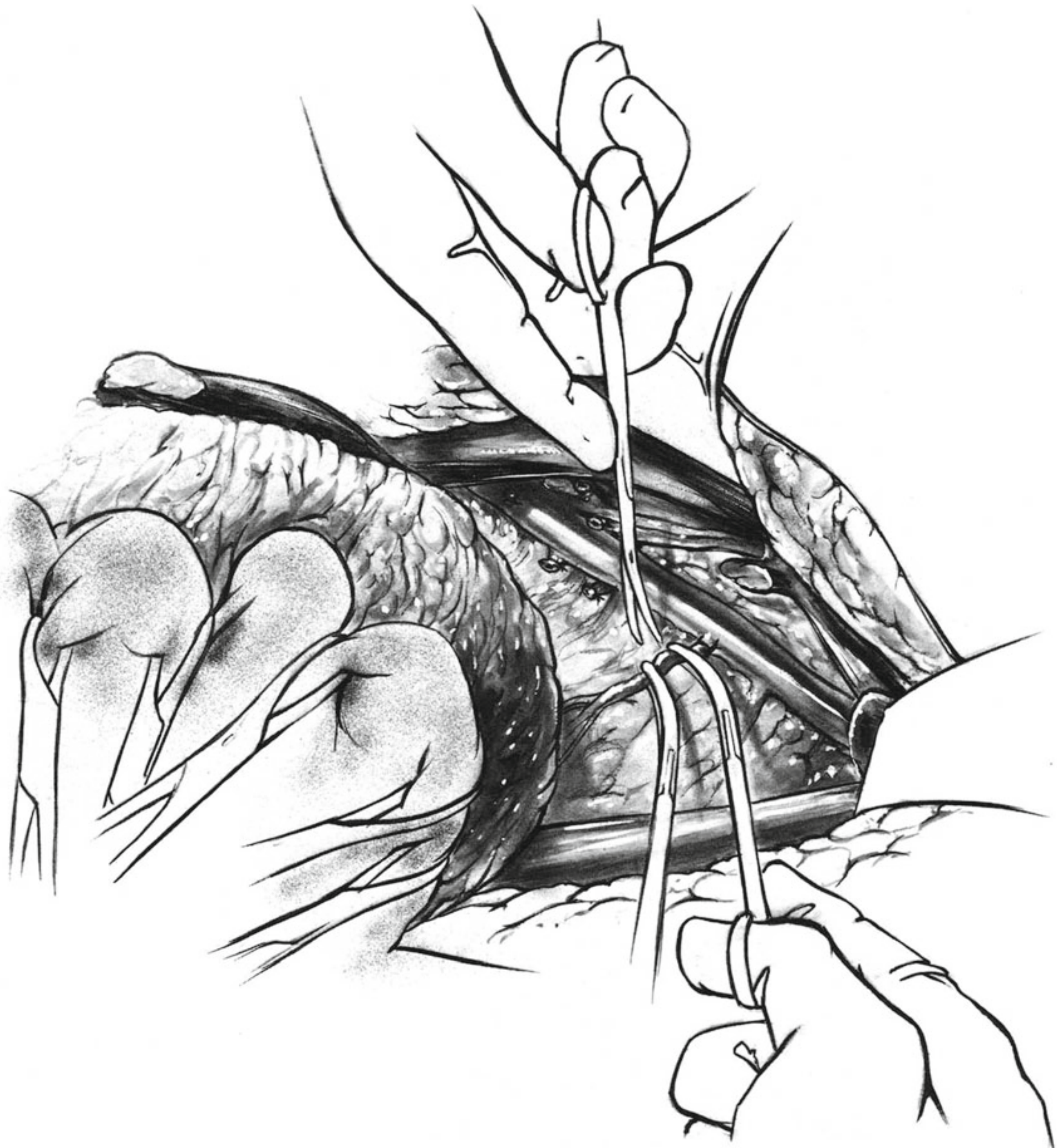

Fig. 115.5

curved Metzenbaum scissors. When a patch of skin has been sufficiently defatted to convert it into a full-thickness graft, the undersurface of the skin assumes a characteristic pitted appearance. Place the full-thickness skin graft into the defect and tailor its dimensions so there is mild tension on the graft after it is sutured into place.

First, suture the edges of the skin down to the chest wall musculature with interrupted 3-0 silk: About six such sutures can stabilize the perimeter of the defect. Then insert a continuous over-and-over suture of atraumatic 5-0 nylon to attach the skin graft to the edges of the skin defect using small bites. Skin staples comprise another good method for fixing the graft in place.

Make multiple puncture wounds in the skin graft with a No. 10 scalpel blade to permit seepage of serum from the wound through the graft. Apply a single layer of iodophor gauze over the skin graft, and over this layer, place a small mass of gauze fluffs. Tie the long ends of the previously placed silk sutures over the gauze stent to fix the skin graft in position with some pressure.

This step may be accelerated by omitting sutures entirely and fixing the skin graft in place with Steri-Strip adhesive tapes or skin staples. The gauze fluffs are then taped into place over the graft.

Split-Thickness Skin Graft

When there is no surplus of skin on the chest wall to be harvested for a skin graft, use a dermatome to obtain a split-thickness graft from the anterolateral portion of the upper thigh. After this area has been cleansed with soap and an

Fig. 115.6

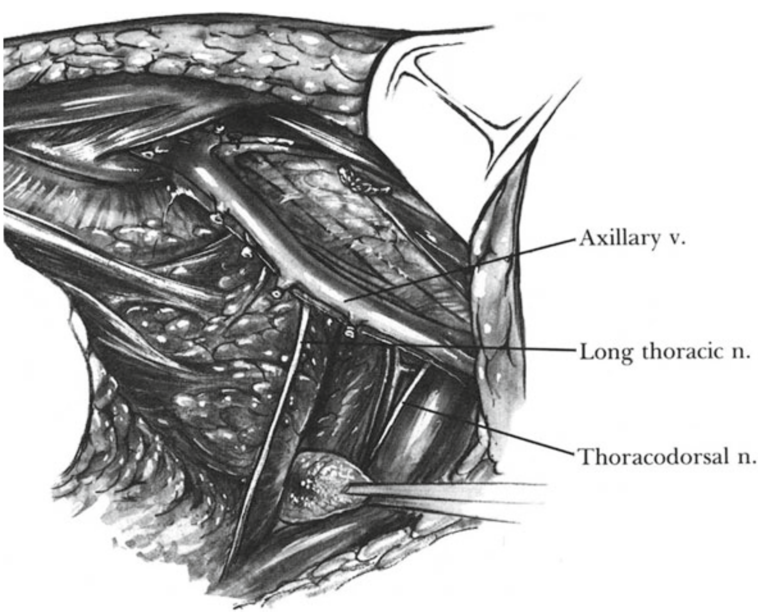

Fig. 115.7

iodophor solution has been applied, dry the area and apply a sterile lubricating solution of mineral oil. Have the assistants then stretch the skin by applying traction in opposite directions with wooden tongue depressors. Set the dermatome so the graft is 0.015 in. thick. Apply the dermatome to the surface of the skin with firm pressure and activate it. Maintain firm, even pressure while moving the dermatome cephalad. It may be helpful for the scrub nurse to pick up the cut edge of the graft with two forceps while the surgeon continues to operate the dermatome until an adequate patch of skin has been obtained. Place the skin graft in a normal saline solution temporarily. Apply a moist laparotomy pad to the donor site.

Dress the donor site with a semipermeable plastic adhesive skin covering followed by a dry sterile dressing. Suture the skin graft into the defect as described above.

Postoperative Care

Unless there are signs of infection, leave the gauze stent from the skin graft in place for 5–7 days. Afterward, leave the graft exposed or cover it with a loose, dry dressing.

Remove the gauze dressing from the donor site the day after surgery, but leave the plastic dressing intact until the site is healed (1–2 weeks). If blood or serum accumulates under the plastic dressing, aspirate it with a small sterile needle. This method of treating donor sites significantly reduces pain.

See also Chap. 114.

Complications

See Chap. 114.

With reference to the skin graft, complications include *infection* of the grafted area and occasionally of the donor site. *Failure of a complete "take"* is generally due to hematoma or serum collecting underneath the graft and separating it from its bed. It can be prevented by careful hemostasis at the time of surgery and by making several perforations with a scalpel blade to permit seepage of serum.

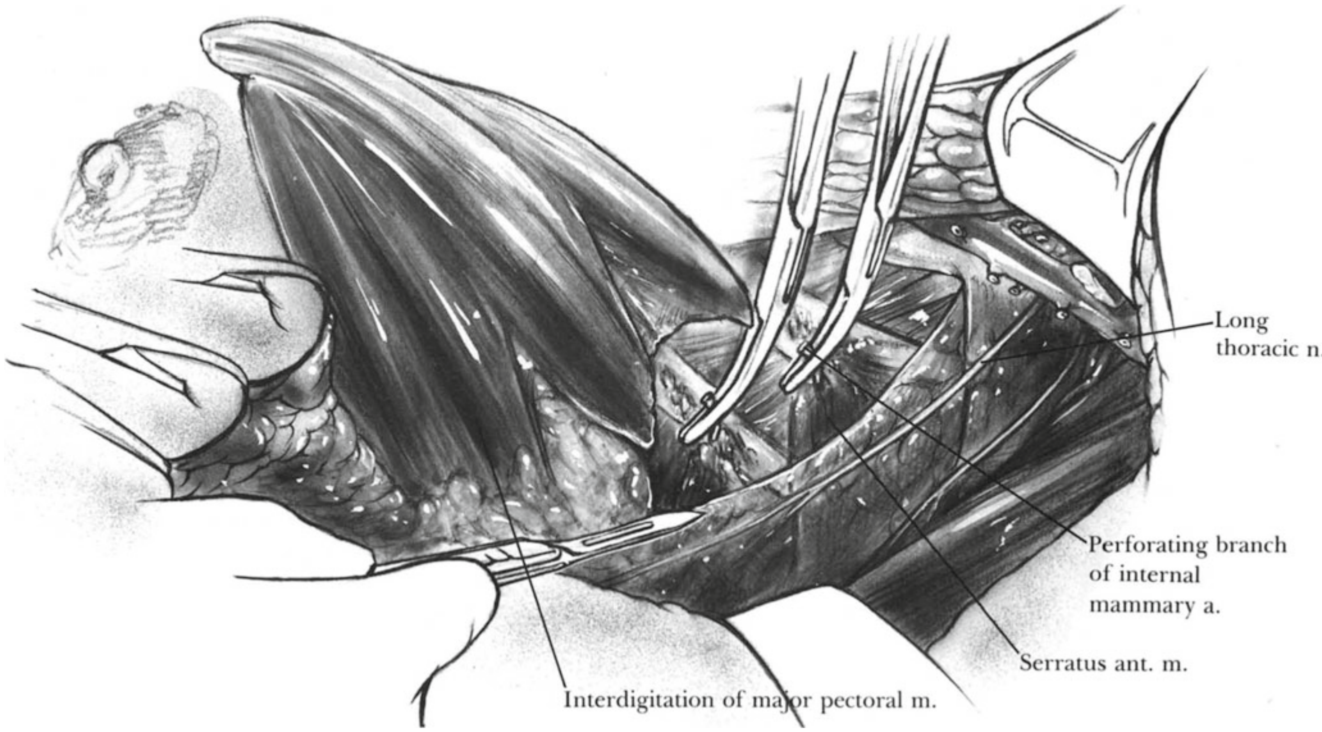

Fig. 115.8

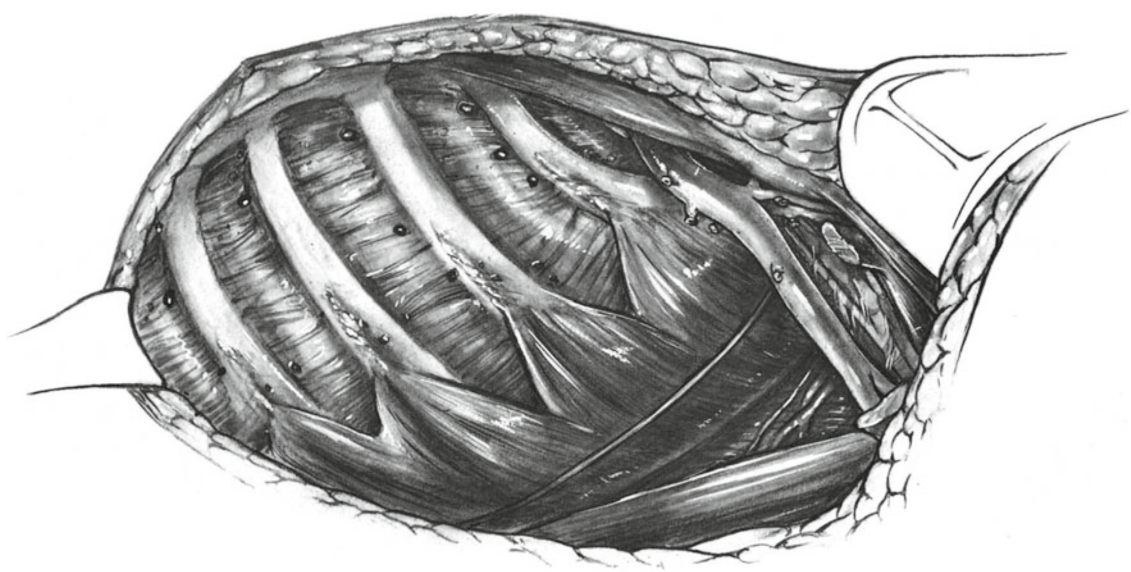

Fig. 115.9

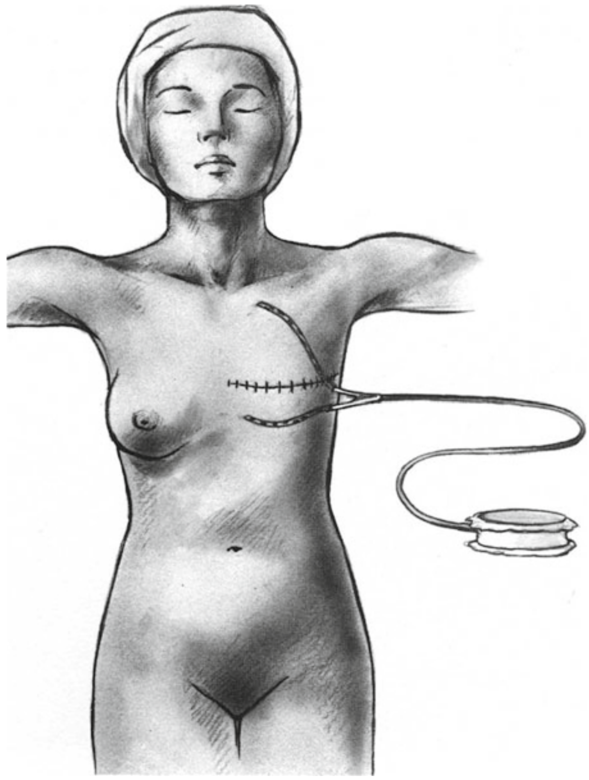

Fig. 115.10

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116 Wide Local Excision and Sentinel Lymph Node Biopsy for Melanoma

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Wide Local Excision

The diagnosis of melanoma is usually made by punch or excisional biopsy. Occasionally a shave biopsy will have been performed. Wide local excision is indicated for local control. The width of the margin required is determined by the thickness of the lesion. In situ melanomas require only a relatively narrow margin; conversely, thick melanomas require a 2.0 cm margin.

Sentinel Lymph Node Biopsy

Sentinel lymph biopsy is used to stage clinically node-negative patients whose melanomas exhibit any of the following characteristics:

- Thickness ≥1.0 mm
- Ulceration
- Mitotic index >1

In most cases, a positive sentinel lymph node is considered an indication for completion node dissection (see Chaps. 117 and 118).

Contraindications

Widespread metastatic disease may be a contraindication.
Sentinel node biopsy is rarely indicated in known node-positive patients.

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Preoperative Preparation

Wide local excision requires no specific preoperative preparation.
Patients receive an injection of technetium 99m in nuclear medicine several hours before surgery. Lymphoscintigraphy is performed to determine the drainage pattern and help guide incision placement.
Blue dye, if used, is injected on the operating table after induction of anesthesia.

Pitfalls and Danger Points

Inadequate excision
Failure to identify a positive sentinel lymph node due to technical problems or poor localization

Operative Strategy

Wide local excision may be performed alone or with sentinel lymph node biopsy. Often the diagnosis of melanoma will have been made before the patient is first seen by the surgeon.

Biopsy

The manner in which that diagnostic biopsy was done can make the subsequent excision easier or harder. Therefore, a few words are in order about the unique considerations involved in doing a biopsy for possible melanoma. First, the thickness of the melanoma is a crucial prognostic factor. It can only be determined by a full-thickness biopsy that goes down into the underlying fat. For this reason, conservative excisional biopsy, incisional biopsy of the thickest portion of a large lesion, or punch biopsy is strongly preferred over shave biopsy.

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Align the long axis of the biopsy wound with the long axis of any subsequent wide excision site to minimize the amount of tissue that must be removed at wide excision. For the extremities, this requires placing the long axis parallel to the long axis of the limb (rather than in a natural skin crease). For the torso, incisions parallel to the likely lymphatic drainage pattern are often preferred; however, the skin is usually loose enough that a skin crease incision can be made. If the lesion is large, take a representative biopsy from the thickest (non-ulcerated) part of the lesion either by making a small incision or performing a punch biopsy.

Wide Local Excision

The margin is defined from the edge of the lesion or edge of the biopsy site if the lesion has been "biopsied away." For in situ lesions (such as lentigo maligna, the large freckled lesion often found on the face of elderly patients), a margin of 0.5 cm is adequate. For invasive lesions, the following margins are generally accepted:

- Thickness <1.0 mm requires a 1.0 cm margin.
- 1–2 mm requires margins of 1–2 cm (there are little data to guide clinical decision making, so judgment is required and generally the wider margins are used if sufficient loose skin is available—such as the torso—and the narrower ones used in cosmetically difficult areas such as the face).
- >2.0 mm requires a 2.0 cm margin.

First draw a circle of the appropriate size around the lesion. Then plan the long axis of your excision site and draw triangles at both ends to convert your circle into a lens-shaped excision. Usually a ratio of length to width of 3.5:1 is advocated to allow closure without "dog ears" at the ends, but fatter excisions can be used if necessary.

When planning the long axis of the excision site, take the following general guidelines into consideration. For the extremities, use an incision parallel to the long axis of the extremity. If possible, put your long axis parallel to likely lymphatic drainage pathways. Plan your excision first and worry about closure later.

Take your wide excision down to fascia. It is no longer considered necessary to take the fascia with the excision. Generally, primary closure is possible. Sometimes a local rotation or tissue-transfer flap technique may allow closure (see references at the end). Split-thickness skin graft is an alternative when primary or transposed local tissue closure is not feasible.

Sentinel Lymph Node Biopsy

The general strategy and considerations for successfully sentinel lymph node biopsy are discussed in detail in Chap. 113 and will not be repeated here.

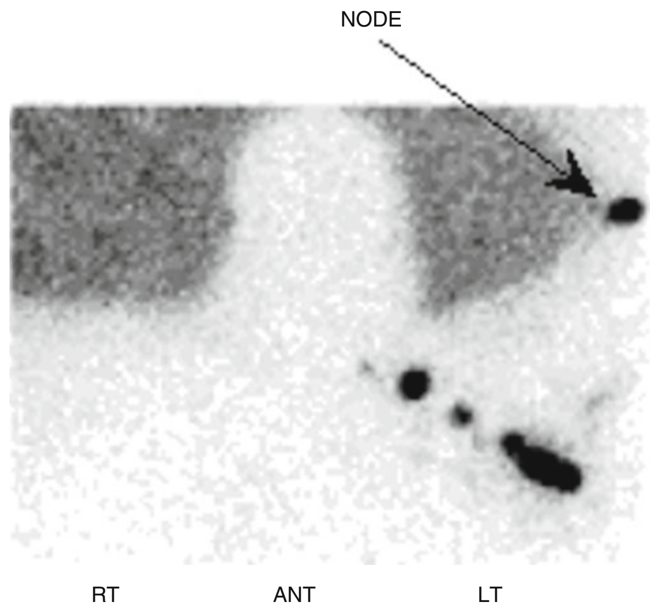

Fig. 116.1 A melanoma of the finger has drained to epitrochlear and axillary nodes (Courtesy of Dr Jennifer Carr, senior resident, and Dr James V Howe, IV, Professor of Surgery, University of Iowa Carver College of Medicine, Iowa City, IA)

Melanomas of the extremities drain in a predictable fashion to regional nodes, most commonly the axillary or inguinal nodes. Distal extremity melanomas sometimes drain to intermediate node basins such as the popliteal or epitrochlear nodes (Fig. 116.1). If so, that would be the "sentinel node" harvested. Thus, even for extremity melanoma, lymphoscintigraphy may be helpful. Truncal melanomas exhibit somewhat less predictable patterns. The trunk can be divided into four quadrants by a vertical line down the middle and a transverse line at the level of the umbilicus anteriorly and L2 posteriorly (the "belt line" or line of Sappey). Generally the lymphatics drain to the regional lymph node basin in their respective quadrant; thus, the skin of the left upper quadrant of the trunk will usually drain to the left axilla and so on. The line of Sappey is a watershed area and varies from person to person, so lymphatic drainage in this region is particularly prone to variation. Hence, the use of radioisotope and lymphoscintigraphy to localize the node is of crucial importance. Figure 116.2 shows an atypical drainage pattern that would not have been predicted based upon anatomic location.

Blue dye is used in addition to radiocolloid to enhance accuracy. It also makes it easy to see and clip or ligate lymphatics and thus may minimize subsequent lymphocele formation. Because blue dye travels through the lymphatic system rapidly, it is injected just before surgery.

Use the gamma probe to identify the region of greatest radioactivity and make an incision over this spot (see Chap. 113). Always make this incision in such a way that you can easily incorporate it into a subsequent lymphadenectomy incision, should this be required.

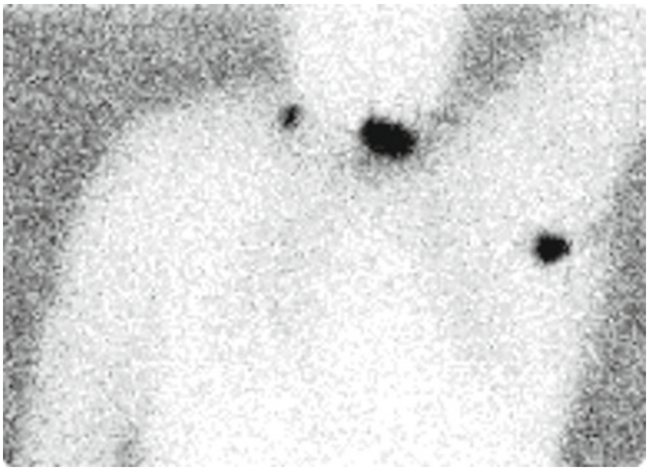

Fig. 116.2 A melanoma of the back has drained to both a left axillary and a right supraclavicular node (Courtesy of Dr Jennifer Carr, senior resident, and Dr James V Howe, IV, Professor of Surgery, University of Iowa Carver College of Medicine, Iowa City, IA)

Enter the nodal basin and palpate and inspect for abnormal nodes before proceeding. Remove any abnormal, radioactive, or blue node. The background count should be less than 10 % of the hottest node.

Documentation Basics

- Lymphoscintigram findings
- Counts and appearance (blue dye? abnormal to inspection or palpation?), number of nodes
- Margin taken
- Complex layered closure (if used)
- Flap closure (if used)
- If split-thickness skin graft, document area grafted in square centimeters.

Operative Technique

Frequently, wide excision and sentinel node biopsy are done under the same anesthesia. It may be possible to position the patient to allow both procedures to be done under the same prep, for example, a melanoma of the anterior trunk which drains to the axillary region. However, in many cases, it will be necessary to reposition the patient and re-prep and redrape to provide optimum exposure for both portions of the operation.

Inject the blue dye for sentinel node biopsy in four quadrants around the lesion or biopsy site, generally within the field that will be excised during wide excision. Massage the dye into the tissues. If this step is performed immediately after induction of anesthesia, usually sufficient time will have passed for the dye to migrate out of the local site by the time incision is made.

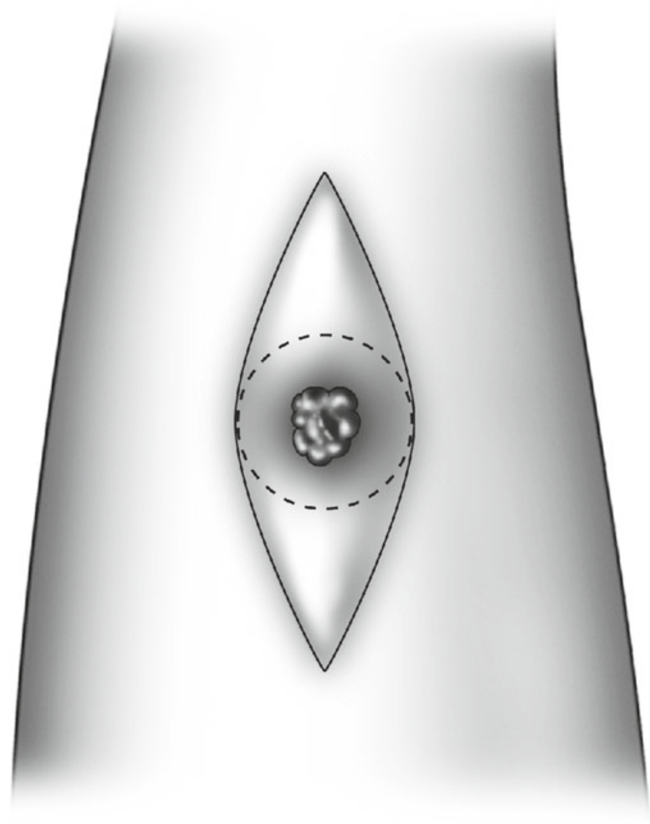

Fig. 116.3

Wide Local Excision

Draw a circle around the melanoma or the biopsy site. The radius of the circle depends upon the thickness of the melanoma, with 1 cm being adequate for thin melanomas (<1.0 mm) and 2 cm required for thick melanomas (≥2.0 mm). As noted previously (see Operative Strategy), intermediate-thickness melanomas generally are excised with 1–2 cm margins.

Convert the circle to an elliptical or lens-shaped incision by outlining two triangles at apposing ends (Fig. 116.3). Align the long access of the resulting incision with the regional lymphatics or the long axis of the limb (if arm or leg). Melanomas of the head and neck present particular challenges (see references at the end).

Incise the skin sharply and deepen the incision straight down to the deep fascia. Grasp one end of the specimen with an allis clamp and remove it by following the generally avascular plane just superficial to the deep fascia (Fig. 116.4). It is not necessary to remove the fascia. Orient the specimen with two sutures (e.g., long stitch = lateral, short stitch = superior) and submit it for pathological examination.

Undermine the incision in all directions by further dissection in the avascular plane superficial to the deep fascia. Close it in layers with interrupted 3-0 Vicryl and interrupted

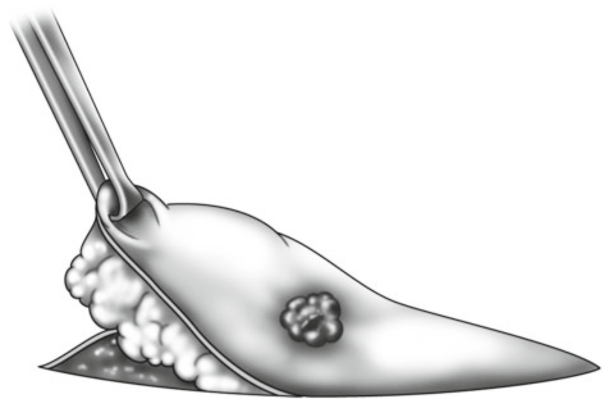

Fig. 116.4

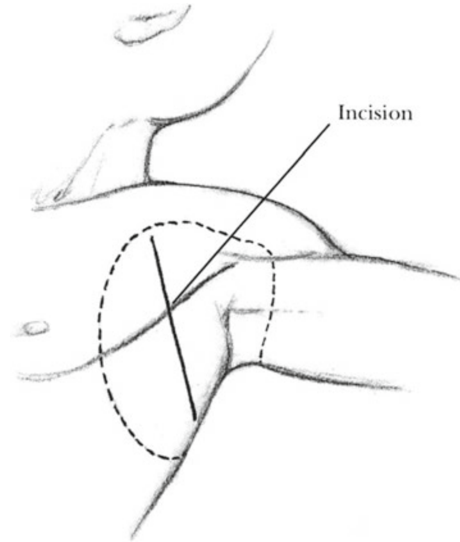

Fig. 116.5

vertical mattress sutures of 3-0 or 4-0 nylon. We rarely use a subcuticular closure for this purpose, as the incision is generally under some tension.

If the wound will not come together without undue tension, consider using a local flap (see references at the end). This decision is best made at the initial part of the procedure and the incision outlined accordingly. Alternatively, cut a split-thickness skin graft to secure coverage.

Sentinel Lymph Node Biopsy

Reposition and drape the patient, if necessary, to provide optimal exposure of the appropriate nodal basin as determined by the lymphoscintigram. Use the sterile gamma probe to identify the region of greatest radioactivity and make an incision directly over this spot. The incision can be as short as 1–2 cm in slender patients. Obese patients will require longer incisions, sometimes up to 3–4 cm. Plan the incision so that it could be excised easily during a subsequent lymphadenectomy, should this be required. Typical incisions for lymphadenectomy are shown in Figs. 116.5 and 116.6.

Be alert for blue lymphatics and, if you see one, gently dissect superficial to this and in a direction away from the primary site until you see the lymphatic dive deep to the appropriate draining node. If it is necessary to divide a lymphatic trunk, secure it with clips or ties to minimize seroma formation.

As with sentinel node biopsy for breast cancer (see Chap. 113), it is generally necessary to go through the superficial fascia to enter the space in which lymph nodes are found. Carefully inspect and palpate the fatty areolar tissue in this space. Any palpably or visibly abnormal nodes should be removed. Also remove any node that has taken up the blue dye or that is radioactive. Number the nodes as they are removed.

Perform a 10 s count on each node. Take time to find the hottest spot on the node. Continue to seek nodes until the

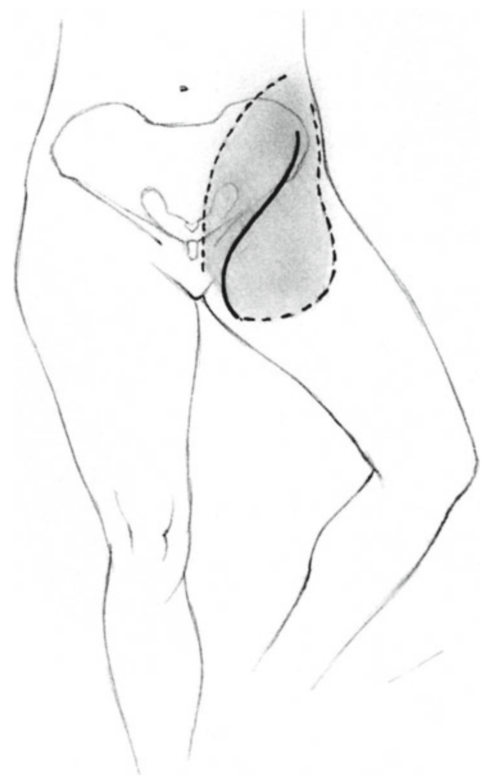

Fig. 116.6

background (post-excision) count is less than 10 % of the hottest node.

Obtain hemostasis and lymph stasis. Close the incision in layers (without drainage) with interrupted 3-0 Vicryl and running 4-0 Monocryl.

Postoperative Care

Although the incidence of lymphedema is lower after sentinel node biopsy than after lymphadenectomy, patients should be informed of the signs and symptoms. Any indication of lymphedema requires prompt treatment.

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117 Axillary Lymphadenectomy for Melanoma

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Malignant melanoma with positive sentinel node biopsy (see Chaps. 109 and 116)

Palpable lymph node metastases from other primary malignancies involving the skin of the upper extremity and shoulder, breast, and upper trunk

For breast cancer, the standard completion axillary node dissection is less radical than that described here. See Chap. 113 for details. In very rare circumstances, the radical dissection described here may be necessary for local control.

Preoperative Preparation

Obtain either fine-needle aspiration cytology positive nodal disease or a sentinel lymph node (SLN) biopsy positive for melanoma.

Perform staging studies such as computed tomography (CT) of the chest or abdomen, as indicated for the particular malignancy.

Pitfalls and Danger Points

Nerve injury (lateral pectoral, long thoracic, or thoracodorsal nerve; brachial plexus)

Injury to axillary vein

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Operative Strategy

Fundamentally, axillary lymphadenectomy employs the same strategy as that used for the modified radical mastectomy. Adipose and lymphatic tissues inferior to the axillary vein are excised en bloc from the clavicle to the anterior border of the latissimus muscle. Adequate exposure requires that the arm be flexed on the trunk to relax the major pectoral muscle during the medial part of the dissection. The levels of the axilla from level I (the lowest) to level III (the highest) are discussed in Chap. 114. Optimal access to level III nodes requires division and sometimes even removal of the minor pectoral muscle as described here. The long thoracic and thoracodorsal nerves may be preserved if they are not involved with tumor.

Documentation Basics

- Findings
- Level III nodes removed?
- Pectoralis minor muscle divided?
- Nerves preserved?

Operative Technique

See Chap. 114.

Incision

The skin incision, in a general way, follows the course of the axillary vein. Start the incision at the lateral border of the major pectoral muscle, and continue laterally across the axilla to the level of the latissimus muscle. The line of the incision is shown in Fig. 117.1. Frequently the incision

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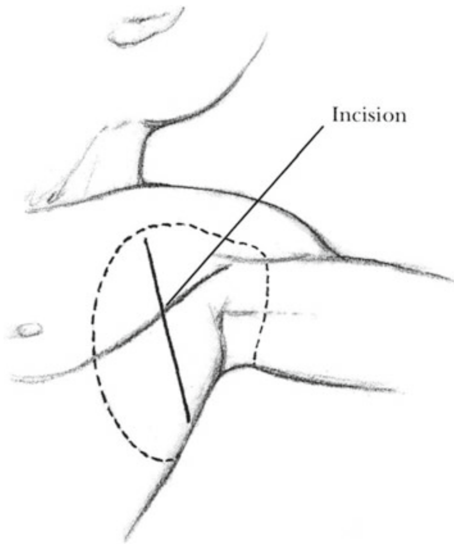

Fig. 117.1

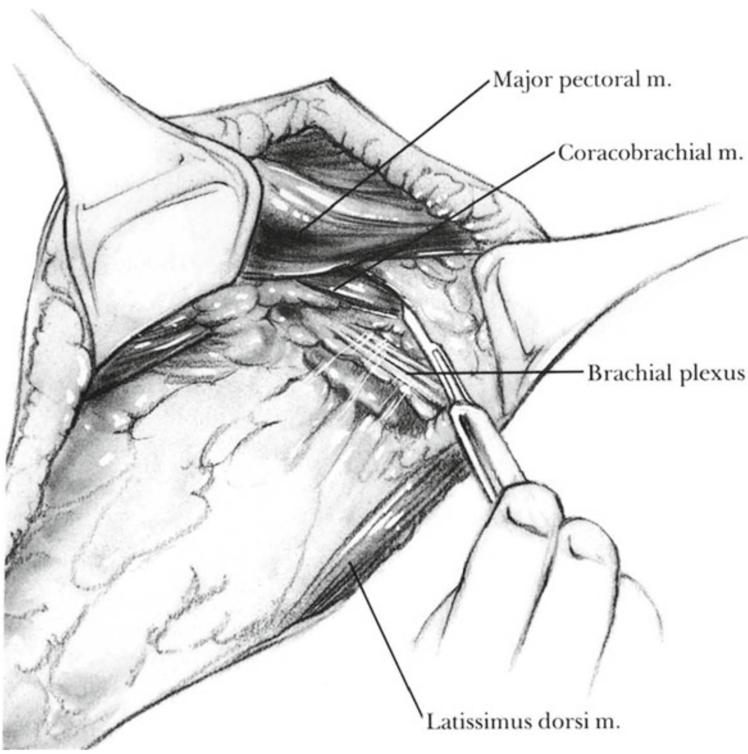

Fig. 117.2

can be made much shorter and confined to the area directly below the hair-bearing area of the axilla. An alternate skin incision, preferred by some surgeons, can be made parallel to the edge of the major pectoral muscle and slightly lateral to it. Elevate both the superior and inferior skin flaps, leaving no more than 8 mm of fat on the skin over the area indicated by the dotted lines in Fig. 117.1. The superior dissection exposes the anterior surface of the major pectoral muscle

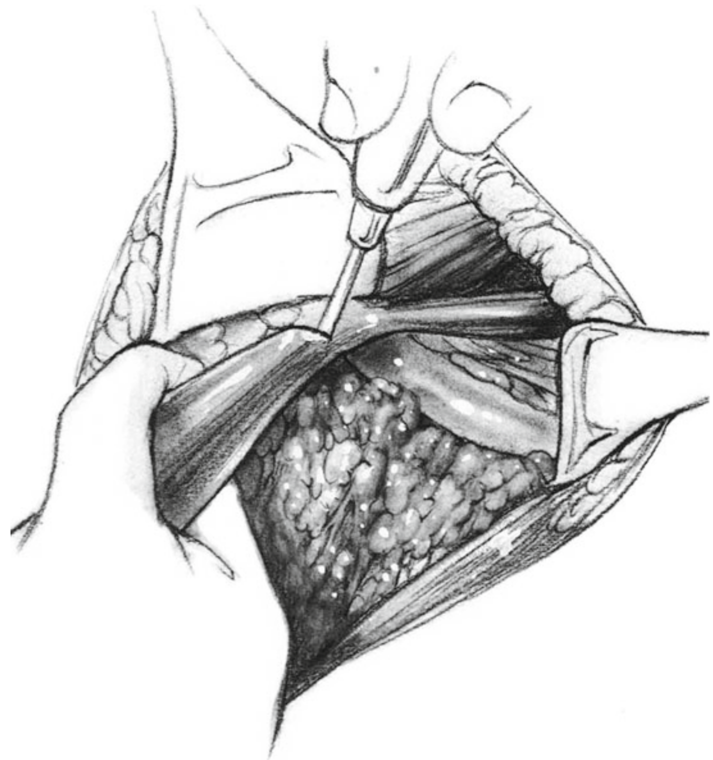

Fig. 117.3

in its medial aspect, the fat overlying the axillary vein and brachial plexus in the middle, and the coracobrachialis and latissimus muscles laterally (Fig. 117.2). Dissect the lower flap for a distance of 8 cm.

Exposing the Axillary Contents

Incise the fascia overlying the lateral border of the major pectoral muscle, and dissect it away from the undersurface of the muscle. Insert a Richardson retractor underneath the pectoral muscle and expose the coracobrachial muscle. Dissect fat and fascia off the inferior surface of the coracobrachial muscle, and continue this dissection toward the coracoid process where the coracobrachial meets the minor pectoral muscle. Encircle the minor pectoral muscle with the index finger, and divide it near its insertion using electrocautery (Fig. 117.3) if level III lymph nodes are to be excised. Branches of the medial pectoral nerve are seen entering the minor pectoral muscle near its *lateral* border. Divide these nerves, but take care to *protect the pectoral nerve*, *which emerges along the medial margin of the minor pectoral muscle* because this nerve largely constitutes the innervation of the major pectoral muscle. Freeing the minor pectoral muscle from the chest wall improves exposure for the axillary dissection. Incise the fat along the anterior border of the latissimus muscle to identify the lateral boundary of the lymphadenectomy.

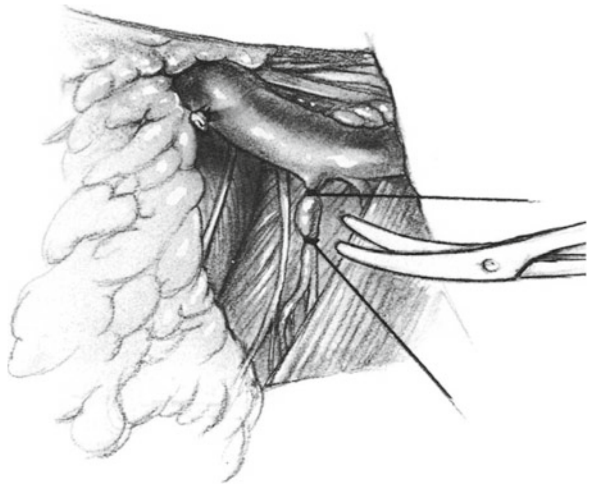

Fig. 117.4

Incise the thin layer of costocoracoid ligament at a level calculated to be just cephalad to the course of axillary vein. Do not skeletonize the nerves of the brachial plexus as it may produce a permanent painful neuritis. After dividing this ligament, sweeping the loose fat in a caudal direction generally exposes the axillary vein.

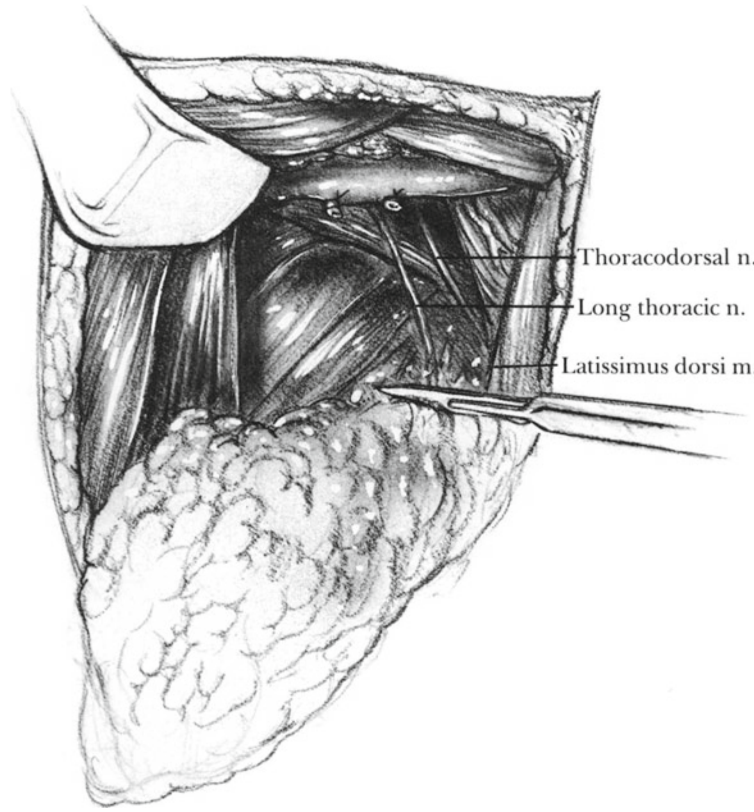

Fig. 117.5

Clearing the Axillary Vein

Identify the axillary vein in the lateral portion of the axilla. Elevate its adventitia with a Brown-Adson or DeBakey forceps and incise it with Metzenbaum scissors. Continue this division of the adventitia in a medial direction until the clavicle is reached. Several branches of the lateral anterior thoracic and thoracoacromial nerves and blood vessels are encountered crossing over the axillary vein. Divide each between hemostatic clips.

Dissect the adventitia in a caudal direction exposing the various branches of the axillary vein coming from below. Divide and ligate or clip each of the branches that enters the axillary vein on its inferior surface (Fig. 117.4). Preserve the subscapular vein, which enters the posterior wall of the axillary vein.

Dissecting the Chest Wall

Incise the clavipectoral fascia on a line parallel and just caudal to the axillary vein beginning at the level of the clavicle and continuing to the subscapular space. Suture a label to the lymph nodes at the apex of the dissection (near the clavicle). Make a vertical incision in the fascia from the apex of the dissection downward for 4–6 cm parallel to the sternum. Now sweep the lymphatic and adipose tissue, leaving its proximal half attached to the thorax. Divide the intercostobrachial nerve that emerges from the second intercostal space and enters the specimen. At this point in the dissection, the anterior and inferior portions of the axillary vein have been cleared along the upper 6–10 cm of the anterior chest wall.

Subscapular Space

In the subscapular space, use a gauze pad to dissect the loose fat and areolar tissue bluntly from above downward to clear the space between the scapula and the lateral chest wall. This step exposes the long thoracic nerve, which tends to hug the thoracic cage. Identify the thoracodorsal nerve, which crosses the subscapular vein and moves laterally together with the vessels supplying the latissimus muscle (Fig. 117.5).

If the anterior border of latissimus muscle was not dissected free during the first step in this operation, liberate this muscle now, preserving the thoracodorsal nerve. Dissect the specimen free of the chest wall after dissecting out and preserving the long thoracic nerve. Label the lateral margin of the lymph node dissection to orient the pathologist.

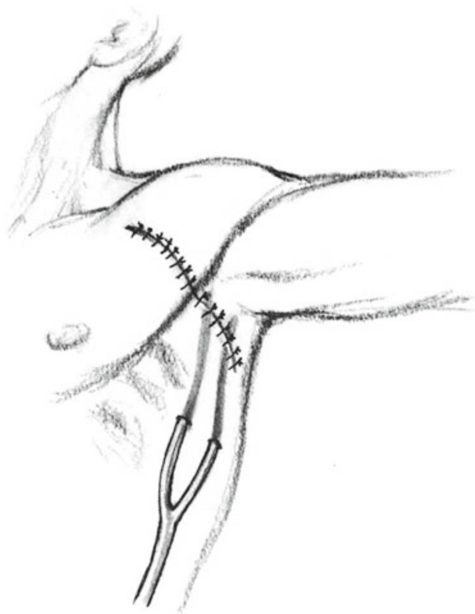

Fig. 117.6

Drainage and Closure

Make a puncture wound in the anterior axillary line about 10 cm below the armpit and pass a closed suction catheter into the apex of the axillary dissection near the point where the axillary vein goes under the clavicle. It may be necessary to suture the catheter in place with fine absorbable suture material.

Close the skin incision with interrupted 4-0 nylon sutures or skin staples. Attach the catheter to a closed suction drainage device (Fig. 117.6).

Postoperative Care

Maintain suction on the catheter until the drainage is less than 30 ml/day, and then remove the catheter.

Limit abduction of the arm during the first postoperative week, but thereafter encourage the patient to exercise the shoulder joint through its entire range of motion.

Encourage the patient to achieve full ambulation on the day after the operation.

A seroma may develop under the skin flap later in the postoperative course. If so, aspirate the fluid once or twice weekly as necessary.

Complications

Hematoma or seroma
Wound infection
Lymphedema (see Chap. 114)

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118 Inguinal and Pelvic Lymphadenectomy

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Metastatic involvement of inguinal lymph nodes secondary to malignant melanoma or squamous carcinoma of the skin of the lower extremity, lower trunk, or external genitalia (see Chap. 116)

Preoperative Preparation

Prescribe perioperative systemic antibiotics.

Prior to hospitalization, have the patient's lower extremity measured for a fitted elastic stocking to cover the area from the toes to the upper thigh.

Evaluate the extent of disease (computed tomography, magnetic resonance imaging, position emission tomography).

Pitfalls and Danger Points

Impairing the viability of the skin flaps
Injuring the iliofemoral artery or vein
Injuring the femoral nerve and its branches

Operative Strategy

Preserving Skin Viability

Traditionally, surgeons have used a vertical elliptical incision centered on the femoral vessels and have emphasized wide dissection of thin skin flaps. This practice often leads to areas of necrosis in the dissected skin. Delayed healing by secondary intention then causes some degree of subacute cellulitis and occlusion of collateral lymphatic pathways, increasing the incidence or severity of postoperative lymphedema of the extremity.

It is not necessary to dissect the skin flaps beyond the confines of the femoral triangle. The less extensive the dissection, the less impairment there is of the blood supply to the skin flaps. A primarily oblique skin incision along the inguinal crease is less apt to cause loss of viability than is the vertical incision.

Extent of Lymphadenectomy

Two lymph node groups are accessible and may be removed during a groin dissection: inguinal and pelvic lymph nodes. The inguinal (or superficial) nodes are located in the femoral triangle based on the inguinal ligament, with its apex formed by the crossing of the adductor longus and the sartorius muscles. The pelvic (or deep) component of the dissection includes the lymph nodes in a triangular area whose apex is formed by the bifurcation of the common iliac artery and whose base is essentially the fascia over the obturator foramen. The extent of lymphadenectomy is determined by the nature of the pathology. For example, extensive involvement of the inguinal nodes by melanoma of the lower extremity is generally considered an indication to remove the pelvic nodes. In such a case, the dissection

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generally begins with the superficial component and then progresses more deeply.

Exposing the Iliac Region

When exposing the region of the iliac vessels for a pelvic lymphadenectomy, two approaches have commonly been employed. One involves vertical division of the inguinal ligament along the line of the iliofemoral vein with later resuturing of this ligament and the floor of the inguinal canal. In some patients this suture line is insecure, resulting in a hernia. Moreover, patients in whom this approach is employed appear to have an increased number of skin complications. An alternative approach to the pelvis for iliac lymphadenectomy is to place a second incision in the lower abdomen parallel to and about 3–4 cm cephalad to the inguinal ligament. After this incision has been carried through the transversalis fascia, the peritoneal sac is retracted upward to expose the iliac vessels and their adjacent fat and lymph nodes. Exposure by this approach is adequate, and closing the incision is simple.

Documentation Basics

- Findings
- Superficial or superficial and deep?
- Transposition of sartorius muscle or not?

Operative Technique

Incision and Exposure

Position the lower extremity so the thigh is mildly abducted and flexed as well as being externally rotated. Support the leg in this position by a firm pillow or sandbag.

Start the incision 2–3 cm cephalad and medial to the anterosuperior spine of the ilium. Continue caudally to a point 1–2 cm below the inguinal crease. Continue along the inguinal crease in a medial direction until the femoral vein has been reached. At this point curve the incision gently in a caudal direction for about 5 cm, as noted in Fig. 118.1. Elevate the cephalad skin flap with rake retractors. Use electrocautery with a low cutting current or a scalpel to dissect the skin flap in a superior direction in a plane that leaves 4–5 mm of subcutaneous fat on the skin. In obese patients we make the plane of dissection somewhat deeper than 4–5 mm. As the skin flap is dissected toward the outer margin of the operative field, increase the thickness of the flap in a tapered fashion so the base of the flap is thicker than its apex. The cephalad margin of the dissection should be 5–6 cm above the inguinal ligament. Now dissect the inferior skin flap in a similar fashion. Remember that it is not necessary to elevate this skin flap beyond the lower boundaries of the femoral triangle. The lateral boundary consists of the medial border of the sartorius muscle, and the lateral aspect of the adductor longus muscle is the medial boundary. The apex of the femoral triangle constitutes the point where the sartorius muscle meets the adductor longus. Dissecting the skin beyond the femoral triangle has no therapeutic value and may impair blood supply to the skin.

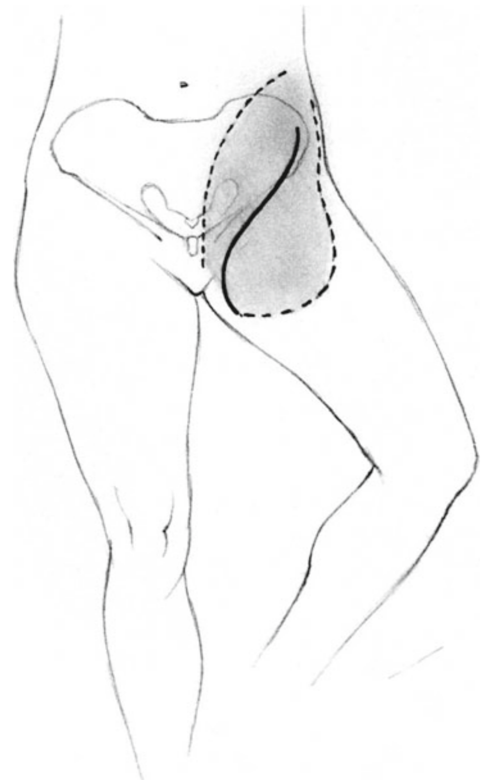

Fig. 118.1

Exposing the Femoral Triangle

Initiate the dissection along a line parallel and 5–6 cm cephalad to the inguinal ligament. Incise the fat down to the aponeurosis of the external oblique muscle. Using a scalpel, dissect the abdominal fat off this aponeurosis down to and beyond the inguinal ligament. In men, identify and preserve the spermatic cord as it emerges from the external inguinal ring (Fig. 118.2).

Use a scalpel or Metzenbaum scissors to incise the fat overlying the adductor longus muscle just below the inguinal ligament, about 2 cm medial to the pubic tubercle. Expose the muscle fibers of the adductor muscle and use a scalpel to dissect the fat and fascia down along the lateral boarder of this muscle. Continue the dissection along this muscle in a caudal direction to a point where the sartorius muscle crosses the lateral margin of the adductor longus muscle. Sweep the

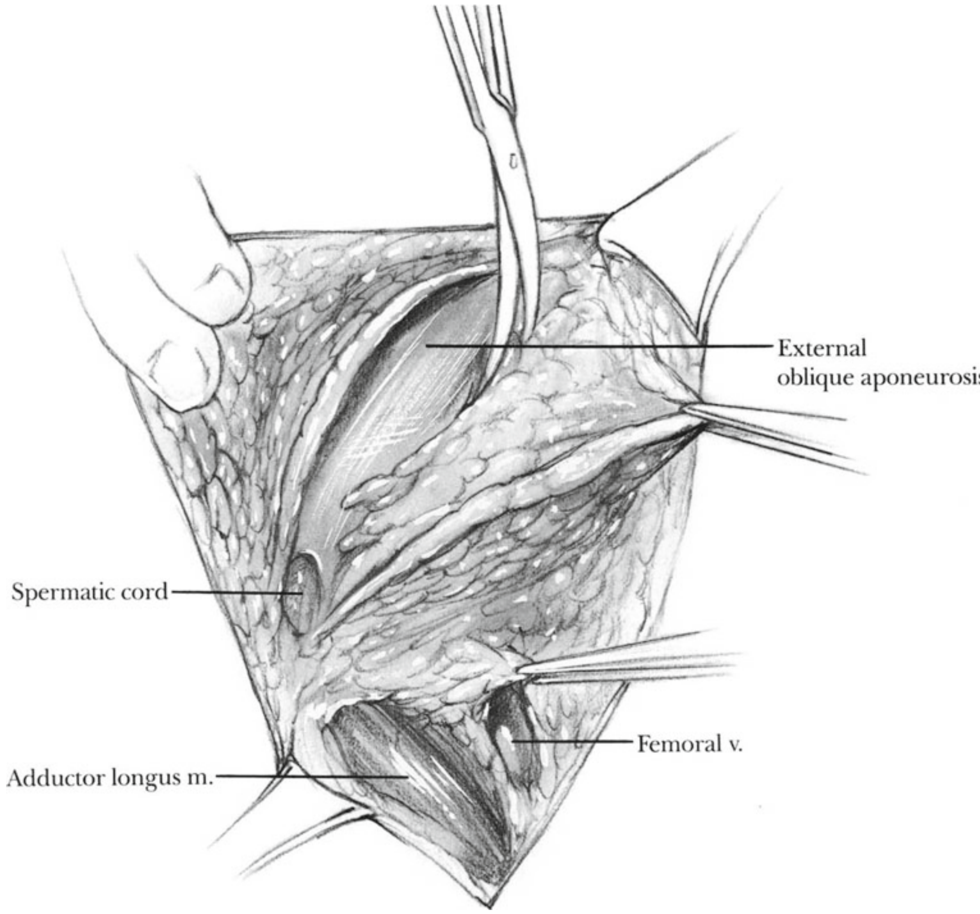

Fig. 118.2

muscle fascia, fat, and lymph nodes in a medial direction (Fig. 118.3). At the apex of the femoral triangle, identify, ligate, and divide the internal saphenous vein. Then incise the fascia overlying the sartorius muscle beginning at the apex of the femoral triangle and continuing in a cephalad direction up to the origin of the sartorius muscle at the iliac bone. Sweep the fat, lymphatic tissue, and fascia overlying the sartorius muscle by dissecting in a medial direction.

Dissecting the Femoral Artery, Vein, and Nerve

Identify the femoral artery and vein near the apex of the femoral triangle. Using Metzenbaum scissors dissection, elevate the areolar tissue and fat from the anterior surfaces of the femoral vessels proceeding in a cephalad direction (Fig. 118.3). Dissect the specimen from the medial border of the femoral triangle in a lateral direction to expose the medial aspect of the femoral vein. There are no branches on this side of the vein. Identify the entrance of the internal saphenous vein into the anterior surface of the femoral vein. Ligate and divide the saphenous vein. This dissection has exposed the pectineus muscle deep to the femoral vein and medial to the adductor longus muscle. The femoral canal is located deep to the inguinal ligament just medial to the femoral vein. Remove and identify the cephalad lymph node situated in this triangle, and label it for the pathologist. Continue to dissect the specimen laterally, exposing the length of the femoral artery. Several small arterial branches going to the specimen must be divided and ligated before the specimen can be separated from this vessel. Note that the femoral nerve, situated just lateral to the femoral artery, is covered by a thin fibrous layer of the femoral sheath. Carefully incise this layer at a point below the inguinal ligament and lateral to the femoral artery. Identify and preserve the branches of the femoral nerve as the nerve passes deep to the sartorius muscle. After this step, detach the specimen.

Irrigate the operative field and achieve complete hemostasis by means of PG ligatures and electrocautery. This step concludes the inguinal (superficial) groin dissection. The appearance of the operative field is illustrated in Fig. 118.4.

Transposing Sartorius Muscle

Necrosis of the skin overlying the femoral vessels occurs in some patients and endangers the viability of these structures. To protect the femoral artery and vein from the consequences of a possible slough, we prefer to transpose the sartorius

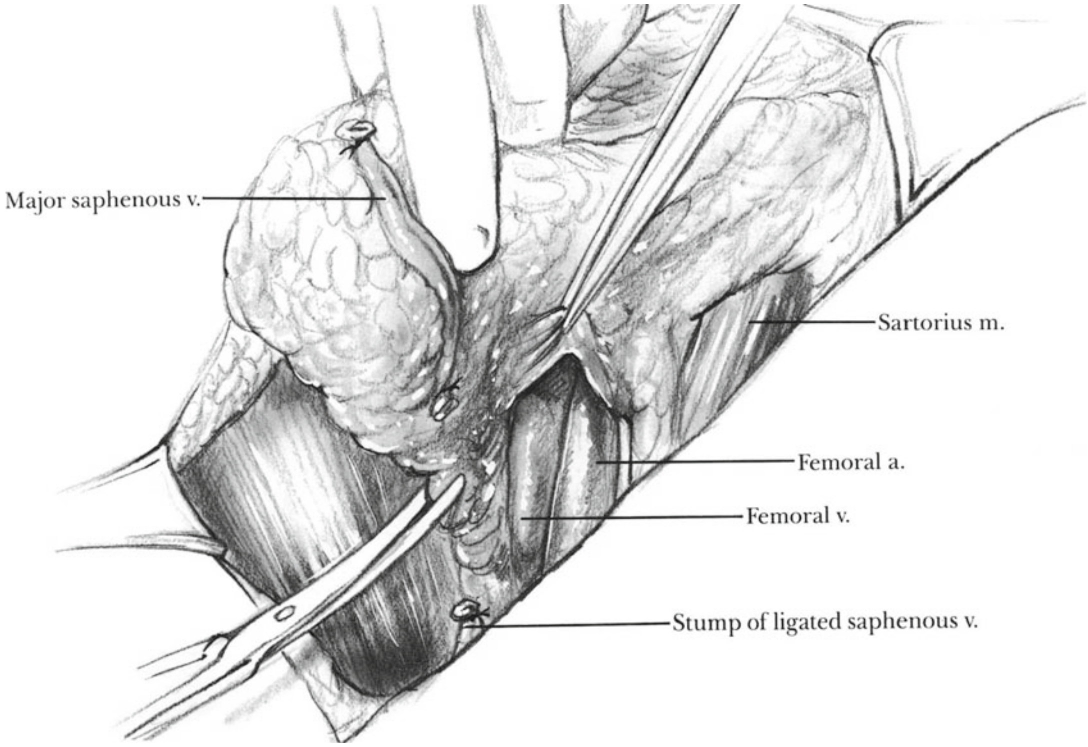

Fig. 118.3

muscle in a medial direction, so it lies over the femoral vessels (Fig. 118.5). This step is optional. Transect the sartorius muscle at its insertion with the electrocoagulating device (Fig. 118.6). Free the proximal 6–7 cm of this muscle from underlying attachments, and transpose it in a medial direction, so it is now situated in a vertical line overlying the femoral vessels. Suture the cut end of the sartorius muscle to the inguinal ligament using interrupted 3-0 Tevdek sutures (Fig. 118.7) prior to closing the skin.

Pelvic Lymphadenectomy

Make an incision with the scalpel in the direction of the fibers of the external oblique aponeurosis at a level about 3–4 cm above the inguinal ligament from the region above the external inguinal ring to the anterosuperior spine (Fig. 118.7). Divide the underlying internal oblique muscle with the electrocoagulator, carrying the incision through the transversus muscle together with the underlying transversalis fascia but not through the peritoneum. This procedure is similar to that used in Chap. 88 for the exposure required during a Cooper's ligament repair of an inguinal or femoral hernia. Identify the deep inferior epigastric artery and vein arising just above the inguinal ligament from the external iliac artery and vein. Ligate and divide the deep inferior epigastric vessels. Use gauze dissection to sweep the peritoneum together with the abdominal contents in a cephalad direction. Insert a moist gauze pad and a wide, deep retractor to elevate these structures out of the pelvic cavity. *Identify and preserve* the ureter, which generally remains adherent to the peritoneal layer and has been elevated together with the abdominal structures behind the retractor.

The area to be dissected is that contained between the external iliac and the internal iliac vessels down to the obturator membrane overlying the obturator foramen (Fig. 118.8). Initiate the mobilization by dissecting the lymph nodes and fat overlying the external iliac artery and vein beginning at the inguinal ligament and proceeding in a cephalad direction to the junction with the internal iliac vessels. Be careful when clearing fat and lymphatic tissue from the iliac vein, as this structure is quite fragile. Lacerations of the vein produce considerable hemorrhage that is difficult to control. After sweeping the fat and lymphatic tissues from the apex of the dissection in a downward direction, identify and preserve the obturator artery and vein. Terminate the dissection at this point and remove the specimen. Hemostasis is achieved during this dissection primarily by careful application of hemoclips and ligatures. After hemostasis is ensured, irrigate the pelvis with a dilute antibiotic solution.

Close the incision of the lower abdomen in layers by inserting interrupted 2-0 silk sutures into the transversalis fascia and the overlying aponeurosis of the transversus muscle, then into the internal oblique muscle, and finally into the external oblique aponeurosis. Close the defect in the femoral canal by suturing the inguinal ligament down to Cooper's

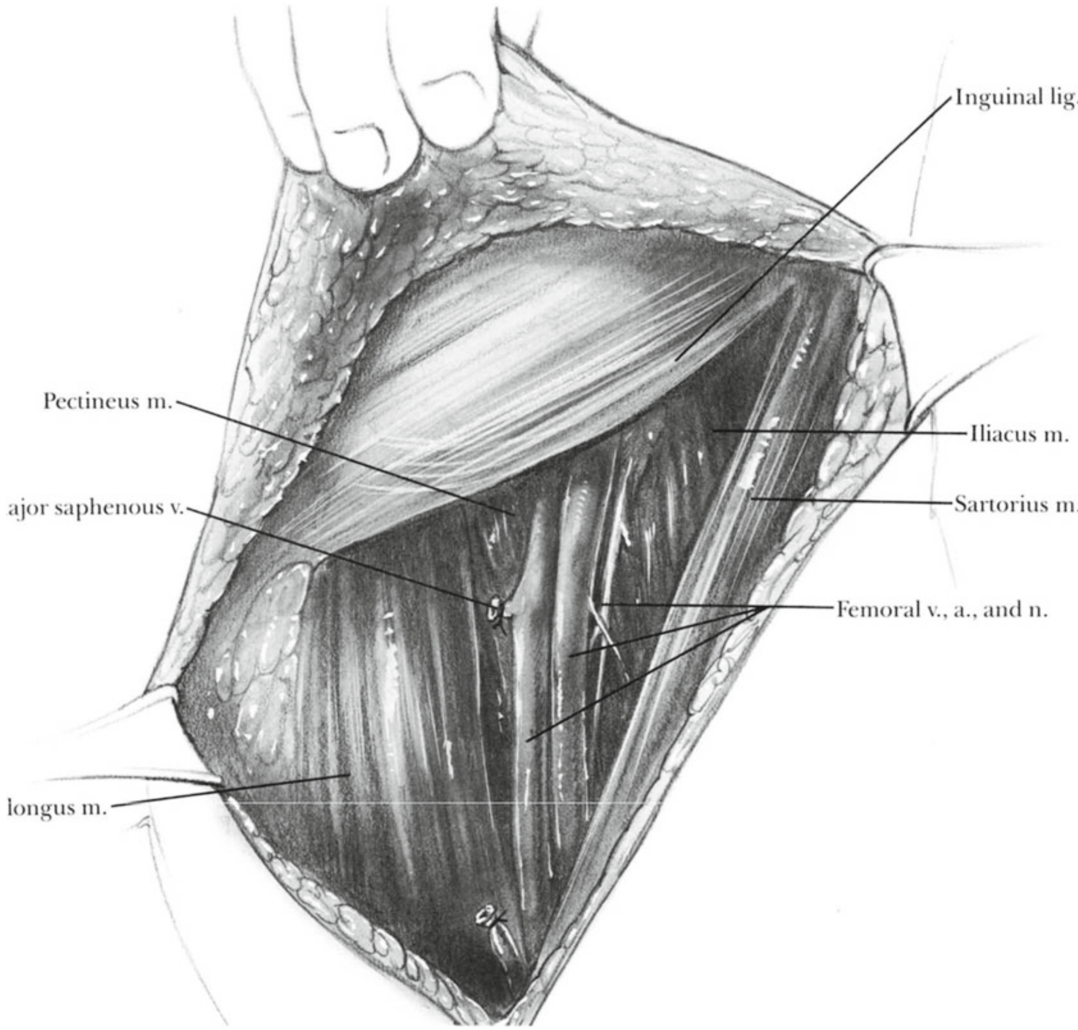

Fig. 118.4

ligament or the pectineus fascia from below. No drains are placed in the pelvis.

Skin Closure and Drainage

Drain the area of the femoral triangle by passing two perforated plastic catheters (3.0 mm in internal diameter) through puncture wounds in the area of the inguinal lymphadenectomy. Attach the catheters to a closed suction drainage device. Irrigate the operative field again with a dilute antibiotic solution. Trim away any portion of the skin that seems devitalized. Close the skin with interrupted sutures of 4-0 nylon.

Postoperative Care

Prescribe perioperative antibiotics.

Continue closed suction drainage until the volume is less than 40 ml/day.

In the operating room, apply the elastic stocking that was ordered preoperatively to fit this patient's lower extremity.

Keep the patient at bed rest with the extremity elevated for no more than 2–3 days. Thereafter, although patients are permitted to walk, they should spend only a short time sitting in a chair. Rather, much of the day should be spent in bed with the leg elevated. After discharge from the hospital, patients should continue to wear a snug elastic stocking up to the upper thigh for at least 6 months. For the first 6–8 weeks, they should lie down with the leg elevated for 1 h three times daily; otherwise permanent lymphedema of the extremity is likely.

Complications

Skin necrosis is preventable if care is taken when preparing the skin flaps and if unnecessarily extensive dissection of the skin flaps is avoided.

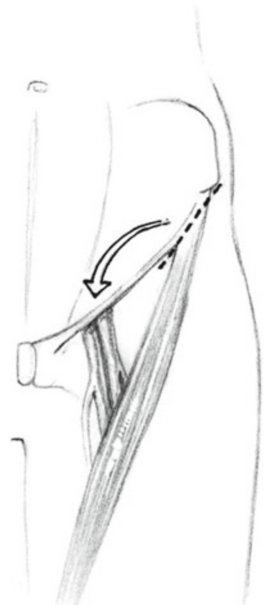

Fig. 118.5

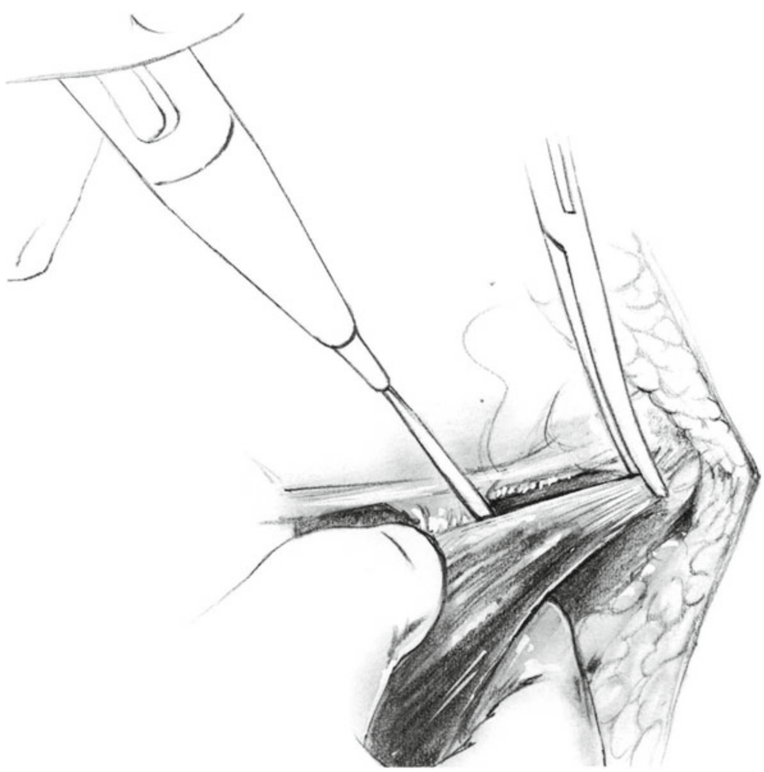

Fig. 118.6

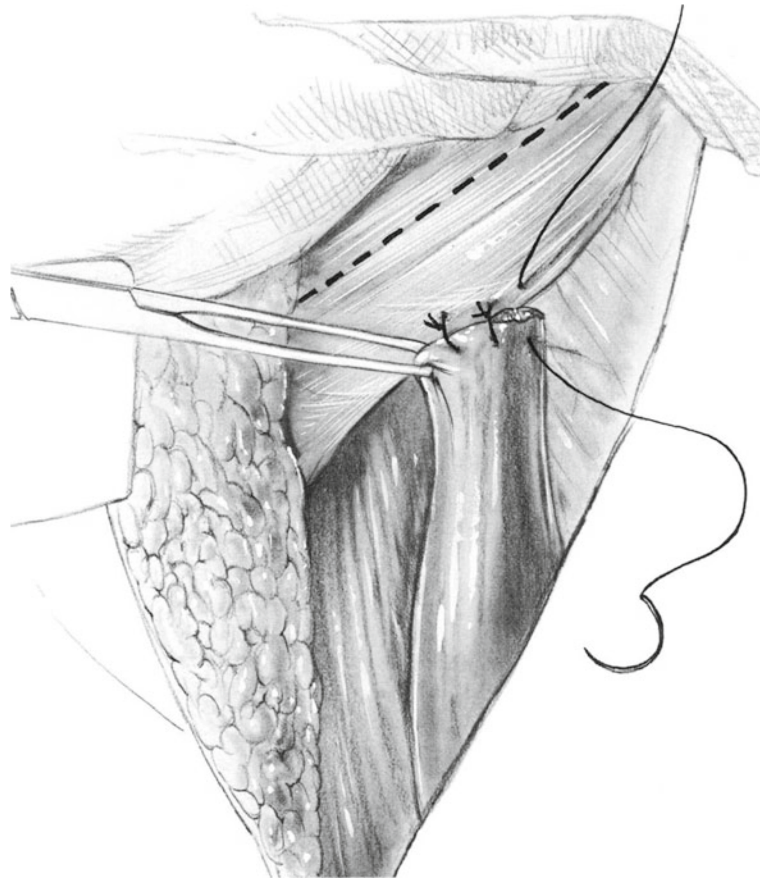

Fig. 118.7

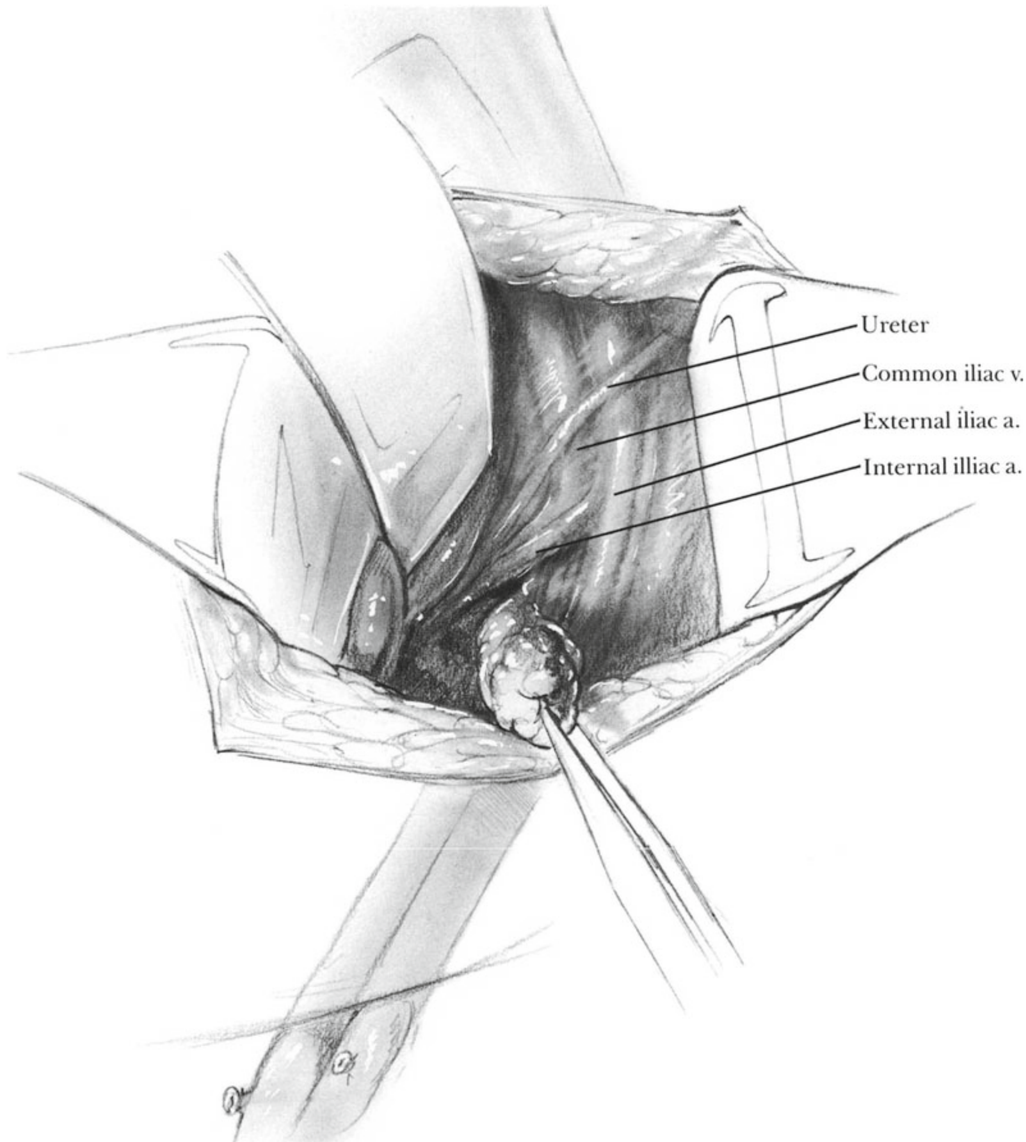

Fig. 118.8

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Part XII

Thyroid, Parathyroid, and Adrenal

Concepts in Thyroid, Parathyroid, and Adrenal Surgery

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Philip M. Spanheimer and Ronald J. Weigel

Thyroid

Thyroid surgery has progressed significantly since it was first reliably performed in the second half of the nineteenth century by Billroth and Kocher. In most cases a diagnosis is established by history, physical exam, biochemical tests, imaging, and, in cases of suspected malignancy, fine-needle aspiration biopsy (FNAB). Open biopsy or simple enucleation of thyroid nodules is generally not performed. Rather, a lobe or majority of a lobe, if not most or all of the gland, is resected in situations where resection is indicated or a tissue sample with gland architecture is needed to rule out malignancy. Thyroid resections are performed for benign disorders and thyroid cancer with the extent of resection dependent on the specific pathology being treated.

Benign Disorders

Graves' Disease

Diffuse toxic goiter, or Graves' disease, is a disorder characterized by the classic triad of goiter, hyperthyroidism, and exophthalmos. Graves' disease is caused by the production of antibodies that bind to the thyroid-stimulating hormone (TSH) receptor causing thyrocytes to proliferate and produce excess thyroid hormone. This results in symptoms of hyperthyroidism including heat intolerance, increased sweating, and weight loss. Additionally approximately 50 % of patients with Graves' disease develop ophthalmopathy characterized by prominent stare, periorbital edema, conjunctival swelling, proptosis, and limitation of upward and lateral gaze. Graves' disease is diagnosed biochemically with a suppressed thyroid-stimulating hormone (TSH) with or without elevated free T4 or T3. A TSH below the normal range and ophthalmopathy is diagnostic for Graves' disease. In the absence of ophthalmopathy, an I123 uptake scan should be performed to distinguish Graves' disease (diffuse uptake) from other causes of hyperthyroidism, such as toxic nodule or toxic multinodular goiter.

Currently there are three modalities for the treatment of Graves' disease: antithyroid medications, thyroid ablation, and thyroidectomy. Typically first-line treatment is antithyroid medication followed by ablation with radioactive iodine (RAI) for refractory cases. Operative management is recommended for patients with suspicious nodules or known thyroid malignancy, those who have a contraindication to radioactive ablation (including pregnancy and the desire to become pregnant), and patients who have symptoms of tracheal, esophageal, or venous compression. Relative indications include severe ophthalmopathy, which is not improved with antithyroid medication, and poor compliance with medications.

Controversy exists as to the extent of thyroidectomy. Most surgeons advocate total or near-total thyroidectomy for patients with known or possible thyroid cancer, severe symptoms, and those having had life-threatening reactions to antithyroid medications. The remaining patients should undergo subtotal thyroidectomy. Leaving more thyroid tissue increases the chance of recurrence while lowering the chance of postoperative hypothyroidism. Typically surgeons are recommended to leave a 4–7 g remnant in adults and 3 g in children. Prior to surgery patients should be started on Lugol's iodide three drops twice daily to reduce the vascularity of the gland. When performing subtotal thyroidectomy, tissue can be left on either side (Dunhill operation) or total lobectomy on one side with subtotal lobectomy on the other. Although the Dunhill operation offers theoretical benefits in minimizing dissection around the recurrent laryngeal nerves and parathyroid glands, both procedures have similar rates of complication and recurrence. Long-term follow-up with

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TSH is recommended for all patients with Graves' disease after any procedure. Recurrent Graves' disease is usually managed with RAI, but in refractory cases, completion thyroidectomy can be necessary.

Toxic Multinodular Goiter

Toxic multinodular goiters (TMNG) typically occur in older patients with a history of nontoxic MNG. Symptoms are often precipitated by iodide administration, as occurs with contrast media or amiodarone and usually include atrial fibrillation and congestive heart failure with or without other symptoms of hyperthyroidism. Diagnosis is made by elevated free T4 or T3 levels with a suppressed TSH and increased uptake in multiple nodules on RAI scan. Since radioiodine is usually inadequate to ablate the thyroid gland in these patients, surgical resection is the first-line treatment for patients with TMNG, most commonly with subtotal or total thyroidectomy. Postoperatively, patients are placed on thyroid hormone to suppress recurrent goiter formation, so leaving adequate thyroid tissue to prevent hypothyroidism is not necessary. Care must be taken in identifying the recurrent laryngeal nerve as it can be displaced laterally or anteriorly by the goiter. FNAB should be performed on dominant and enlarging nodules to rule out malignancy.

RAI can be used but requires higher doses and has a lower success rate than with Graves' disease and is typically reserved for elderly patients and those that are not operative candidates.

Toxic Adenoma

Toxic adenomas are characterized by somatic mutation of the TSH receptor leading to autonomous proliferation and synthesis of thyroid hormone. Most occur in young patients and arise from long-standing nodules that are noted to have a rapid increase in size. RAI scanning shows increased uptake in the nodule with suppression of the remainder of the gland. Small nodules typically can be managed medically while large nodules can be treated with lobectomy or isthmusectomy. Total thyroidectomy is rarely required as these nodules have a low rate or recurrence and very low malignant potential.

Riedel's Thyroiditis

Riedel's thyroiditis is a rare disorder characterized by the replacement of the thyroid parenchyma with fibrous tissue. It is most common in middle-aged women, and although the exact etiology is unknown, it is believed to be autoimmune mediated. The most common symptoms are of mass effect on the trachea and esophagus (dyspnea, dysphagia, hoarseness). Later patients develop symptoms of hypothyroidism as glandular tissue is replaced by fibrosis. Diagnosis is made after palpation of a "woody," fixed thyroid. Open biopsy confirms the diagnosis as FNAB is not diagnostically useful.

Thyroidectomy is the first-line treatment for Riedel's thyroiditis. Goals of the operation are to relieve compression on the trachea by wedge excision of the isthmus and as an open biopsy to confirm the diagnosis. More extensive resection is not recommended due to invasive fibrosis, which renders surgery difficult. Patients require thyroid hormone replacement after developing hypothyroidism, and some patients with continued symptoms after wedge resection improve with corticosteroids.

Goiter

A goiter is any enlargement of the thyroid gland and can be diffuse, uninodular, or multinodular. Most are caused by the inability to synthesis adequate thyroid hormone leading to thyroid hyperplasia from persistent TSH stimulation. Causes range from dietary deficiency of iodine to inherited disorders in the enzymes of thyroid hormone synthesis, although in most cases no cause can be identified. Most patients are asymptomatic, but as goiters become large, they cause compressive symptoms including dysphagia, dysphonia, and even tracheal deviation and obstruction of venous flow in the neck. Typically patients are biochemically euthyroid and RAI scan shows patchy uptake. FNAB should be performed on any dominant or enlarging nodules as 5–10 % of patients with multinodular goiter develop malignancy.

Most patients do not require treatment other than correction of the underlying cause, if one can be identified. Operative indications include obstructive symptoms, substernal extension, proven or suspected malignancy, continued growth despite T4 suppression, and cosmesis. Subtotal and total thyroidectomy are the most commonly performed procedures; management of patients with confirmed or suspected malignancy will be discussed in the next section. Adequate remnant thyroid tissue does not need to be left as all patients require suppressive postoperative thyroid hormone.

Thyroid Carcinoma

The majority of thyroid nodules are benign; however, it is important to determine the risk for underlying malignancy. Risk factors for malignancy include local symptoms (pain, dysphagia, hoarseness, choking), history of external beam radiation, and family history of either medullary or nonmedullary thyroid cancer. Following identification of a thyroid nodule, FNAB should be performed. Patients with history of external beam radiation or a strong family history have an increased concern for malignancy and in some cases may require thyroidectomy despite a negative FNAB. If the FNAB is nondiagnostic, it should be repeated. For patients with a cystic nodule and benign FNAB, the cyst contents should be aspirated. Aspiration can be performed as many as three times, after which the patient should undergo thyroidectomy for recurrent cysts. Patients with colloid nodules and benign FNAB who are otherwise asymptomatic should be followed clinically. Thyroid resection should be performed on these patients if growth of the nodule is observed or if they develop symptoms. Patients with benign cytology can be treated with suppressive T4 therapy, but treatment has not been shown to influence the development or progression of thyroid carcinoma, the rate of thyroidectomy, or overall survival.

Recommendations for patients with "indeterminate" or suspicious follicular cytology on FNAB are made according to the underlying risk of malignancy. Some surgeons advocate hemithyroidectomy with intraoperative pathology, with completion thyroidectomy for malignancy. However, the false-negative rate of intraoperative pathology is around 20 % leading to a high rate of reoperation. The advantages of hemithyroidectomy include eliminating the risk of bilateral recurrent laryngeal nerve injury and permanent hypocalcemia and preventing the need for thyroid hormone replacement in 60–80 % of patients. Patients with thyroiditis or multinodular disease have a higher incidence of requiring thyroid hormone replacement following hemithyroidectomy.

Papillary Thyroid Carcinoma

Papillary carcinoma of the thyroid is the most common malignant disorder of the thyroid and accounts for 80 % of all thyroid malignancies. Patients with papillary thyroid carcinoma have a 10 years survival that is greater than 95 %. Criteria that predict higher mortality are older patients, poorly differentiated tumors, extrathyroid invasion, metastasis, and tumor size.

The extent of surgery for papillary carcinoma is somewhat controversial. Some authors feel that due to the low mortality of the condition, patients with low-risk cancers are adequately treated with thyroid lobectomy. Others favor total thyroidectomy to enable use of RAI, reduce recurrence and reoperation, and enable use of thyroglobulin level to access for recurrent disease. Patients with aggressive tumors displaying capsular or vascular invasion and multifocal tumors and patients with bulky lymph nodes should undergo total thyroidectomy and, when appropriate, central neck dissection.

The extent of neck dissection in papillary thyroid cancer is highly debated. Patients with papillary carcinoma commonly require a level VI lymph node dissection for clinically involved nodes. Palpable nodes in the central compartment and lateral neck should be removed, and patients with confirmed lateral nodal metastasis (either preoperatively with ultrasound and FNAB or on intraoperative frozen section) should undergo modified radical neck dissection. In patients with clinically negative nodal disease, the use of prophylactic node dissection is advocated by some investigators; however, the risk of nerve injury and hypoparathyroidism has led many experts to reserve neck dissection to those with clinically involved nodes.

Follicular Thyroid Carcinoma

Follicular carcinoma of the thyroid gland accounts for around 10 % of thyroid cancer in non-iodine-deficient areas and is more common in regions of iodine deficiency. Diagnosis by FNAB is complicated by the inability to distinguish follicular adenoma from carcinoma. Around 20 % of follicular lesions are malignant, with up to a 50 % incidence in older patients with large nodules.

Due to the risk of malignancy, patients with follicular lesions on FNAB should undergo thyroid resection. In some institutions, patients undergo thyroid lobectomy with intraoperative frozen section and completion thyroidectomy for malignancy. Solitary follicular nodules in the setting of a normal contralateral lobe can be treated with lobectomy, and no further treatment is necessary if pathology confirms benign disease. Distinction of adenoma from carcinoma can be difficult, and up to 20 % of patients with benign frozen section will reveal malignancy on formalin-fixed paraffin-embedded final pathology. Patients with malignancy on final pathology should return to the operating room for completion thyroidectomy. Although completion thyroidectomy in the setting of adequate resection margins has not been shown to increase survival, this approach enables the use of thyroglobulin as a marker of recurrence and allows for RAI ablation if metastatic disease is present. Prognosis for patients with follicular carcinoma is good, with 10- and 20-year mortality around 15 and 30 %, respectively. Higher mortality is observed in older patients, larger tumors, higher tumor grade, tumors with vascular or extrathyroid invasion, and patients with distant disease.

Medullary Thyroid Carcinoma

Medullary carcinoma (MTC) arises from the parafollicular or C cells of the thyroid that produce calcitonin. Most MTCs arise sporadically, but approximately 25 % occur due to the inherited conditions familial medullary thyroid cancer (FMTC) and multiple endocrine neoplasia (MEN) 2A and 2B. Both FMTC and the MEN2 syndromes are caused by mutations in the RET proto-oncogene. All patients with MTC should be screened for RET mutations and the presence of concurrent pheochromocytoma, as failure to identify a pheochromocytoma could result in hypertensive crisis and death. Patients with MTC and pheochromocytoma generally have bilateral adrenal disease, and adrenal disease should always be addressed before any other manifestation of MEN syndromes.

Total thyroidectomy is the preferred treatment for MTC due to the high incidence of bilateral disease and the unresponsiveness to 131I. All patients with MTC should undergo bilateral central neck dissection at the time of operation, and patients with positive nodes, palpable nodes, or tumor size greater than 1.5 cm should undergo modified radical neck dissection.

With increased detection of RET mutations, there is an increasing role for prophylactic thyroidectomy. Prophylactic thyroidectomy results in high rates of disease cure before disease can be clinically detected. Patients with RET mutations should be managed according to the risk of that specific mutation as defined by the American Thyroid Association guidelines. In some patients with low-risk mutations, it is safe to delay prophylactic thyroidectomy when calcitonin levels and neck ultrasonography are normal. However, the penetrance of MTC in patients with RET mutations approaches 100 %, and all patients with identified mutations should undergo prophylactic thyroidectomy at a time indicated by their specific mutation.

Hurthle Cell Carcinoma

Hurthle cell carcinoma is a rare tumor accounting for around 3 % of thyroid malignancies. The World Health Organization classifies Hurthle cell carcinoma as a type of follicular thyroid carcinoma, and like follicular carcinoma, diagnosis of Hurthle cell carcinoma cannot be made on FNAB. Hurthle cell carcinoma are more likely to be multifocal and bilateral, more likely to metastasize to lymph nodes and distant sites, and have a higher mortality (20 % at 10 years) compared to follicular carcinoma. These findings have led some groups to consider Hurthle neoplasms a separate entity.

Operative management consists of hemithyroidectomy with isthmusectomy and intraoperative frozen section, followed by completion thyroidectomy for malignancy. Due to the higher incidence of spread, patients with Hurthle cell carcinoma should undergo routine central neck dissection and modified radical neck dissection when palpable nodes are present.

Parathyroid

The parathyroid glands are responsible for the production of parathyroid hormone (PTH), the most important hormone in calcium homeostasis. Embryologically the superior parathyroid glands are derived from the fourth branchial pouch and the inferior glands from the third branchial pouch. The glands remain closely associated with their pouch derivatives: the thyroid gland for the superior and the thymus for the inferior. In most patients the superior glands lie dorsal to the recurrent laryngeal nerve at the level of the cricoid cartilage, with the inferior glands located ventral to the nerve. Enlarged glands can migrate in position and can displace the RLN.

Primary Hyperparathyroidism

The exact cause of primary hyperparathyroidism (HPT) is not known, although multiple inherited syndromes have been described. Primary HPT is the most common clinical manifestation of MEN1. Presently the most common presentation is asymptomatic individuals noted to have elevated serum calcium on screening tests. The diagnosis is made biochemically by elevated serum calcium, with elevated serum PTH and normal vitamin D and creatinine. The most common symptoms include bone and abdominal pain, fatigue, kidney stones, and bone demineralization.

Treatment of primary HPT is parathyroidectomy. Operative indications include markedly increased serum calcium, an episode of hypercalcemic crisis, reduced creatinine clearance, kidney stones, or significant decrease in bone mass. Localization studies are not used for diagnostic purposes but should be performed for operative planning. Currently imaging modalities include 99m technetium-sestamibi scan, neck ultrasound, and 4D-CT scan. Due to the high false-positive and false-negative rates for all imaging individually, most centers use a combination of imaging for preoperative localization. Intraoperative localization can also be difficult, and although hypercellular glands are usually darker, firmer, and more vascular than normal glands, the distinction sometimes requires the help of an experienced pathologist. Intraoperative pathology is essential in all cases to confirm abnormal glands and identify additional hypercellular glands.

Approximately 85 % of patients with primary hyperparathyroidism have a single adenoma, while the remaining 15 % have multiple gland disease that may involve two, three, or all four parathyroid glands. Patients with four abnormal glands (parathyroid hyperplasia) should be treated with 3.5 gland parathyroidectomy. Patients are successfully treated by the removal of all hyperfunctioning parathyroid glands, and 95 % of patients can be cured with a single neck exploration. Adequacy of surgical resection is assessed based on removing all hypercellular glands and by at least a 50 % reduction in intraoperative PTH level following resection.

Secondary and Tertiary Hyperparathyroidism

Secondary HPT is characterized by chronically low serum calcium and elevated phosphorus leading to high levels of parathyroid hormone. The most common cause is chronic renal failure, but other causes include inadequate calcium or vitamin D intake or absorption. Treatment is accomplished medically through low-phosphate diet, phosphate binders, and calcium and vitamin D supplementation. Recently, calcimimetics have been shown to improve osteitis fibrosa cystica associated with secondary HPT. Traditional operative indications are calcium phosphate product >70, calcium >11 with elevated PTH, calciphylaxis, and progressive bone demineralization; however, further study is needed to define the role of parathyroidectomy versus calcimimetic therapy for secondary hyperparathyroidism.

In most cases renal transplant is curative, but some patients develop tertiary HPT from autonomous functioning parathyroid tissue. Calcium load from tertiary HPT can put the transplanted kidney at risk, and patients should undergo four-gland exploration with ½-gland reimplantation if calcium and PTH remain elevated 1 year after transplant. Single-gland parathyroidectomy should not be performed for tertiary HPT as those patients have a much greater incidence of persistent and recurrent disease.

Parathyroid Carcinoma

Carcinoma of the parathyroid gland is rare and accounts for only 1 % of cases of primary hyperparathyroidism. Carcinoma is suspected preoperatively in patients with very high calcium and PTH, palpable neck mass, and severe symptoms. Often it is identified intraoperatively by invasion into surrounding structures. Surgical resection consists of en bloc resection including the ipsilateral thyroid lobe. Modified radical neck dissection should be performed if metastases to the lymph nodes are identified.

Minimally Invasive Parathyroidectomy

With increasing sensitivity and specificity of imaging and biochemical tests, some patients that account for the 85 % of primary hyperparathyroidism caused by a single adenoma are identifiable preoperatively and can undergo parathyroidectomy without four-gland exploration. Advantages for minimally invasive parathyroidectomy (MIP) include improved incisional cosmesis and decreased trauma to tissue from surgical dissection. Indications for MIP are identical to traditional exploration. Patients are selected based on concordant imaging indicating a single abnormal gland; however, MIP can have low rates of recurrent and persistent symptoms even in the setting of discordant or inconclusive imaging. Recent studies suggest that four-dimensional CT scan is the most sensitive tool for adenoma localization but adds to the cost of preoperative localization. As with traditional neck exploration, a significant drop in intraoperative PTH is highly predictive of adequate resection. Patients who fail to have a 50 % drop in PTH following resection of one gland should undergo continued exploration until PTH drop indicates all hyperfunctioning parathyroid tissue has been removed.

Adrenal

The adrenal glands are paired dual-functioning endocrine organs. The outer cortex is derived from the mesodermal tissue near the gonads and produces aldosterone, cortisol, and sex steroids. The inner medulla is derived from ectodermal tissue in the neural crest and functions to produce catecholamine hormones. Due to the embryologic origins, ectopic adrenal cortical tissue can be found in association with the testes or ovaries, while ectopic adrenal medullary tissue can be found in the neck, para-aorta, or most commonly to the left of the aortic bifurcation near the inferior mesenteric artery origin (organ of Zuckerkandl). Recent advancements in laparoscopic techniques have led to the safe performance of laparoscopic adrenalectomy for benign and metastatic disease, although an open operation remains the standard of care for large lesions (>6 cm) and primary adrenal malignancy.

Adrenal "Incidentaloma"

Adrenal incidentalomas are lesions discovered on imaging performed for unrelated indications and occur on 1–5 % of abdominal CT scans. The majority of incidentalomas are nonfunctioning tumors; however, up to 20 % of patients are found to have asymptomatic biochemical abnormalities. Hypertensive patients should be tested for serum electrolytes and plasma aldosterone and renin to rule out Conn's syndrome. Patients should undergo dexamethasone suppression test or 24-h urine cortisol to rule out subclinical Cushing's syndrome, 17-ketosteroids to rule out sex hormone excess, and 24-h urine collection of catecholamines, metanephrines, VMA, or plasma metanephrines to rule out pheochromocytoma. Patients with functional tumors discovered as incidentaloma should be treated as indicated by that tumor.

Determining malignant potential of an adrenal incidentaloma is often difficult. Most commonly, size greater than 6 cm is used to stratify patients into high- and low-risk groups. More recently, characteristics on imaging are being used to access malignant potential. Tumors that are homogenous, well encapsulated, and hypoattenuating on CT and have low signal intensity on T2 MRI tend to be benign. Tumors with evidence of invasion, irregular features, or high density or attenuation have higher incidence of malignancy. Size cutoff for adrenalectomy is controversial and ranges from 3 to 5 cm depending on the author. Patient risk for malignancy is stratified according to the size and radiographic findings, and patients with suspected malignancy should undergo open adrenalectomy.

Conn's Syndrome

Conn's syndrome is characterized by excess secretion of aldosterone by the adrenal gland and can be primary or secondary. Secondary hyperaldosteronism is caused by a perceived low-flow state in the juxtaglomerular apparatus of the kidney from renal artery stenosis, congestive heart failure, cirrhosis, or other causes, which leads to secretion of renin and subsequent activation of the renin-angiotensin-aldosterone system. Secondary hyperaldosteronism is successfully treated with treatment of the underlying cause.

Primary hyperaldosteronism is the autonomous secretion of aldosterone from one or both adrenal glands. The classic picture involves a hypertensive patient with hypokalemia; however, as awareness of this condition and screening methods improve, the diagnosis is now being made increasingly in normokalemic patients. The diagnosis is confirmed with a plasma aldosterone concentration to plasma renin activity level of 25–30:1. It is essential that patients have normal sodium and potassium levels, and antihypertensives (especially ACE inhibitors and ARBs) are held prior to testing. After diagnosis CT scan should be performed to distinguish unilateral (70 %) from bilateral (30 %) disease. Surgical management is successful in patients with a unilateral aldosterone-producing adenoma (APA), whereas surgery should be avoided in patients with bilateral adrenal hyperplasia. Hence, identifying patients that are appropriate for adrenalectomy depends on distinguishing unilateral adenoma from bilateral hyperplasia, and if the CT results are not clear, selective adrenal vein catheterization for measurement of aldosterone levels, with cortisol measured as a success of sampling, should be performed.

Bilateral hyperplasia is managed medically, while adrenalectomy, either open or laparoscopic, is very effective for improving hypokalemia and hypertension in patients with unilateral disease. Patients should be monitored closely following adrenalectomy and may require mineralocorticoid or glucocorticoid replacement, although this typically resolves within 3 months.

Cushing's Syndrome

Cushing's syndrome is characterized by excess secretion of cortisol from the adrenal cortex. Most commonly it is caused by secretion of ACTH due to an adenoma of the anterior pituitary gland (Cushing's disease). Cushing's syndrome can also be caused by ectopic secretion of ACTH by carcinoid tumors, small-cell lung tumors, medullary thyroid cancer, and pancreatic islet cell tumors. Cushing's syndrome is only caused by primary adrenal etiology, adenoma or adenocarcinoma, around 20 % of the time.

Determining the etiology is imperative for treatment. The 24-h urinary cortisol measurement and, more recently, the salivary cortisol measurement are sensitive and specific for hypercortisolism. The corticotropin-releasing hormone (CRH) test is most useful for determining primary adrenal hypercortisolism, as these patients have only a mild increase in ACTH compared to a much larger increase for other causes of Cushing's syndrome. Both CT and MRI are 95 % sensitive in identifying adrenal tumors and can be useful in distinguishing adenomas from carcinomas. Patients with adrenal adenomas are treated with laparoscopic adrenalectomy or with open adrenalectomy for tumors greater than 6 cm. Patients require pre- and postoperative steroids due to long-standing suppression of the contralateral gland, which can be required for as long as 2 years after resection.

Sex Steroid Hypersecretion

Functional tumors of the innermost cells of the adrenal cortex, the zona reticularis, result in hypersecretion of sex steroids. Most tumors produce androgens and lead to symptoms of masculinization, but feminizing tumors can occur. When the diagnosis is suspected, patients should undergo testing for DHEA for virilizing tumors, or for elevated urinary 17-ketosteroids and estrogen levels for feminizing tumors. Operative resection with laparoscopic adrenalectomy, or open for tumors greater than 6 cm, is recommended. Malignancy is difficult to determine on histology, so patients should be followed for recurrence. In patients with persistent symptoms after resection, metastasis is suspected and can be treated with adrenolytic drugs such as mitotane, aminoglutethimide, and ketoconazole.

Adrenocortical Carcinoma

Carcinoma of the adrenal cortex is a rare condition. Roughly half of adrenocortical carcinomas are functional, with cortisol being the most commonly secreted hormone. Treatment of adrenocortical carcinoma relies primarily on the adequacy of surgical resection. For this reason, resection is recommended with an open approach through a subcostal or thoracoabdominal incision to permit ideal exposure, maximize vascular control, and limit the chance of rupture. Rupture causes seeding of the peritoneum with tumor cells and can lead to implantation.

Pheochromocytoma

Pheochromocytoma is characterized by excess catecholamine production leading to classic signs and symptoms of hypertension, headache, palpitations, and diaphoresis. There is a strong association with pheochromocytoma and MEN2 syndromes, von Hippel-Lindau syndrome, and type 1 neurofibromatosis (von Recklinghausen disease). Diagnosis can be difficult and often relies on a combination of history, biochemical tests, and imaging. Urinary metanephrines are the most sensitive screening test. In most patients CT and MRI are able to identify pheochromocytoma, but in some patients, especially patients with ectopic pheochromocytoma, 131I MIBG scan can be useful. About 10 % of patients with pheochromocytoma have bilateral disease and 10 % have extra-adrenal disease.

Definitive management is with surgical resection with laparoscopic adrenalectomy for tumors less than 6 cm, open adrenalectomy for larger tumors. Prior to surgical resection, patients should undergo alpha blockade for 1–3 weeks and adequate alpha blockade is imperative prior to resection. Patients should also be volume resuscitated as removal of the tumor leads to decreased vasoconstriction and these patients present with volume depletion. Due to intraoperative blood pressure lability, patients should have close hemodynamic monitoring with arterial and central lines, and the surgeon should avoid excessive manipulation of the tumor until the adrenal vein is controlled.

Laparoscopic Adrenalectomy

Laparoscopic adrenalectomy is a safe and effective procedure for the surgical management of adrenal disease. Depending on surgeon experience and preference, laparoscopic adrenalectomy is the preferred procedure for most patients requiring removal of one or both adrenal glands. Situations where open adrenalectomy is recommended over laparoscopic currently only include tumor size greater than 6 cm and adrenocortical carcinoma.

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Thyroidectomy

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Indications

Congenital abnormalities.
Goiter.
Hyperthyroidism.
Selected solitary thyroid nodules.
Thyroid carcinoma.
See Chap. 119.

Preoperative Preparation

Patients undergoing thyroidectomy for hyperthyroidism require careful preoperative preparation to decrease the vascularity of the thyroid and the risk of thyroid storm. To accomplish this, agents commonly used are antithyroid medications, beta blockers, and Lugol's iodine (or supersaturated potassium iodide SSKI) solution. Because of the long half-life of thyroxine (T_4), treatment with beta blockers is generally continued for 7–10 days postoperatively.

In situations where preexisting vocal cord dysfunction is suspected or patients have had prior neck surgery, either direct or indirect laryngoscopy may be beneficial to assess the baseline function of the vocal cords.

A patient suspected of having medullary carcinoma of the thyroid should undergo preoperative studies to detect a pheochromocytoma or a primary hyperparathyroidism, which commonly coexists in the setting of MEN-2 syndrome.

In case of thyroidectomy for the solitary thyroid nodule, workup may include any or all of the following:

- Thyroid function tests
- Ultrasonography
- Fine-needle aspiration cytology
- Radionuclide scintigraphy
- Thyroid suppression therapy

Pitfalls and Danger Points

- Trauma to recurrent laryngeal or superior laryngeal nerves
- Trauma to or inadvertent excision of parathyroid glands
- Inadequate preoperative preparation of the toxic hyperthyroid patient resulting in postoperative thyroid storm
- Inadequate surgery for thyroid cancer

Operative Strategy

Performance of thyroidectomy requires careful exposure, meticulous hemostasis, and detailed knowledge of regional anatomy. Variations in anatomy are common, and the thyroid surgeon must progress slowly, carefully, identifying all structures in a bloodless field.

Preserving the Superior Laryngeal Nerve

The internal branch of the superior laryngeal nerve penetrates the thyrohyoid membrane and is the sensory nerve of the larynx; the external branch controls the cricothyroid muscle. Although it is possible to damage both branches of the superior laryngeal nerve by passing a mass ligature around the superior thyroid artery and vein above the superior pole of the thyroid, the external branch is the one most often injured. Transection of the external branch impairs the patient's ability to voice high-pitched sounds. Because the external branch may be intertwined with branches of the superior thyroid artery and vein as shown in Fig. 120.1,

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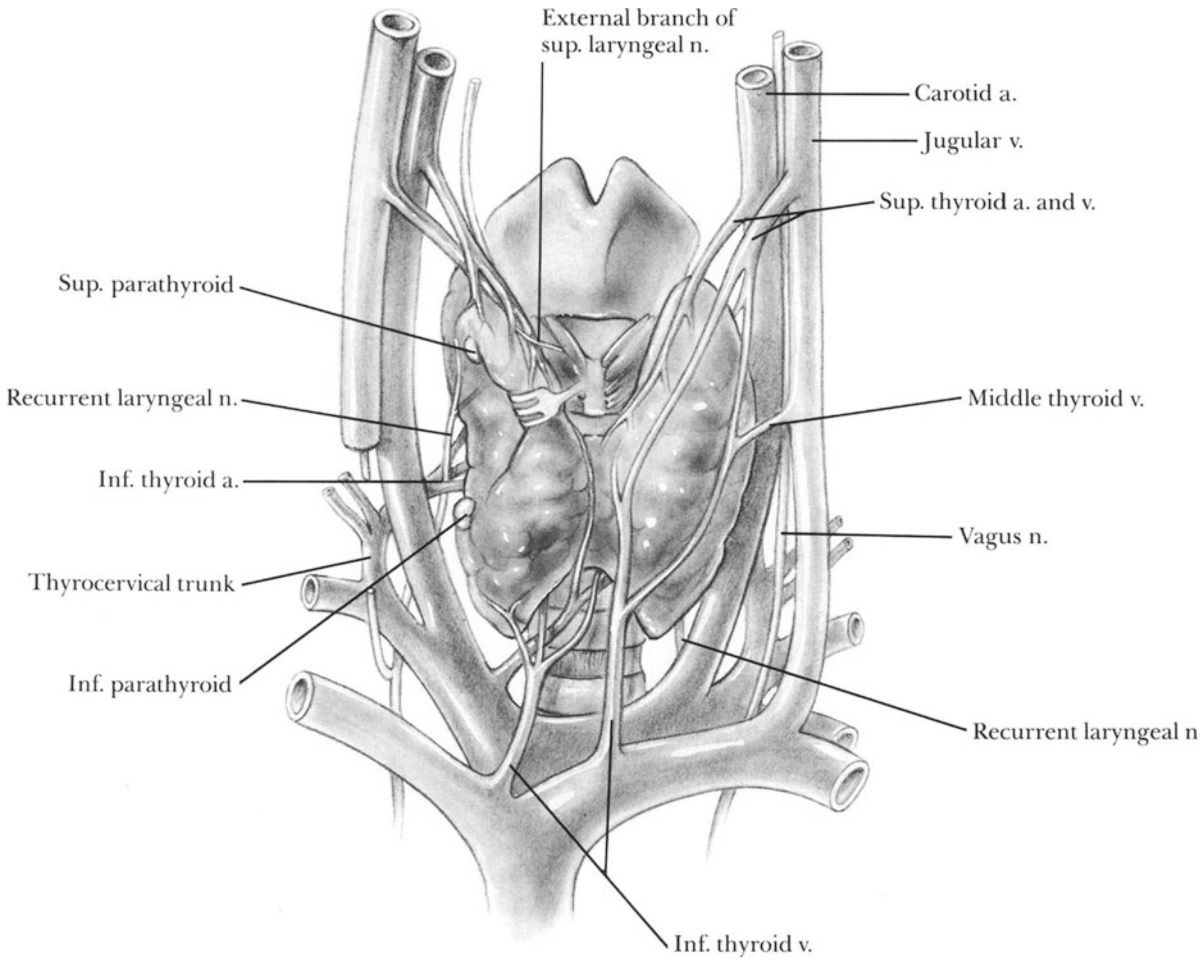

Fig. 120.1

avoiding damage to this nerve requires that each branch of the superior thyroid vessels be isolated, ligated, and divided individually at the point where it enters the thyroid gland. If the superior thyroid artery and vein are dissected *above* the superior pole of the thyroid, it is necessary to identify and preserve the superior laryngeal nerve and its branches. This step is not necessary if the terminal branches of the superior thyroid vessels are individually isolated and ligated.

Identification and Preservation of Recurrent Laryngeal Nerve

The recurrent laryngeal nerve ascends slightly lateral to the tracheoesophageal groove. The nerve almost always makes contact with the inferior thyroid artery, passing directly under or over the artery. Sometimes the nerve passes between the branches of the inferior thyroid vessel. Above the level of the artery, the nerve ascends to enter the larynx between the cricoid cartilage and the inferior cornu of the thyroid cartilage. In this area the nerve lies in close proximity to the posterior capsule of the thyroid gland. It may divide into two or more branches prior to entering the larynx. On rare occasions the recurrent nerve does not recur but travels from the vagus directly medially to enter the larynx near the superior thyroid vessels or at a slightly lower level relative to the thyroid gland.

Preserving Parathyroid Glands

Preventing damage to the parathyroid glands requires the surgeon to achieve thorough familiarity with the anatomic location and appearance of these structures. The surgeon who takes the time to identify the parathyroid glands during every thyroid operation soon finds that this maneuver can be accomplished with progressively more efficiency. The inferior parathyroid gland is frequently found in the fat that surrounds the inferior thyroid artery at the point where it divides into several branches. Normally, the inferior gland is anteromedial to the recurrent laryngeal nerve, and the superior parathyroid is posterolateral to the nerve. With the thyroid gland retracted anteriorly, both parathyroids may assume an

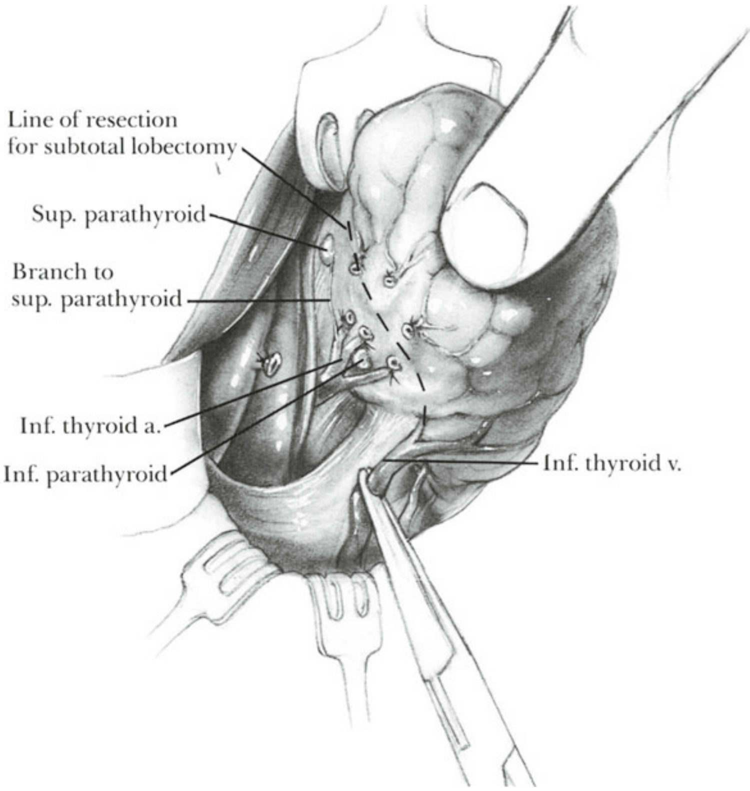

Fig. 120.2

anteromedial position relative to the nerve. The superior gland is generally situated on the posterior surface of the upper third of the thyroid gland, fairly close to the cricoid cartilage. Frequently, the parathyroids are loosely surrounded by fat and are golden yellow in color. Measuring only about 5–8 mm in maximum diameter, the average gland weighs about 30 mg.

One method for protecting the parathyroid glands is to preserve the posterior capsule of the thyroid gland by incising the thyroid along the line sketched in Fig. 120.2. Also, divide the branches of the inferior thyroid artery at a point distal to the origin of the blood supply to the parathyroids. When a total lobectomy is performed, the only means of ensuring preservation of the parathyroid glands is to identify the inferior and superior glands positively. Then dissect each gland carefully away from the thyroid without impairing its blood supply.

Operative Technique

Intraoperative Preparation

Position the patient supine on the operating room table. Place a shoulder roll, if necessary, to assist with extension of the neck. Tuck the arms by the patient's side and pad all pressure points. Then place the operating table in a modified "beach-chair" position with slight reverse Trendelenburg.

Antibiotics are not typically indicated for thyroid operations.

Incision and Exposure

Make a slightly curved incision in a natural skin crease approximately 1 cm caudal to the cricoid cartilage. The incision should extend approximately 4–5 cm for a normal sized gland. Take care to ensure symmetry (Fig. 120.3). A longer incision may be needed in patients with large goiters. Using a scalpel or electrocautery, carry the incision down through the skin and subcutaneous tissue to the platysma muscle. The latter is easier to identify in the lateral portions of the incision.

Divide the platysma using electrocautery. Place skin hooks or Kelly clamps in the dermis to assist with the creation of sub-platysmal flaps. Using a gauze sponge to provide counter traction, begin medially and carry the dissection out laterally. If the plane of dissection is carried down to the cervical fascia, a number of veins are encountered that produce unnecessary bleeding. There is a thin layer of fat deep to the platysma muscle, and leaving this layer on these veins avoids this problem (Fig. 120.4). Continue the dissection along the deep surface of the platysma muscle in a cephalad direction using both sharp and blunt maneuvers. Follow the avascular areolar plane superiorly to the thyroid cartilage and inferiorly to the suprasternal notch. A self-retaining retractor may be placed to hold back the skin flaps.

Palpate the prominence of the thyroid cartilage to identify the midline. Make an incision through the cervical fascia in the midline and extend the incision to expose the full length of the strap muscles (sternothyroid muscle and sternohyoid muscle) (Fig. 120.5). Elevate the sternohyoid muscle in the midline; then elevate the sternothyroid muscle and dissect the thyroid capsule away from it on both sides. This permits adequate digital exploration of the entire thyroid gland. In most cases retracting the strap muscles laterally while the thyroid lobe is retracted in the opposite direction provides good exposure for thyroidectomy. If the gland is unusually large or the exposure is inadequate, do not hesitate to transect the sternohyoid and sternothyroid muscles. Transect them in their upper thirds as their innervation from the ansa cervicalis enters from below (Fig. 120.6).

Identification and Ligation of the Isthmus and Middle Thyroid Vein

At this point, some surgeons opt to transect the isthmus of the thyroid. After placing self-retaining retractors to hold back the strap muscles, identify the isthmus. Dissect the

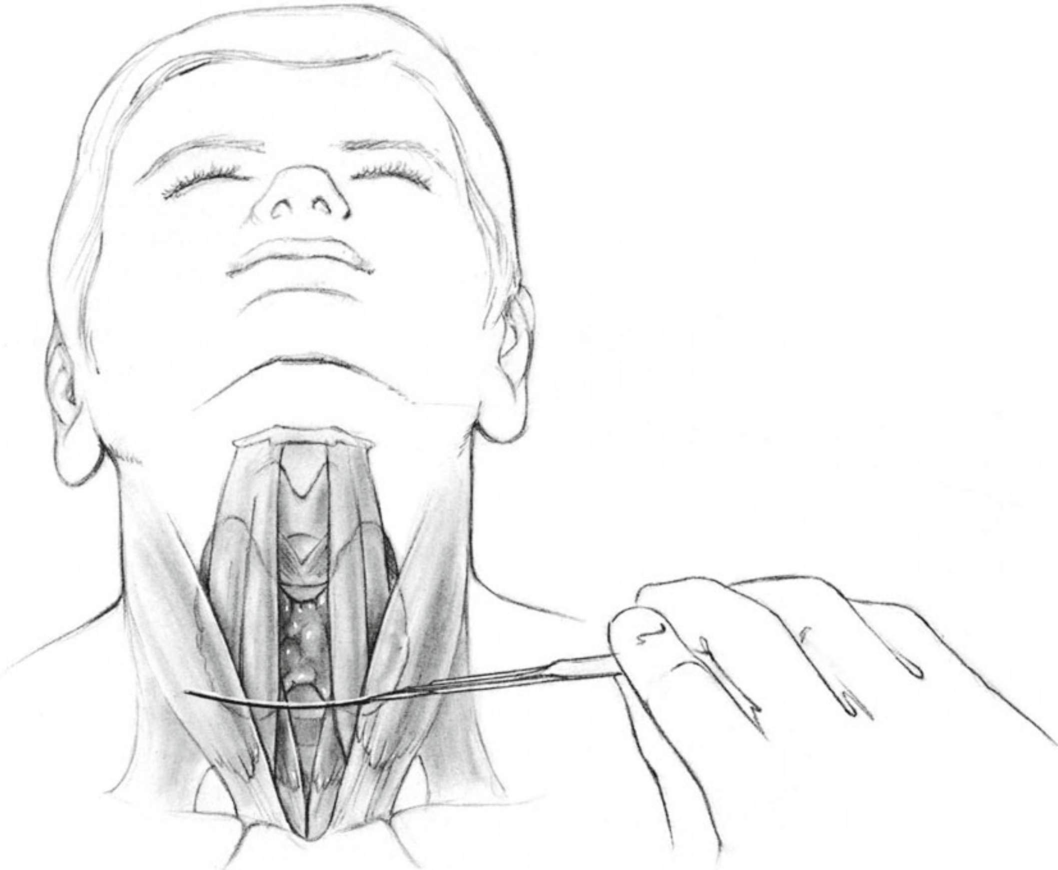

Fig. 120.3

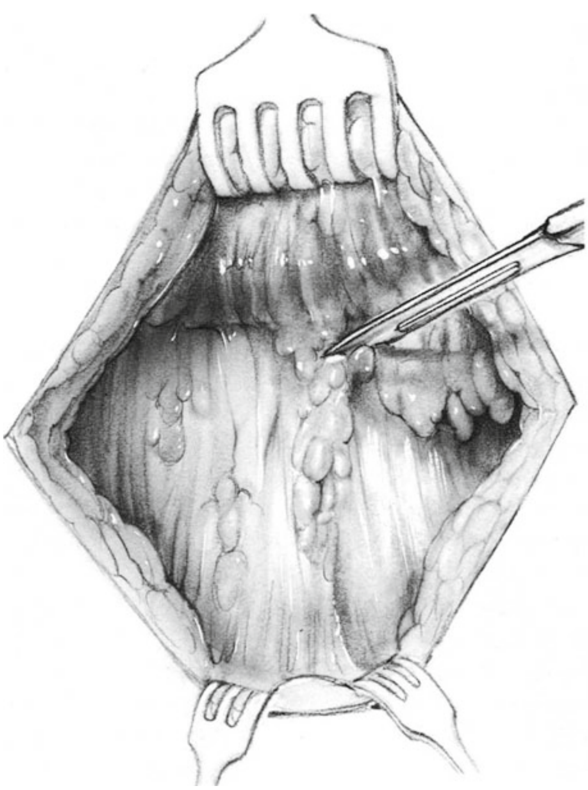

Fig. 120.4

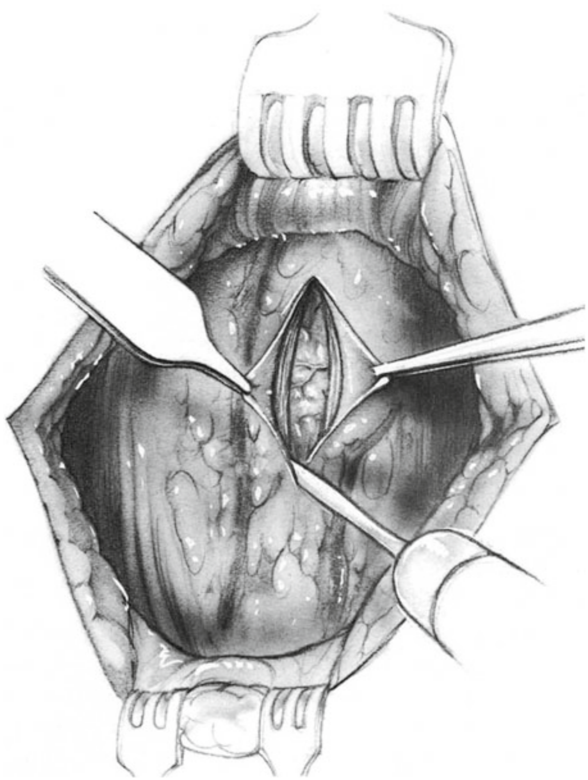

Fig. 120.5

Fig. 120.6

isthmus off of the trachea both inferiorly and superiorly using blunt dissection and electrocautery. The isthmus may be divided between clamps and vascular control obtained by suture ligation or oversewing of the cut ends. Devices such as a harmonic scalpel or vessel-sealing system may be used to transect the isthmus and may be used throughout the procedure in place of suture ligatures. The isthmus may also be divided last, once entire dissection is completed.

Once the upper portion of the thyroid isthmus is identified, a fingerlike projection of thyroid tissue may be seen extending from the region of the isthmus in a cephalad direction. It represents the pyramidal lobe of the thyroid, a vestigial remnant of the thyroglossal tract. If a thyroidectomy is being performed for Graves' disease, it is important to remove the pyramidal lobe. Otherwise, postoperatively it may become markedly hypertrophied and cause a significant cosmetic deformity overlying the thyroid cartilage.

Once this is accomplished, retract the lobe medially and identify and ligate the middle thyroid vein. This may improve the mobility of the thyroid and assist in exposure. Retract the strap muscles laterally and the thyroid medially. Using blunt and sharp dissection, sweep the lateral tissue away from the lateral most aspect of the thyroid. The middle thyroid vein should be visible in this plane. Ligate the vein using silk ties or other devices, as indicated above (Fig. 120.7).

Dissecting the Superior Pole and Superior Parathyroid Gland

With a retractor drawing the upper portion of the strap muscles in a cephalad direction, retract the superior pole of the thyroid laterally and use a peanut sponge dissector to sweep the upper pole of the thyroid away from the larynx. This maneuver separates the upper pole from the external branch of the superior laryngeal nerve, which is closely applied to the cricothyroid muscle at this level (discussed below). Also free the lateral portion of the superior pole by blunt dissection. One or two small veins may be entering the posterior portion of the upper pole. Be careful to identify and ligate these branches if encountered. Then identify the terminal branches of the superior thyroid artery and vein. Ligate and divide each of these vessels between suture ligatures (Fig. 120.8) or other vessel-sealing devices. After they have been ligated and divided, the superior pole of the thyroid is completely liberated and can be lifted out of the neck.

Now search along the posterior surface of the upper third of the thyroid lobe for the superior parathyroid gland. Its usual location is sketched in Fig. 120.8, and the typical anatomy is shown in greater detail in Fig. 120.1. Variations are extremely common. Dissect the parathyroid gland away from the thyroid into the neck, carefully protecting it.

Identification of Inferior Pole Vessels

Next attention turns to identification and ligation of the inferior pole vessels. Staying close to the thyroid tissue, dissect from medial to lateral and take care not to injure the recurrent laryngeal nerve. Locate the inferior thyroid vessels and ligate these vessels using suture ligature or vessel-sealing devices (Fig. 120.9). In some cases, the thyroid ima artery may be encountered at this point. Ligate this vessel in a similar fashion.

Identification of the Recurrent Laryngeal Nerve and Inferior Parathyroid Gland

With both the superior and inferior poles of the thyroid mobilized, the recurrent laryngeal nerve is able to be identified. Dissection may be carried out lateral to medial or vice versa based on the surgeon's preference.

For most surgeons the best way to locate the recurrent laryngeal nerve is to trace the inferior thyroid artery from the point where it emerges behind the carotid artery to the point where it crosses over or under the recurrent nerve. Often a very slim vessel can be seen along the nerve. Using the inferior thyroid artery as a guide, locate the recurrent nerve

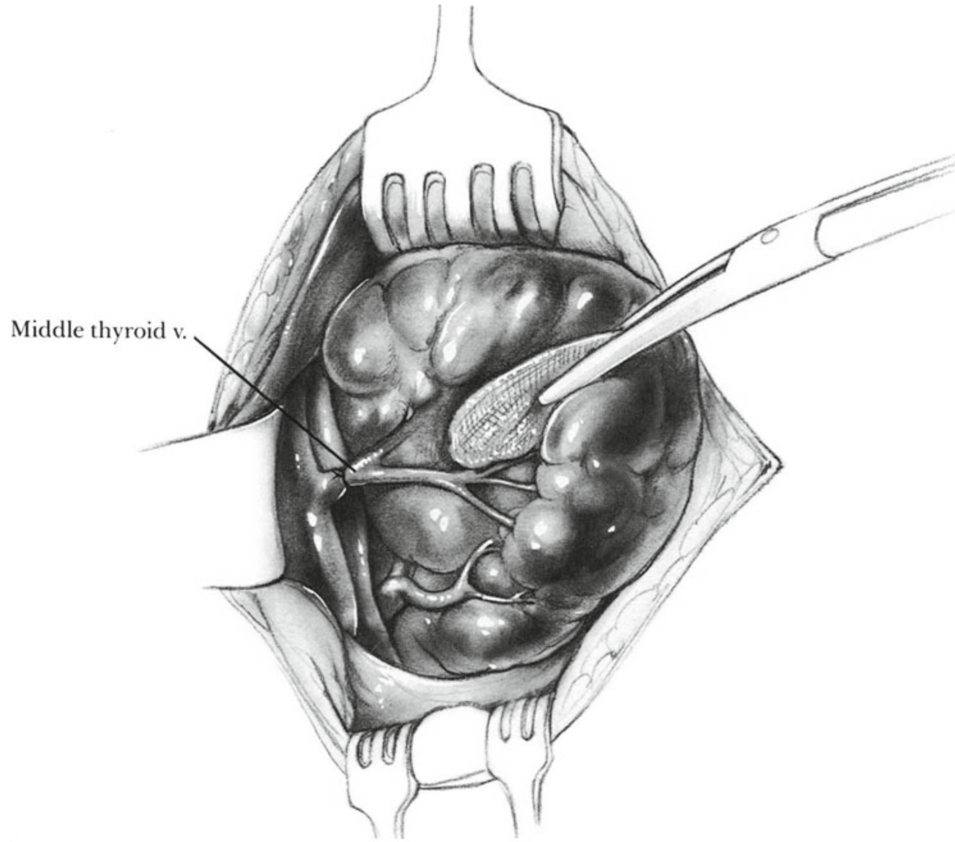

Fig. 120.7

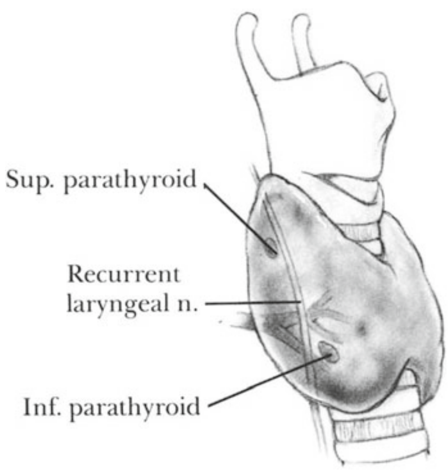

Fig. 120.8

immediately deep to or superficial to this artery and carefully dissect the nerve in a cephalad direction until it reaches the cricothyroid membrane just below the inferior cornu of the thyroid cartilage. Remember that the nerve may divide into two or more branches in the area cephalad to the inferior thyroid artery. Once the nerve has been exposed throughout its course behind the thyroid gland, it is a simple matter to avoid damaging it.

A nerve stimulator may be used to assess function of the nerve at various stages of the dissection. This is done by placing an index finger deep along the posterior lamina of the cricoid and stimulating the recurrent laryngeal nerve with a neurostimulator to feel for contraction of the cricoarytenoid muscle through the wall of the hypopharynx. Additional methods to assess functions of the nerve include direct laryngoscopy or continuous monitoring by electromyography. Intraoperative neural monitoring is gaining widespread acceptance as an adjunct to the gold standard of visual identification of the recurrent laryngeal nerve. It does have some limitations and additional research and standardization of techniques and results is needed.

Identify the inferior parathyroid gland, generally located close to the point at which the inferior thyroid artery divides into its branches (Fig. 120.10). Divide each of these branches of the inferior thyroid artery between ligatures on a line medial to the parathyroid gland so the blood supply to the parathyroid is not impaired.

At this point the thyroid may be elevated off of the trachea using either blunt or sharp dissection. Dissection may be carried out from a lateral to medial fashion, transecting the ligament of Berry to elevate the thyroid from the trachea. Care is taken to ensure preservation of the recurrent laryngeal nerve throughout this dissection.

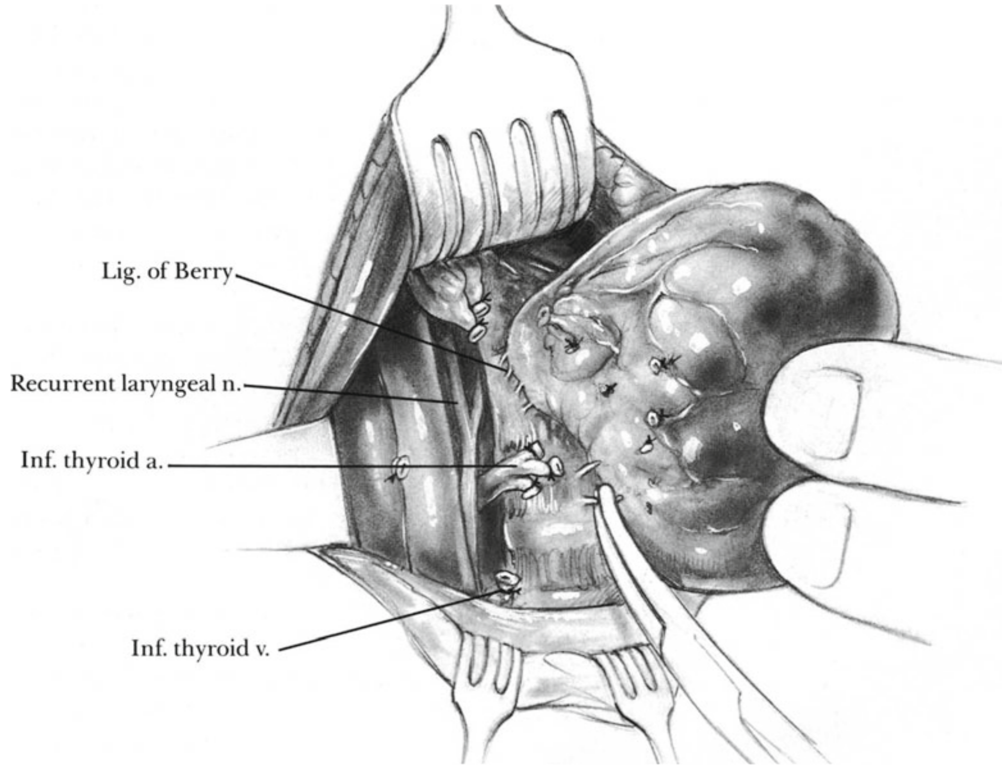

Fig. 120.9

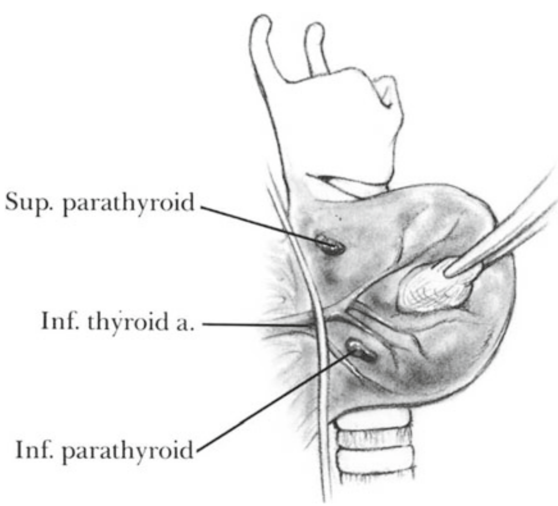

Fig. 120.10

Reimplantation of Parathyroid Glands

If a parathyroid gland has been inadvertently excised, and this is recognized during the operation, it is possible to reimplant the parathyroid. The parathyroid should be placed in a container filled with normal saline and then placed on ice. When ready for reimplantation, cut the gland into small segments (approximately 1 × 1 mm) using a scalpel. These segments may then be placed or injected into a pocket of the sternocleidomastoid or brachioradialis muscle. Generally, a permanent suture to close the pocket and clips are placed to mark the site. In addition, glands without visible vascular supply should be reimplanted. Intraoperative measurements of PTH levels (less than 10 pg/mL) during total thyroidectomy may suggest the need for reimplantation.

Subtotal Thyroid Lobectomy

If subtotal resection of the lobe is the operation elected, free the upper pole completely and divide the lobe along the line of resection as outlined in Fig. 120.2. At this level of the dissection both parathyroid glands and the recurrent nerve, all of which have been previously identified, may be left in their normal locations. Divide the remaining gland between hemostats or using a vascular sealing device until the anterior surface of the trachea has been reached. If hemostats are used, the cut surface will need to be oversewn. At this point, transect the isthmus as described below, if this maneuver was not performed earlier in the surgery. Some surgeons suture the lateral margin of the residual segment of thyroid to the trachea, but this step is not essential. When subtotal thyroidectomy is being performed for Graves' disease, leave no more than 2–4 g of thyroid tissue on each side.

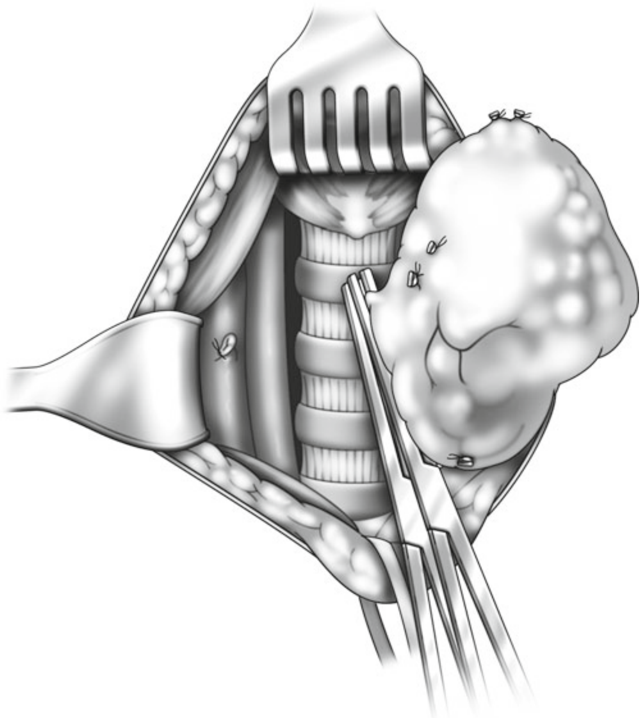

Fig. 120.11

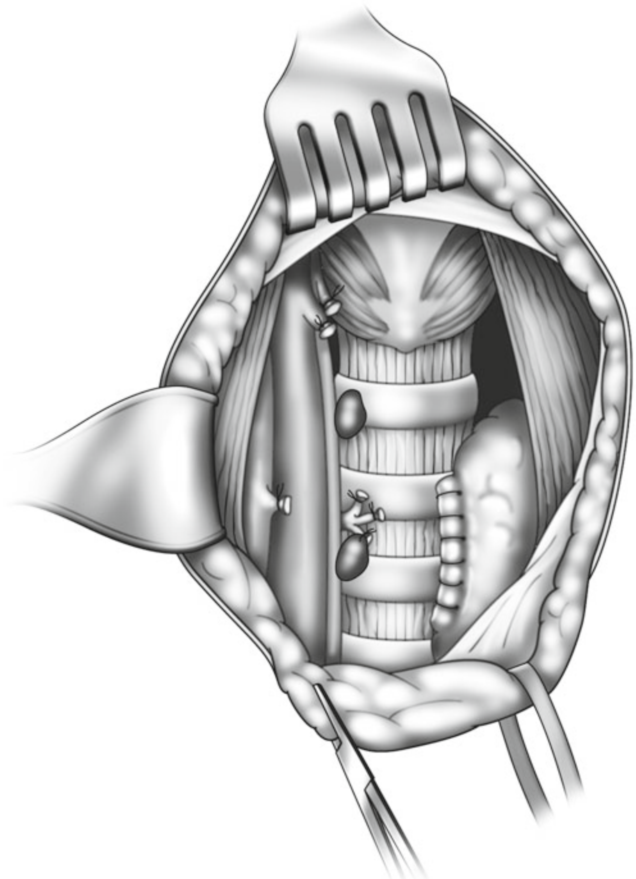

Fig. 120.12

Total Thyroid Lobectomy

Before considering total lobectomy, be certain you have positively identified the recurrent nerve and the superior and inferior parathyroid glands. After these structures have been dissected away from the thyroid, proceed with the total lobectomy. The gland is firmly attached to the two upper tracheal rings by dense fibrous tissue that constitutes the ligament of Berry (Fig. 120.9). The upper portion of the recurrent laryngeal nerve passes close to the point where this ligament attaches to the trachea. Moreover, often there is a small artery passing close to the recurrent nerve in this ligament. Be careful to control this vessel without injuring the nerve before dividing the ligament. After this ligament has been freed, the thyroid lobe can easily be liberated from the trachea by clamping and dividing several small blood vessels until the isthmus has been elevated.

The isthmus may be divided serially between hemostats, leaving the other lobe of the thyroid in place, and then oversewn for hemostasis as seen in Figs. 120.11 and 120.12. If the isthmus has been divided earlier in the surgery, the thyroid just needs to be dissected off the trachea using scalpel or electrocautery.

Fig. 120.13

Partial Thyroid Lobectomy

On some occasions what appears to be an obviously benign lesion occupies a small portion of the thyroid gland. Under these conditions, local excision or partial lobectomy may be indicated. The stapling device is sometimes useful under these conditions. Figures 120.13 and 120.14 illustrates removal of the lower half of the right thyroid lobe, a stapling device having been used first to close and control bleeding from the remaining segment of thyroid and then to divide the isthmus. Remember that *identification and preservation* of

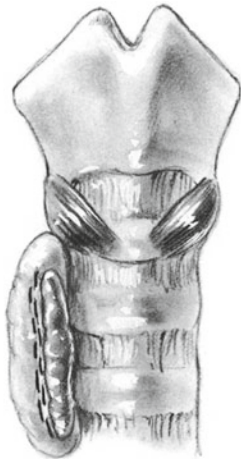

Fig. 120.14

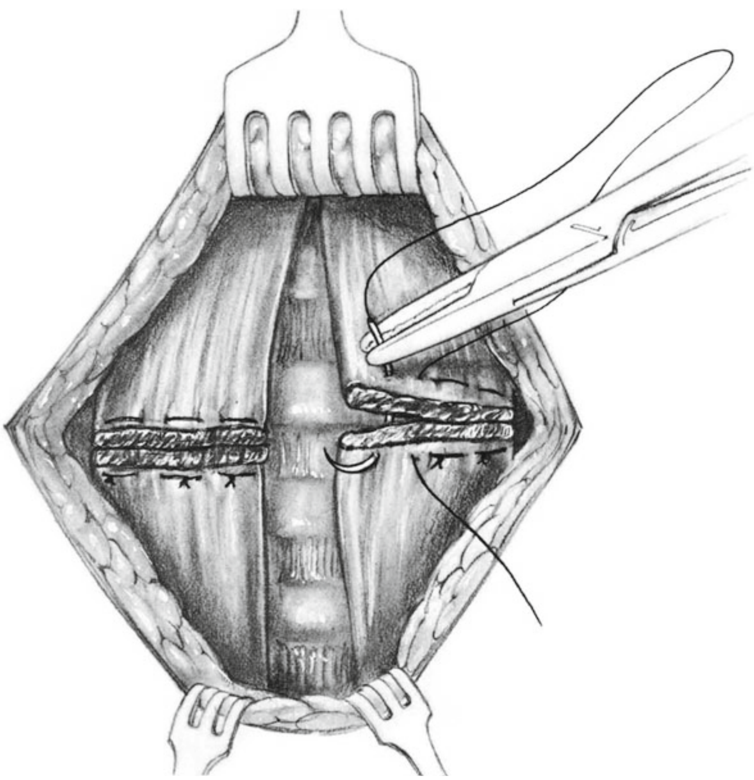

Fig. 120.15

the recurrent nerve must be achieved early in the dissection. If the gland is fairly thick, use 4.8 mm staples.

Closure

Prior to closure, irrigate the operative field with saline and obtain *complete* hemostasis by ligatures and electrocautery. Always keep the recurrent nerve and the parathyroid glands in view while taking these steps. In the situation where the strap muscles have been transected, reapproximate these two muscles by means of sutures of 2-0 Vicryl, as illustrated in Fig. 120.15. In other cases simply suture the right and left strap muscles together loosely with interrupted 3-0 Vicryl sutures. It is not necessary to place drains in the thyroidectomy bed. After the strap muscles have been reapproximated, suture the divided platysma muscle together using interrupted 3-0 Vicryl stitches. Close the skin using a running subcuticular 4-0 absorbable suture.

Postoperative Care

Carefully observe the patient's neck for signs of swelling or ecchymosis. Active bleeding in the bed of the excised thyroid gland can rapidly compress the trachea and cause respiratory obstruction, especially if the bleeding is due to a major artery. Under rare circumstances, it is necessary to remove all sutures in the skin and strap muscles to release the blood clot at the patient's bedside. In most cases, evacuate the blood clot in the operating room. After removing a large goiter, occasionally there is gradual swelling of the tissues of the neck due to slow venous bleeding that infiltrates the tissues. It may produce respiratory distress due to laryngeal edema. This patient requires orotracheal intubation and evacuation of the clot in the operating room. It is rare that exploration or a tracheostomy must be done at the patient's bedside.

Following total thyroidectomy, check for hypocalcemia by measuring the serum calcium level until the patient is discharged. Hypocalcemia may occur due to inadvertent damage to the parathyroid glands. Observe for signs and symptoms of hypocalcemia: paresthesia of the extremities or face, Trousseau's sign, or Chvostek's sign. These generally appear when the calcium level drops below 7–8 mg/dL. Give oral calcium carbonate tablets (2–8 g/day) as required to maintain the serum calcium level. If calcium administration alone does not control the symptoms, supplemental vitamin D may be given (typically as calcitrol). Treat the symptoms with intravenous calcium gluconate (1 g of a 10 % solution several times a day or a continuous intravenous infusion) if the symptoms persist despite oral supplementation. The milder form of hypocalcemia following thyroid surgery is usually transient because it is caused by minor trauma to the parathyroid glands. Severe postoperative hypoparathyroidism is often permanent.

Patients undergoing total thyroidectomy will also develop hypothyroidism and require thyroid hormone supplementation. Replace with levothyroxine (synthetic T4) starting at a dose of 1.6 μg/kg. TSH levels should be reassessed after 6 weeks of therapy. Patients undergoing lobectomy or bilateral subtotal thyroidectomy may also need thyroid hormone supplementation, depending on the volume of thyroid tissue remaining and especially if there is underlying Hashimoto's thyroiditis. Monitoring of these patients' TSH levels at periodic intervals is advised.

In patients with Graves' disease, carefully monitor vital signs to detect early evidence of *thyroid storm*. Patients who were prepared for operation with propranolol require treatment with this medication for 7–10 days following the operation.

Complications

Hematoma with possible tracheal compression and respiratory distress may occur.

There may be *injury to the recurrent laryngeal nerve*. If the injury is unilateral, it generally produces some degree of hoarseness and weakness of the voice. Postoperative hoarseness may be also due to transient vocal cord edema or vocal cord injury caused by the endotracheal tube used for anesthesia. The patient who has undergone trauma to both recurrent laryngeal nerves may develop complete *airway obstruction* from marked narrowing of the glottis requiring prompt endotracheal intubation and then tracheostomy. This complication may become evident immediately after extubation in the operating room with the development of stridor. If this occurs, immediate reintubation is necessary. This complication is rare. The airway may later be improved by an arytenoidectomy.

Superior laryngeal nerve injury may result in the patient being unable to utter high-pitched sounds.

Hypoparathyroidism, transient or permanent, results from inadvertent removal of or trauma to several of the parathyroid glands. If during operation it is noted that one or more parathyroid glands have been removed, they should be reimplanted. If the fragments are sufficiently small, satisfactory function may develop. Transient hypoparathyroidism, lasting as long as several months, may result from manipulation of the parathyroid glands without permanent damage.

Thyroid storm may develop following thyroidectomy for Graves' disease, especially if the preoperative preparation has not been adequate. This condition is characterized by fever, severe tachycardia, mental confusion, delirium, and restlessness. Rarely seen today, thyroid storm may be treated by adequate doses of propylthiouracil and intravenous sodium iodide; it may also be treated with propranolol, 2 mg IV with electrocardiographic control followed by 10–40 mg PO several times a day. A hypothermia blanket may be required to manage the high fever.

Minimally Invasive Thyroidectomy

As the field of minimally invasive surgery has evolved, these techniques have been applied to thyroidectomy. The scope of minimally invasive thyroidectomy encompasses mini-incision open, video-assisted, and complete endoscopic thyroidectomy. The latter can also be performed with robotic assistance. Similar to other minimally invasive approaches, minimally invasive thyroidectomy has been reported to provide less tissue trauma, less postoperative pain, shorter hospital stay, improved patient comfort, and improved cosmesis. Additionally, visualization using video assistance provides a magnified view of important structures. The endoscopic approach utilizes the same basic principles of conventional thyroidectomy and can be carried out under either general or local anesthesia. The approach may be either transaxillary, supraclavicular, or subclavicular. Contraindications to the endocscopic approach include overall large size of the thyroid (>50 mL), nodules greater than 30 mm, history of thyroiditis or prior neck surgery, and advanced stage cancers. Although these techniques have been shown to be feasible, further long-term studies are needed to determine their advantages and cost-effectiveness over the more traditional open approach.

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Parathyroidectomy

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Sonia L. Sugg and Nelson J. Gurll

Indications

Primary hyperparathyroidism is a common disease. The diagnosis is made by finding persistent hypercalcemia and an elevated serum parathyroid hormone (PTH) concentration. Other causes of hypercalcemia are ruled out by the history, particularly the use of lithium and thiazide diuretics. A 24-h urine collection is valuable for documenting the extent of hypercalciuria and to rule out familial hypocalciuric hypercalcemia (FHH). Parathyroidectomy is recommended in most patients to prevent the osseous and renal complications of hyperparathyroidism and to relieve symptoms such as fatigue and bone pain. Complications include hypercalcemic crisis, kidney stones, decreased renal function, decreased bone mineral density (BMD), and fractures. Cinacalcet, a calcimimetic that reduces serum calcium and PTH concentrations, is a nonoperative option. However, it is expensive, often poorly tolerated, and is primarily used in patients who are poor surgical candidates (Messa et al. 2011). Some patients with mild hypercalcemia and no symptoms may be observed. The Third International Workshop issued guidelines on the indications for surgery in patients with asymptomatic primary hyperparathyroidism as the following (Bilezikian et al. 2009): serum calcium >1.0 mg/dL (0.25 mmol/L) above the upper limit of normal, creatinine clearance reduced to <60 mL/min, BMD T-score <−2.5 at any site and/or previous fracture fragility, and age <50 years. The cause for primary hyperparathyroidism in most patients is unknown. It can be induced by neck irradiation, or it may be familial in origin. Hyperparathyroidism occurs in at least 90 % of patients with multiple endocrine neoplasia type I (MEN-I), 10–40 % of patients with MEN-IIA, and rarely in those with MEN-IIB. Primary hyperparathyroidism is a result of single-gland disease (adenoma) in 80–90 % and multiple-gland disease (multiple adenomas or hyperplasia) in 10–20 %. Parathyroid cancer is rare.

Secondary hyperparathyroidism results from chronic renal failure (CRF) or malabsorption and is characterized by hypocalcemia and hyperphosphatemia. It is common in patients with CRF and usually responds to treatment with phosphate binders, calcium, and vitamin D. About 5–10 % of these patients require parathyroidectomy because of metabolic complications or symptoms. Some patients with CRF develop tertiary hyperparathyroidism with autonomous parathyroid function resulting in hypercalcemia despite removal of the stimulus (for hyperparathyroidism) by dialysis or renal transplantation. The National Kidney Foundation clinical practice guidelines (KDOQI 2009) defined indications for surgery in chronic kidney disease patients with secondary hyperparathyroidism as the following: calciphylaxis with elevated PTH levels, severe hyperparathyroidism (persistent serum PTH >800 pg/mL), associated with hypercalcemia and/or hyperphosphatemia that are refractory to medical therapy. In patients with tertiary hyperparathyroidism after successful renal transplantation, persistent hypercalcemia is an indication for parathyroidectomy.

Preoperative Preparation

Preoperative Imaging

If a four-gland exploration is planned, preoperative imaging is unnecessary. A decision to operate should be based on the biochemical diagnosis and symptoms, and not upon results of the imaging study. Many patients with indications for surgery (10–40 %) will have negative imaging studies. Minimally invasive parathyroidectomy (MIP) requires accurate preoperative imaging, usually consisting of one or more

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of the following tests: sestamibi (+/− SPECT and SPECT/CT), ultrasound, and 4D-CT. If a gland can be identified on preoperative imaging, then the patient is eligible for MIP

Intraoperative PTH Monitoring (IOPTH)

Parathyroid hormone levels are monitored before and after removal of the parathyroid adenoma, using a rapid assay performed intraoperatively. If the level drops appropriately, it confirms single-gland disease and predicts operative success with the minimally invasive approach. It can also be used in the setting of secondary hyperparathyroidism to assess the adequacy of resection; however, the criteria are not as well established.

Laryngoscopy may be done routinely or selectively in patients with voice symptoms or prior neck surgery.

Dialysis with regional heparinization the day before operation for secondary hyperparathyroidism

Pitfalls and Danger Points

The major pitfall is failing to cure the disease because of missing multiglandular disease or failing to find the offending adenoma:

- Performing a MIP without intraoperative PTH may result in missing multiple-gland disease and operative failure.
- Misinterpretation of preoperative imaging tests and intraoperative PTH levels can lead to operative failure or unnecessary bilateral exploration.

Injury to the recurrent laryngeal nerve is possible with resultant change in voice, aspiration of liquids, failure to protect the airway, and possible upper airway obstruction. Damage to the motor branch of the superior laryngeal nerve produces changes in the voice pitch and strength.

Recurrence of hypercalcemia is low after excision of a solitary parathyroid adenoma but higher with hyperplasia, familial disease, or secondary hyperparathyroidism.

Removal of too much parathyroid tissue is also possible, especially if everything found at operation is biopsied or excised.

Operative Strategy

Curing the Disease

The sine qua non of parathyroid surgery is a bloodless field. The presence of blood around a lymph node or a bit of fat will make it look like a parathyroid gland. It is for this reason that we perform careful dissection with fine instruments. We do not use electrocautery close to the recurrent laryngeal nerve to avoid injuring it by local spread of the electrical current.

The role of a pathologist is mostly supportive. They can tell us that we removed or biopsied parathyroid tissue and the weight of the material. The decision about what to do is based on the gross findings.

A minimally invasive or focused parathyroidectomy is guided by preoperative imaging, which can often distinguish between superior (anatomically posterior) vs. inferior (anatomically anterior) gland. This information is used to guide the operative approach, including placement and length of incision. IOPTH monitoring confirms adequate removal of hyperfunctioning parathyroid tissue.

A subtotal parathyroidectomy or a total parathyroidectomy with autotransplantation (of fresh or cryopreserved tissue) is performed for hyperplasia, MEN-I, MEN-IIA, and secondary hyperparathyroidism. The choice of which procedure to use depends on the findings at operation, the relative risks of hypocalcemia and recurrent hypercalcemia, the availability of cryopreservation, patient reliability, and surgeon preference.

The cervical thymus is removed from patients with primary or secondary hyperplasia because of the 15–25 % incidence of supernumerary parathyroids (many of which are in the thymus) in these conditions (Edis and Levitt 1987).

Preserving the Recurrent Laryngeal Nerve

The superior parathyroids are lateral and posterior to the nerve, and the inferior parathyroids are generally anterior and medial to the nerve (Fig. 121.1). The recurrent laryngeal nerve inserts into the larynx just caudad to the caudad edge of the cricothyroideus muscle, so the superior pole of thyroid can be mobilized cephalad to this muscle without worrying about damage to this nerve (Fig. 121.2). Even a nonrecurrent

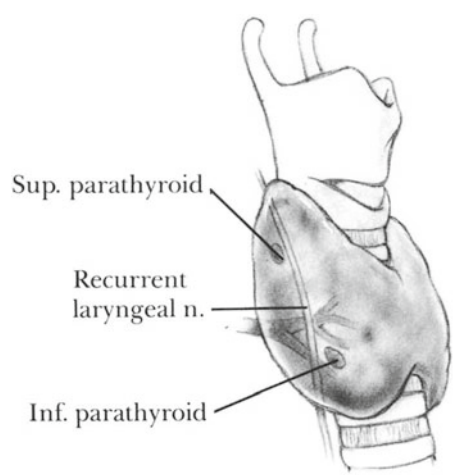

Fig. 121.1

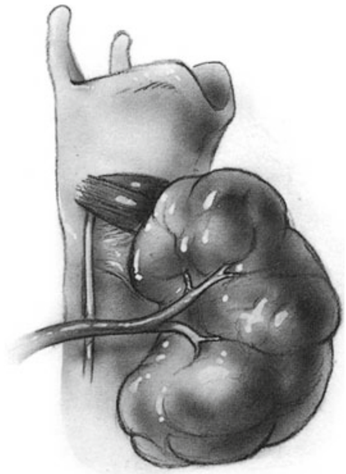

Fig. 121.2

recurrent laryngeal nerve, which occurs on the right side with an incidence of only 1 %, still inserts into the larynx caudad to the cricothyroideus muscle. The nerve can bifurcate, but generally it does so within about 1 cm of its insertion into the larynx. Gross identification of the nerve is aided by the presence of a vasa vasorum that looks like a "red racing stripe" on the anterior surface of the nerve. The nerve runs slightly obliquely in the tracheoesophageal groove. Structures running along this course are not the inferior thyroid artery (which is a misnomer). This artery actually corresponds in position to the middle thyroid vein. Unfortunately, the nomenclature suggests to the novice that the artery should be running from an inferior location cephalad to the thyroid, whereas it runs transversely in the neck. The recurrent laryngeal nerve is most commonly injured at the ligament of Berry, as the nerve can be closely adherent to or even run through the substance of the ligament.

Preserving the Superior Laryngeal Nerve

The motor branch of the superior laryngeal nerve may descend low and anterior to, interdigitate with branches of, or be enveloped in the same fascial sheath as the superior thyroid artery (Fig. 121.3). This makes injury to the nerve possible particularly during thyroid lobectomy. It is less of a problem during parathyroidectomy but still must be borne in mind. Some surgeons verify the position of this nerve on the basis of electrical stimulation to see movement of the cricothyroideus muscle (see Chap. 120).

Preserving Normal Parathyroid Tissue

In a four-gland exploration, the neck should be explored on both sides before excising or biopsying tissue. Parathyroids

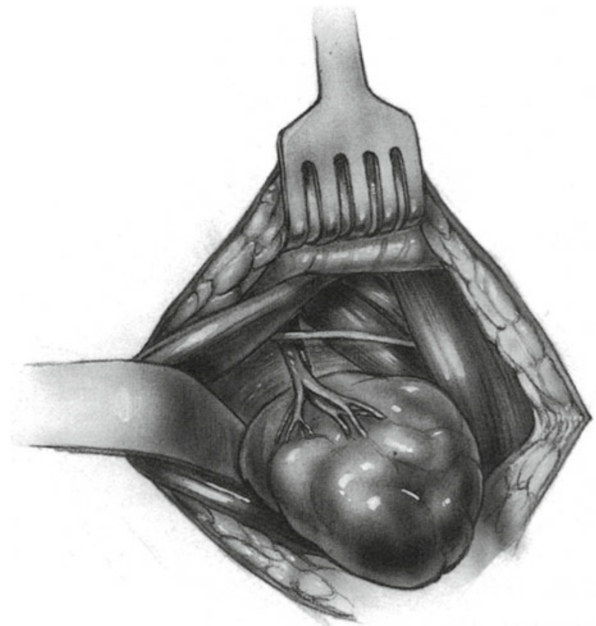

Fig. 121.3

that are normal grossly should not be excised. We tend to be conservative in our operations, preferring to excise only abnormally enlarged parathyroids and biopsy the next largest normal parathyroid. Gross identification of the parathyroids is adequate if the surgeon is experienced.

Documentation Basics

- Precisely document extent of exploration and findings: specifically note which glands were identified, which were removed, and which, if any, could not be found.
- Document autotransplantation, if performed.

Operative Technique

Incision and Exposure

Mark a line (a skin crease or one of Langer's lines) at the base of the neck with the patient sitting in a comfortable position (with arms folded in the lap) to achieve the best cosmetic result. To wait until the patient is supine and then mark the incision belies the fact that most people see the patient erect. The shift in the skin line when they do become supine varies two to three fingerbreadths above the sternal notch, and the depth of the sternal notch varies from patient to patient, making the incision line variable in its ultimate location.

Place a folded sheet longitudinally along the thoracic spine to allow the shoulders to roll laterally. Extend the neck gently with a rolled towel underneath the neck and the patient's head in a donut or padded support. Move the patient to the barber chair position with arms at the side and flexion at the hips and the knees.

Make a 3–8 cm skin incision with a no. 15 blade (see Fig. 120.3). The length of the incision depends upon the patient's anatomy, the surgeon's experience, and the type of surgery planned – MIP vs. four-gland exploration. Divide the subcutaneous tissues and platysma muscle transversely. The platysma may be represented by its fascia in a small incision, as the muscle itself may be located lateral to the midline. Elevate sub-platysmal skin flaps cephalad to the notch of the thyroid cartilage and caudad to the sternal notch (see Fig. 120.4). Incise the investing layer of the deep cervical fascia in the midline from notch to notch (see Fig. 107.6). If a MIP is planned, a less extensive flap dissection and incision of the deep cervical fascia may be done. Separate the strap muscles from each other and from their contralateral partners. Divide the areolar tissue between the thyroid and the strap muscles.

Minimally Invasive Parathyroidectomy

Approach the side of the localized gland and divide the areolar tissue between the thyroid and strap muscles. Leave the other side undisturbed. The imaging studies will often indicate whether the enlarged gland is superior or inferior (embryological origin, not anatomic location). A superior gland will be posteriorly located, most commonly lateral to the upper half of the thyroid gland. It could also be in the tracheoesophageal groove, often having dropped into the inferior position as it enlarged. The inferior gland will be anterior, usually adjacent to the inferior thyroid lobe, or in the thyrothymic tract. The thyroid lobe may be retracted with a small sponge mounted on a hemostat (Kittner). After the enlarged gland is located, gently dissect it away from its surroundings and identify and ligate its blood supply with a fine suture or clip. Avoid handling the gland with metal instruments, as it will fracture. Avoid electrocautery, as the nerve may be close. It is not necessary to identify the laryngeal nerves or the other parathyroid gland. With the limited exposure of this approach, meticulous hemostasis and knowledge of neck anatomy is crucial to avoid complications.

Four-Gland Exploration

Identify Crossing of the Inferior Thyroid Artery and the Recurrent Laryngeal Nerve

Mobilize the thyroid lobe medially to separate it from the carotid sheath. The middle thyroid vein need not be divided. The recurrent laryngeal nerve runs posterior (most commonly) or anterior to the inferior thyroid artery and sometimes even interdigitates with branches of the artery. The relation of the inferior thyroid artery and recurrent laryngeal nerve is important because we locate the parathyroids relative to the crossing of the nerve and the artery.

Find the nerve low in the neck, and trace it cephalad by careful blunt dissection anterior to the nerve. This generally allows you to find and preserve the bifurcation and avoid injury to the nerve at the ligament of Berry.

Identifying Inferior and Superior Parathyroids

The two parathyroids on each side are often surprisingly close to each other. The superior parathyroids are usually juxtacricoidal, and the inferior parathyroids are usually within a 2 cm radius of the inferior pole of the thyroid. Inspect the posterior capsule of the thyroid and the areas posterior and lateral to the thyroid. A reddish-brown color is the visual clue to an adenoma. It is different in appearance from the thyroid, bits of fat, or lymph nodes. The normal parathyroid is yellow-brown and generally tongue-shaped, although it can have other shapes. Gently palpate these areas to detect masses. Follow the course of the recurrent laryngeal nerve. Inspect and palpate both sides of the neck to determine if you are dealing with a solitary adenoma or multiglandular disease. It may be necessary to mobilize the superior pole of the thyroid to find the superior parathyroid.

Resecting the Adenoma

Mobilize the adenoma from surrounding tissues gently, making sure you have preserved the recurrent laryngeal nerve. Divide the hilar blood supply to the adenoma between clamps and ties of fine permanent sutures. Do not grasp the adenoma with forceps, which would increase the chance of breaking the capsule, leading to implantation of parathyroid tissue and recurrent hypercalcemia.

Biopsying Normal Parathyroid

Biopsy the next largest parathyroid gland (Fig. 121.4). Mobilize the antihilar one-third to one-fourth of the parathyroid sharply and excise it as a biopsy. The cut edge of a parathyroid typically bleeds uniformly, which helps with its identification. Control the bleeding with a hemostatic clip, which also marks the position of this gland.

Subtotal Parathyroidectomy

The term "three-and-a-half-gland parathyroidectomy" is imprecise and should be abandoned. First fashion a well-vascularized remnant of the most normal-looking

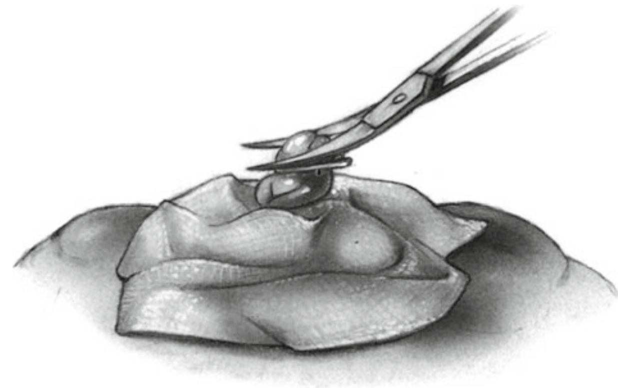

Fig. 121.4

parathyroid away from the recurrent laryngeal nerve. Excise tissue sharply from the antihilar end until the remnant is about 50 mg (5×3×2 mm). Mobilize and excise each of the other parathyroids sequentially, looking back to confirm the viability of the original remnant before excising the next gland. If this remnant is not viable, fashion another well-vascularized remnant from one of the remaining glands. This practice provides four opportunities to obtain a well-vascularized remnant.

Total Parathyroidectomy with Autotransplantation

Remove all four parathyroids. Set aside parathyroid tissue for autotransplantation immediately (on ice) or after cryopreservation (slow freezing).

Make a longitudinal incision in the volar aspect of the nondominant forearm. Sharply divide subcutaneous tissues down to the fascia of the forearm musculature. Create 12–15 pockets in the volar aspect of the forearm musculature using the electrocautery unit for the fascia and careful blunt dissection in the direction of the muscle fibers to avoid eschar and hematoma formation, respectively. Mince a parathyroid into 1×1×1 mm pieces. Place each piece in an individual muscle pocket, and close it over with a fine permanent suture; mark it with a hemoclip. Close the skin with absorbable subcuticular sutures and adhesive skin strips.

Sequence for an Unfound Adenoma

Explore for the adenoma in all the usual locations (Akerstrom et al. 1984). Follow the branches of the inferior thyroid artery, which can be a clue to its location. Gently pull on an enlarged branch of the inferior thyroid artery going to a suspected adenoma after you have found three normal parathyroids. Incise the thyroid capsule over any area of discoloration

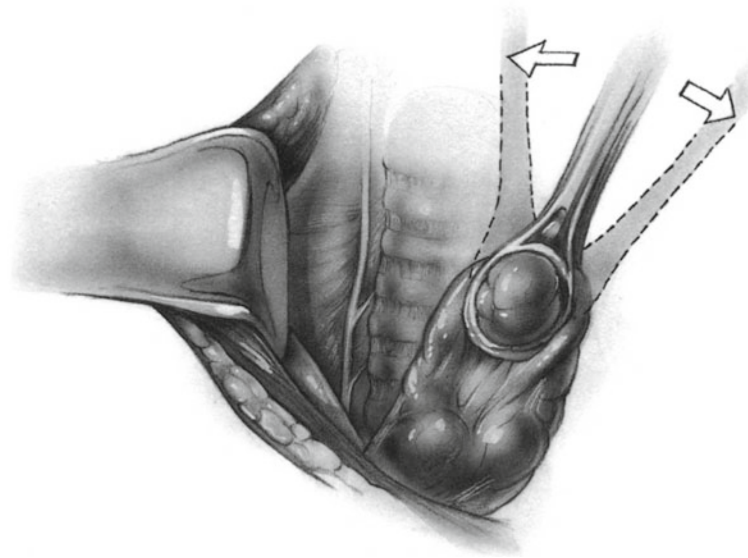

Fig. 121.5

that might be due to devascularization of an intrathyroidal parathyroid. Mobilize the thyrothymic ligament to help mobilize the cervical thymus to search for an intrathymic parathyroid adenoma. Inspect and palpate behind the pharynx and esophagus. Open the carotid sheath to inspect for parathyroids associated with the vagus nerve. Inspect and palpate again along the embryologic course of the parathyroids from the hyoid bone to the aortic arch.

Consider performing a thyroid lobectomy on the side of a missing superior parathyroid adenoma. The technique is similar to that shown in Chap. 107. With ultrasound, most intrathyroidal parathyroid adenomas may be identified preoperatively or intraoperatively.

Perform a cervical thymectomy for a missing inferior parathyroid adenoma. Grasp thyrothymic fat and thymus with ring forceps. Sharply mobilize the tissue off the trachea between the recurrent laryngeal nerves as far caudad as you can reach. Bluntly mobilize it from underneath the manubrium aided by a rocking, back-and-forth motion of the ring forceps grasping the tissue (Fig. 121.5). Excise this tissue.

Closure

Achieve hemostasis using fine suture-ligatures or clips (small or micro) for bleeding close to the recurrent laryngeal nerve. Close the strap muscles in layers with interrupted absorbable sutures and the investing layer of the deep cervical fascia with a running absorbable suture. Close the platysma muscle with interrupted absorbable sutures, and approximate the skin edges with subcuticular absorbable sutures and adhesive skin strips.

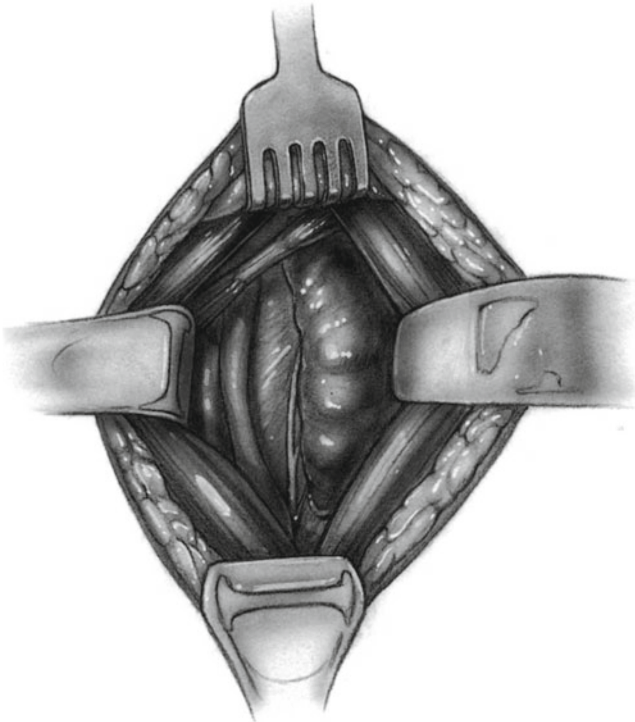

Fig. 121.6

Reoperation

Reoperation may be indicated if the patient does not achieve normocalcemia and has significant disease. Localization studies are required, and we prefer two concordant localizing studies prior to reoperation. Reoperation without definitive localization is often unrewarding.

Posterior Approach

If the suspected adenoma is localized to one side, incise the investing layer of deep cervical fascia between the strap muscles and the sternocleidomastoid muscle on that side (Fig. 121.6). Dissect down to the carotid sheath. Divide or mobilize and retract the omohyoid muscle. Find the recurrent laryngeal nerve. Approach the thyroid from its lateral aspect, avoiding scars from the previous operation. If the suspected adenoma has not been localized, re-exploration on both sides is necessary. Do this in a systematic way, exploring the usual locations first, as the missing adenoma is usually there.

A partial or full median sternotomy is almost never done at the initial exploration but may be necessary if the suspected adenoma is in the chest. Incise the skin vertically in the midline from the midpoint of the low-collar incision to the third intercostal space or to the xiphoid process. Place a finger behind the sternum. Cut the manubrium and the sternum with a vibrating saw in the midline after dividing the muscles. Retract the sternum. The sternum should be closed with wire sutures.

Postoperative Care

Cover the incision with a dry sterile dressing. Give clear liquids the night of the operation, and advance some patients to a regular diet if tolerated. Check them closely for upper airway obstruction and signs of damage to the parathyroids or laryngeal nerves. Check the serum calcium level daily. Incisional pain is tolerable and responds to acetaminophen with or without codeine.

Dialyze patients with secondary hyperparathyroidism 1–2 days after operation using regional heparinization. These patients are prone to prolonged and severe hypocalcemia. The following are management recommendations from the National Kidney Foundation clinical practice guidelines (KDOQI 2009):

The blood level of ionized calcium should be measured every 4–6 h for the first 48–72 h after surgery and then twice daily until stable.

If the blood levels of ionized or corrected total calcium fall below normal (<3.6 mg/dL [0.9 mmol/L] corresponding to corrected total calcium of 7.2 mg/dL [1.80 mmol/L]), a calcium gluconate infusion should be initiated at a rate of 1–2 mg elemental calcium per kilogram body weight per hour and adjusted to maintain an ionized calcium in the normal range (4.6–5.4 mg/dL [1.15–1.36 mmol/L]). *A 10-mL ampule of 10% calcium gluconate contains 90 mg of elemental calcium.*

The calcium infusion should be gradually reduced when the level of ionized calcium attains the normal range and remains stable.

When oral intake is possible, the patient should receive calcium carbonate 1–2 g three times a day, as well as calcitriol of up to 2 μg/day, and these therapies should be adjusted as necessary to maintain the level of ionized calcium in the normal range.

If the patient was receiving phosphate binders prior to surgery, this therapy may need to be discontinued or reduced as dictated by the levels of serum phosphorus.

Complications

Bleeding is a possibility after any neck exploration and is of vital concern when it causes tracheal compression and respiratory compromise. It usually manifests the evening of operation as dyspnea and is managed by evacuating the hematoma emergently using a sterile clamp that has been taped to the bed for just this possibility. Take the patient to the operating room to explore the neck. Usually no single bleeding point is found.

There are several causes of *upper airway obstruction* in addition to hematoma. The most common is soft tissues, usually the tongue, falling posteriorly. This complication typically occurs in the recovery room and is usually reversed by the chin-lift or jaw-thrust maneuver. *Laryngospasm* is also possible particularly early after operation and is often relieved by the same maneuvers but may require reintubation. *Recurrent laryngeal nerve palsy*, particularly bilaterally, can cause upper airway obstruction. It is typically seen right after operation but may be delayed because of swelling, causing paresis of the nerve 1–2 days postoperatively. It may require reintubation or tracheostomy. Finally, *laryngeal tetany* can cause upper airway obstruction because of hypocalcemia from hypoparathyroidism. It responds quickly to parenteral calcium.

Recurrent laryngeal nerve palsy can arise simply from dissecting the nerve (without a direct injury). Identifying the recurrent laryngeal nerve at operation decreases the chance of permanent palsy in thyroidectomy but has not been studied in parathyroidectomy. A nerve transection during neck exploration should be repaired using magnification, microsurgical instruments, and fine permanent sutures to approximate the neurilemmal sheath.

Superior laryngeal nerve palsy is uncommonly detected. It should be a problem only to patients who use their voice professionally, such as the opera star Amelita Galli-Curci, whose career was cut short by injury to this nerve at thyroidectomy.

Patients may develop *hypocalcemia* as the disease reverses itself after successful parathyroidectomy. It is usually temporary and responds to parenteral and oral calcium. Give calcium gluconate 1 g IV and then calcium carbonate 1.5 g PO qid. For significant hypocalcemia, I usually add Rocaltrol 0.25–0.50 μg PO qd. If the serum calcium is normal 1–2 weeks postoperatively on oral calcium alone, the calcium dose can usually be tapered and stopped or reduced to replacement doses given for optimal bone health.

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Adrenalectomy

122

Carol E.H. Scott-Conner

Indications

Open transabdominal adrenalectomy may be used in any situation where it is necessary to remove the adrenal gland. It has been largely superceded by laparoscopic adrenalectomy (see Chap. 123) for removal of small benign tumors. Open surgery remains the preferred approach for:

- Large tumors, where the laparoscopic approach would be difficult or the risk of malignancy is high.
- Known (primary) malignant adrenal tumors such as adrenocortical carcinoma.
- It is the safety net procedure when laparoscopic adrenalectomy is not progressing well or when uncontrollable hemorrhage occurs.

Contraindications to resection of a primary adrenal carcinoma generally include the following: known metastatic disease, encasement of adjacent critical structures (the celiac axis on the left, porta hepatis, or inferior vena cava on the right). In selected cases, chemotherapy followed by surgery may be employed. Tumors that extend into the ipsilateral kidney may require en bloc nephrectomy. In these cases, insufficient contralateral renal function can contraindicate resection.

Preoperative Preparation

Work-up will have included imaging studies such as CT and/or MRI scan. Studies to assess function are performed selectively and include:

- Plasma metanephrines, normetanephrines, fractionated catecholamines
- Plasma aldosterone and renin
- Plasma cortisol and ACTH
- Plasma electrolytes
- 24-h urine VMA, metanephrines, fractionated catecholamines

Patients with pheochromocytomas require very careful preparation for surgery with hydration and alpha- followed by beta-adrenergic blockade (see Chap. 123).

Blood for transfusion, if needed

Pitfalls and Danger Points

Adrenal tumors, like many other endocrine tissues, readily autotransplant. This means that disruption of the capsule and spillage of adrenal tissue may result in recurrence. Therefore, do not perform any unnecessary preoperative biopsies. Avoid disrupting the capsule and remove the tumor en bloc with a margin of surrounding soft tissue and resect any locally adherent structures.

Bleeding may occur. The short, fat right adrenal vein is fragile and easily damaged. Large right adrenal tumors may require mobilization of the right lobe of the liver, in some cases best done through a thoracoabdominal incision.

Unrecognized or inadequately prepared pheochromocytomas can result in hypertensive or hypotensive crises.

Adrenal insufficiency may occur during the postoperative period (see Complications, below).

Operative Strategy

For most patients, an extended subcostal incision provides excellent exposure. This incision can be extended upward as a median sternotomy if needed (Fig. 122.1). A thoracoabdominal incision also gives excellent exposure, particularly for bulky right adrenal malignancies, but has largely been superceded by the median sternotomy extension. Always perform a thorough exploration for metastatic disease, which will generally preclude resection. Invasion into adjacent

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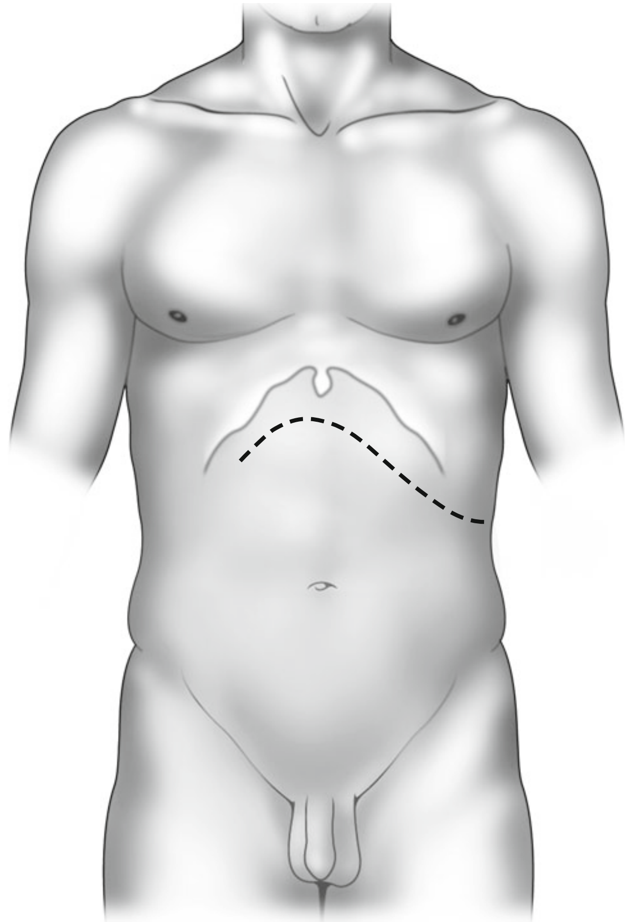

Fig. 122.1

critical structures should have been identified on preoperative imaging studies, but findings at exploration may require modification of operative strategy.

Exposure is enhanced by placing a roll under the ipsilateral flank or costal margin or breaking the operating table.

On the left, adequate exposure of the adrenal gland for smaller tumors may only require wide entry into the lesser sac through the gastrocolic omentum. Larger tumors are best exposed with complete medial visceral rotation, including spleen and tail of pancreas.

On the right, the right triangular ligament of the liver will need to be divided and the liver retracted cephalad. The hepatic flexure of the colon is released and the colon retracted inferiorly and medially. Wide exposure of the inferior vena cava is obtained by performing a complete Kocher maneuver.

After obtaining sufficient exposure, place fixed retractors and assess the extent of the tumor, mobility, adherence to adjacent tissues, and, if necessary, regional lymph nodes.

On the left, the adrenal vein drains into the left renal vein. Multiple adrenal arteries need to be controlled and divided. On the right, the adrenal vein is very short and fat, and it drains directly into the inferior vena cava. It is easily injured. Typically, the right adrenal vein is taken as the last step in right adrenalectomy.

Operative Technique

Left Adrenalectomy

Position the patient supine. Place a roll under the ipsilateral flank or costal margin, or break the table to widen the distance between the costal margin and the pelvis. Make a long left subcostal incision. Explore the abdomen, carefully assessing for presence of distant metastases, size and degree of fixation of adrenal tumor, and involvement of regional lymph nodes.

If the tumor is small, adequate exposure may be obtained by creating a generous opening in the gastrocolic omentum. Divide the omentum with clamps and ties to secure branches of the gastroepiploic arcade. Retract the stomach cephalad and the colon inferiorly. Generally the first vessels to divide are the adrenal vein (which drains into the left renal vein) and the inferior adrenal artery (which originates in the left renal artery) as shown in Fig. 122.2. Secure these vessels with ties and use the stump for retraction of the gland.

The plane deep to the adrenal gland is usually avascular and can be gently developed by careful sharp and blunt dissection. The middle adrenal artery arises from the aorta, and the multiple superior adrenal arteries arise from the inferior phrenic artery. These vessels enter on the medial and upper aspect of the adrenal gland, typically by dividing into multiple tiny twigs. The Harmonic scalpel is useful here (Fig. 122.3). After division of these vessels, the adrenal gland should be attached only by some remaining filmy attachments. Take care to remove any adherent tissue en bloc, and carefully seek and remove any regional lymph nodes.

If the tumor is large, better exposure is obtained by an extensive medial visceral rotation. Incise the peritoneum lateral to the spleen, and gently mobilize the spleen and tail of pancreas medially as shown in Fig. 91.3. Mobilize the splenic flexure as well. The resection then proceeds as previously outlined.

Obtain hemostasis and close the incision without drains.

Right Adrenalectomy

Position the patient supine as described above. Make a long right subcostal incision and explore the abdomen.

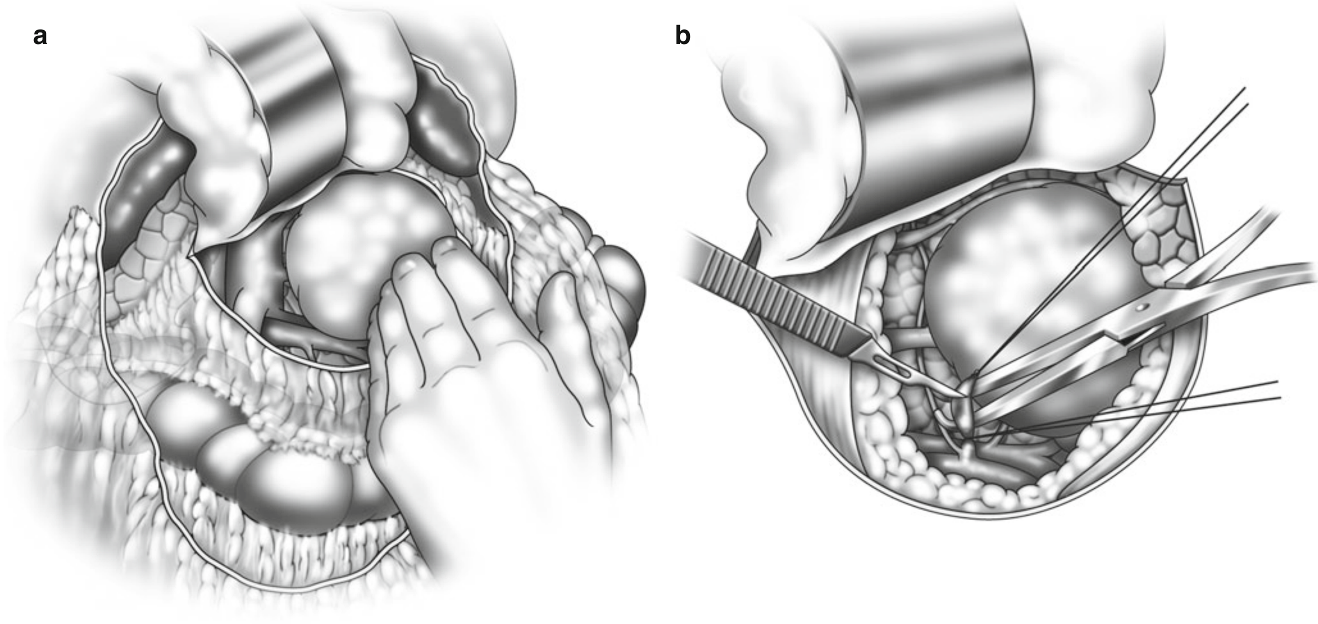

Fig. 122.2

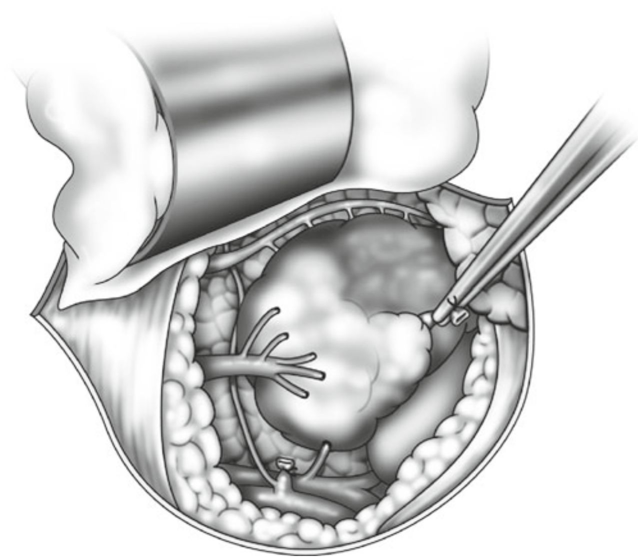

Fig. 122.3

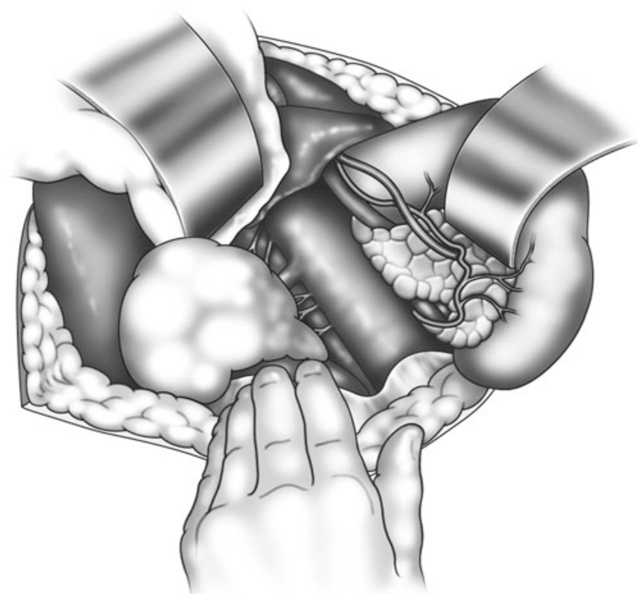

Fig. 122.4

Incise the right triangular ligament and gently retract the liver cephalad. Divide the hepatocolic ligament and mobilize the hepatic flexure of the colon downward. Incise the peritoneum lateral to the duodenum, and perform a complete Kocher maneuver as shown in Figs. 89.2 and 89.3. Place fixed retractors to expose the adrenal gland (Fig. 122.4).

The lateral border of the right adrenal gland is generally the least vascular part, because the blood supply comes from superiorly, medially, and inferiorly. Begin the dissection laterally by incising the peritoneum or tissues lateral to the adrenal. Take care to include a margin of soft tissue rather than entering the plane on the capsule of the adrenal, to minimize the chance of inadvertent spillage of adrenal tissue.

Similarly, the plane deep to the adrenal gland is generally avascular. Develop this plane by gentle sharp and blunt dissection.

Divide the multiple superior and inferior adrenal arteries with the Harmonic scalpel (Fig. 122.5). This will leave the medial attachments, including the right adrenal vein, as the last part of the dissection. If difficulty is anticipated during

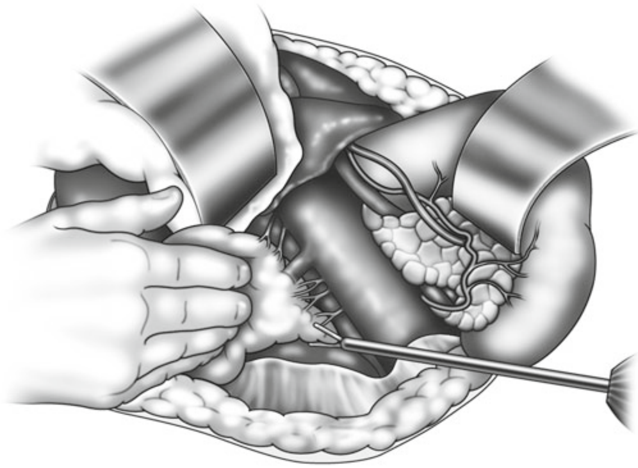

Fig. 122.5

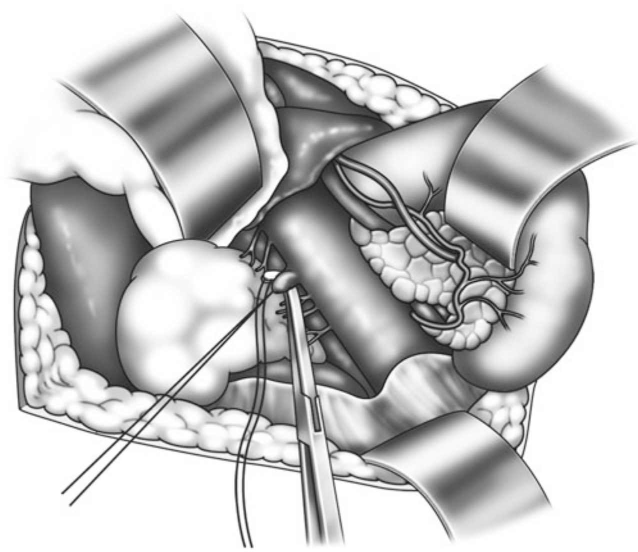

Fig. 122.6

this phase, take time to mobilize the inferior vena cava enough to apply a Satinsky or other “side-biting” vascular clamp. The right adrenal vein is quite fragile; take care during mobilization and ligation (Fig. 122.6). Alternatively, use an endoscopic vascular stapler to secure and divide the vein.

If the vein is lacerated, torrential bleeding may occur. In this situation, do not attempt to blindly clamp the stump, as this rarely succeeds and is likely to further injure the vein. Obtain control with finger pressure. Then apply a vascular clamp, or have an assistant apply pressure to the inferior vena cava above and below the site of bleeding with two sponge sticks. Then carefully suture ligate the stump (Fig. 122.7).

Obtain hemostasis and close the incision without drains.

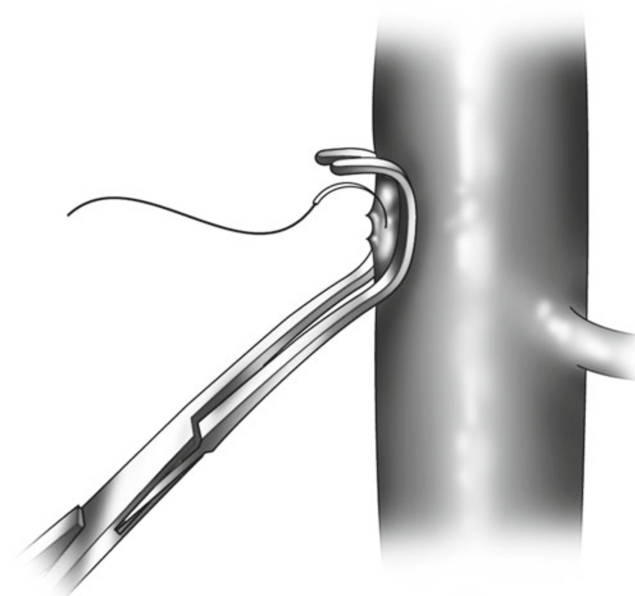

Fig. 122.7

Postoperative Care

Postoperative care is similar to that for any abdominal surgery patient. Patients with pheochromocytoma should be observed overnight in ICU. Beta blockade is gradually weaned.

Glucocorticoid deficiency may occur after removal of a functioning adenoma or carcinoma. The patient will then require replacement glucocorticoids until the contralateral adrenal gland is able to provide adequate output.

Complications

Bleeding from the adjacent solid organs (liver or spleen) can usually be controlled during surgery, but is best avoided.

Bleeding from the right adrenal vein is managed by direct pressure, adequate exposure and mobilization of the inferior vena cava, control with a Satinsky or other side-biting vascular clamp, and direct suture of the ostium on the vena cava.

Pheochromocytoma patients often experience hypotension during the immediate postoperative period. Adequate fluid replacement, use of pressors, and monitoring in ICU are required.

Peritoneal recurrence due to implantation of adrenal tissue is less common after open adrenalectomy but still occurs.

Further Reading

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Laparoscopic Adrenalectomy

123

Jennifer C. Carr and James R. Howe

Indications

Primary tumors of the adrenal gland
- Adenoma – usually those less than 5 cm, where the risk of adrenocortical cancer is low, although this point is controversial
- Pheochromocytoma
- Aldosteronoma

Metastatic tumors of the adrenal gland
Adrenal hyperplasia

Preoperative Preparation

Preoperative laboratory studies:
Type and crossmatch blood
Evaluation for functional tumors:
- Plasma metanephrines, normetanephrines, fractionated catecholamines
- Plasma aldosterone and renin
- Plasma cortisol and ACTH
- Plasma electrolytes
- 24-h urine VMA, metanephrines, fractionated catecholamines
- Preoperative diagnostic imaging studies:

Computed tomography (CT) of the abdomen/pelvis and/or abdominal magnetic resonance imaging (MRI) of the adrenals
Metaiodobenzylguanidine (MIBG) scanning for pheochromocytoma (rarely)

Preoperative preparation for suspected pheochromocytoma: Initiate alpha-blockade prior to the initiation of beta-blockade. Phenoxybenzamine is the preferred alpha-blocker and is dosed as follows: 10 mg orally twice daily for 3 days, then 10 mg orally three times daily for 3 days, then 20 mg orally twice daily for 3 days, and then 20 mg in am/10 mg at noon/20 mg in pm for 3 days; the last dose is given the night before surgery (none the morning of surgery). Three days prior to operative intervention, start beta-blockade, such as propranolol 10 mg orally three times daily for 3 days (the last dose given the morning of surgery). During alpha-blockade, patients are urged to drink freely to replete plasma volume and to check and record their pulse and blood pressure daily. A physician or nurse should check in with patients to make sure their blood pressure is not too low.
Intravenous fluids
Preoperative antibiotics
Orogastric tube
Foley catheter
Pneumatic compression stockings

Pitfalls and Danger Points

Hypertensive crisis (in patients with pheochromocytomas not adequately blocked)
Hypotension (after removal of pheochromocytoma)
Adrenal insufficiency (after removing a gland for Cushing's syndrome, or if there has been previous contralateral adrenalectomy or possibly nephrectomy)
Need for conversion to open adrenalectomy
Inadvertent injury to adjacent organs, including colon, spleen, pancreas on the left; colon, duodenum, and liver on the right
Devascularization of the upper pole of the kidney
Injury of the left renal vein or IVC

Operative Strategy

This chapter describes the transabdominal approach to laparoscopic adrenalectomy. References at the end describe alternative retroperitoneal approaches.

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Left adrenalectomy requires mobilization of overlying colon, spleen, and tail of pancreas to expose the adrenal gland. It is important to ensure adequate mobilization of the splenic flexure and to limit the medial aspect of the superior dissection to avoid injury to the colon and stomach. Resection of the left adrenal requires control of the left adrenal vein and branches of the adrenal artery, originating from the inferior phrenic artery, aorta, and renal artery. It is possible the blood supply may also originate from the intercostal and gonadal vessels. These arteries branch into an extensive plexus in the capsule and require careful dissection. Attempts should be made to minimize tumor manipulation as well as to avoid rupture of the tumor capsule if present.

On the right, the hepatic flexure of the colon must be retracted down and the right lobe of liver retracted cephalad. The right adrenal vein is short and fat; this fragile vessel drains directly into the inferior vena cava. Adequate exposure of this vessel is facilitated by developing the areolar plane over the anterior and right lateral aspect of the inferior vena cava, after obtaining adequate exposure of the adrenal gland. The right adrenal vein is generally secured and divided with a vascular stapler or clips. The stump of the vein which remains attached to the adrenal can be used as a convenient handle for manipulating the gland.

Operative Technique

Patient Positioning

Position the patient on a beanbag, in the lateral decubitus position. Place the kidney rest between the 11th rib and the iliac crest, raise it to its highest position, and then flex the table.

Pad and support the ipsilateral arm on a moveable upper arm rest (such as a Ming Sling), and place a roll in the dependent axilla. Lean the patient back approximately 15° to increase the anterior exposure, and then inflate the beanbag. Place two pillows between the patient's legs, and secure the hips and shoulders by tape (over a folded towel) extending from one edge of the table to the other (Fig. 123.1a).

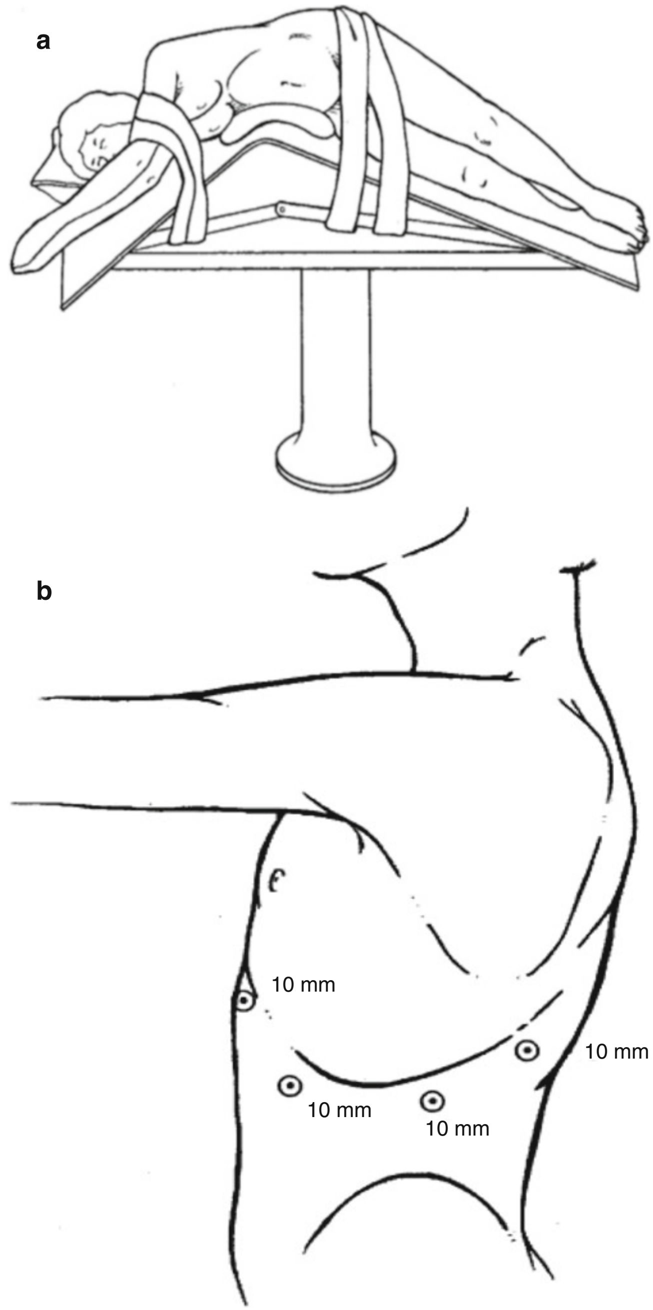

Fig. 123.1 (From Scott-Conner CEH, editor. Retroperitoneal approach. The SAGES manual: fundamentals of laparoscopy, thoracoscopy, and GI endoscopy. New York: Springer; 2006, with permission)

Port Placement

For transperitoneal laparoscopic adrenalectomy, four ports are used. In order to ensure appropriate space for the instruments, place each 8–10 cm apart. Place the lateral-most port through the flank between the iliac crest and 11th rib. Prior to insufflation, mark the location of the ports, two fingerbreadths below the costal margin. The most medial port is located in the epigastrium or subxiphoid region, in the midline. The lateral port is marked between the iliac crest and 11th rib in the midaxillary line, and the other two are distributed between these two with 8–10 cm between each port (Fig. 123.1b). The first port is placed via an open approach, at the site of the second most medial position.

After placing the first port, confirm intra-abdominal positioning, and insufflate to 15 mmHg. Place the remaining ports under direct visualization. Place the next more lateral port, followed by the most lateral. Place these after assessing whether the right or left colon needs to be mobilized, which is unusual on the right, but common on the left. Finally, place

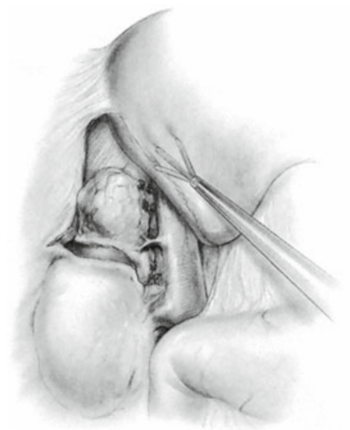

Fig. 123.2 (From Brunt LM. Laparoscopic adrenalectomy. Lap Surg Abdom. 2004;213–37, with permission)

the most medial port. This port often traverses the falciform ligament – and this is facilitated by pushing the liver down with an instrument at the time of this insertion.

Right Adrenalectomy

Place ports as noted above and insufflate to 15 mmHg with carbon dioxide. Before placing the lateral port, visualize the hepatic flexure of colon. If there is adequate space, place the port under direct visualization. However, if more space is necessary, the hepatic flexure may need to be mobilized.

Use the midclavicular port for the camera, preferably a 30° scope. Place a fan retractor through the subxiphoid port, and use it to retract the liver medially. Elevate the lateral peritoneum with an atraumatic grasping clamp, and divide the right triangular ligament at the peritoneal reflection using a harmonic scalpel. Carry this as far superiorly as technically feasible, making sure not to go as high as the right hepatic vein. Use the fan retractor to gently lift and retract the lateral edge of the liver.

Open Gerota's fascia over the middle of the kidney in a vertical fashion, extending this incision cephalad to where the lateral edge of the liver meets the diaphragm. Beginning at the superior pole of the kidney, divide the perinephric fat along this line back to the diaphragm, leaving some fatty tissue attached to the adrenal. Push the lateral fat away. Next, open the peritoneum 1 cm lateral to the liver, extending up to the diaphragm, and inferiorly to the upper third of the kidney.

Medially, identify the vena cava just below the liver edge and gently dissect the space between it and the superior pole of the kidney (Fig. 123.2). This concludes the medial most extent of the dissection. As dissection continues, gentle retraction of the inferior vena cava in a medial fashion as well as elevation of the liver will help expose the adrenal gland.

As the adrenal gland comes into view, liberate it from the perinephric fat with the harmonic scalpel, beginning at the superior and lateral aspects. The harmonic scalpel is preferred, as the arterial supply to the adrenal is not often visualized. If the adrenal is not encountered in this manner, continue dissection through the perinephric fat, superomedially from the point of earlier fat bisection. Again, if the lateral edge is still not located, continue dissection in the plane between the superior pole of the kidney and the vena cava until it is visualized.

After dissecting free the superior and lateral aspects of the adrenal, clear the area between the adrenal and kidney. Take care with this dissection, as the blood supply to the superior pole of the kidney is found inferomedially in this space.

Then retract the adrenal laterally, and use the harmonic scalpel to clear the areolar tissue between the vena cava and the inferior aspect of the gland. Carefully dissect with the harmonic scalpel superior and medial to the adrenal, hugging the top of the adrenal gland, to avoid injury to the adrenal vein.

The right adrenal vein is shorter in length than on the left and drains directly into the vena cava. Careful dissection is necessary to avoid conversion to an open procedure secondary to vascular injury in this area. Use gentle blunt dissection to open the space between the lateral wall of the vena cava and the adrenal gland. Then use a dissector to open up the posterior plane, joining the openings created superiorly and inferiorly.

Position an Endo GIA stapler with a 2.5 mm vascular load, with one fork posterior and one anterior to the adrenal vein. Fire it to secure and divide the adrenal vein (Fig. 123.3). Take down any additional attachments with the harmonic scalpel until the gland is free.

Place the adrenal gland in an endoscopic bag, and remove it through the midclavicular port site. Check the resection area for adequate hemostasis along the vena cava and the adrenal bed and for adequate blood flow to the superior pole of the kidney.

Check the surrounding area for extra-adrenal or residual tissue.

Irrigate the field and close the fascia with 0 Vicryl sutures. Close the skin incisions with 4-0 Monocryl subcuticular sutures.

Left Adrenalectomy

Port placement is the same as with a right adrenalectomy but on the left side of the patient. Use a 30° scope passed through the subxiphoid site. Grasp the splenic flexure with an atraumatic grasping clamp. Divide peritoneal attachments near the splenic flexure, using the harmonic scalpel along the lateral aspect for about 15 cm and in the direction of the transverse colon for about 10 cm. This frees up the lower aspect of the kidney.

After mobilizing the splenic flexure, place the lateral port under direct visualization. Move the camera to this lateral-most port, and pass a fan retractor in the most medial port. Use this to gently elevate the lateral aspect of the spleen.

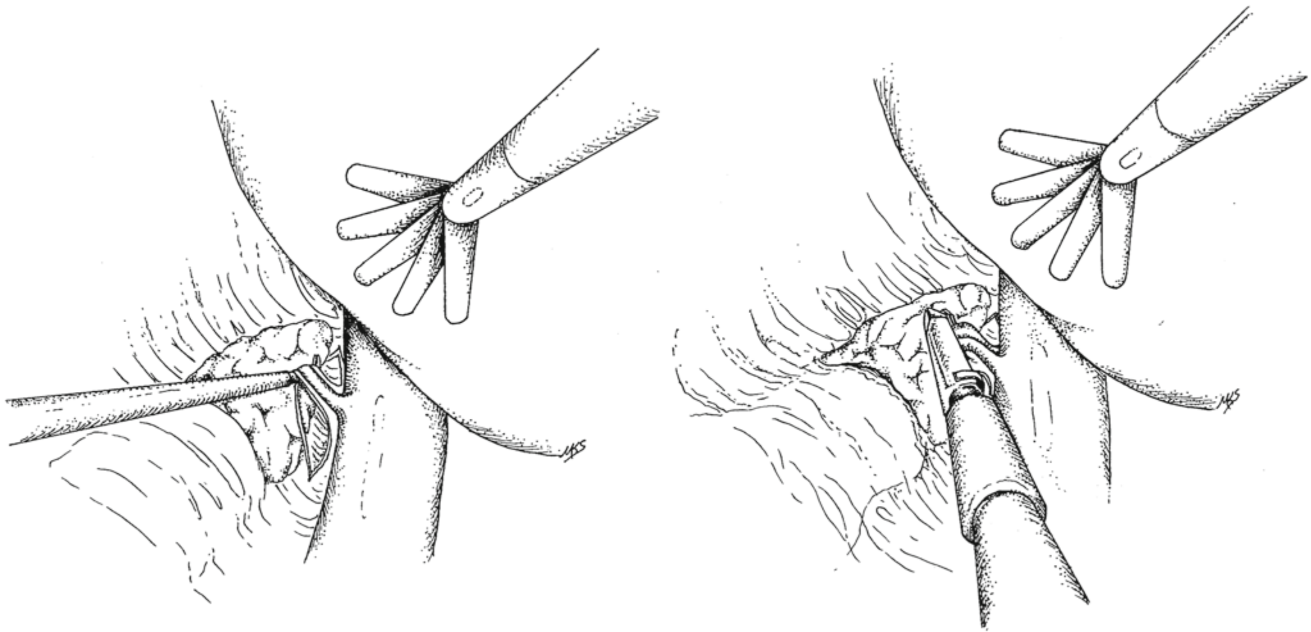

Fig. 123.3 (From Scott-Conner CEH, editor. Retroperitoneal approach. The SAGES manual: fundamentals of laparoscopy, thoracoscopy, and GI endoscopy. New York: Springer; 2006, with permission)

Working with harmonic scalpel and graspers placed through the two middle ports, take down the peritoneal attachments of the spleen are taken down. As the spleen is rotated medially and cephalad, the perinephric fat over the kidney should come into view.

Open Gerota's fascia as described for right adrenalectomy. Divide the perinephric fat with the harmonic scalpel just cranial to the superior pole of the kidney, continuing straight vertically, then deeper posteriorly toward the diaphragm, and at the upper aspect, medially toward the stomach and aorta. As dissection continues in this superomedial trajectory, the adrenal should come into view (Fig. 123.4). This is facilitated by gently retracting the spleen and lateral peritoneum medially with the fan retractor. If necessary, during this dissection, change the position of the scope and instruments for improved traction and visualization.

Dissect along the superolateral aspect of the gland with the harmonic scalpel. Grasp the superior adrenal fat and use this to rotate the gland anteriorly for optimal exposure and takedown of the superomedial attachments. Dissect the lateral edge of the gland off the medial edge of the kidney in an avascular plane.

Next, pull the gland laterally, and continue the dissection between the fat/edge of the adrenal and aorta, in the areolar plane which presents itself when there is adequate traction.

Carefully dissect the inferior edge of the adrenal from the surrounding fat. At the medial aspect, dissect posteriorly, taking care not to injure the renal or adrenal vein. Develop the space between the kidney and inferior aspect of the adrenal, and then connect this posteriorly to the opening made in the medial inferior aspect. Place an Endo GIA 45 stapler with a 2.5 mm load across the space and fire it to divide the adrenal vein within. Alternatively, as the vein is longer on the left, it may be dissected free (Fig. 123.5) and clipped.

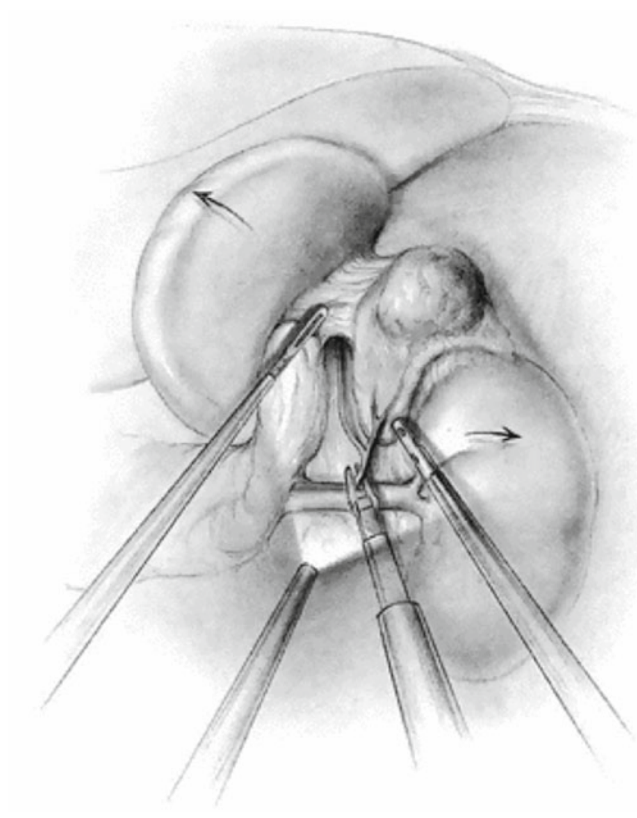

Fig. 123.4 (From Brunt LM. Laparoscopic adrenalectomy. Lap Surg Abdom. 2004;213–37, with permission)

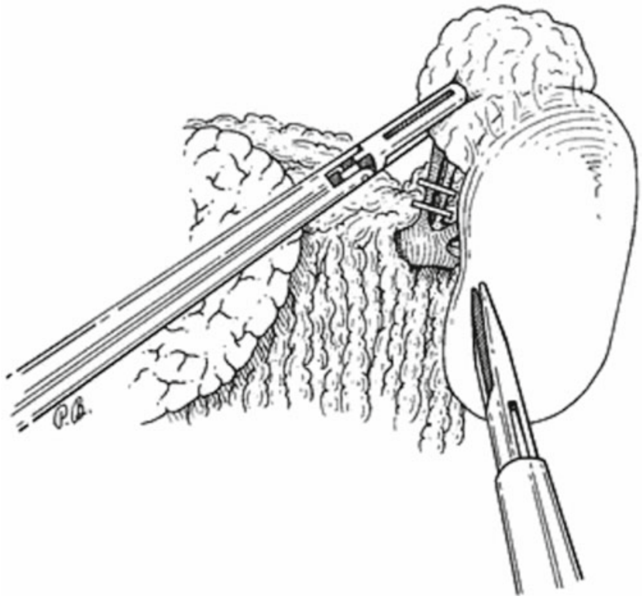

Fig. 123.5 (From Smith CD, Weber CJ, Amerson R. Laparoscopic adrenalectomy: new gold standard. World J Surg. 1999;389–96, with permission)

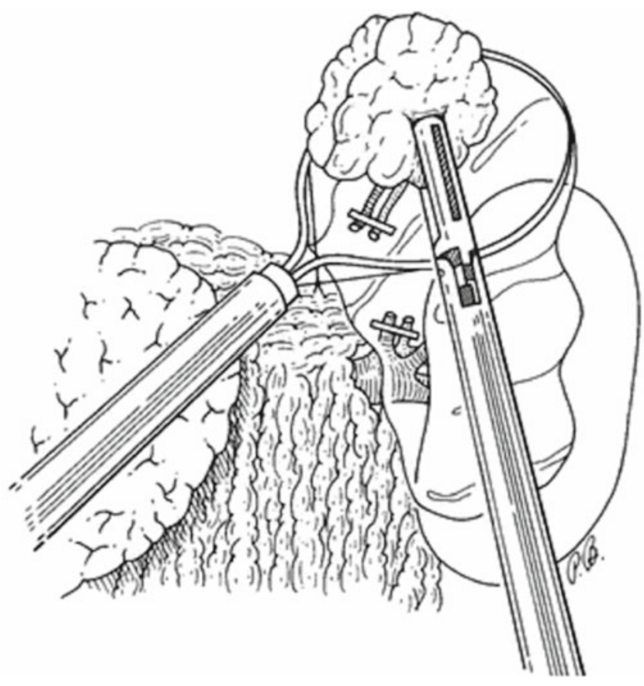

Fig. 123.6 (From Smith CD, Weber CJ, Amerson R. Laparoscopic adrenalectomy: new gold standard. World J Surg. 1999;389–96, with permission)

Remove the adrenal gland via an endoscopic retrieval bag (Fig. 123.6), via the midclavicular port site. Inspect the resection area for adequate hemostasis and adequate blood flow to the superior pole of the kidney. At this time, also search the area for extra-adrenal or residual tissue. Irrigate the field and then close the fascia with 0 Vicryl suture. Close the skin with 4-0 Monocryl in a running subcuticular fashion.

Postoperative Care

In the absence of complications, such as bleeding or internal organ injury, patients are admitted to a general surgical floor postoperatively. Patients with pheochromocytomas are observed overnight in the ICU for hypotension and are transferred to floor on postoperative day 1; beta-blockade is weaned postoperatively. Postoperative antibiotics are not administered. The diet is advanced as tolerated, and patients are ambulated early. Most patients are discharged 2–3 days postoperatively.

Complications

Bleeding from retraction of the liver or spleen is usually controllable with use of the argon beam coagulator. Bleeding from the right hepatic vein, IVC, or renal vein/artery on the right side is an indication for immediate conversion to an open procedure; on the left, the splenic artery and vein can be injured as the spleen is retracted if the dissection is carried out too medially, and inferiorly the renal vein and artery, all of which should lead to open conversion.

Visceral injury may occur if the splenic flexure of the colon is not adequately and carefully mobilized; if the superior dissection is taken too medially, the stomach may be encountered on the other side of the spleen.

Obese patients may occasionally develop *rhabdomyolysis* from prolonged positioning on one side, which is identifiable by its characteristic dark urine in the Foley bag. Adequate hydration (with or without alkalinization) is important for management.

Hypotension is typical after adrenalectomy for pheochromocytoma, even with adequate alpha-blockade. This may require pressors in the early postoperative period, and therefore pheochromocytoma patients should be observed in the ICU overnight.

Sometimes it can be *difficult to locate the adrenal*, especially in large patients with small glands (such as in aldosteronoma). Some advocate using laparoscopic ultrasound to help find the gland. If one continues to struggle, consider opening the medial port site enough to accommodate a hand port; in these difficult situations, one can often palpate the relatively firmer adrenal tissue within the softer perinephric fat, which can help getting the procedure back on track.

Wound infection following a laparoscopic adrenalectomy is rare, but should this be suspected (erythema, purulence at port sites, fever), the incision should be opened for drainage, packed, and allowed to close via secondary intention.

Intestinal *obstruction* due to adhesions occasionally occurs but is a rare complication with the use of laparoscopy.

Port-site *hernia* is possible but again is a rare complication. Should a hernia be identified, discussion with the patient should be had regarding elective repair.

Further Reading

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Parotidectomy

124

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Tumors of the parotid gland
Chronic sialadenitis or calculi of the parotid ducts

Pitfalls and Danger Points

Damage to facial nerve and its branches
Failure to excise a parotid tumor with a sufficient margin of normal parotid tissue

Operative Strategy

Extent of Resection

Although the parotid gland is not anatomically a truly bilobed structure, the surgeon may visualize it as having a superficial lobe and a deep lobe, with the branches of the facial nerve passing between these two structures. Consequently, it is feasible to excise the superficial lobe with preservation of the branches of the facial nerve. This dissection is indicated for most patients who have mixed tumors of the parotid gland. A few mixed tumors arise in the deep lobe of the gland. In these cases, perform a superficial parotid lobectomy to identify each of the facial nerve branches. Then, with preservation of the facial nerve, remove the deep lobe.

Occasional small benign tumors require dissection of the facial nerve only in the region of the tumor. The tumor may then be resected with a good margin of parotid tissue by doing a partial superficial lobectomy.

Malignant tumors of the parotid gland, unless unusually small, should be removed by total parotidectomy with excision of that portion of the facial nerve lying within the tumor. Microsurgical techniques allow the nerve to be reconstructed with a graft, which is often taken from the auriculotemporal nerve.

Locating and Preserving the Facial Nerve

There are two methods for identifying and dissecting the facial nerve. Some surgeons prefer to locate the major trunk of the facial nerve by first identifying a peripheral branch, such as the marginal mandibular branch. They then trace this nerve backward toward its junction with the cervical facial branch and finally to the main facial trunk. We prefer the more common technique of first identifying the main trunk of the facial nerve posterior to the parotid gland. Before it enters the parotid gland, the main facial nerve is a large structure, often measuring 2 mm in diameter. Once this main trunk is identified, the key to the dissection technique is to use either fine, blunt-tipped Jones scissors or a mosquito hemostat. The closed hemostat tip is inserted in the plane immediately anterior to the nerve. After the surgeon gently opens the hemostat, the assistant cuts the loose fibrous tissue that attaches the nerve to the overlying parotid gland. Never divide any parotid tissue before identifying the facial nerve and its branches.

If the proper plane of dissection is maintained, bleeding is rarely a problem. Most bleeding arises from small veins, and it generally stops with application of gauze pressure. An important part of the dissection technique is for the surgeon to apply pressure on the tissue posterior to the nerve with gauze while the assistant applies tension to the superficial lobe of the parotid gland using Allis clamps or small retractors. An occasional small vein must be clamped with a small mosquito hemostat and tied with a fine absorbable ligature.

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Electrocautery may be used for hemostasis in areas of the dissection away from the facial nerve and its branches.

The surgeon should have sufficient familiarity with the appearance of the facial nerve to make a positive visual identification. Occasionally, some fibers of questionable nature attach to the facial nerve branches. They may be tested by gently pinching or stimulating the fiber and then looking at the cheek for muscle twitching. This test, of course, requires that the entire cheek and the corner of the eye be exposed when the surgical field is draped.

The key to successful nerve preservation is early identification of the main facial trunk. The facial nerve emerges from the skull through the stylomastoid foramen, which is situated just anterior to the mastoid process and just below the external auditory canal. Beahrs emphasized that if the surgeon places the tip of the index finger over the mastoid process with the fingertip aimed toward the nose the middle of this finger is pointing to the facial trunk, which emerges about 0.5 cm anterior to the center of the fingertip and perhaps 1 cm deep to the external surface of the mastoid process. An idea of the depth at which the nerve emerges can be gained by identifying the posterior digastric muscle and tracing it toward its insertion deep to the mastoid process. The nerve crosses at a level equivalent to the surface of the digastric muscle. In other words, dissect along the anterior surface of the sternomastoid muscle and the mastoid process posterior to the parotid gland. There are no vital structures in this plane crossing superficial to the main trunk of the facial nerve.

There is a tiny arterial branch (posterior auricular artery) crossing just superficial to the facial trunk. If the exposure is not adequate for accurate clamping and ligating, simple pressure stops bleeding from this vessel if it has been transected. Consequently, focus intense attention on an area about 1 cm in diameter just anterior to the mastoid process and about 1 cm deep to its surface. This is where the facial trunk is found unless a tumor in the deep portion of the parotid gland has displaced the nerve to a more superficial plane. The cephalad margin of this 1 cm area of intense attention may be considered to be the fissure between the external auditory canal and the superior portion of the mastoid process.

One should be cautious while elevating the skin flap along the inferior border of the parotid to avoid nerve damage. Avoid elevating the caudal portion of the flap beyond the anterior edge of the parotid gland before the facial nerve dissection because the marginal mandibular branch of the facial nerve emerges from the parotid gland together with the posterior facial vein with which the nerve may be in contact. This is the smallest branch of the facial nerve and the easiest to injure because it is quite superficial at this point. Damage to this nerve causes weakness in the area of the lateral portion of the lower lip.

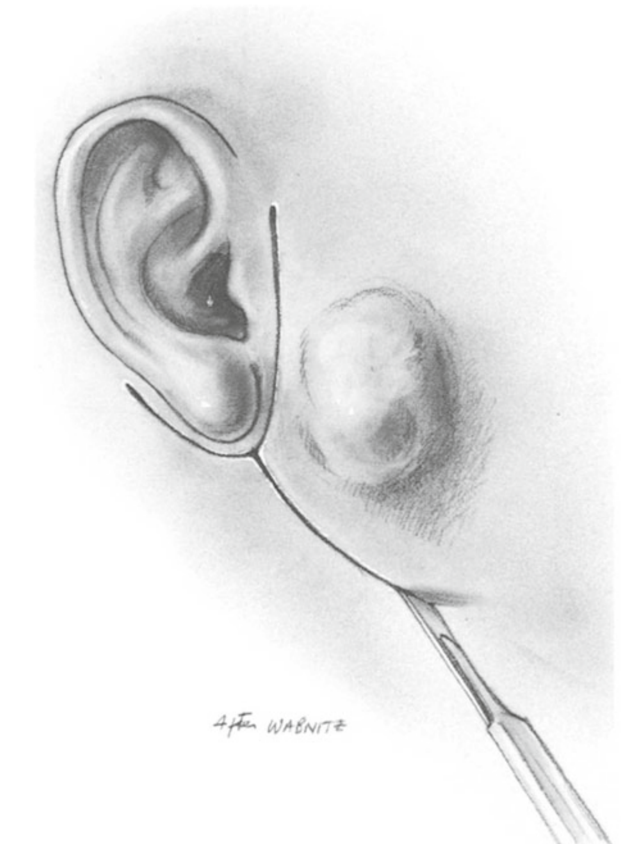

Fig. 124.1

Documentation Basics

- Findings
- Extent of resection

Operative Technique

Incision and Exposure

Although many incisions have been devised for this operation, we prefer the one illustrated in Fig. 124.1. It starts in a skin crease just anterior to the tragus and continues in the form of a Y, as shown. Continue the posterior limb of the incision over the mastoid process in a caudal direction roughly parallel to the underlying sternomastoid muscle down to a point about 1 cm below the angle of the mandible. Do not make the angle of the Y too acute. Carry the incision through the platysma muscle. Obtain hemostasis with accurate electrocautery. Apply small rake retractors to the anterior skin flap and strongly elevate the tissue in the plane just deep to the platysma. As soon as the surface of the parotid gland is exposed, continue the dissection with small Metzenbaum scissors. Some of the fibrous tissue

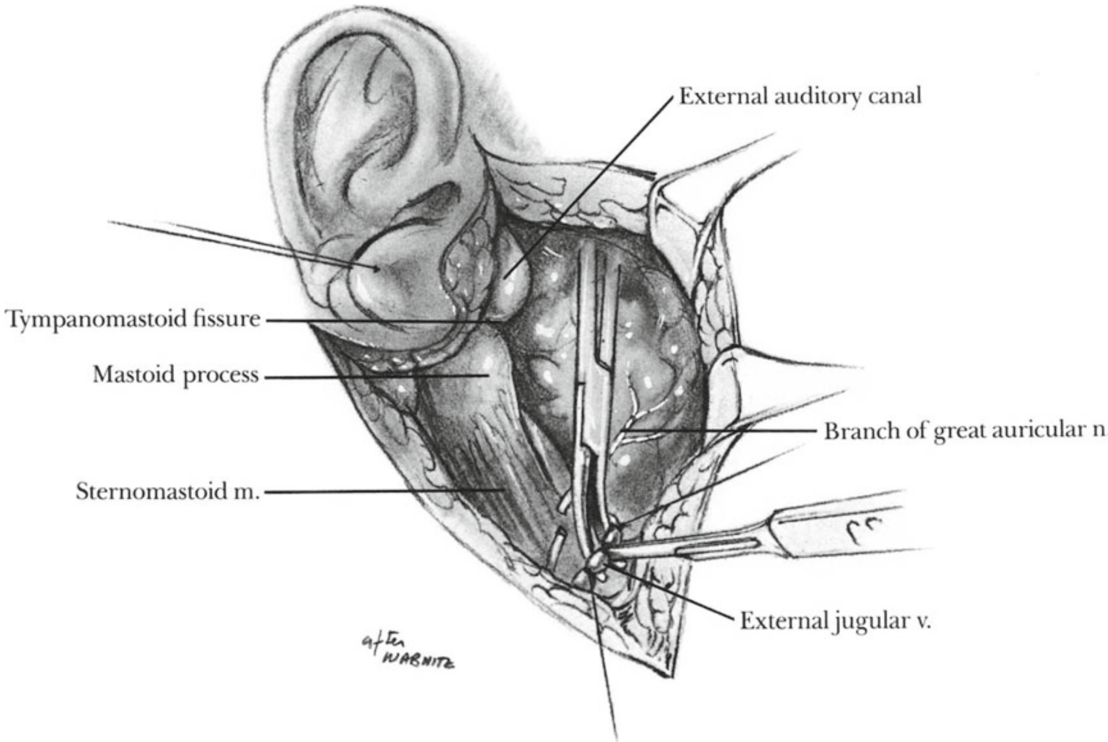

Fig. 124.2

attaching the parotid gland to the overlying tissue resembles tiny nerve fibers. There are no facial nerve fibers superficial to the parotid gland. Therefore each of these fibers may be rapidly divided. If a total superficial lobectomy is planned, continue the dissection in a cephalad direction to the level of the zygomatic process and anteriorly to the anterior margin of the parotid gland. Do not continue the dissection beyond the anterior and inferior margins of the gland, as the small facial nerve branches may inadvertently be injured if this is done before identifying the facial nerve.

Elevate the skin flaps and the lobe of the ear in a cephalad posterior direction to expose the underlying sternomastoid muscle, mastoid process, and cartilage of the external auditory canal. Elevate the posterior flap to expose 1–2 cm of underlying sternomastoid muscle. Obtain complete hemostasis. Some surgeons prefer to place a few sutures to attach the skin flaps temporarily to the underlying cheek, maintaining exposure of the gland.

Exposing the Posterior Margin of the Parotid Gland

Identify the great auricular nerve overlying the surface of the sternomastoid muscle about 3–4 cm caudal to the mastoid process. Divide the branch of the great auricular nerve that enters the parotid gland. Adjacent to this nerve is found the external jugular vein, which is generally also divided and ligated posterior to the parotid gland (Fig. 124.2). Expose the anterior border of the sternomastoid muscle and continue this dissection in a cephalad direction toward the mastoid process. When dissecting the tissues away from the anterior surface of the mastoid process, there may be some bleeding from branches of the superficial temporal vessels. It can be controlled by accurate clamping or electrocautery.

Locating the Facial Nerve

Running from the tympanomastoid fissure to the parotid gland is a fairly dense layer of temporoparotid fascia. Elevate this layer of fascia with a small hemostat or right-angle clamp and divide it (Fig. 124.3). Continue the dissection deep along the anterior surface of the mastoid process. Remember that the main trunk of the facial nerve is located in a 1 cm area anterior to the tympanomastoid fissure and the upper half of the mastoid process at 0.5–1.0 cm depth. Try to identify the small arterial branch of the posterior auricular artery in this area. Divide and ligate it. If it has been inadvertently divided and accurate clamping cannot be achieved, simply apply pressure for a few minutes to stop the bleeding. Continue the blunt dissection using a hemostat until the posterior portion of the parotid gland can be retracted away from the mastoid process. Continuing to separate and divide the fibrous tissue in this area uncovers the main trunk of the facial nerve. Although the nerve usually runs in a transverse direction from the mastoid process toward the gland, it sometimes can run obliquely from the upper left portion of the operative field toward the right lower portion as it enters the parotid gland. Some idea of how deep the dissection must be carried to expose the facial nerve can be obtained by observing the depth of the surface of the posterior digastric muscle as it reaches its origin behind the mastoid process. The nerve is at or just superficial to this vessel (Fig. 124.4).

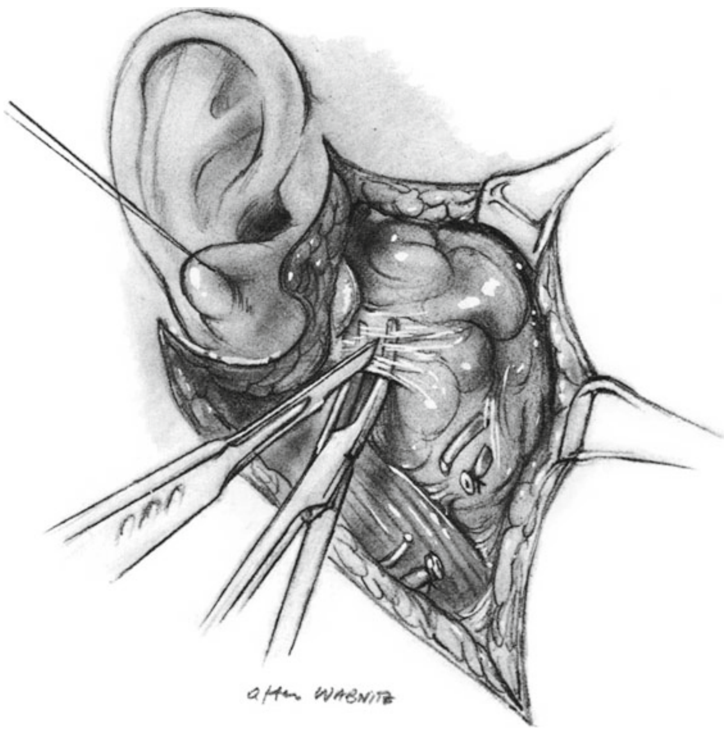

Fig. 124.3

Dissecting Facial Nerve Branches

Apply traction to the superficial lobe of the parotid using several Allis clamps or retractors. Insert a small hemostat in the plane *just superficial* to the facial nerve. Ask the assistant to divide the fibrous tissue being elevated by the hemostat (Fig. 124.4). Continue the dissection in this plane until each of the branches of the facial nerve has been separated from the overlying parotid tissue. Pay special attention to the cervical division and its marginal mandibular branch, as it permits elevation of the lowermost portion of the parotid gland. As the dissection reaches the anterior margin of the parotid gland, identify Stensen's duct. Ligate with 3-0 PG and divide the duct (Fig. 124.5). After all of the nerve branches have been identified and the duct has been divided, remove the superficial lobe of the gland.

Hemostasis during the nerve dissection can generally be achieved by gauze pressure. At this point in the dissection, carefully identify each bleeding point and clamp it with a mosquito hemostat. Ligate with 4-0 or 5-0 PG. Do not use electrocautery in areas close to the nerve.

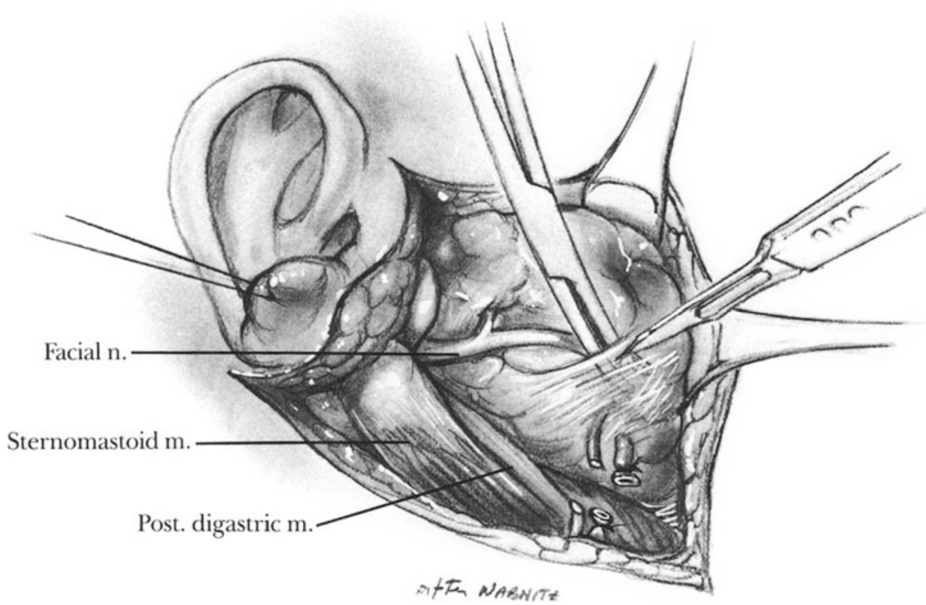

Fig. 124.4

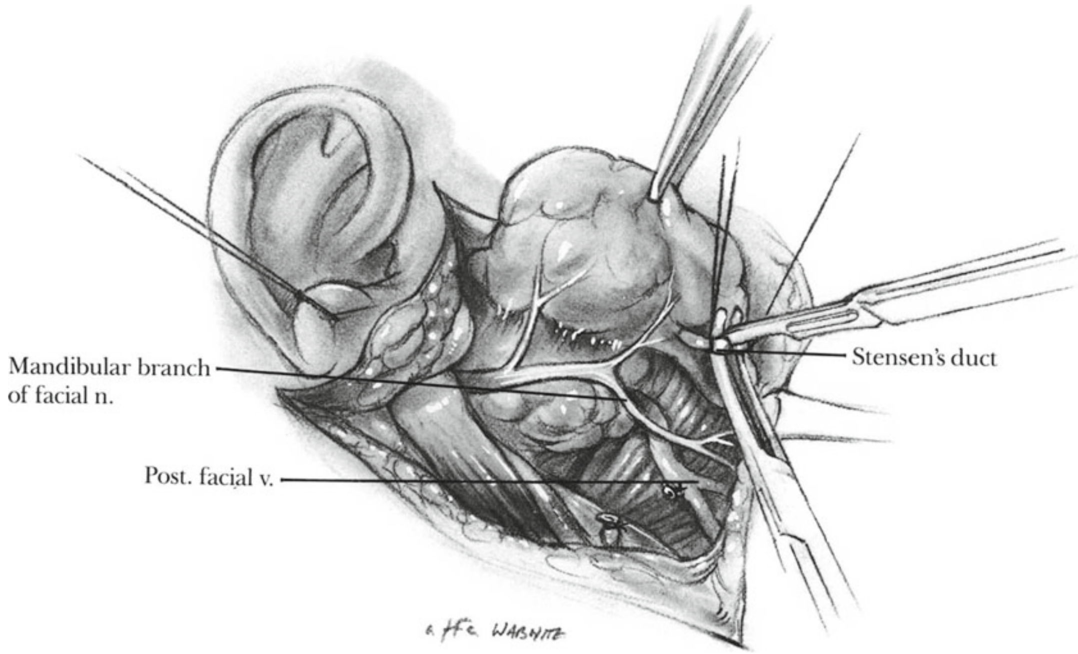

Fig. 124.5

Removing Deep Lobe of Parotid Gland (When Indicated)

To remove the deep lobe of the parotid gland, first excise the superficial lobe of the parotid as described above; then carefully free the lower division of the facial nerve from the underlying tissue. By retracting one or more of these divisions, one can begin to mobilize the deep lobe.

Identify the posterior facial vein. Separate the marginal mandibular nerve branch from the vein; then divide and ligate the posterior facial vein with 4-0 PG as in Fig. 124.6. Now divide the superficial temporal artery and vein as in Fig. 124.7. Elevate the lower border of the gland and divide and ligate the external carotid artery; then divide and ligate the internal maxillary and the transverse facial arteries at the anterior border of the gland. The deep lobe may now be removed. The appearance of the operative field after removing the deep lobe is seen in Fig. 124.8.

Drainage and Closure

Place a small Silastic closed-suction drain through a puncture wound posterior to the incision. Close the incision using interrupted 5-0 PG sutures to the platysma and subcutaneous fat. Close the skin with interrupted 5-0 nylon sutures.

Postoperative Care

Leave the closed-suction drain in place until the drainage has essentially ceased (3–4 days).

Complications

Facial weakness due to nerve damage
Hematoma
Infection
Gustatory sweating. Otherwise known as Frey syndrome, it manifests as almost painful sweating in the skin of the operative area while eating. It occurs to some extent in as many as 25 % of patients. This is believed to be due to the regrowth of parasympathetic motor nerve fibers of the auriculotemporal nerve into cutaneous nerve fibers of the skin flap.
Such crossed innervation of the sweat glands produces uncomfortable gustatory sweating. Loré stated that it may be prevented by removing a section of the auriculotemporal nerve during surgery of the parotid gland.
Salivary fistula. This may appear when a significant portion of the parotid gland has been left intact. It generally corrects itself with expectant treatment.

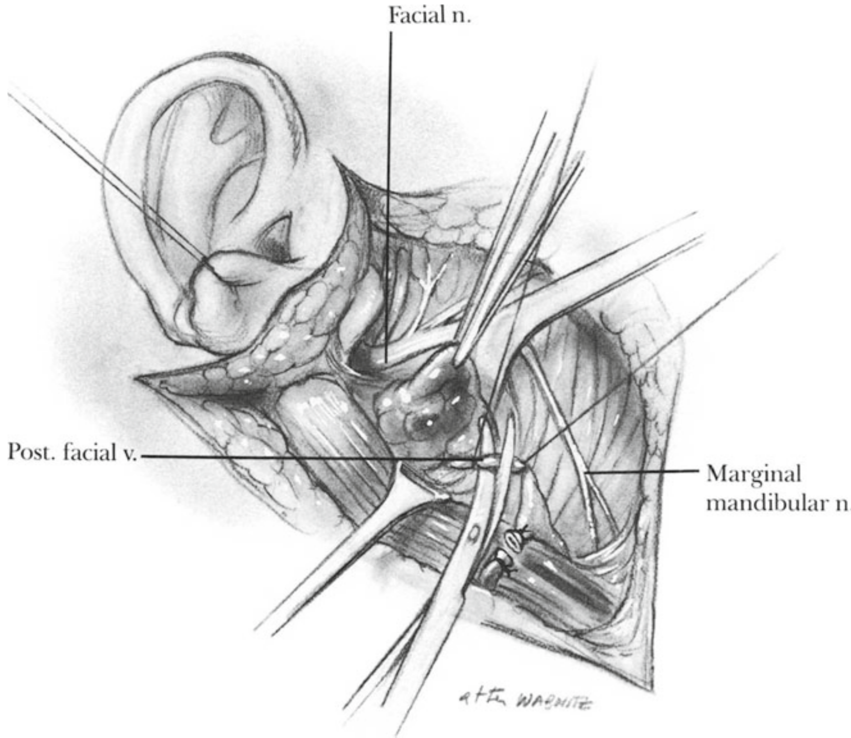

Fig. 124.6

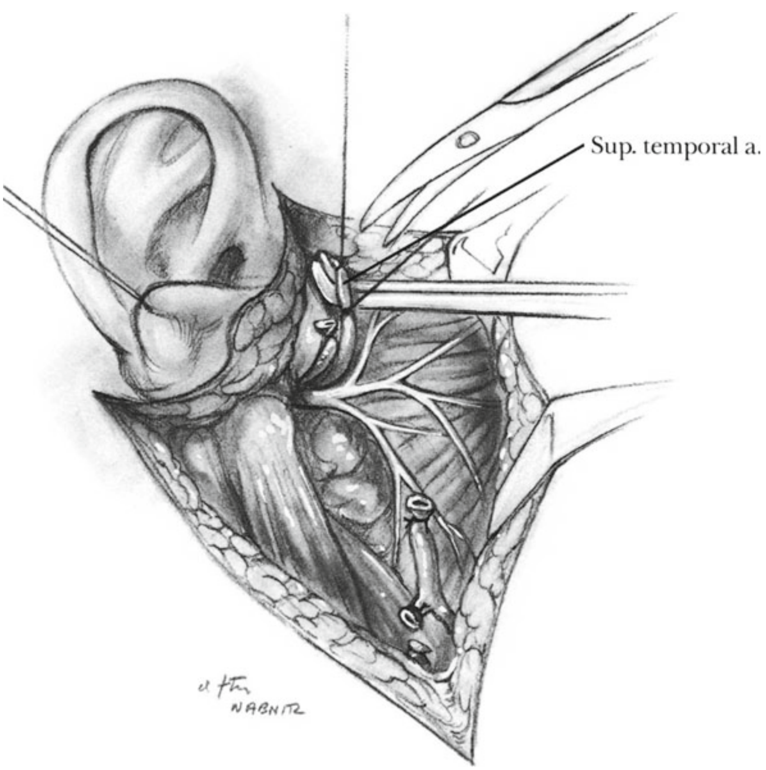

Fig. 124.7

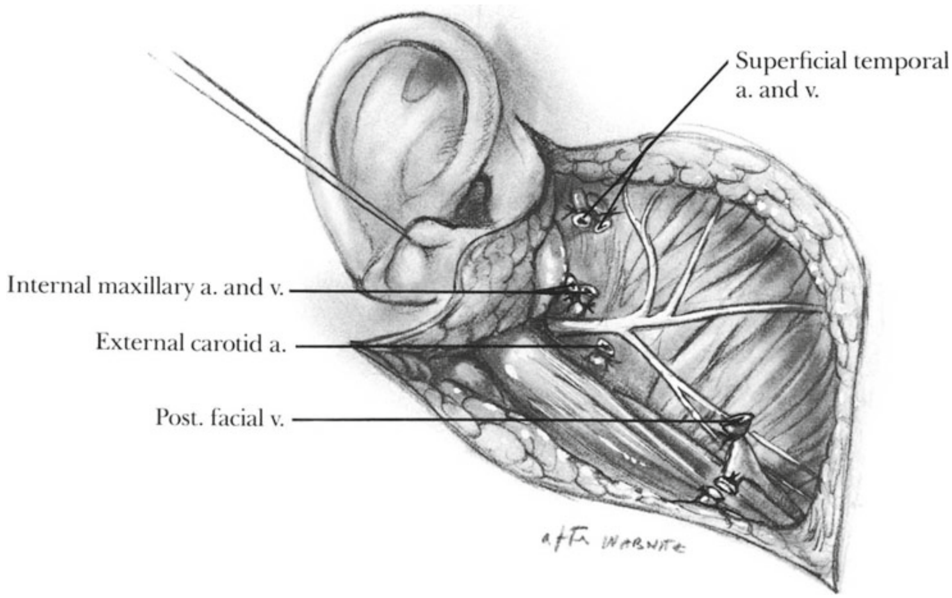

Fig. 124.8

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125 Cricothyroidotomy

Carol E.H. Scott-Conner and Jameson L. Chassin†

Indications

Establishing an emergency airway when oral or nasal endotracheal intubation cannot be achieved

Preoperative Preparation

Like tracheotomy, cricothyroidotomy is simpler to perform in a patient who has already been orally intubated, but many cricothyroidotomy procedures are performed under emergency conditions where no preoperative preparation is possible.

Pitfalls and Danger Points

Erroneous incision in thyrohyoid membrane. A dangerous error, occasionally incurred by a neophyte under conditions of excitement, is to make the incision *above* the thyroid cartilage in the thyrohyoid membrane instead of *below* it in the cricothyroid region. This mistake may cause serious damage to the structures of the larynx. When learning to do this operation, remember that the incision is made at the lower border of the thyroid cartilage between the thyroid and the cricoid cartilages.

Failure to control subcutaneous bleeding. Occasionally a vein in the subcutaneous space is transected. The veins should be ligated or electrocauterized to avoid postoperative bleeding. In the emergency setting, venous bleeding may be temporarily controlled by pressure or packing. Definitive hemostasis can then be obtained after the patient is stabilized.

Operative Strategy

Because cricothyroidotomy is often performed in an emergency situation, local infiltration of the anesthetic into the skin over the cricothyroid membrane is usually employed. In desperate situations, of course, no anesthesia is necessary.

Because the most dangerous error is making the incision in the wrong place, avoid this problem by grasping the lateral margins of the thyroid cartilage between the thumb and the middle finger of the left hand using the tip of the index finger to palpate the space between the lower margin of the thyroid cartilage and the upper margin of the cricoid. With this maneuver, one can accurately pinpoint the proper site for the incision. Under conditions of desperate emergency in the field without instruments, it is possible to perform this procedure with a sharp penknife by inserting the tip of the blade through the skin and the cricothyroid membrane with one motion. Then twist the blade 70–90° to provide a temporary airway until some type of tube can be inserted into the trachea.

Documentation Basics

- Indications
- Size of tube placed

Operative Technique

Place a folded sheet under the patient's shoulders to elevate them 4–8 cm above table level. This extends the neck somewhat. After the usual skin preparation, grasp the lateral margin of the thyroid cartilage between the thumb and the middle

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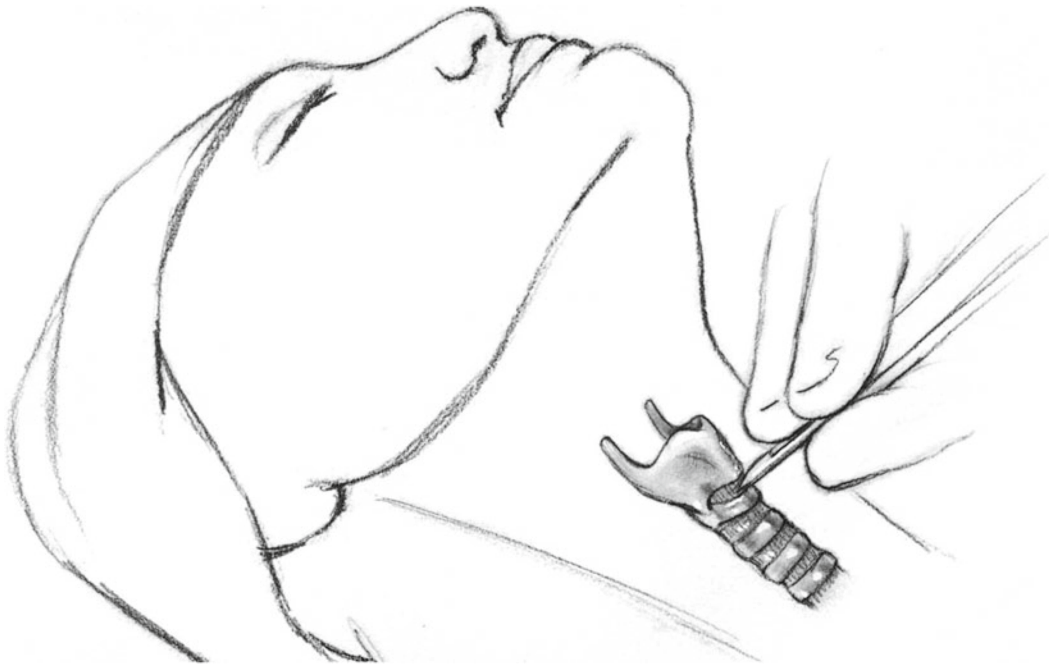

Fig. 125.1

Fig. 125.2

finger of the left hand. Palpate the cricothyroid space accurately with the tip of the index finger; then infiltrate the line of the incision with local anesthesia. Make a 2 cm long transverse incision in the cricothyroid space. Carry the incision down to the cricothyroid membrane. Occlude any bleeding points with ligatures or electrocoagulation. Use a scalpel with a No. 15 blade to stab the cricothyroid membrane (Figs. 125.1 and 125.2). Enlarge the stab wound with a small hemostat or a Trousseau dilator, if available. Then insert heavy Mayo scissors into the incision and spread the tissues transversely (Fig. 125.3) until the opening is sufficiently large to insert a low-pressure cuff tracheostomy tube, generally 8 mm in diameter (Fig. 125.4). Fix the tube in place and maintain it in the same manner as employed for intubation through the traditional tracheostomy incision. Closure of the skin wound is generally not necessary.

Postoperative Care

See Chap. 126.

Complications

Peristomal bleeding
Transient hoarseness
Infection, cellulitis

Subglottic stenosis has not been seen unless the patient had undergone preoperative endotracheal intubation for more than 7 days or had an inflammatory condition of the larynx prior to operation. However, because the cricoid cartilage is a relatively narrow part of the airway, most surgeons will convert the emergency cricothyroidotomy to a formal tracheostomy if prolonged intubation is needed.

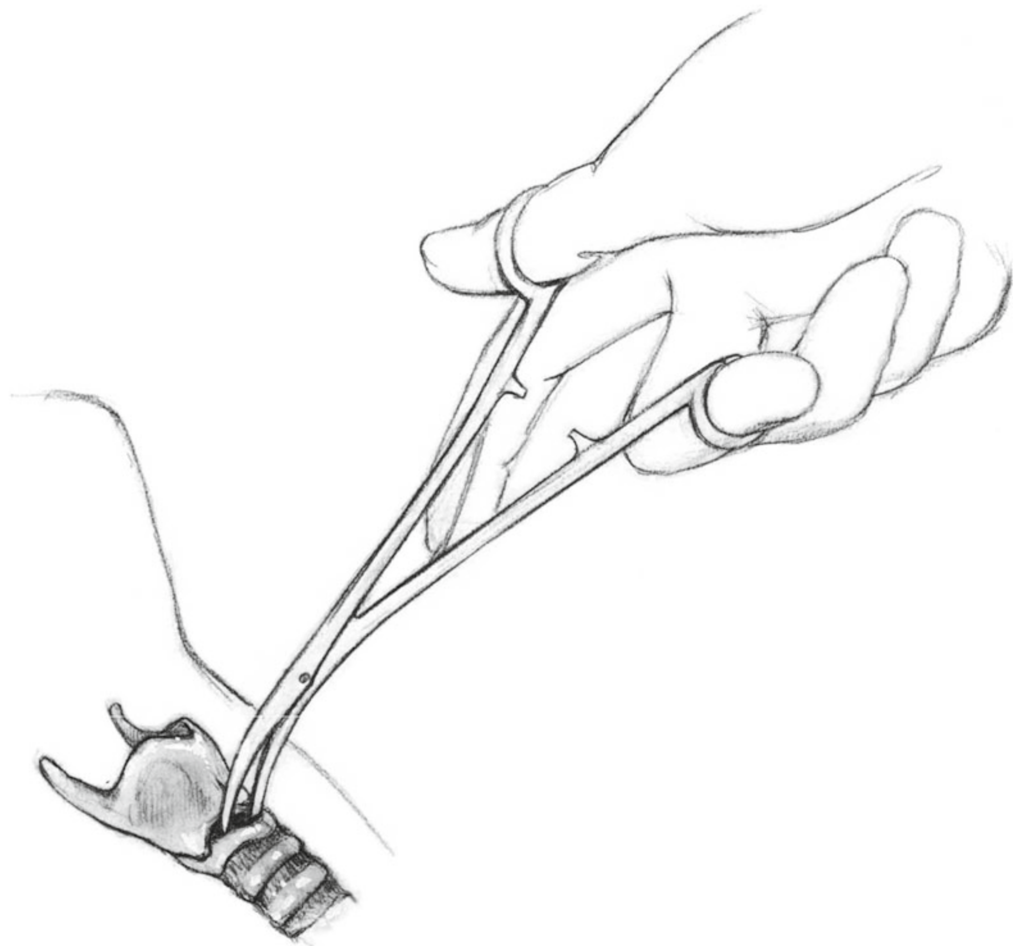

Fig. 125.3

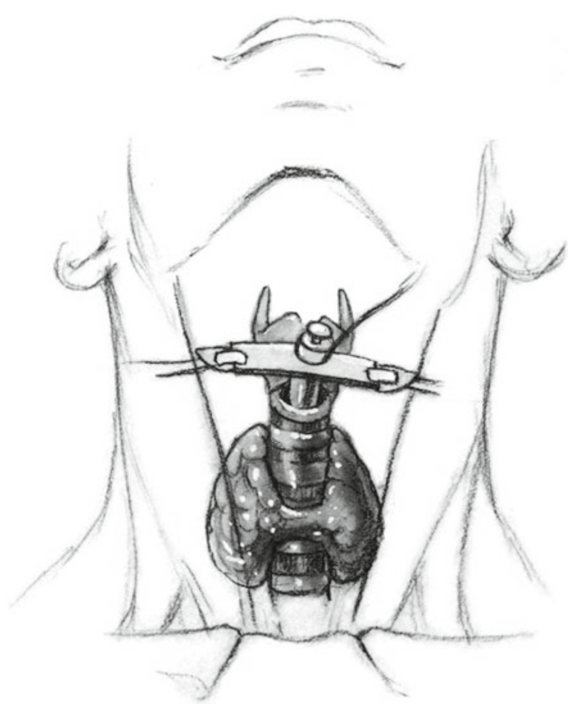

Fig. 125.4

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Tracheostomy

126

K. Shad Pharaon

Indications

Anticipated prolonged intubation
Upper airway obstruction
Radical oropharyngeal or thyroid surgery
Significant maxillofacial trauma

Preoperative Preparation

Pass an oral or nasal endotracheal tube preoperatively whenever possible

Pitfalls and Danger Points

Injury to the cricoid or first tracheal ring during surgery.
Inadequate hemostasis.
Asphyxia.
Injury to the posterior trachea and esophagus may occur during percutaneous tracheostomy.

Introduction

Tracheostomy has several benefits over an endotracheal tube. It is a more secure airway and less prone to accidental extubation particularly during transport. A tracheostomy decreases dead space and airway resistance and obviates the need for an endotracheal tube, which if left in place for too long can cause damage to the lips, mouth, and larynx. It facilitates nursing care, specifically airway suctioning and oral hygiene. Patients with surgical airways are more comfortable than those with endotracheal tubes. They require less sedation; oral nourishment and speech may be possible, and there may be some psychological benefit.

The timing of tracheostomy remains controversial. Many studies have supported early tracheostomy (<7 days) because of less mechanical ventilation, shorter ICU stays, and reduction in pneumonia and mortality. Prolonged intubation (>21 days) increases the chance of subsequent tracheal stenosis. The ideal timing of a tracheostomy is based on individual patient factors, including anticipated improvement or deterioration over time. The current trend is to perform early tracheostomy. Some intensive care units are performing tracheostomies on critical patients by the third hospital day. Tracheostomy should not be performed on patients with advanced ventilator settings such as APRV or with PEEP greater than 10 cm H_2O. Traditionally, tracheostomy has been performed in the operating room using standard surgical principles. In 1985, Ciaglia et al. described an alternative method in which tracheostomy is performed percutaneously, using a Seldinger approach. Both methods are described below.

Operative Strategy

Because most tracheostomy operations are performed with an orotracheal or nasotracheal tube in place, local or general anesthesia may be used. With an indwelling endotracheal tube in place, the risk of anoxia during tracheostomy is virtually eliminated. If for some reason an endotracheal tube is not in place, be certain hemostasis is adequate before opening the trachea. Otherwise, blood may pour into the tracheal stoma, obstructing the airway. Always have an adequate suction apparatus available during tracheostomy. This is one reason a cricothyroidotomy (see Chap. 125) may be a better operation during an emergency situation when an endotracheal tube has not been passed.

If the incision in the trachea is made in the area of the cricoid cartilage or first ring, there is a high risk of subglottic stenosis after the tracheostomy tube has been removed. It should be

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recognized that the opening in the trachea made by the tracheostomy tube heals by cicatrization, incurring the risk of mild narrowing of the trachea at the site of the tracheostomy. If this occurs in the subglottic region, corrective therapy is extremely difficult. For this reason, take every precaution to avoid incising or injuring the cricoid cartilage or first tracheal ring.

A low tracheostomy incision (e.g., at or below the fourth ring) may also entail unnecessary risk for the patient. Pressure exerted by the tip or cuff of the tube may erode into the innominate artery, resulting in massive hemorrhage into the trachea with prompt asphyxiation of the patient. This risk is especially applicable in children, where the innominate artery is relatively close to the tracheostomy site.

Premature dislodgement (before a tract has formed) is a potentially lethal complication. Secure the tube carefully and consider placing a pair of heavy monofilament sutures through the trachea, one on each side, leaving the tails long. These can be used to elevate the trachea into the incision, facilitating tube replacement.

Percutaneous tracheostomy is an attractive alternative to formal surgical tracheostomy. It is more easily performed at the bedside in the critical care unit. This is described at the end of this chapter.

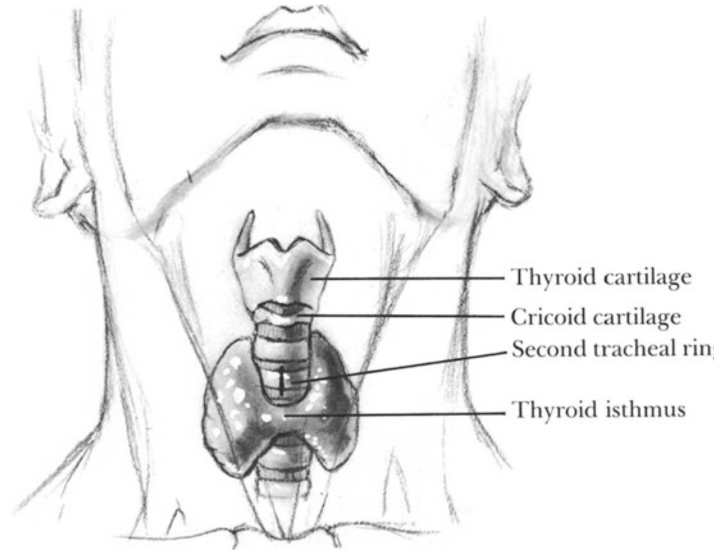

Fig. 126.1

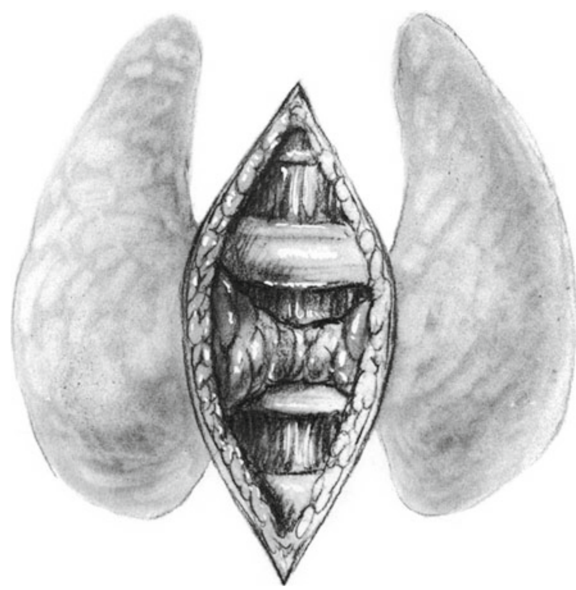

Fig. 126.2

Documentation Basics

- Indications
- Size and make of tracheostomy

Operative Technique: Formal Tracheostomy

Endotracheal Tube

Virtually all patients should have an endotracheal tube in place prior to undergoing tracheostomy.

Incision and Exposure

Position the patient with a folded sheet underneath the shoulders so the neck is extended. The superior thyroid notch, cricoid, and suprasternal notch can usually be palpated through the skin. Although some surgeons believe that a horizontal skin incision produces a better scar, the generally preferred incision is a vertical one beginning at the level of the cricoid and continuing in a caudal direction for about 4–5 cm. This incision gives better exposure and access. Carry the incision through the subcutaneous fat and the platysma muscle directly over the midline of the trachea, exposing the sternohyoid muscles. Achieve complete hemostasis with electrocautery and Vicryl sutures. Now elevate the strap muscles and make a vertical incision down the midline separating these two muscles. Carry the incision down to the upper trachea and expose and divide the capsule of the thyroid gland. Clamp, divide, and ligate all veins in this vicinity. Identify the thyroid isthmus. This bridge of tissue generally lies across the second, third, or fourth tracheal ring (Figs. 126.1 and 126.2).

Identifying the Tracheal Rings

It is imperative to clearly identify the cricoid cartilage and the first tracheal ring. Preserve these two structures from injury.

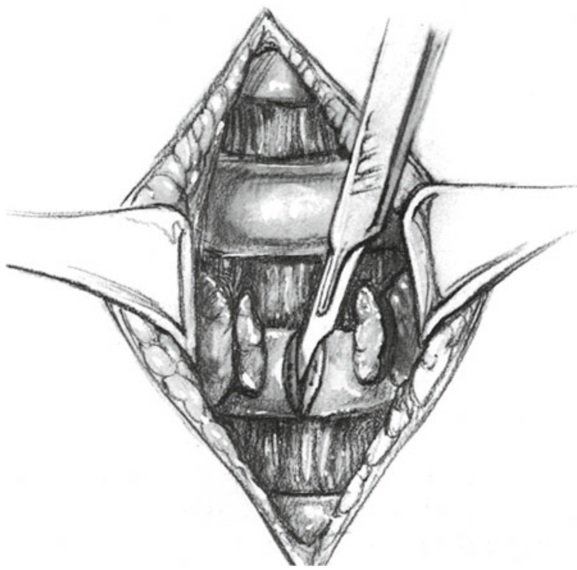

Fig. 126.3

Occasionally it is possible to retract the thyroid isthmus in a cephalad direction to expose the second and third tracheal rings. In most cases, it is necessary to free the thyroid isthmus from the trachea by sliding a right-angle clamp underneath the isthmus and elevating it. Then, divide the isthmus between hemostats and insert suture-ligatures to maintain complete hemostasis. This maneuver clearly reveals the identity of the second and third tracheal rings (Fig. 126.3).

Checking the Tracheostomy Equipment

For most adults, have a size 8 Shiley cuffed tracheostomy tube with disposable inner cannula open on the field. Ensure that the cuff is functional. Insert the obturator into the tracheostomy and have both pieces lubricated. The inner cannula needs to be easily accessible on your field. If your patient has a very obese neck, you may need to have an extended-length tracheostomy tube available.

Opening the Trachea

Once you are certain that hemostasis is complete and that your equipment is functional, it is time to place stay sutures into the trachea. Have the anesthesiologist deflate the cuff of the endotracheal tube while you throw your stitch. Using 2-0 Prolene on SH needle, place a lateral suture around the second tracheal ring and leave the tails long. Repeat this for the other lateral edge of the tracheal ring. Air knots may be tied into the stay sutures. These sutures are left long and taped to the chest of the patient. If the tracheostomy is dislodged prematurely, these sutures can be used to lift the trachea. This

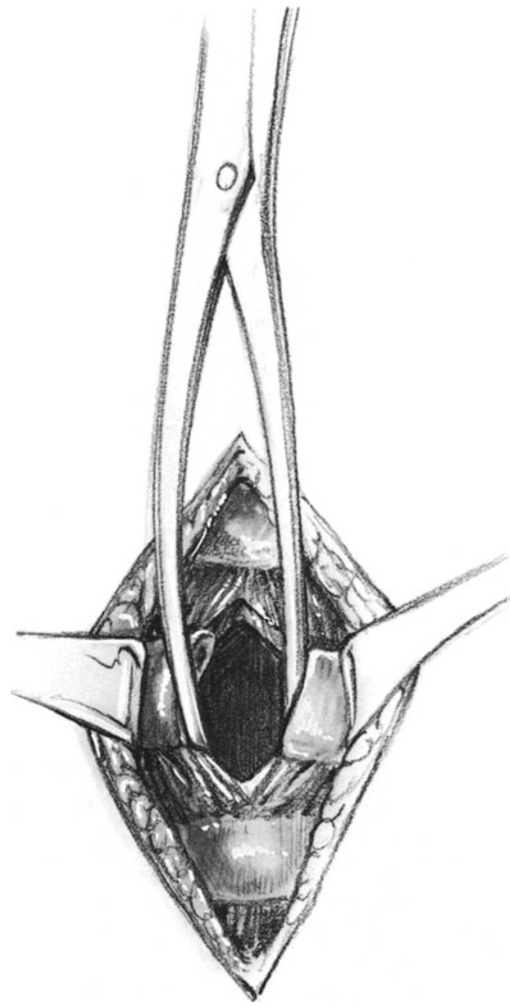

Fig. 126.4

greatly facilitates reinsertion. Remove these stay sutures on postoperative day 7.

In some cases, incising only the second ring provides an adequate tracheostomy opening, but generally it is necessary to incise both the second and third rings. Inserting a single hook retractor to elevate the upper portion of the second ring facilitates this procedure. Insert a scalpel with a No. 15 blade to incise the membrane transversely just above the second ring. Then, "T" it by vertically dividing the second ring with the scalpel (Fig. 126.3) and the third ring if necessary. Never divide the first ring or the cricoid cartilage.

Inserting the Tracheostomy Tube

Retract the edges of the trachea by inserting a hemostat, two small hook retractors, or a Trousseau three-pronged retractor (Fig. 126.4). You will be able to easily see the endotracheal tube. While the anesthesiologist slowly withdraws the endotracheal tube, be ready to insert the lubricated

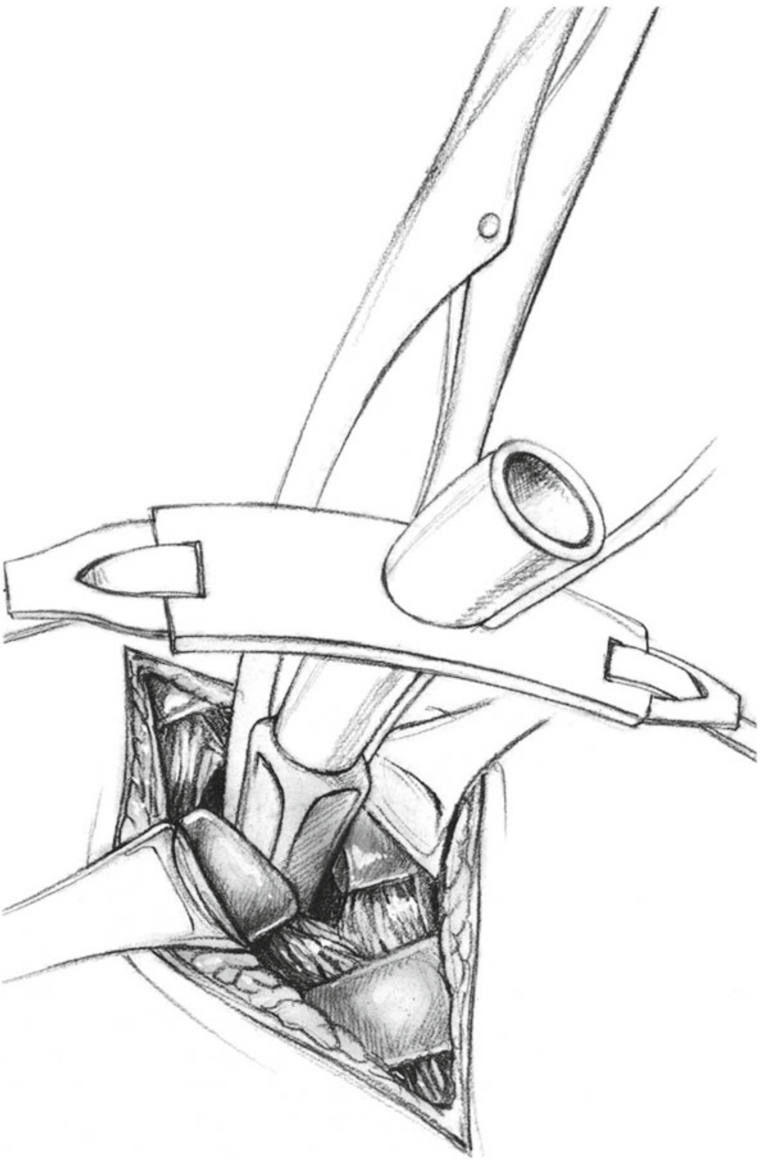

Fig. 126.5

tracheostomy tube with its obturator into the tracheal incision (Fig. 126.5). Quickly remove the obturator and insert the inner cannula into the tracheostomy. Inflate the cuff. The anesthesiologist will hand you the tubing over the ether drape to attach to your tracheostomy. Insert a suction catheter into the tracheostomy tube and aspirate mucus from the bronchial tree if needed.

Closure

Reapproximate the sternohyoid muscles in the midline with interrupted 3-0 Vicryl sutures. Insert several additional sutures to reapproximate the platysma muscle; then, close the skin loosely with interrupted 4-0 nylon sutures. Suture the tracheostomy neck plate to the skin in two places. Tie the cotton tapes together at the back of the patient's neck to guarantee fixation of the tracheostomy tube.

Percutaneous Tracheostomy

Percutaneous dilational tracheostomy was first introduced in the 1950s. The procedure has undergone significant advances. The original method described by Sheldon et al. involved the use of a sharp trochar to gain access to the airway that resulted in several carotid artery and esophageal injuries. The procedure regained popularity in 1985 when Ciaglia et al. developed the serial dilational method by using the Seldinger technique. Commercial kits became available, and then Marelli et al. introduced bronchoscopic guidance in 1990 to facilitate visualization of the tracheostomy site and to verify correct placement of the tracheostomy.

The indications for a percutaneous tracheostomy are the same as for an open tracheostomy with particular attention to some contraindications. Patients needing emergent airway access are not candidates for percutaneous tracheostomy. Patients with obese necks have poor landmarks and are not ideal candidates for the percutaneous approach. In addition, patients with limited neck extension, previous neck surgery (including previous tracheostomy), a large thyroid, or high innominate artery/pulsating vessels near the sternal notch are poor candidates. Percutaneous tracheostomy should not be performed for children under 16 years of age.

The percutaneous approach has a few advantages over the conventional surgical operation. It is simpler, quicker, and less expensive and can be done at bedside without having to move the patient to the operating room. This is a particular attractive option in a critical patient that you suspect could decompensate during transport. Even though an open tracheostomy can theoretically be performed at bedside, most people agree it is better and safer to do in the operating room with experienced operating room personnel, optimal light and instrumentation, greater availability of anesthesiologists, etc. The percutaneous approach is often quicker to do and has lower incidence of postoperative bleeding and infection compared with surgical tracheostomy. Percutaneous tracheostomy is sometimes chosen for patients with a recent median sternotomy. The more cephalad placement of the percutaneous approach is more desirable than an open tracheostomy, keeping tracheal secretions away from the sternotomy incision.

Once the decision to perform a percutaneous tracheostomy has been made, the surgeon must have good lighting available in the intensive care, a video bronchoscopy tower, a physician present for maintenance of the patient's airway and skilled at performing bronchoscopy, a respiratory therapist, the intensive care nurse, a local anesthetic, sedation and analgesia, and a commercially available kit (Ciaglia Blue Rhino Percutaneous Tracheotomy Introducer Kit; Cook Critical Care, Bloomington, IN). Have a formal tracheostomy set immediately available for emergencies. Routine use of bronchoscopic guidance has been suggested by the kit manufacturers and by many authors. Although there are some surgeons that will attempt this procedure without use of bronchoscopy, bronchoscopic guidance for an additional level of safety and confidence is recommended.

Positioning and Setup

Pull the bed away from the wall to allow the bronchoscopist to be at the head of the bed. Usually the respiratory therapist needs to be at the patient's left to help manage the ventilator and help with the video tower. The surgeon will be at the patient's right. Deep sedation will require an analgesic, an anxiolytic, and a paralytic. One option is to bolus the patient with 50 μg of fentanyl and 5 mg midazolam, followed by rocuronium (1 mg/kg). Silicone spray for the bronchoscope and a bite block are useful. Place the patient's ventilator on 100 % FiO_2, and set it to a volume-controlled mode for the duration of the procedure. The patient's monitor with telemetry, pulse oximetry, and blood pressures needs to be clearly visible.

With the patient in the supine position, place a folded sheet underneath the shoulders so the neck is mildly hyperextended. Nasogastric tubes are removed because they restrict posterior displacement of the tracheal wall during the insertion of the dilating catheter, predisposing the tracheal wall to damage. Palpate the superior thyroid notch, cricoid, and suprasternal notch. Prep the patient's entire neck with chlorhexidine. After a bite block is inserted and the bronchoscope is sprayed with silicone, it can be inserted into the endotracheal tube.

Procedure

Using a skin marker, trace out the cricoid cartilage and sternal notch. Open the kit and inject the skin with 1 % lidocaine with epinephrine. Make a 4 cm vertical incision that starts just below the cricoid cartilage and ends about two fingerbreadths above the sternal notch. Bluntly dissect with a hemostat down to the pretracheal fascia. The trachea needs to be visualized, and its cartilage rings need to be palpable. The endotracheal tube needs to be deflated and slowly withdrawn until the cuff is palpable at the level of the cricoid cartilage, which is approximately 16 cm at the lips in an adult. Both the bronchoscopist and the surgeon can look at the video tower and with use of the light reflex can determine the best site for the introducer needle. Insert the needle with its attached cannula and syringe in the midline trachea between the first and second ring or between the third and fourth ring. This should be done under direct bronchoscopic vision. Watching the monitor, you should completely see the needle enter the trachea. Avoid sticking the posterior tracheal wall at all cost. Withdraw the needle, leaving the cannula inside the trachea.

Insert the J-tipped guidewire through the cannula into the trachea toward the carina (Fig. 126.6a). The cannula is then removed leaving the J-tipped guidewire in place. A 14 Fr, 4.5-cm dilator is passed over the wire to dilate the access site (Fig. 126.6b). Some compression of the tracheal wall is expected. Under direct vision, dilate the trachea using the tracheostomy dilator with its preloaded white guiding catheter (Fig. 126.6c). Take care to keep the distal tip of the tracheostomy dilator against the safety ridge of the white guiding catheter. The slippery hydrophilic coating of the tracheostomy dilator allows for smooth dilation. Dilate the stoma up to the skin-level guide on the dilator (38 F) but not past this mark. Next, locate the appropriate size tracheostomy loading dilator. With the 28 F loading dilator inserted into the cuffed tracheostomy tube (Fig. 126.6d) (26 F loading dilator for a size 6 tracheostomy), insert both as a unit into the tracheal lumen under direct visualization (Fig. 126.6e). Remove the J-tipped guidewire, white guiding catheter, and loading dilator. Inflate the cuff, insert the inner cannula, and reattach the ventilator to the patient. The endotracheal tube may now be removed. The bronchoscope can be passed through the new tracheostomy toward the carina for one final look and cleaning. Suture the tracheostomy neck plate to the skin in two places with 3-0 nylon sutures. Tie the cotton tapes together at the back of the patient's neck to guarantee fixation of the tracheostomy tube. A chest x-ray is not routinely required.

Postoperative Care

Humidified air is necessary to prevent crusting of secretions and eventual obstruction of the tracheostomy tube. Use lightweight swivel connectors to attach the tracheostomy tube to the ventilator to avoid unnecessary pressure on the trachea at the stoma.

If the tracheostomy tube must be changed within the first one or two postoperative weeks, be certain to have instruments available for instant endotracheal intubation or emergency cricothyroidotomy if difficulty is encountered when reinserting a tracheostomy tube. Remember, the track between the skin and the tracheal stoma is not established for a variable number of days after the operation. After premature decannulation, the tracheal stoma typically retracts deep into the neck, where it is extremely difficult to find. This procedure must not be performed by the inexperienced.

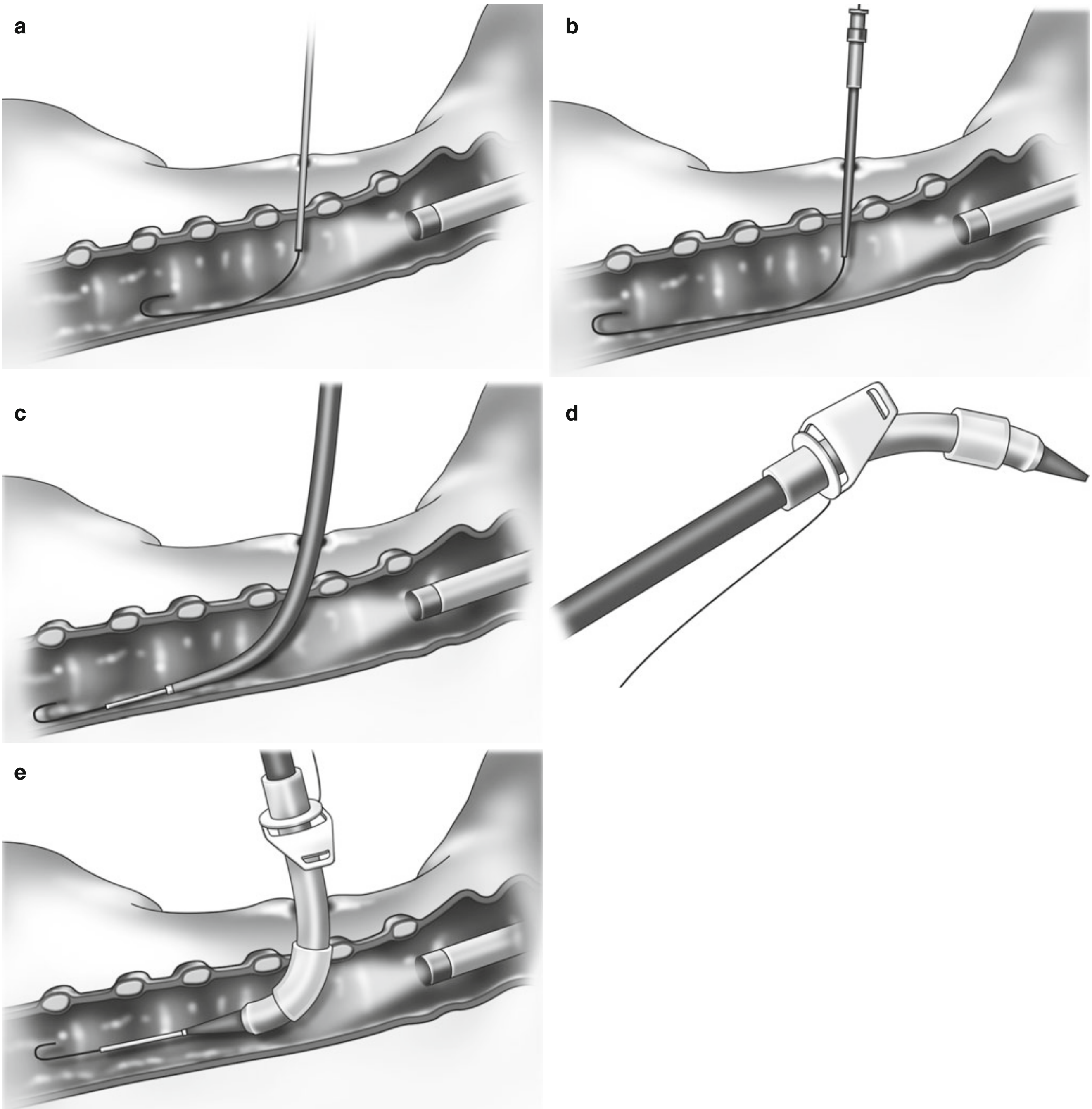

Fig. 126.6

When it is necessary to change the tracheostomy tube, first place the patient in a recumbent position with a sheet or sandbag underneath the shoulders. This maneuver extends the head and neck, bringing the tracheal stoma closer to the skin incision. Only with the patient in this position and with good light and suction at hand should the old tracheostomy tube be removed and replaced. Never attempt this maneuver during the first two postoperative weeks with the patient in a sitting position.

Complications

Hemorrhage following tracheostomy may occur as a result of failing to ligate the bleeding points in the wound. The problem manifests as bleeding around the tracheostomy tube. A far more serious type of hemorrhage may occur late in the postoperative period if the tip of the tracheostomy tube or the balloon cuff erodes through the anterior wall of the trachea into the innominate artery. This is a life-threatening complication manifested by arterial bleeding into the trachea. Emergency management of this condition depends on temporarily controlling the bleeding by inflating the balloon cuff. If inflating the cuff around the tracheostomy tube does not promptly control the bleeding, remove it and immediately insert an orotracheal tube. Secure immediate control of the bleeding by passing an index finger into the tracheostomy stoma and occluding the bleeding site against the underside of the sternum. Sometimes inflating the cuff of the orotracheal tube is sufficient to control the bleeding temporarily. Emergency resection of the innominate artery with suture of both ends may be necessary for definitive repair of the fistula, with resection also of the damaged trachea in some cases. Subcutaneous emphysema may be avoided if the tissues are not sutured too snugly against the tracheostomy tube. There may be some air leakage between the trachea and the tracheostomy tube. If this air has access to the outside, subcutaneous emphysema does not occur.

The role of bronchoscopic guidance in increasing the safety of percutaneous tracheostomy is somewhat controversial. Some think that having a bronchoscope in the endotracheal tube during the procedure can increase the chances of airway complication, but most feel that it actually lowers the chance of a serious operative complication such as posterior tracheal wall injuries, paratracheal placement, or pneumomediastinum. Percutaneous tracheostomy seems to have a lower incidence of peristomal bleeding and postoperative infection compared to surgical tracheostomy, presumably because the stoma fits more snugly around the tracheostomy tube. This lack of dead space serves to both tamponade bleeding and to impede infection. There have been more tracheal ring fractures that occur with the dilating portion of the percutaneous approach. While performing a tracheostomy, loss of a secure airway is a possibility. This can occur by inadvertently withdrawing the endotracheal tube too far or with unsuccessful placement of the tracheostomy tube. If this occurs, the safest maneuver is to reintubate the patient with an endotracheal tube and abort the procedure.

Late sequelae of tracheostomy include symptomatic tracheal stenosis and tracheoinnominate artery fistula. Based on available information, there is no advantage of either technique in preventing these adverse outcomes. Stenosis may occur sometime after the tracheostomy tube has been removed. The stenosis may be at the tracheal stoma or in the area of the trachea occluded by the balloon cuff. Making the incision in the trachea as small as possible may minimize strictures at the stoma level. Constrictions lower in the trachea have been virtually eliminated by large-volume, low-pressure balloon cuffs. If a patient who had a prior tracheostomy ever develops signs of an upper airway obstruction (stridor, wheezing, shortness of breath), a stricture of the trachea should be strongly suspected. A lateral radiograph of the neck can disclose an upper tracheal stricture, and an oblique chest radiograph should identify lower tracheal lesions. Computed tomography or magnetic resonance imaging provides better imaging details. Tracheal resection and anastomosis may be necessary for serious strictures. A granuloma may be resected through a bronchoscope utilizing the laser in some cases.

Wound infection, pneumothorax (rare), and accidental displacement of the tracheostomy tube may also occur. In conclusion, open surgical tracheostomy and percutaneous tracheostomy are both safe and effective approaches to providing a definitive airway in the critically ill.

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