Operative Surgery
MANUAL

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To my parents, my wife Anjana, and children Amit and Shevani, and to the memory of my grandfather, Govindbhai Khatri
VPK

To my family—Elsa, Juan Carlos, Alex Ariel, and Strella—and to the memory of my parents, Olga and Jose Alfredo Asensio
JAA

Foreword

Hamlet confides to Rosencrantz and Guildenstern, "*What a piece of work is a man, how noble in reason, how infinite in faculties, in form and moving how express and admirable, in action how like an angel.*" It is the treasured province and privilege of surgeons to visit in the flesh that express and admirable form. With reverence, humility, and intent to do good, the visitation is an act of grace. With knowledge and skill, there is joy in the exercise. With the anatomy intimately familiar, such journeys are a visit to old friends. When beginning a career of these journeys, nothing is more essential than a first-class guide. Drs. Khatri and Asensio and Elsevier Science have obliged in the publication of this succinct and well-constructed manual. It is a companion, designed to be where the young surgeon finds himself or herself, there where it is needed. The convenience of this manual should not belie the wealth of information it contains. It is a rich source, articulate and approachable in what it has to tell. It is designed to be read or to be consulted frequently for review.

The presentation of each operative procedure begins with a lucid exposition of the pertinent anatomy, the indispensable cornerstone of the surgeon's practical knowledge. Adding the embryology is more than a subtle nicety. It is a reminder of critical three-dimensional relationships. Informative pearls to make the patient ready for surgery are there for the taking. Emphasis is given to operative procedure, so essential to a successful working environment for a surgical procedure. Operations performed well are those in which the surgeon can comfortably see and work. Creating this opportunity is a matter of knowledge and experience. The procedure descriptions reflect a broad experience at the operating table translated into fluent, clear English, a good read for the novice and experienced alike. The illustrations complement the text.

This manual covers the core of general surgery and provides the student of surgery (at any career level) advice on most procedures performed by general surgeons. Information provided can be extended to procedures not included. The text is a window to the extensive experience of Dr. Khatri, who has trained in and taught surgery on both sides of the Atlantic. He has an abiding interest in the craft of surgery and in teaching it, and no less skill in rendering his thoughts and ideas into print. This manual is a guide on which the student or surgeon in training can build

personal experience and more readily absorb the advice and teaching of his or her mentor. It is also a guide for the experienced who are diligently preparing themselves to revisit some part of the express and admirable form. It will be a valued companion on the journey.

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Foreword

As you are reading this foreword, you may be thinking that we do not need another manual demonstrating surgical techniques. However, Khatri and Asensio, the authors of this particular operative surgery manual, have created something that did not exist before. For surgical residents or medical students embarking on a surgical rotation or a general surgery residency program, this operative surgery manual is invaluable.

Khatri and Asensio have done a fine job in covering the major anatomic sites, which are described in a way that provides a quick knowledge base and a feel for the specific surgical procedure. It is difficult to use a large operative textbook as a reference to prepare for the next day's surgical procedures if one is preparing for three or four cases. *Operative Surgery Manual* is a practical book, which succinctly describes the operative technique in a simple narrative form with key illustrations. The manual is small enough that it can be carried in the pocket of the resident or medical student to be readily available on call to prepare for any emergency case.

Because in all training programs in the United States there is a long gap between the time anatomy is taught in the first year of medical school and the resident's surgical rotations, Khatri and Asensio have added clinically relevant anatomy and embryology in each of the sections described. Therefore, the residents and medical students can have easy access under one cover to information on anatomy, embryology, and operative technique. A focused preoperative preparation section is also included.

Vijay P. Khatri, MD, is well qualified to have put this operative surgery manual together. Aside from his general surgery training, he has been a National Institutes of Health T32 Laboratory Research Fellow at the Roswell Park Cancer Institute in Buffalo, New York, and has had additional training in surgical oncology at the same institution. His experience as a teacher and mentor to medical students and surgical residents is evident in this manual.

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Preface

Surgery does the ideal thing—it separates the patient from his disease. It puts the patient back to bed and the disease in a bottle.

Logan Clendening (1884–1945)

The fundamental goal in the creation of the *Operative Surgery Manual* was to provide surgical trainees and medical students with a practical guide to commonly encountered surgical procedures. Much emphasis has been placed on maintaining a standardized format throughout the manual to allow the reader to predict the flow of the chapters. The detailed narrative text is complemented with illustrations created by a single artist to maintain a uniform presentation style and conceptual consistency that facilitates comprehension of the operative procedure.

The major purpose of the *Operative Surgery Manual* is to bring to the reader a "one-stop" reference including embryology, anatomic facts of practical value, focused preoperative preparation, and a concise description of contemporary operative technique. Furthermore, as a reasonably sized book it can be carried in the pocket and be readily available to review surgical technique before scrubbing for the operation.

To prepare for operative procedures, often surgical residents have needed to refer to surgical texts that contain encyclopedic amounts of surgical knowledge that can be difficult to cover expeditiously. Alternatively, a surgical atlas that has exhaustive illustrations accompanied by brief text cannot convey the subtleties of operative technique. In the *Operative Surgery Manual*, we present a succinct yet detailed narrative of surgical techniques, which we hope can familiarize the reader with the essential elements of the operative procedures. Furthermore, we recognized that for most surgical residents and medical students, several years have passed since their anatomy lectures during the first year of medical school. Knowledge of surgical anatomy represents a critical foundation for students embarking on a surgical rotation and even more so for surgical trainees. The importance of anatomy was well expressed by one of my surgical teachers, who stated, "If you know what structures to save, the rest can go." This lighthearted but poignant statement has remained an important aphorism for one of the authors' (VPK) successful approach to complex multiorgan resections in surgical oncology.

Being knowledgeable of the essential facts of human development greatly clarifies gross anatomy. However, to refresh his or her knowledge of anatomy and embryology, the reader may need to refer to yet another textbook.

The *Operative Surgery Manual* has been organized into 7 major sections with 50 chapters. The large section on Abdomen has been further divided into anatomic site subsections: *abdominal wall*, *esophagus/ stomach/duodenum/small bowel*, *hepatobiliary system*, *pancreas*, *spleen*, and *large* *bowel/anorectum*. Each chapter contains relevant embryology, surgical anatomy, and the operative procedure. The surgical procedure is divided according to the important phases for expeditious conduct of the operation: *position*, *incision*, *exposure and operative technique*, and *closure*. This format has been maintained throughout the textbook to provide consistency to the reader. Several chapters discussing emergency operations have been included: *perforated peptic ulcer*, *bleeding duodenal ulcer*, *esophageal perforation*, *appendectomy*, and *femoral embolectomy*. Advanced operative procedures such as *radical and modified radical neck dissection*, *Ivor-Lewis esophagectomy*, *radical gastrectomy*, *pancreaticoduodenectomy* (*Whipple procedure*), *hepatic resection*, *subtotal colectomy/panproctocolectomy and J-pouch reconstruction*, and *radical cystectomy* are just some of the chapters that senior trainees should find particularly informative.

To maintain our objective of keeping this textbook a handy manual, we have selected routine operations that will be encountered on a day-to-day basis by the surgical trainee. Although there has been an explosion in advanced laparoscopic surgery, we have limited our coverage to the most commonly performed laparoscopic procedures. We welcome comments from readers regarding topics they believe would further enhance the *Manual's* utility.

This book reflects our passion as surgical educators and our hope that it finds itself a unique niche as a learning resource for medical students and surgical trainees at all levels.

Vijay P. Khatri MD, FACS
Juan A. Asensio MD, FACS

Acknowledgments

Although the *Operative Surgery Manual* represents an individualistic approach to surgical technique, we acknowledge that this work could not have been completed without enormous contributions by various individuals. We are grateful for the energetic editing by Shirley Cable, whose enthusiasm and attention to every sentence has enhanced the *Manual's* clarity. The text has been admirably complemented with high-quality illustrations by Peggy Firth.

We extend our appreciation to Lisette Bralow, Elsevier Science, for supporting our vision and shepherding us through the conceptual plans and subsequent development of the textbook. Joe Rusko, Acquisitions Editor at Elsevier Science, has been instrumental during the ever important last sprint towards successful completion of the *Operative Surgery Manual*. Appreciation is due also to Amy Norwitz and the production staff at Elsevier Science for their tireless efforts during the final assembly. Thanks also go to Sandra Moura, Jackie Stout, and Espie Gutierrez, who have been responsible for much of the correspondence during the final phase of the textbook and needless to say for the preservation of our sanity. We also owe a great deal to our patients for their trust and acknowledge the residents and medical students for their intellectual stimulation and curiosity that inspire us to be better educators.

Finally, we would like to thank our spouses, who have been extremely supportive during the entire preparation of this text.

Head and Neck Surgery

Chapter 1 - Thyroidectomy

EMBRYOLOGY

During the fourth week of fetal development, an endodermal thickening develops in the floor of the primitive pharynx at the junctional area between the first and second pharyngeal pouches called the foramen cecum. The endodermal thickening, which represents the primitive thyroid tissue, penetrates the underlying mesenchymal tissue and begins to descend anterior to the hyoid bone and the laryngeal cartilages to reach its final adult position in front of the trachea. The thyroid diverticulum becomes bilobed and develops into two lateral lobes and a median isthmus. The thyroid gland is temporarily attached to the lumen of the foregut at the foramen cecum by the thyroglossal duct, which eventually solidifies and disappears. The distal portion of the thyroglossal duct gives rise to the pyramidal lobe and the levator superioris thyroideae in adults. Ectopic thyroid tissue can be found at any point along its embryologic descent.

ANATOMY

The thyroid gland weighs about 25 g and is composed of two lobes attached by the isthmus. The isthmus is related posteriorly to the second, third, and fourth tracheal rings; knowledge of this relation is pertinent during the performance of tracheostomy. A variable-sized pyramidal lobe arises from the isthmus and is directed upward usually to the left, although it may be absent in 50% of individuals. The gland lies on the anterolateral aspect of the cervical trachea and extends from the level of the thyroid cartilage to the fifth or sixth tracheal ring. Anteriorly it is covered by the pretracheal fascia, strap muscles, and, more laterally, the sternocleidomastoid muscle. The blood supply to

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the thyroid gland is derived from (1) the superior thyroid artery, which arises from the external carotid artery and descends to the upper pole of the gland; (2) the inferior thyroid artery, a branch of the thyrocervical trunk that arises from the subclavian artery; and (3) the inconsistently present thyroidea ima artery, arising from the innominate artery, right subclavian artery, or aortic arch. Venous drainage is from the (1) superior thyroid vein, which drains directly into the internal jugular vein, (2) middle thyroid vein, which drains into the internal jugular vein and is the first vessel encountered during thyroidectomy, and (3) inferior thyroid vein, which leaves the lower border of the gland to join the left innominate vein (Fig. 1–1).

Several important structures are in close relation to the gland and are of surgical relevance. The external laryngeal nerve, a branch of the superior laryngeal nerve, accompanies the superior thyroid pedicle and travels medially to supply the cricothyroid muscle. If this nerve is severed, it alters the voice pitch, which is particularly important to singers. The recurrent laryngeal nerve is a branch of the vagus, and embryologically it arises in close relation to the fourth aortic arch. Because of the descent of the fourth aortic arch vessels (the subclavian artery on the right and the aortic arch on the left), the recurrent nerves first are drawn caudally into the mediastinum and then course upward toward their final destination, the vocal cords. The nerve usually lies in the tracheoesophageal groove near the terminal branches of the inferior thyroid artery (see Fig. 1–1). The recurrent laryngeal nerve is usually found in Simon’s triangle, which is formed by the inferior thyroid artery superiorly, the common carotid artery laterally, and the esophagus medially. The surgeon also needs to be aware of the presence of a nonrecurrent laryngeal nerve. The posterior aspect of each thyroid lobe is related to the parathyroid glands and is at risk of injury during thyroidectomy. The anatomy of the parathyroid glands is described in Chapter 2 .

SPECIAL PREPARATION

Apart from ordering routine investigations and reviewing special investigations that may have been performed, such as thyroid function tests, ultrasonography of the thyroid, isotope scan, and fine-needle aspiration, cytology must be reviewed. Serum calcium level is obtained because hyperparathyroidism may coexist.

Indirect laryngoscopy is performed preoperatively to evaluate the mobility of the vocal cords and detect unsuspected vocal cord paralysis (if paralysis is present, it is essential not to damage the recurrent laryngeal nerve supplying the normal vocal cords). Patients who are thyrotoxic should be rendered euthyroid. This can be achieved medically by the use of carbimazole. If the patient has evidence of sympathetic overdrive such as tachycardia, a beta-blocker such as propranolol is added but must be continued postoperatively for 8 to 10 days. There is no need to use iodides,

Figure 1-1 Blood supply of the thyroid gland and the important adjacent anatomic structures.

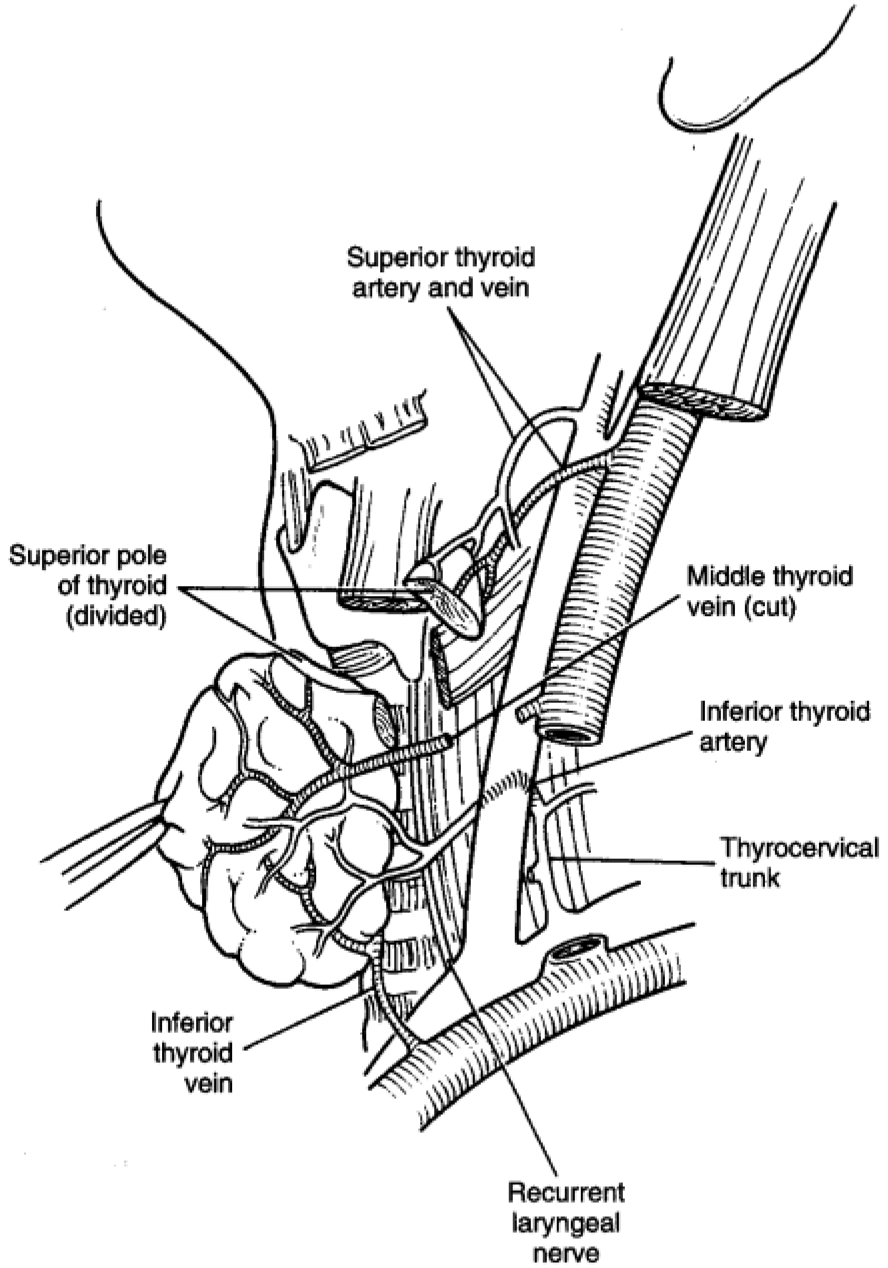


Figure 1-2 After division of the middle thyroid vein, the thyroid lobe is retracted medially to expose the parathyroid glands, recurrent laryngeal nerve, and inferior thyroid artery.

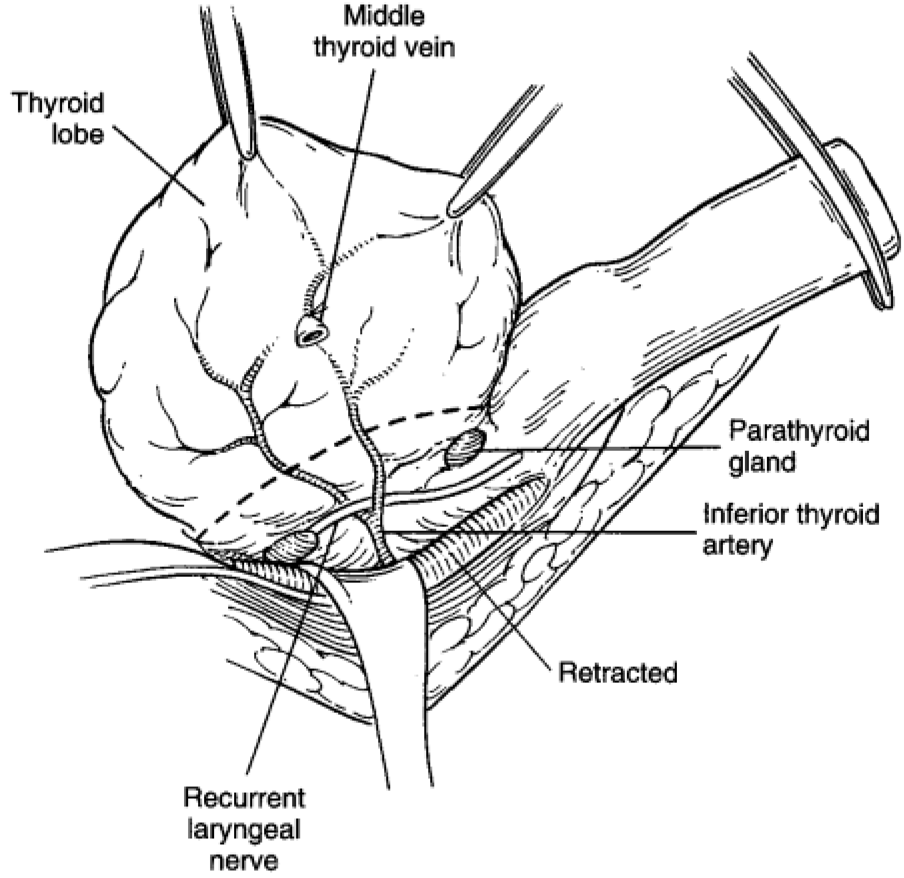


Figure 2-1 Location of the inferior parathyroid adenoma adjacent to the inferior thyroid artery and recurrent laryngeal nerve. The superior parathyroid gland is invariably found behind the upper pole of the thyroid gland or at the cricothyroid junction.

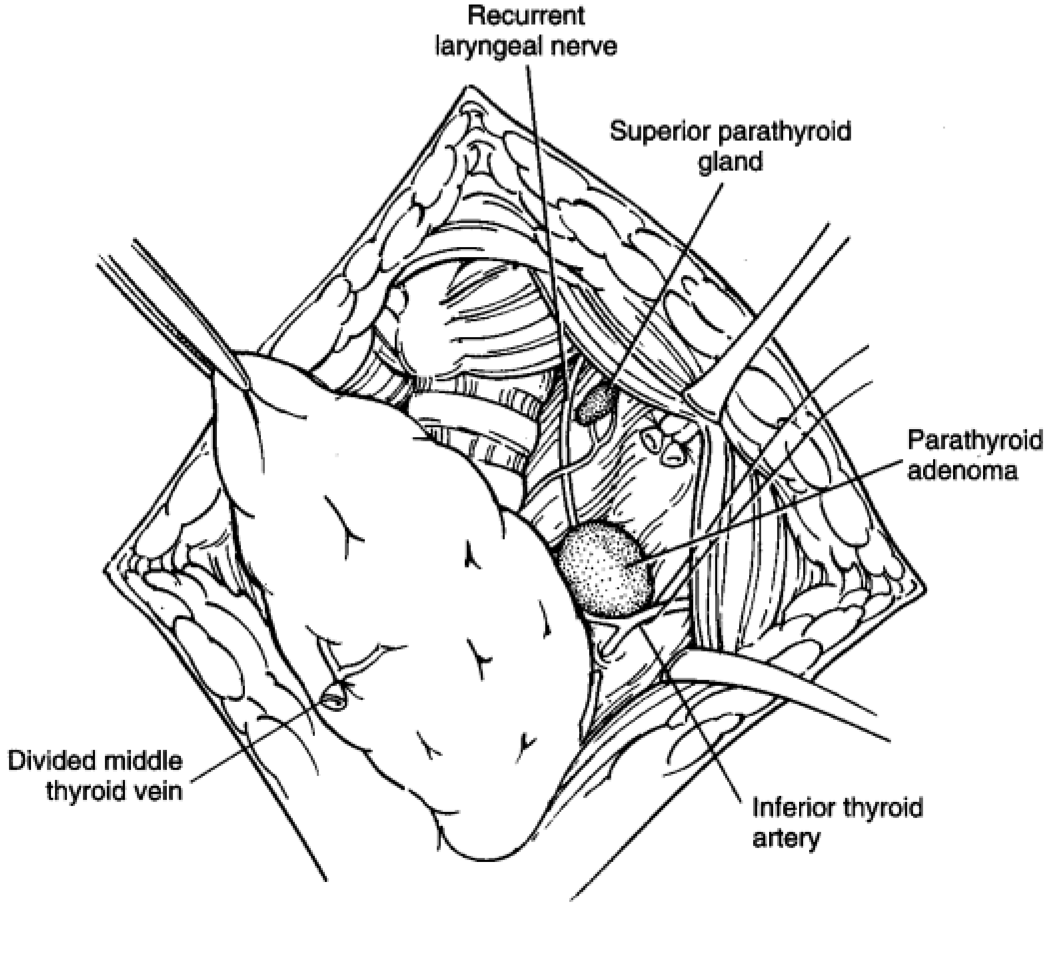


Figure 3-1 *A*, The transverse incision is shown in relation to the underlying bony structures. *B*, After the thyroid isthmus is retracted superiorly, the tracheostomy tube is inserted with the assistance of the tracheal retractor.

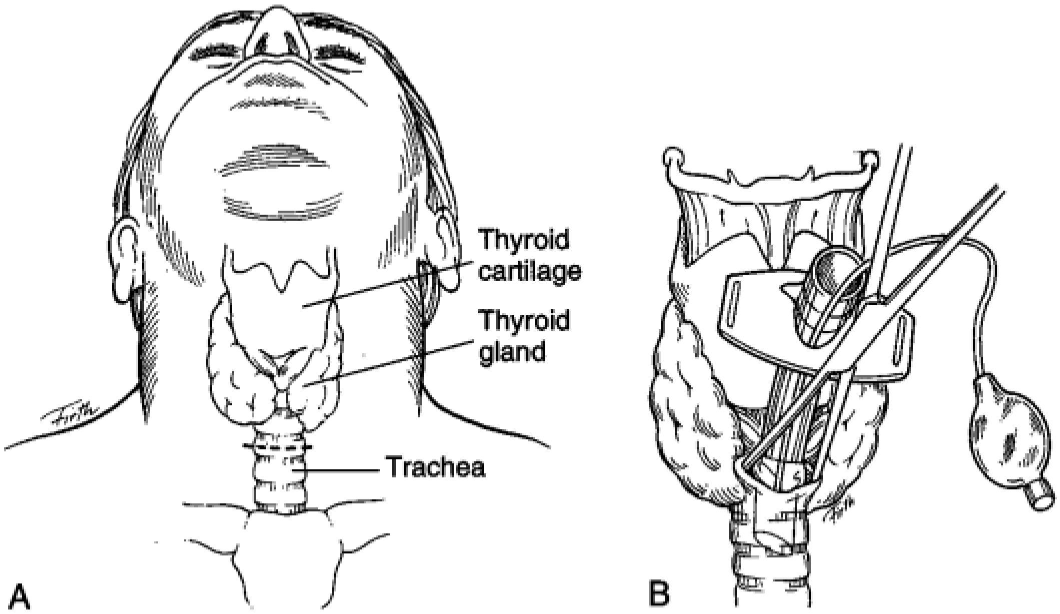
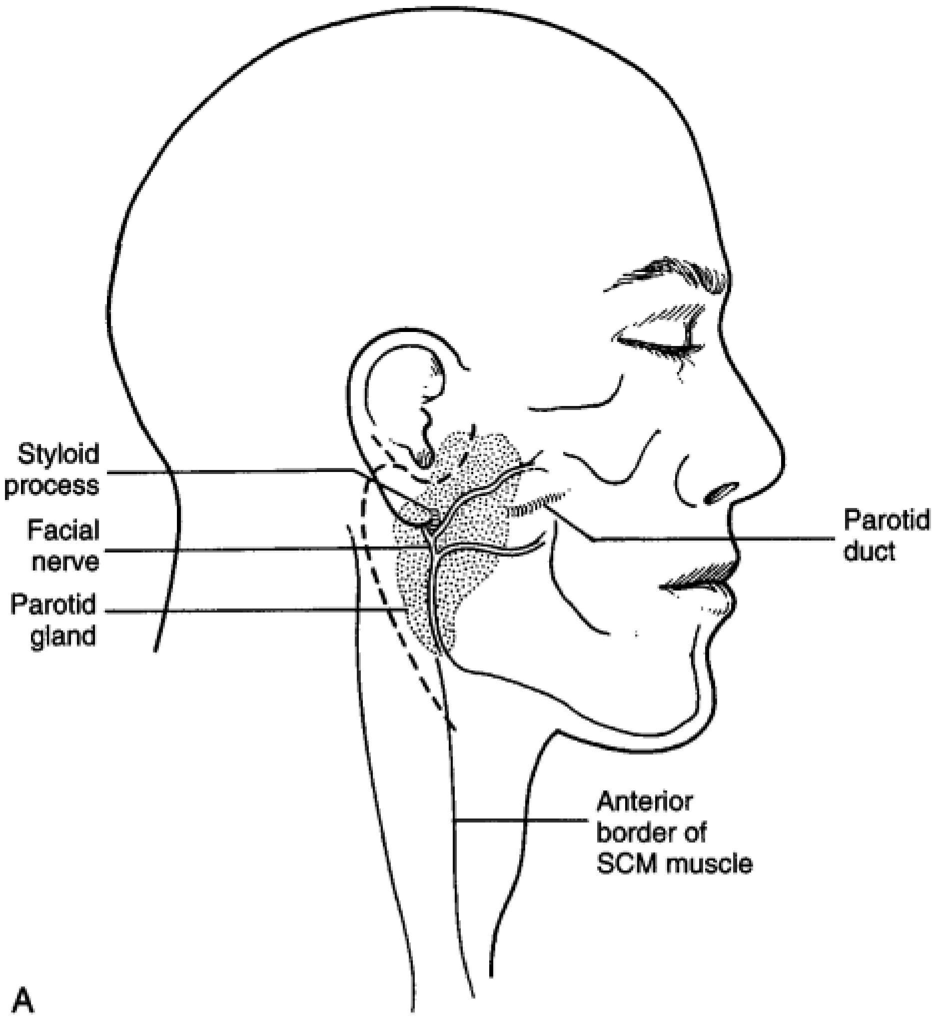


Figure 4-1 *A*, The incision used to perform parotidectomy. *B*, The cartilaginous part of the external auditory meatus is identified in relation to the mastoid process. The facial nerve is found at the depth of the posterior belly of the digastric muscle coursing forward toward the parotid gland. SCM, sternocleidomastoid.



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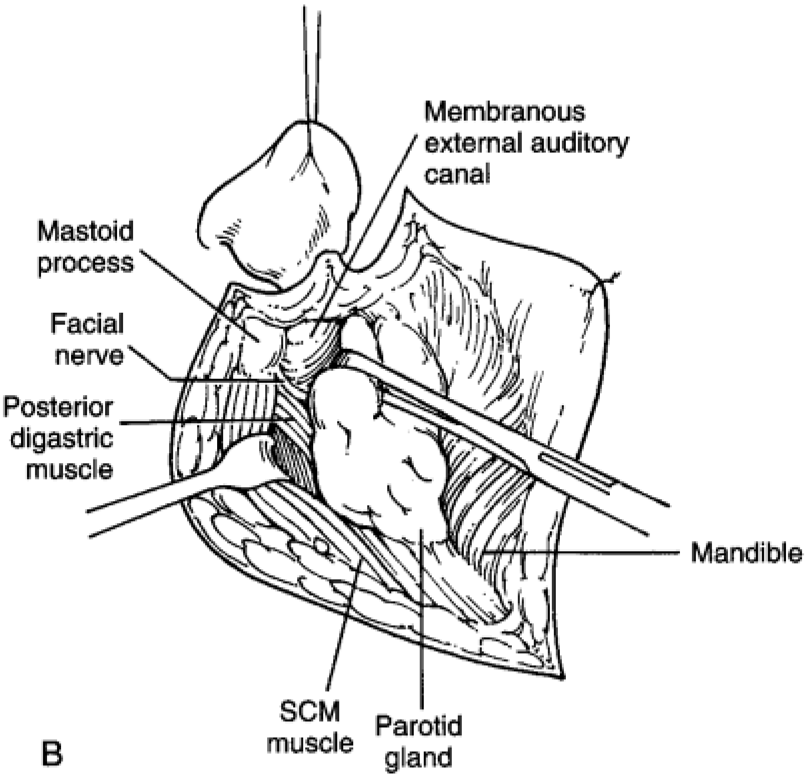


Figure 5-1 *A*, Incision used to perform submandibular gland resection. Important anatomic structures are shown. *B*, Mylohyoid muscle is retracted to expose the submandibular duct and lingual and hypoglossal nerves.

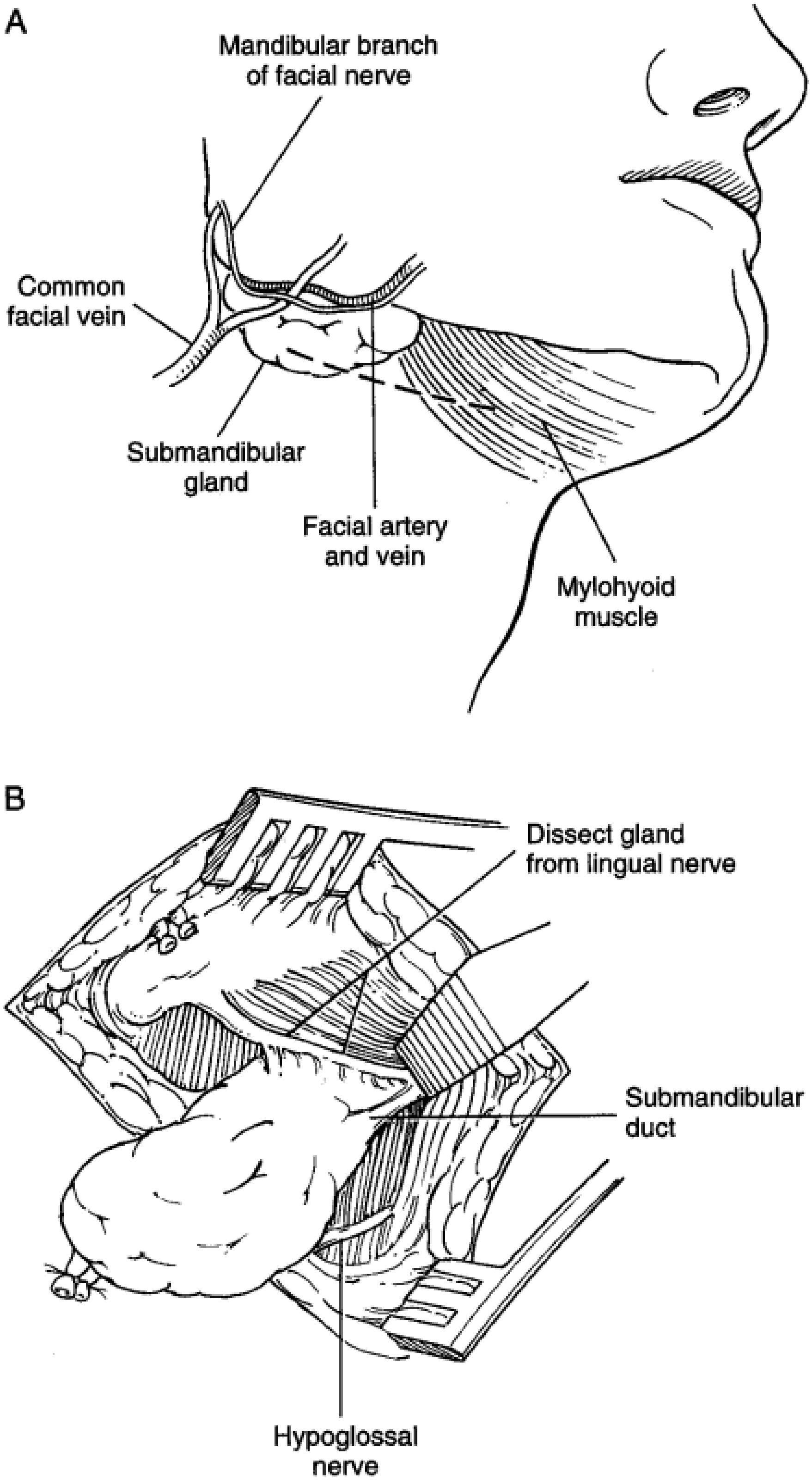


Figure 6-1 *A*, The muscles of the posterior triangle and the cervical sensory and motor roots are exposed. SCM, Sternocleidomastoid. *B*, The internal jugular vein has been divided and the specimen is carefully freed from the carotid sheath. Dissection is proceeding toward level I.

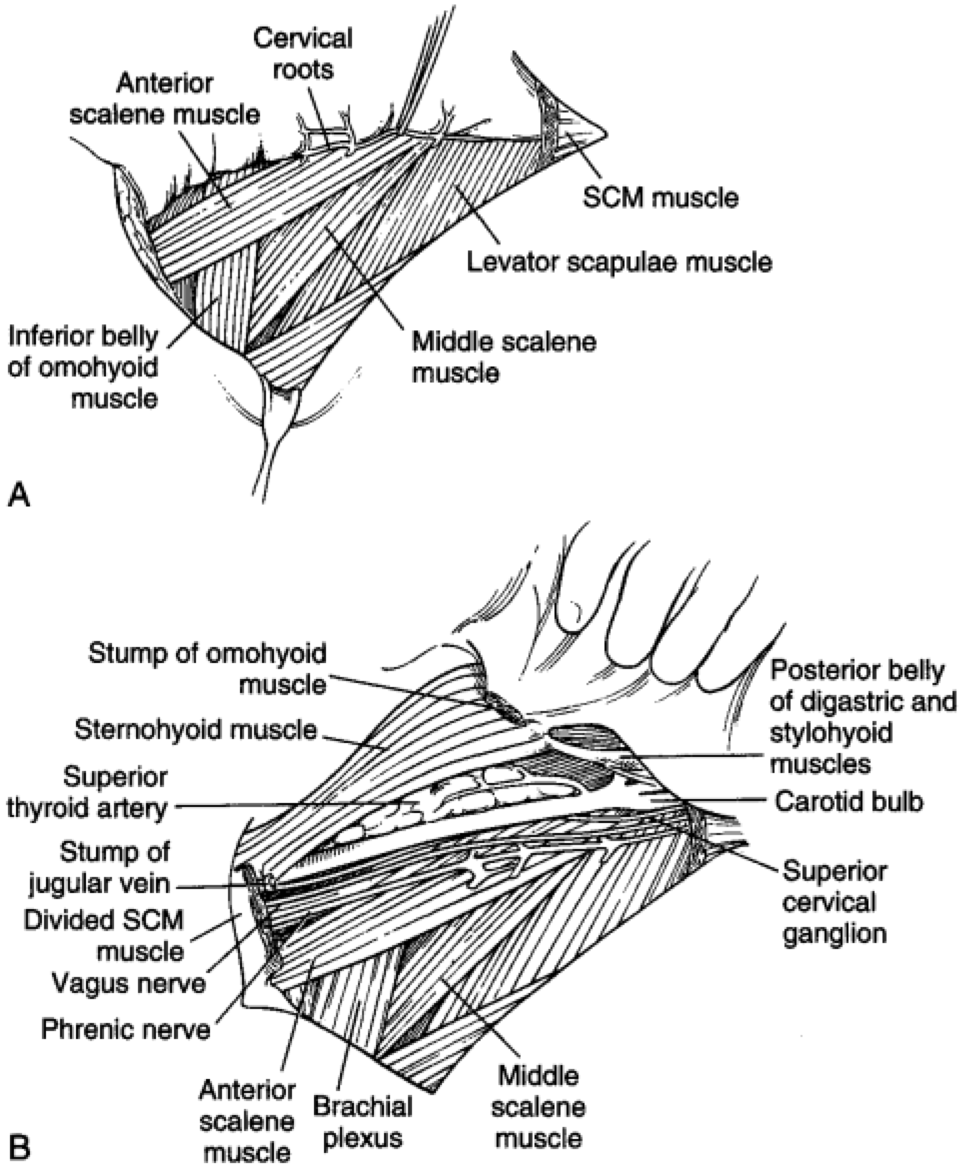
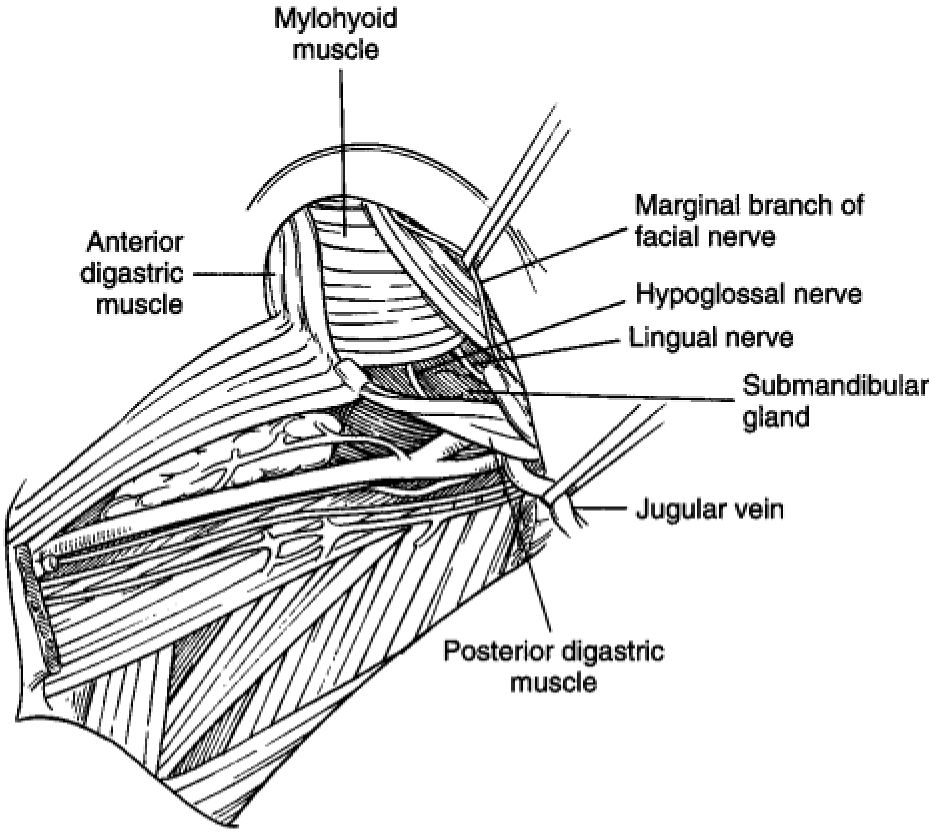


Figure 6-2 Operative field at completion of procedure.



Thoracic Surgery

Chapter 7 - Thoracotomy and Lung Resection

EMBRYOLOGY

The respiratory system begins as an entodermal outgrowth from the ventral surface of the foregut, immediately inferior to the hypobranchial eminence. This diverticulum begins to grow caudad to form the midline trachea and at its most distal portion divides into two lateral branches, the lung buds. The right lung bud divides into three branches, forming the main bronchi, and the left divides into two main branches, thus representing the adult pulmonary lobar anatomy. During this period, the respiratory diverticulum has a wide-open connection to the foregut that begins to separate due to the formation of the tracheoesophageal septum. The connection to the foregut is maintained only at the most proximal portion—the laryngeal orifice.

The lung buds are surrounded by splanchnic mesoderm, which forms the visceral pleura. As the lung buds further develop and repeatedly divide in a dichotomous fashion, they grow into the pericardioperitoneal canal. At the end of the sixth month, approximately 17 generations of subdivisions have formed, and at the seventh month the terminal bronchioli expand to form the alveoli. The block of mesodermal tissue surrounding the bronchial tree differentiates into cartilage, muscle, and blood vessels.

ANATOMY

The lungs are paired organs that lie within their pleural sacs and are attached to the mediastinum at the hilum. The lungs are spongy and elastic in consistency,

which allows them to conform to the contours of the thoracic cavity. Each lung has an apex directed toward the thoracic inlet and a base lying on the diaphragm. The lungs are divided into lobes by fissures, which extend deep into their parenchyma. The oblique fissure divides the left lung into an upper lobe and a lower lobe. The oblique and horizontal fissures divide the right lung into upper, middle, and lower lobes. The anteroinferior part of the left upper lobe, lying adjacent to the cardiac notch, is known as the lingula and represents the middle lobe. However, there can be variations in the lobar pattern; in particular, the horizontal fissure may be incomplete and occasionally additional lobes may be present.

The trachea divides into the right and left main-stem bronchi. The left upper lobe bronchus arises from the main-stem bronchus within the lung and divides into five segmental bronchi, with two passing to the lingula. The left main-stem bronchus continues into the lower lobe and divides into five segmental branches. The right upper lobe bronchus arises from the right main-stem bronchus, and soon after entering the lung it divides into three segmental bronchi. The middle lobe divides into two segmental branches. Finally, the continuation of the right main-stem bronchus passes to the lower lobe and divides into five segmental branches. Each segmental bronchus is distributed to a functionally independent unit of lung tissue—a *bronchopulmonary segment.*

The bronchial branches of the descending thoracic aorta supply the lung. The bronchial veins drain into the azygos and hemiazygos veins. Lymphatic drainage is via the superficial subpleural lymphatic plexus and a deep plexus of vessels accompanying the bronchi. Both groups drain through hilar lymph nodes to the tracheobronchial nodes around the bifurcation of the trachea and then to the mediastinal lymphatic trunks. The pulmonary plexus provides the nerve supply to the lungs and contains the sympathetic fibers from the upper thoracic segments and the parasympathetic fibers from the vagus nerve.

PREOPERATIVE PREPARATION

Before any surgical intervention, the surgeon should review the chest x-ray, computed tomography scan of the chest, and results of the fiberoptic bronchoscopic biopsy. Positron emission tomography is now becoming the standard of care to assess for extrapulmonary metastases. Pulmonary function tests should have been obtained to determine whether the patient has adequate lung capacity to tolerate certain resections.

Operative Procedure

POSITION

For a standard posterolateral thoracotomy, the patient is placed in the straight lateral position. A Foley catheter, a central venous catheter on the side of the thoracotomy, and a radial artery catheter on

the side opposite the thoracotomy are placed. General anesthesia is administered with the use of a double-lumen endobronchial tube. The patient is prepped and draped.

INCISION

A posterolateral thoracotomy incision is made beginning posteriorly midway between the spinous process of the vertebrae and the medial border of the scapula, extends one to two fingers-breadth below the tip of the scapula, and is continued forward below the level of the nipple.

EXPOSURE AND OPERATIVE TECHNIQUE

The incision is carried down to the level of the fascia. The auscultatory triangle is identified, and the fascia is divided to allow the surgeon to pass two fingers below the chest wall muscles (Fig. 7–1 *A*). The latissimus dorsi posteriorly and the serratus anterior muscle anteriorly are divided with electrocautery (Fig. 7–1 *B*). A scapula is lifted to count the ribs after the first or second rib is identified. The fifth intercostal space is chosen, and the intercostal muscles along the upper border of the sixth rib are divided with electrocautery (Fig. 7–1 *C*). Before the surgeon enters the thoracic cavity, the ipsilateral lung is collapsed by the anesthesiologist to avoid injury. A careful exploration of the thoracic cavity is performed to inspect for presence of pleural implants, pleural effusion, and enlarged mediastinal lymph nodes. If the thoracotomy is for resection of a lung tumor, this lesion is identified and any extension of this lesion into the hilum or mediastinal structures is also defined. Dissection begins by opening the mediastinal pleura and carefully dissecting and identifying the main pulmonary artery and both the superior and inferior pulmonary veins. Vessel loops are placed around these vessels.

Right Pulmonary Resections

The initial step is to identify the azygos vein, which is ligated in continuity with 2-0 silk sutures and divided. Just inferior to the angle between the azygos vein and the superior vena cava, the main pulmonary artery can be located. Using a meticulous combination of sharp and blunt dissection, the operator places a vessel loop around the main pulmonary artery. Just inferior to the main pulmonary artery, the superior pulmonary vein is identified and carefully dissected, and a vessel loop is placed around it. More inferiorly, the inferior pulmonary ligament is carefully divided with Metzenbaum scissors or electrocautery. The inferior pulmonary vein is identified, and a vessel loop is placed around it.

Right Upper Lobectomy

To perform a right upper lobectomy, both the pulmonary artery and the vein are dissected peripherally toward the right upper lobe to carefully

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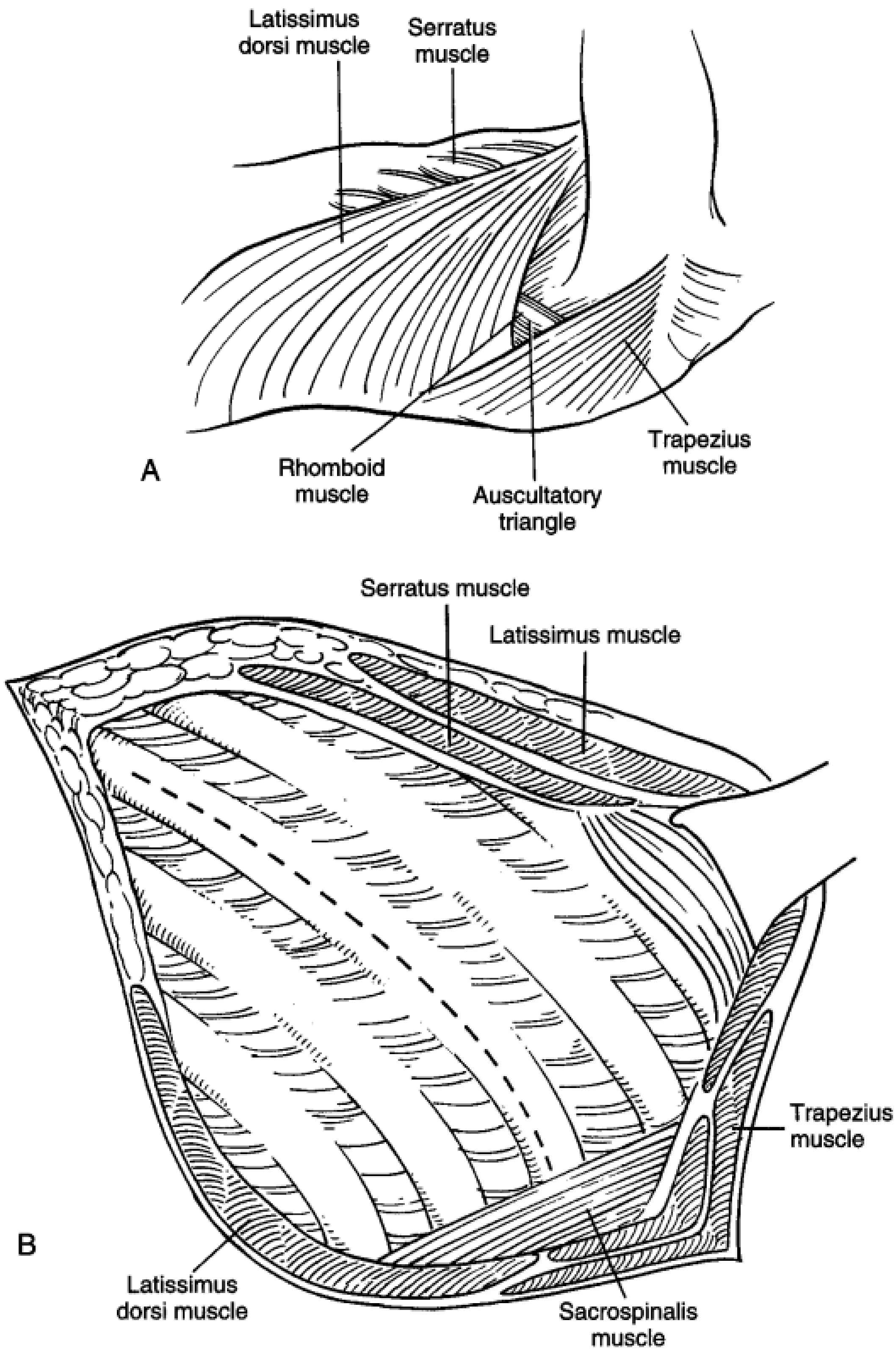
Figure 7-1 *A,* Muscles encountered when the thoracotomy incision is performed. The auscultatory triangle can be seen. *B*, Muscles have been divided, and the fifth rib is identified. *C*, The fifth intercostal space is chosen and the intercostal muscles along the upper border of the sixth rib are divided with electrocautery. The intercostal neurovascular bundle can be seen beneath the lower border of the rib.



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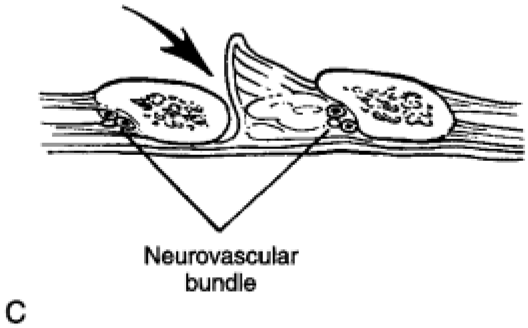


Figure 8-1 The incisions used to perform a total three-stage esophagectomy.

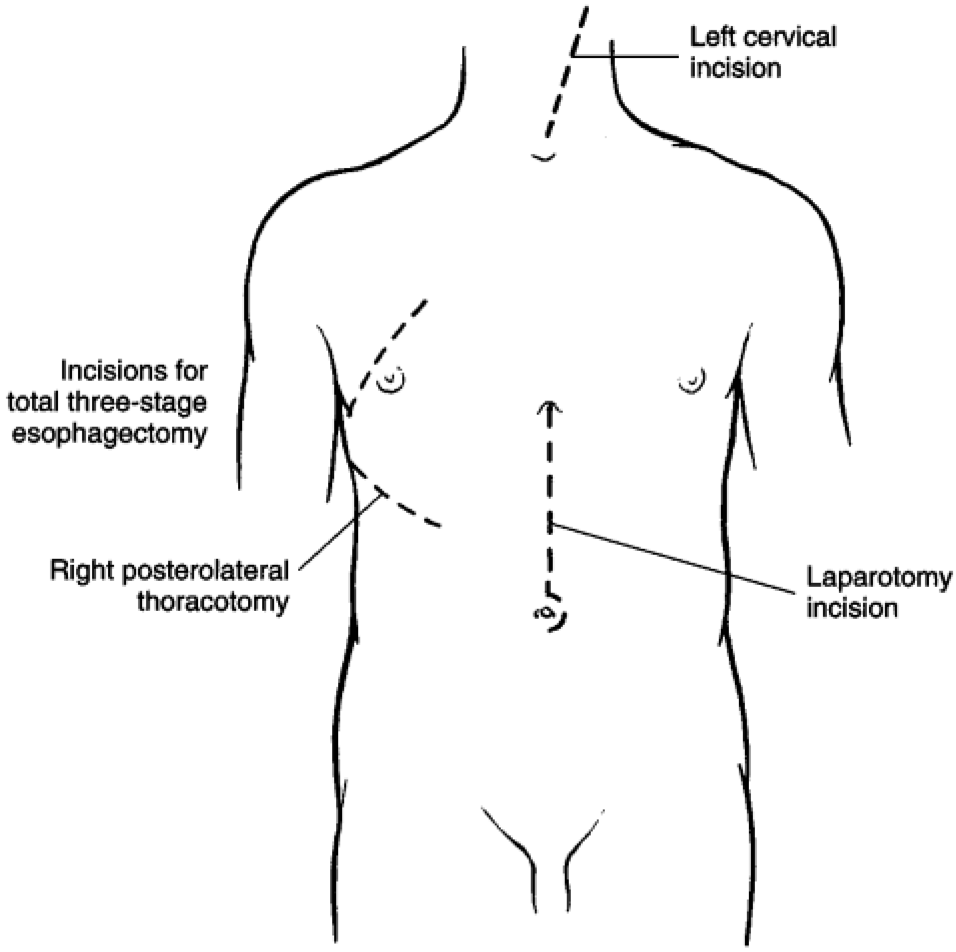


Figure 8-2 Key elements of the mobilization of the stomach, with retention of an intact gastroepiploic arcade, pyloroplasty, and division of the gastric cardia to create a gastric tube.

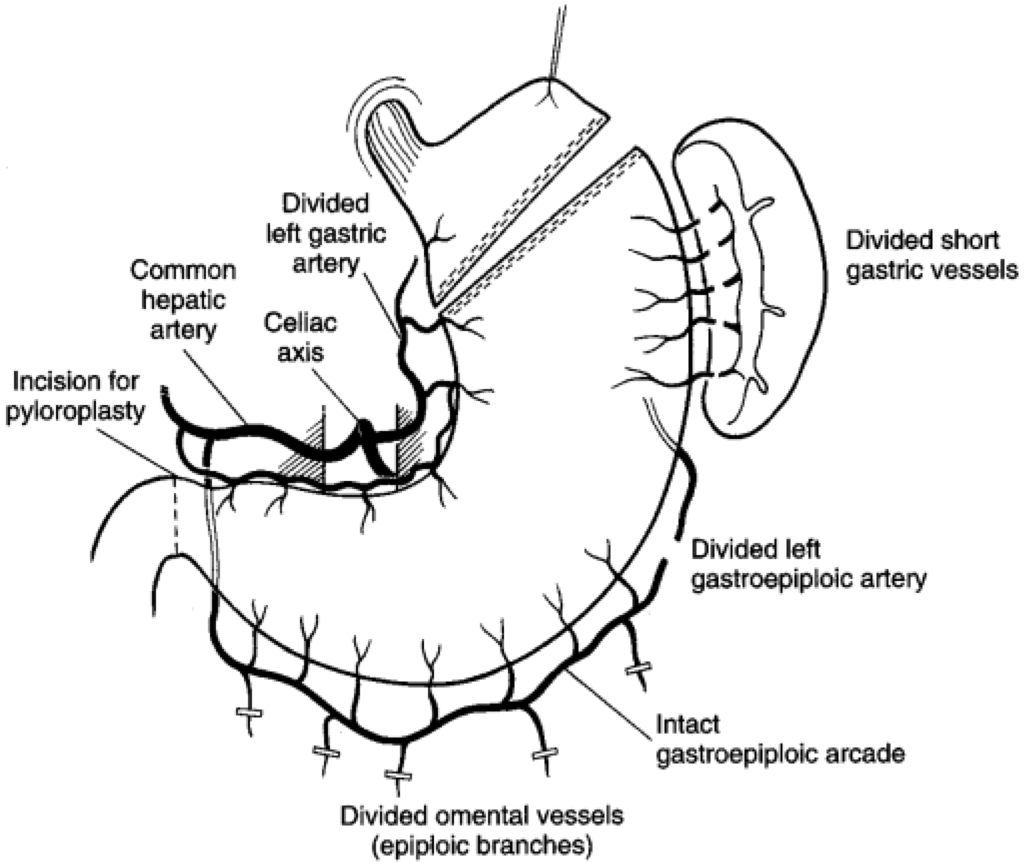


Figure 8‑3 Completed cervical anastomosis.

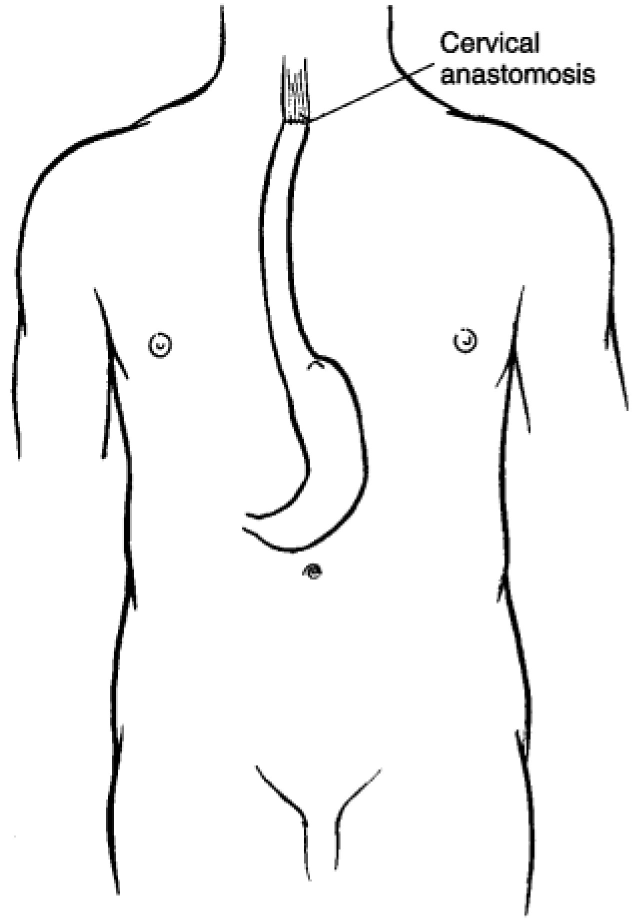


Figure 9‑1 Incision along the anterior border of the sternocleidomastoid muscle to expose the cervical esophagus.

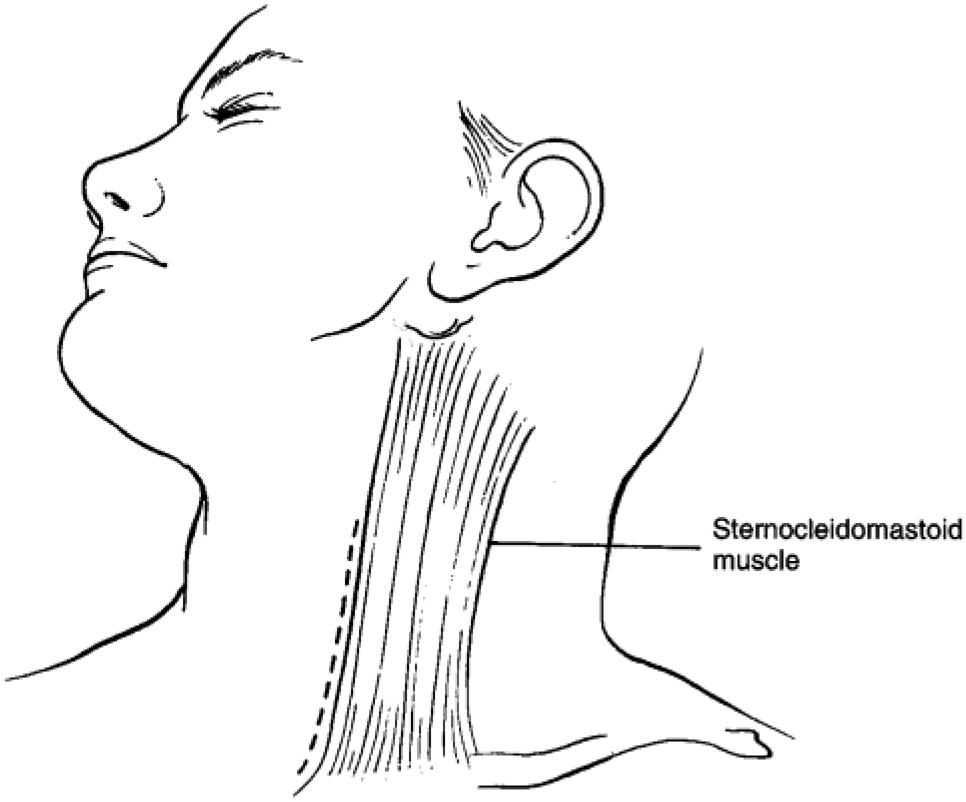
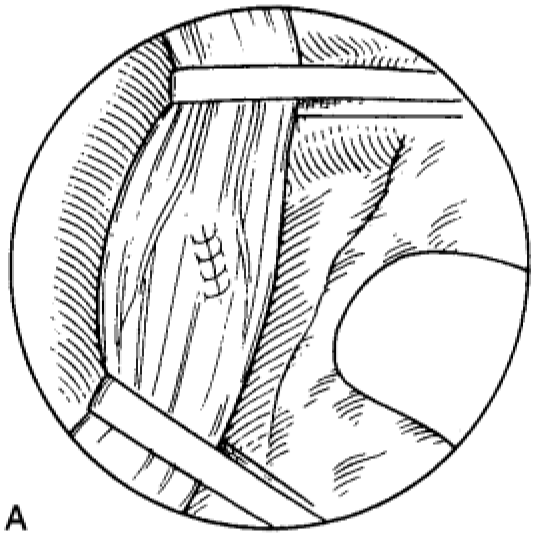
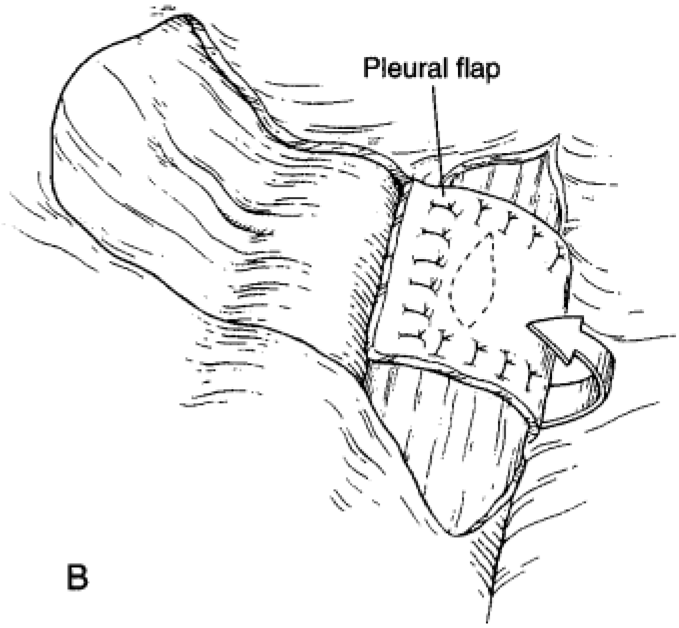


Figure 9‑2 *A*, Primary closure of the perforation. *B*, Construction of a pleural flap.





B

Breast Surgery

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Chapter 10 - Breast Biopsy

Operative Procedure

POSITION

The patient lies in the supine position with the ipsilateral arm abducted to 90 degrees. The entire breast is prepped, and sterile drapes are placed. The procedure may be performed under general anesthesia or under local anesthesia with accompanying sedation provided by the anesthesiologist.

INCISION

A curvilinear incision is marked directly over a palpable mass. A circumareolar incision can be used for central lesions. The incision should be planned appropriately so that it can be incorporated in subsequent mastectomy if needed. Avoid linear radial incisions. The incision should be long enough to allow the mass to be removed easily without excessive skin retraction.

EXPOSURE AND OPERATIVE TECHNIQUE

The steps involved in performing the breast biopsy are outlined in Figure 10–1 . The skin and subcutaneous tissue are infiltrated with 1% lidocaine and incised. Additional local anesthesia is injected within the adjacent breast tissue. Breast flaps are created using sharp dissection. Dissection proceeds while aiming to achieve at least a 1-cm margin around the breast mass.

The mass with the accompanying breast tissue is grasped and retracted toward the surgeon while counter-traction is provided with a deep Richardson retractor. The mass is sharply dissected circumferentially until the breast tissue can be lifted out of the wound. The specimen is excised after ensuring that adequately deep margins

Figure 10-1 *A–C*, Steps involved in excision of a breast mass. *D–F*, Steps involved in excision of a breast mass.

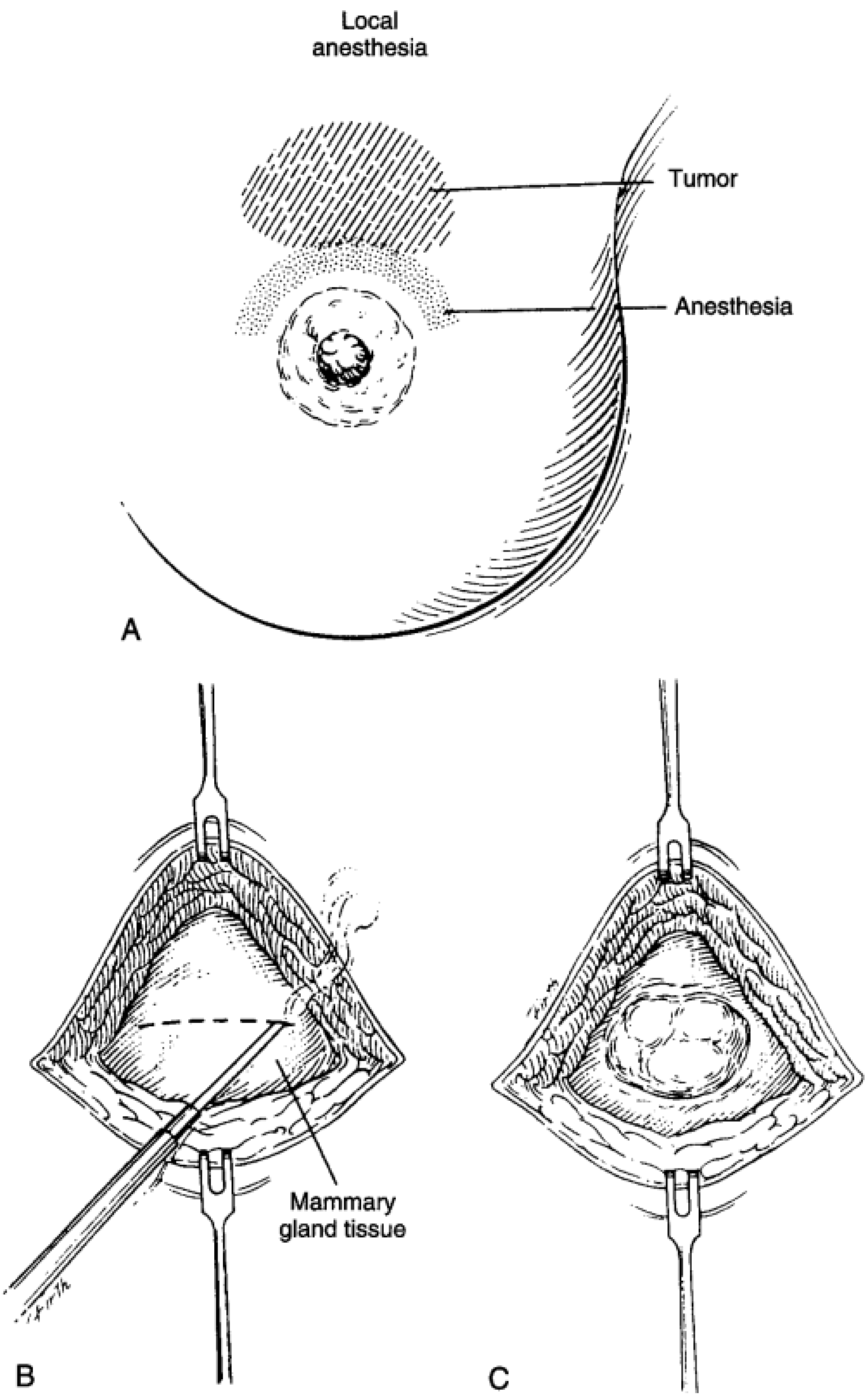


Figure 10-1 *A–C*, Steps involved in excision of a breast mass. *D–F*, Steps involved in excision of a breast mass.

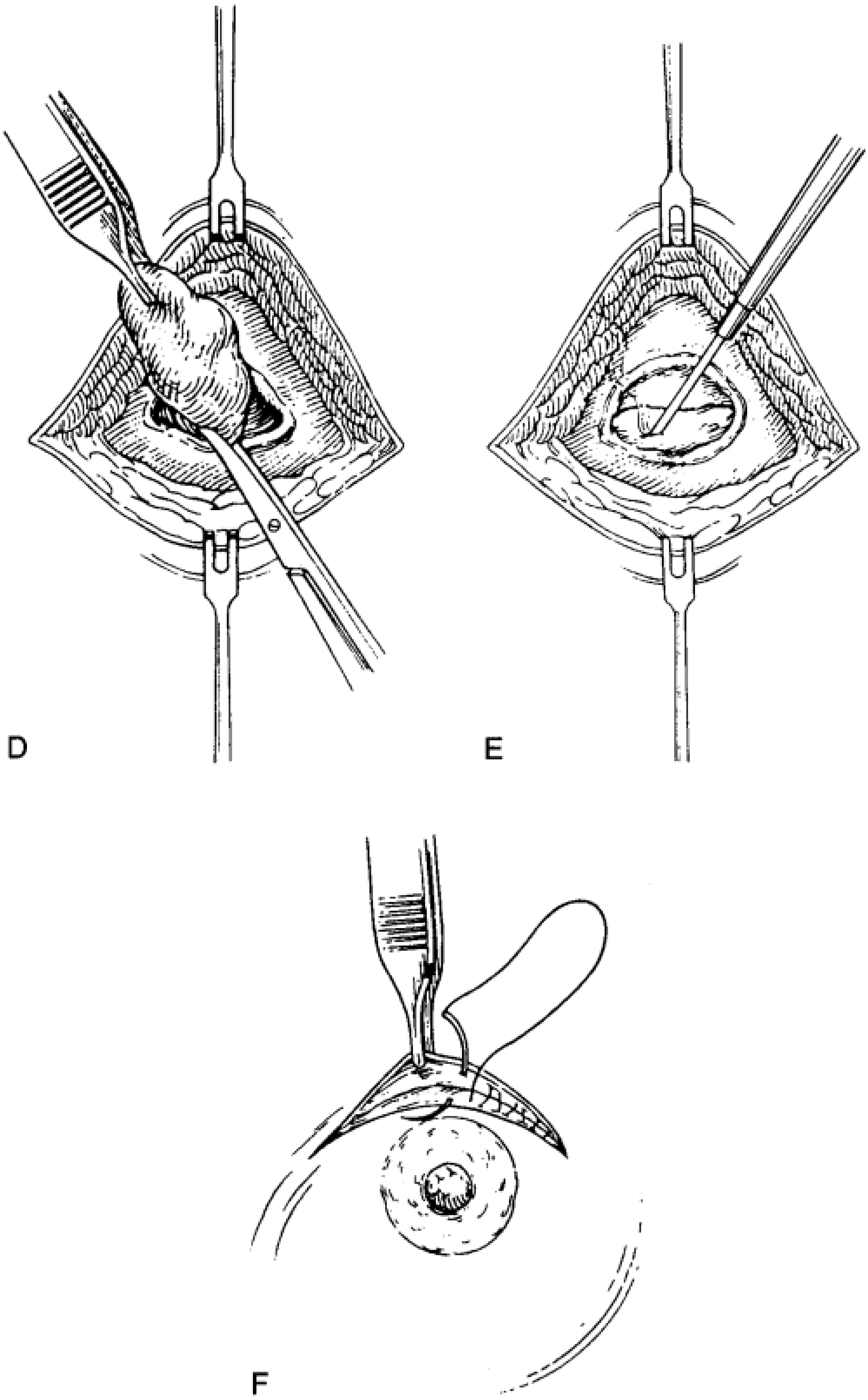


Figure 11-1 The elliptic incision encompassing the prior biopsy site and the limits of dissection are shown. The underlying muscles are seen on the left. *(Redrawn from Hindle WH. Breast care: A clinical guidebook for women's primary health care providers. New York: Springer-Verlag, 1999.)*

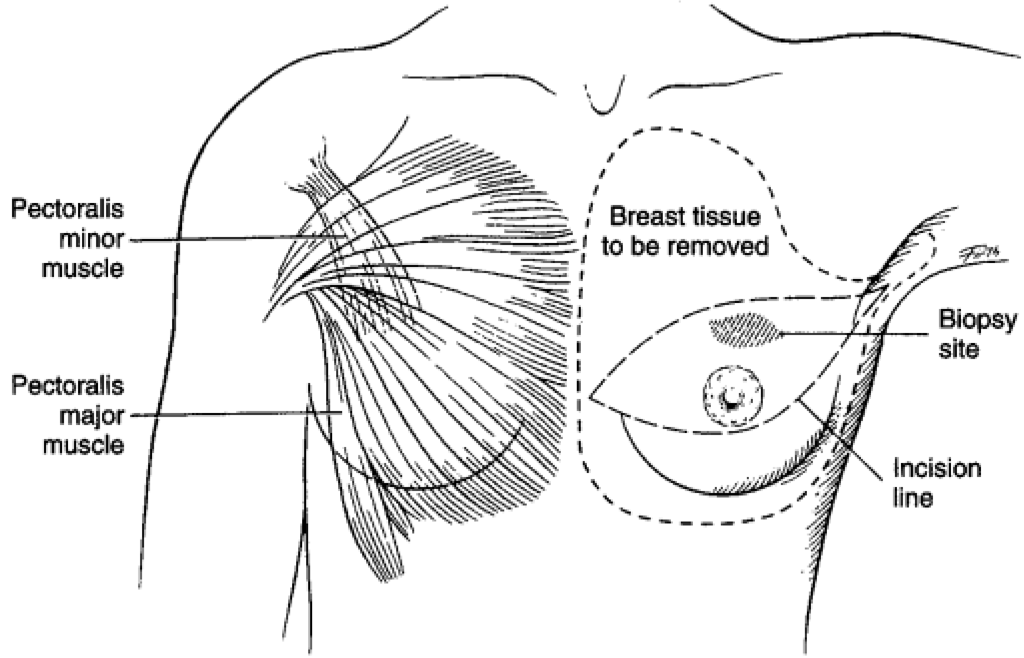


Figure 11-2 After creating the flaps, the breast tissue is dissected from the underlying pectoralis major muscle. On the lateral chest wall, the long thoracic and thoracodorsal nerves can be seen.

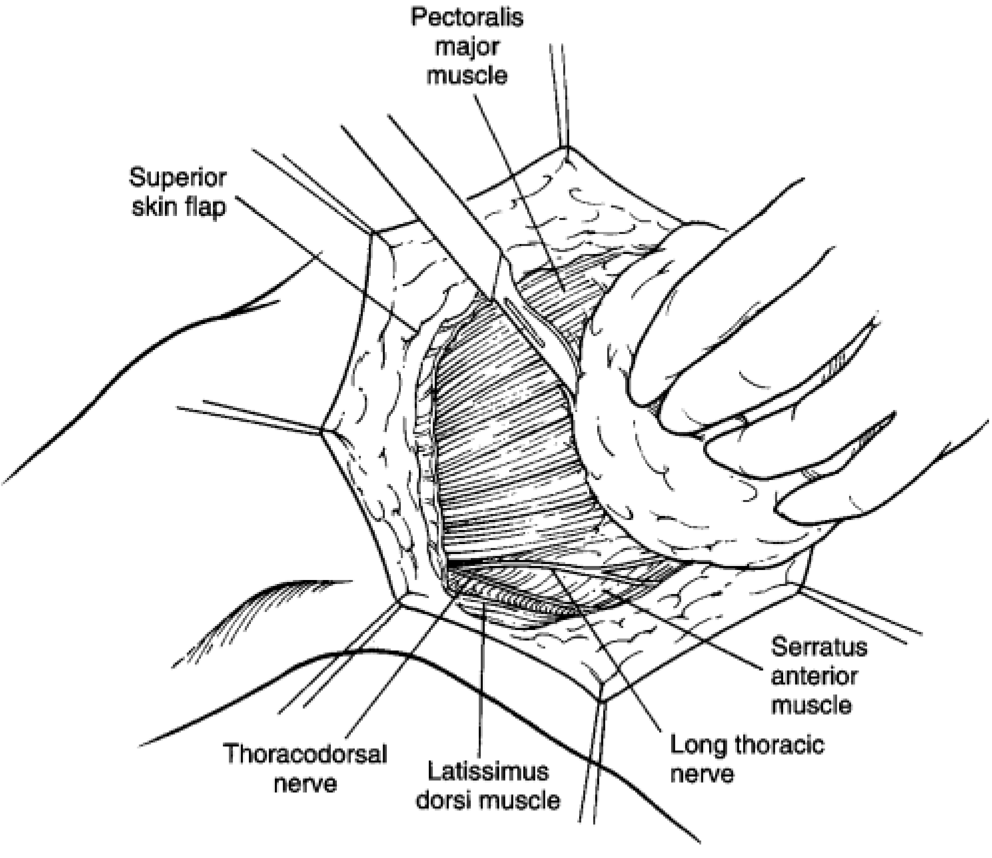
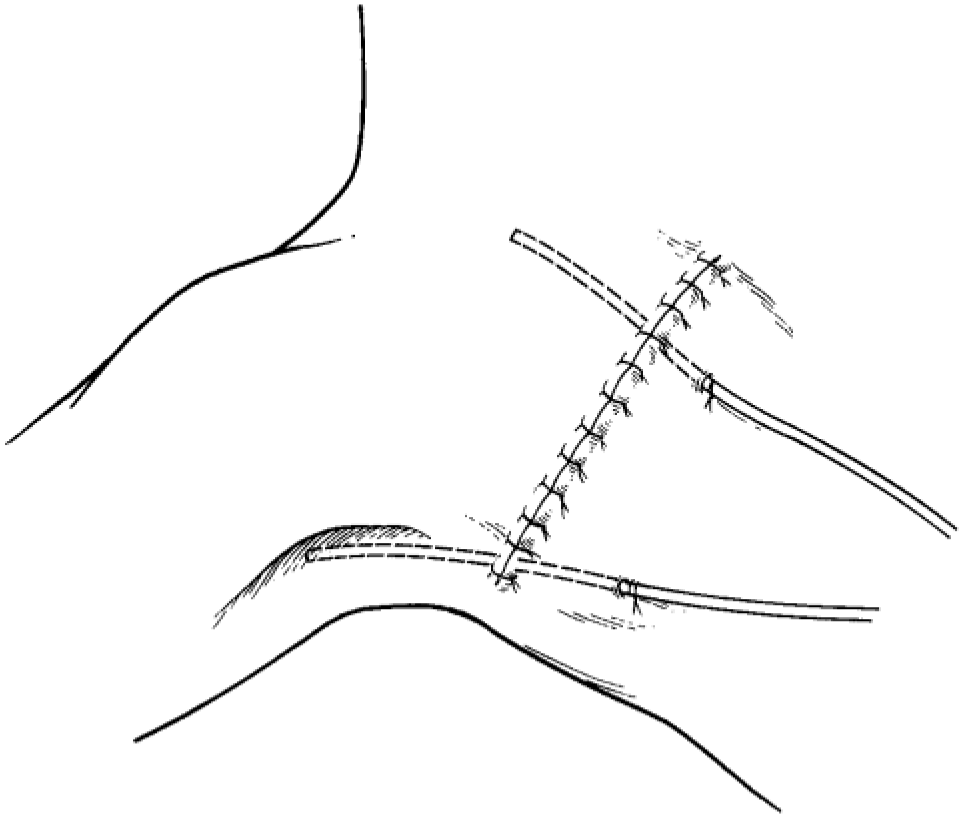


Figure 11-3 Closure of the incision after two closed suction drains are placed.



Posterior wall: composed from above downward by the subscapularis, latissimus dorsi, and teres major muscles.

Lateral wall: the intertubercular groove on the shaft of the humerus to which is attached the pectoralis major, latissimus dorsi, and teres major muscles.

Medial wall: serratus anterior overlying the upper ribs and intercostal spaces.

Base: formed by the skin, subcutaneous tissue, and axillary fascia.

Apex: formed by the outer border of the first rib, superior border of the scapula, and middle third of the clavicle.

Clinically, the axilla is divided into levels using the pectoralis minor muscle as a reference—level I is below, level II is posterior to, and level III is superior to the pectoralis minor muscle (Fig. 12–1). The axilla contains adipose tissue, axillary lymph nodes, the axillary artery/vein

Figure 12‑1 The levels of axillary lymph node tissue in relation the pectoralis minor muscle.

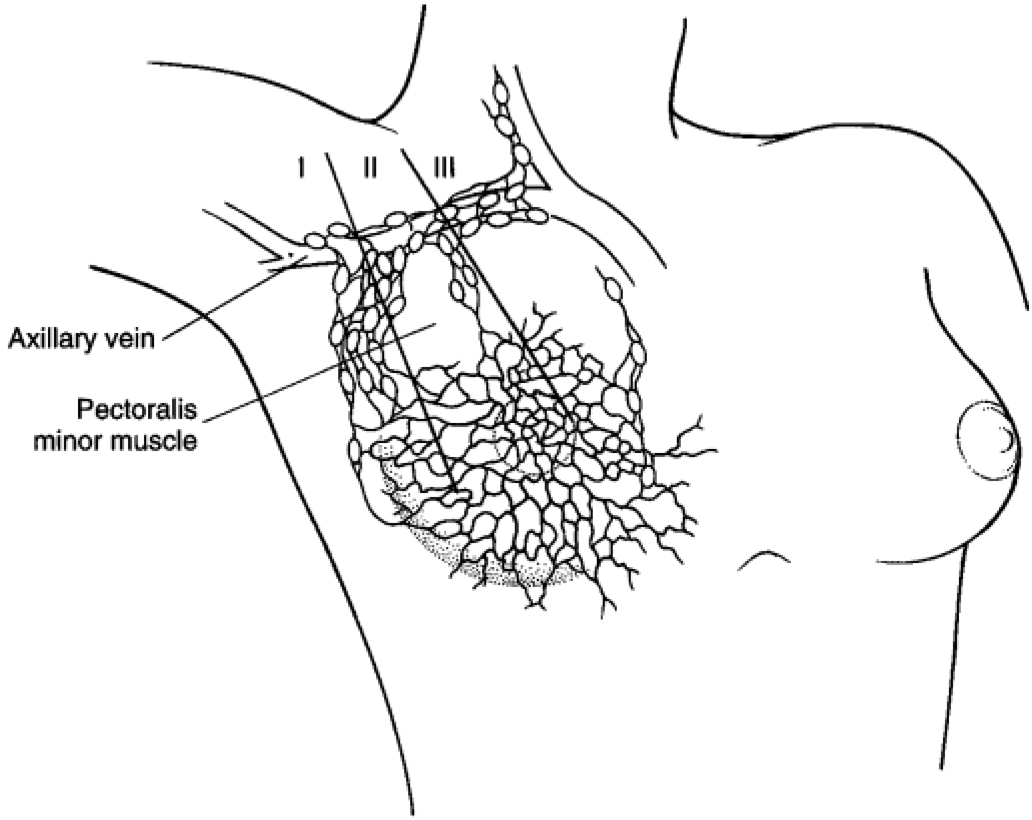


Figure 12-2 Incision is made approximately two fingers-breadth below the axillary crease.

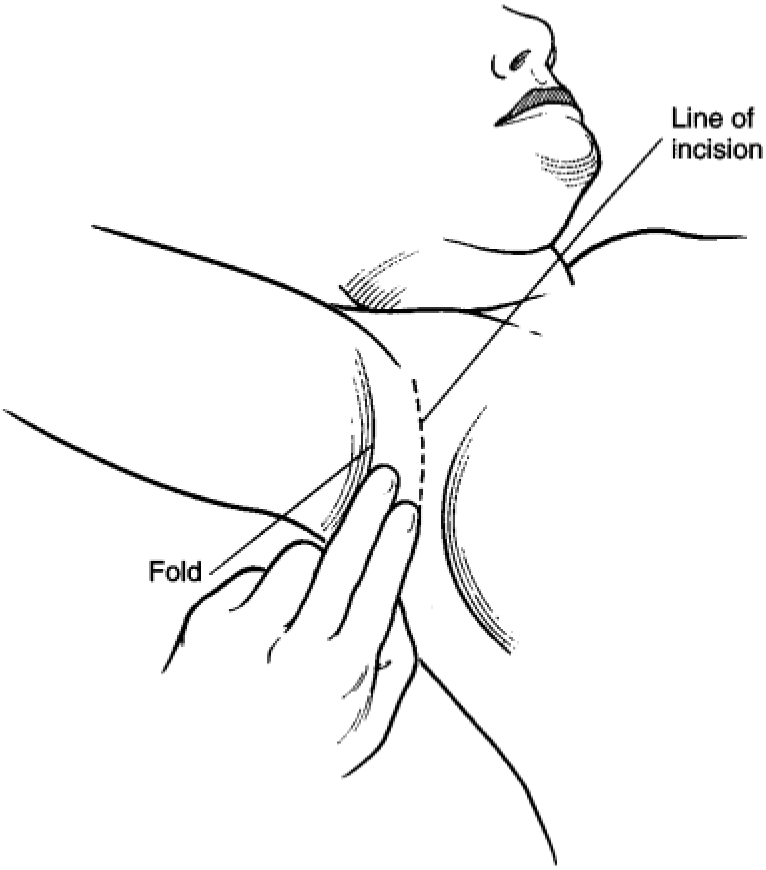
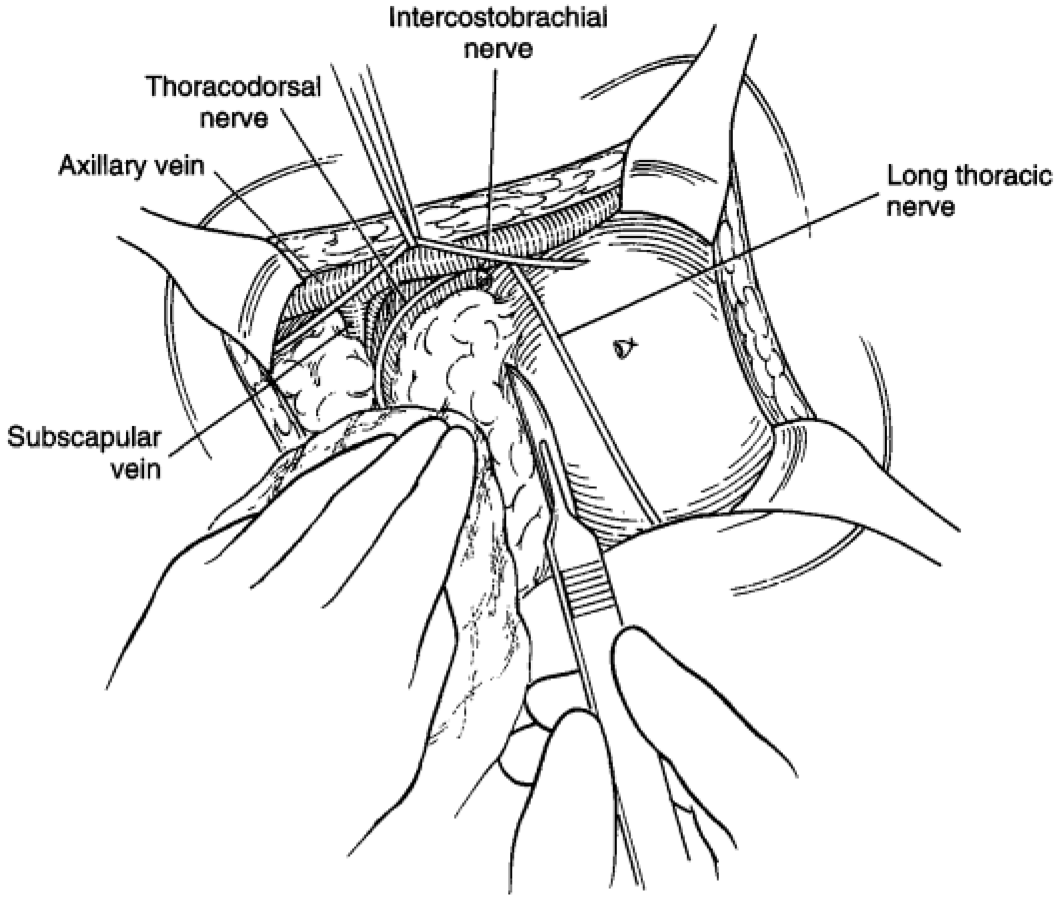


Figure 12-3 The important structures exposed during axillary dissection include the axillary vein and the intercostobrachial, thoracodorsal, and long thoracic nerves. With these structures in view, the axillary tissue is dissected off the lateral chest wall.



Abdomen

ABDOMINAL WALL

Chapter 13 - Inguinal Hernia Repair

ANATOMY

The inguinal canal is an oblique space measuring 4 cm in length that lies above the medial half of the inguinal ligament. At its medial end there is a triangular opening, called the external inguinal ring, that lies above and lateral to the pubic crest. The internal inguinal ring is located at the lateral end and represents an opening within the transversalis fascia. The boundaries of the internal inguinal ring are superiorly the transverus abdominis arch, inferiorly the iliopubic tract, and medially the inferior epigastric vessels. The thickened fascia overlying the epigastric vessels is called Hesselbach's ligament. The internal inguinal ring is located 1 cm above the femoral artery pulse or midway between the anterior superior iliac spine and pubic tubercle.

The relationships of the inguinal canal are as follows:

Anterior: external oblique fascia along the entire length with contribution from the internal oblique fascia at the lateral one third.

Posterior: fusion of the transversalis fascia and the transversus abdominis fascia.

Inferior (floor): the inguinal ligament and its shelving edge and medially the lacunar ligament of Gimbernat.

Superior (roof): the arch formed by the internal oblique and transversus abdominis muscle (conjoint tendon).

The contents of the inguinal canal include the following:

Male: the spermatic cord travels through the inguinal canal and consists of three nerves, three arteries, and three other structures. The nerves are the ilioinguinal nerve, the genital branch of the genitofemoral nerve, and the sympathetic nerves. The three arteries are the spermatic artery from the aorta, the artery to the vas deferens from the superior vesicle, and the cremasteric artery from the deep epigastric artery. The remaining other three structures include the vas deferens, the pampiniform venous plexus, and the lymphatic channels. The cord has three coverings—the outer external spermatic fascia, the middle cremasteric muscle layer, and the inner internal spermatic fascia—which are derived from the external oblique fascia, internal oblique muscle, and transversus fascia, respectively.

Female: the round ligament of the uterus, ilioinguinal nerve, and genital branch of the genitofemoral nerve.

Several named condensations of fascia or ligaments in relation to the inguinal canal are used during various repairs of inguinal hernias:

Inguinal ligament (Poupart's ligament): This is the condensed lower portion of the external oblique fascia and extends from the anterior superior iliac spine to the pubic tubercle. Its medial third has a free edge, whereas the lateral two thirds are attached to the iliopsoas fascia.

Pectineal ligament (Cooper's ligament): This is a strong ligament attached to the pubic ramus and formed jointly from the aponeurosis of the internal oblique, transversus abdominis, and pectineus muscles.

Iliopubic tract (Thompson's ligament): This is the condensed part of the transversalis fascia and extends from the pectineal ligament medially, forms the inferior border of the internal ring and the anterior wall of the femoral sheath, and attaches laterally to the iliopectineal arch (medial thickening of iliopsoas fascia).

PREOPERATIVE WORK-UP

Exacerbating factors contributing to the development of hernia must be identified. These include chronic constipation, chronic cough, prostatic hypertrophy, and any other condition that would chronically elevate intra-abdominal pressure. Appropriate measures must be taken to correct or at least improve these exacerbating conditions preoperatively. This is particularly important in order to achieve lower hernia recurrence rates. A very large inguinoscrotal hernia that contains a large proportion of the intra-abdominal contents is known as loss of domain. Acutely reducing these contents within the abdomen during the process of hernia repair may cause

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diaphragmatic compromise, leading to postoperative respiratory failure. To prevent this complication, repeated abdominal pneumoperitoneum needs to be undertaken to increase the capacity of the intra-abdominal cavity. In patients with uncontrolled ascites secondary to cirrhosis, elective repair of the hernia may be hazardous because it can lead to hepatic decompensation and death. Before repair of a symptomatic hernia in these patients, placement of a temporary peritoneovenous shunt (LaVeen or Denver shunt) or transjugular intrahepatic portosystemic shunt should be considered.

Patients presenting acutely with a strangulated hernia require emergent operative intervention and therefore are rapidly assessed and resuscitated. Symptomatic incarcerated hernias must be repaired urgently.

In the presence of a large inguinal or inguinoscrotal hernia, it is wise to place a Foley catheter, because the bladder can often become part of the wall of the sliding hernia. Prophylactic antibiotics are administered.

Operative Procedure

POSITION

The patient is placed in the supine position.

ANESTHESIA

For a routine uncomplicated hernia repair, local anesthesia with sedation is generally adequate. In the presence of strangulation or incarceration, general anesthesia is preferred. Alternatively, spinal anesthesia can be used, particularly in elderly patients with comorbid conditions.

INCISION

An incision is usually made parallel to and approximately 2 cm above the inguinal ligament. For adequate exposure the incision should extend from the level of the pubic tubercle to the internal ring at the level of the femoral pulse. Some surgeons prefer a skin-crease incision, which tends to be placed farther away from the pubic tubercle medially and has the disadvantage of causing difficult access to the external ring.

EXPOSURE AND OPERATIVE TECHNIQUE

Numerous methods of hernia repair have been described in the literature: Bassini, McVay, Shouldice, and the tension-free Lichtenstein, to name a few. Interested readers can obtain details in well-known textbooks dealing with the subject. The initial dissection is identical for all procedures, but procedures differ in how the floor of the hernia is repaired.

Before the hernia repair is begun, local anesthesia is administered. Either 1% lidocaine or a mixture containing 1% lidocaine, 0.25% Marcaine, and bicarbonate solution can be used. First the ilioinguinal nerve is infiltrated. This is located approximately 1 cm medial and inferior to the

anterior superior iliac spine. Intradermal and the subcutaneous tissues are infiltrated at the site of the proposed incision. The skin and the subcutaneous tissue are incised with a no. 10 scalpel. Two branches of the superficial epigastric veins are invariably encountered; they are clamped, divided, and ligated with 3-0 silk sutures. A self-retaining Weitlaner retractor is placed. At the lateral end of the incision the subcutaneous tissue is further incised until the external oblique fascia is identified. At this point further local anesthesia is infiltrated beneath the external oblique fascia. The rest of the subcutaneous tissue is now incised down to the level of the external oblique fascia. The self-retaining retractor is repositioned.

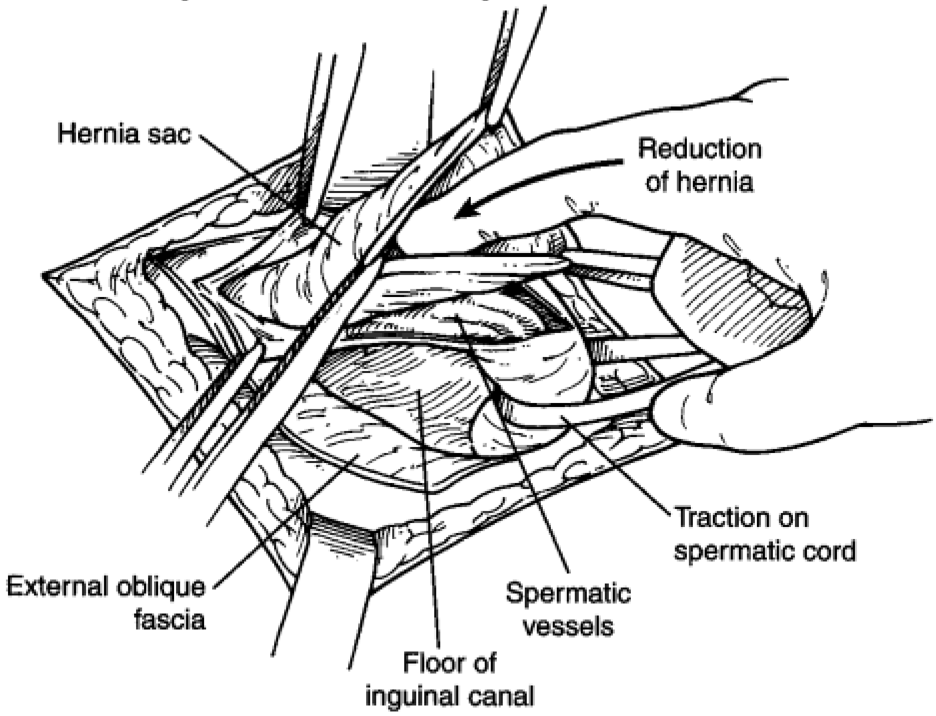
At this point the external ring is identified on the medial aspect. With a no. 15 scalpel an incision is made into the external oblique fascia along its fibers. The edges of this incision are grasped with Kelly clamps, and the external oblique fascia is carefully dissected free from the underlying areolar tissue and both the ilioinguinal and genitofemoral nerves. While these two nerves are protected, the inguinal canal is opened by extending the incision toward the external ring. The two nerves are then carefully freed, preserved, and retracted out of the way. If needed, these nerves can be directly infiltrated to provide local anesthesia.

The entire cord needs to be carefully freed from the floor of the inguinal canal. This is best started at the level of the pubic tubercle. The operator grasps the cord structures with the left hand, and using the right index finger palpates the pubic tubercle and gently elevates the cord using a combination of blunt and sharp dissection. A quarter-inch Penrose drain is placed around the cord to facilitate retraction. The cremasteric muscles are divided, and the cremasteric artery is ligated to carefully delineate the internal ring. Particular care is taken to avoid injuring the inferior epigastric vessels that are present on the medial border of the internal ring.

To identify the indirect sac, dissection is commenced on the anterolateral aspect of the cord. First, the spermatic coverings arising from the internal oblique and the transversus muscle are divided. A shiny white sac is identified, grasped with hemostats, and dissected free from the cord structures. If the distal end of the sac is visualized, this is also grasped so that the entire sac can be resected. The sac is dissected proximally toward the internal ring. The sac needs to be opened to inspect its contents and to exclude the presence of a sliding hernia (Fig. 13–1). If the distal end of the sac is not visualized, it can be transected at any convenient location along the spermatic cord. The distal end is left open to allow drainage. If the sac is devoid of any abdominal contents, it is twisted and suture ligated at the level of the internal ring with 2-0 absorbable sutures. If, on the other hand, a sliding hernia is present, the sac is trimmed to the level of the sliding structure and closed with continuous 2-0 absorbable sutures.

After the indirect sac has been resected, the internal ring is evaluated. If it is widened due to the presence of the hernia sac and its contents, it

Figure 13-1 The hernia sac is dissected free from the cord and then opened to reduce its contents. A Penrose drain placed around the cord provides traction that facilitates dissection.



Posterior: pectineal ligament (Cooper's ligament).

Lateral: femoral vein.

Medial: edge of the lacunar (Gimbernat's) ligament. In about 10% of cases, the abnormal obturator artery passes adjacent to the lacunar ligament and may be injured during division of the lacunar ligament.

The femoral canal normally contains fat and a lymph node called Cloquet's node.

PREOPERATIVE PREPARATION

Preoperative preparation will depend on the mode of presentation, in particular whether the femoral hernia is incarcerated or strangulated. If the patient has an associated small bowel obstruction, appropriate measures such as placement of nasogastric tube for decompression, intravenous fluid resuscitation, and placement of Foley catheter need to be instituted.

Operative Procedure

POSITION

The patient is placed in the supine position. The inguinal area and lower abdomen are prepped and draped in the usual fashion.

EXPOSURE AND OPERATIVE TECHNIQUE

The approach for repair of the femoral hernia depends on the mode of presentation.

Low Approach

For uncomplicated elective repair of a femoral hernia, the low approach is commonly used. An oblique incision is made over the hernia, approximately one finger-breadth below the medial half of the inguinal ligament (Fig. 14–1 *B*). The incision is carried through the subcutaneous tissue until the hernia sac is encountered. The sac is gently grasped with a Babcock clamp and dissected sharply down to the level of the neck (Fig. 14–2 *A*). At the level of the hernia sac, the femoral vein laterally and the greater saphenous vein entering the femoral vein from its medial side are identified and preserved. The sac is opened and the contents reduced. The neck of the sac is transfixed with 2-0 absorbable sutures with particular care taken to ensure that structures such as bowel and bladder that may form part of the wall are not injured. The femoral canal is repaired with three or four interrupted 2-0 polypropylene monofilament sutures to approximate the inguinal ligament to the pectineal ligament (Fig. 14–2 *B*). Injury to the femoral vein is avoided by retracting this vessel with the index finger while the sutures are placed. Avoid narrowing the femoral vein. An alternative method of repair involves placing into the femoral canal a Marlex mesh plug that is then secured in place with 2-0 polypropylene monofilament sutures.

High Approach (Pre-peritoneal)

This approach is preferred if the femoral hernia is strangulated or there is associated small bowel obstruction. An incision can be made in the inguinal region (see Fig. 14–1 *B*). Alternatively, an oblique incision is made along the lateral border of the rectus sheath. The anterior rectus sheath is opened and the rectus muscle is retracted medially. The transversalis fascia is incised and the peritoneum is dissected toward the femoral canal. While counter-pressure is provided in the groin, an attempt is made to gently reduce the hernia sac. If there is still difficulty in reducing the hernia, the medial edge of the femoral ring can be sharply divided. The area must be

Figure 14-1 *A*, Anatomy of the femoral canal. *B*, Incisions used for repair of femoral hernia.

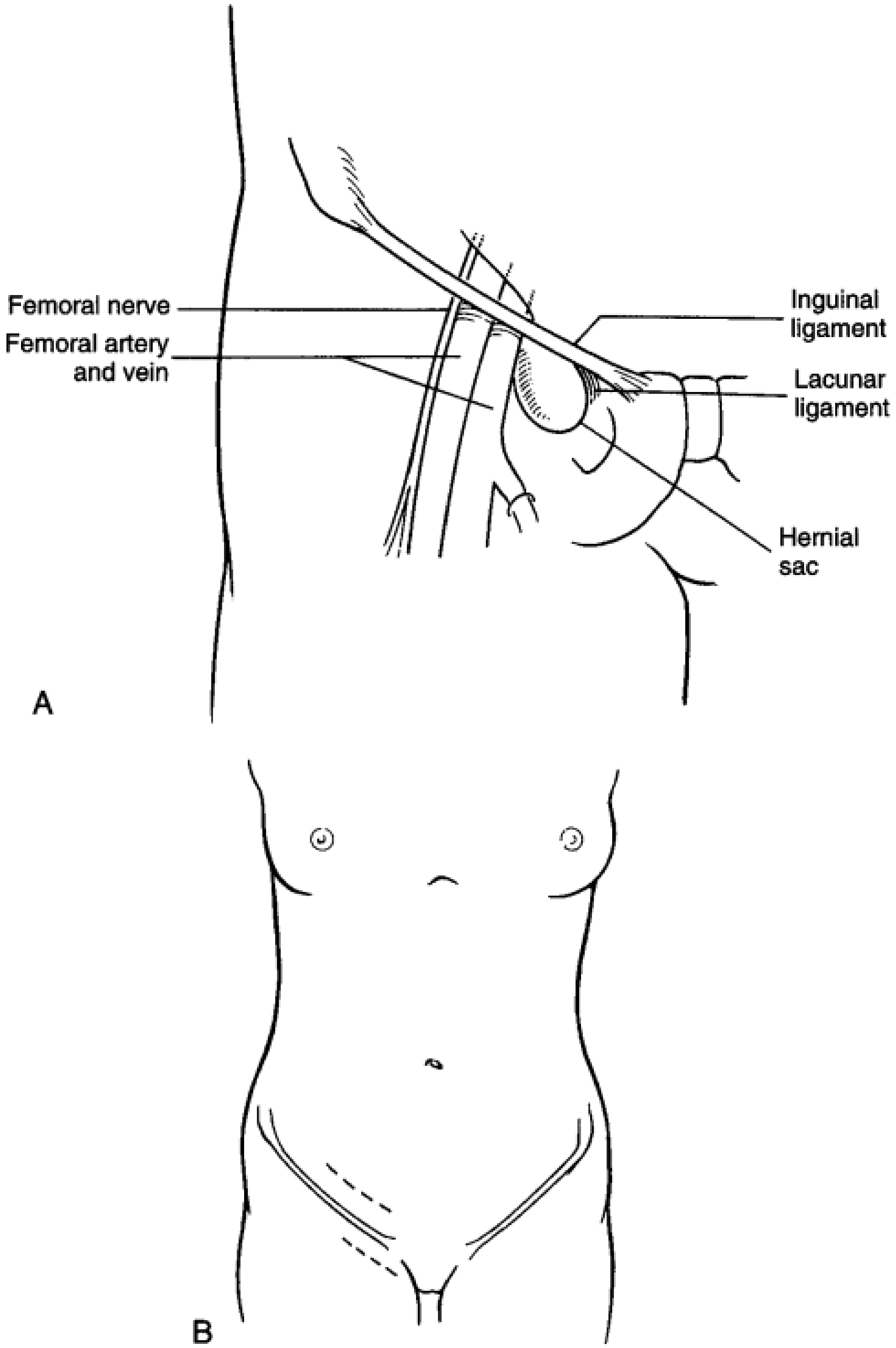


Figure 14‑2 *A*, The sac is grasped and dissected free; the operator must be cognizant of the femoral vein present on the lateral aspect. *B*, The inguinal ligament is sutured to the pectineal ligament.

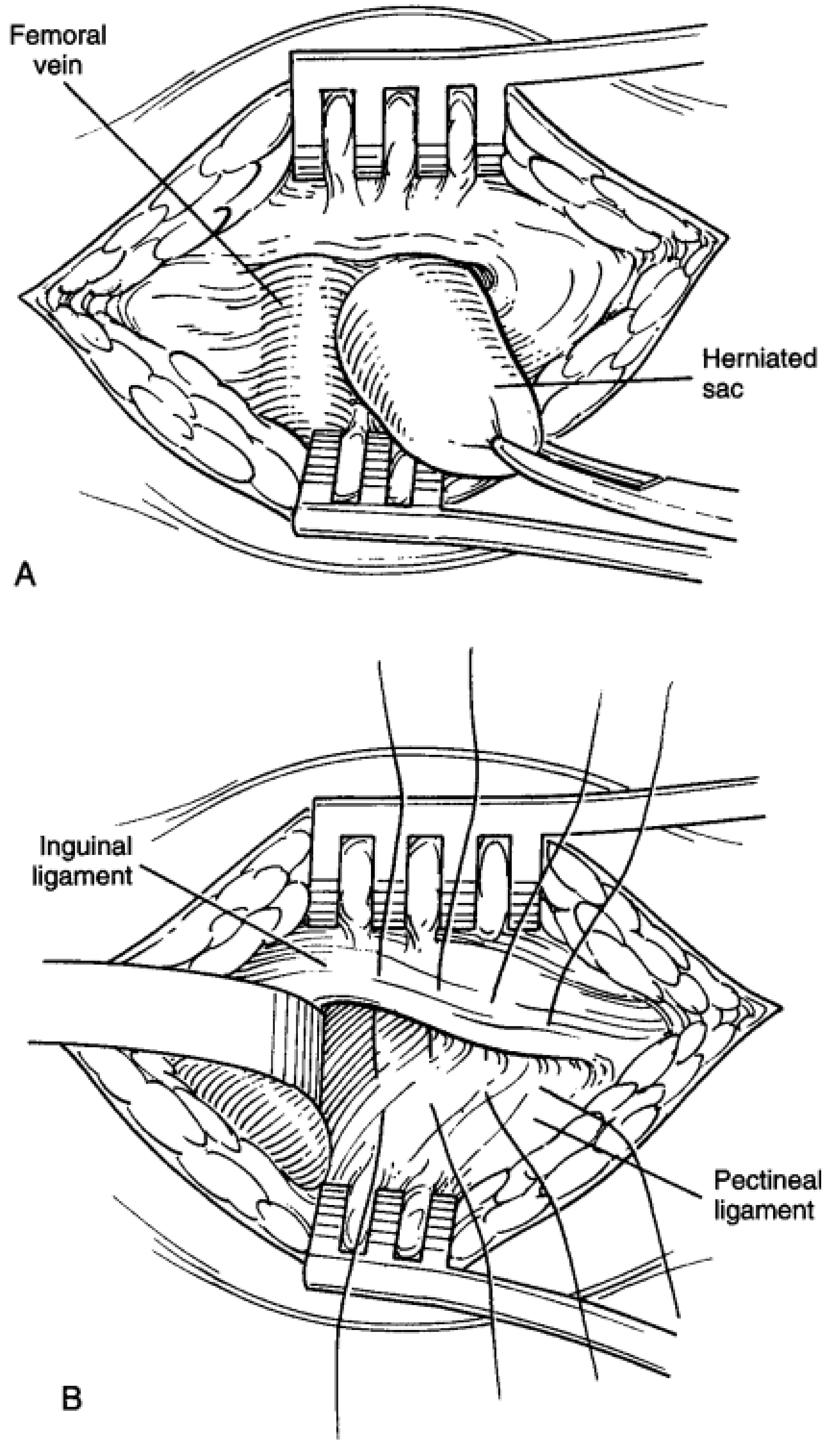
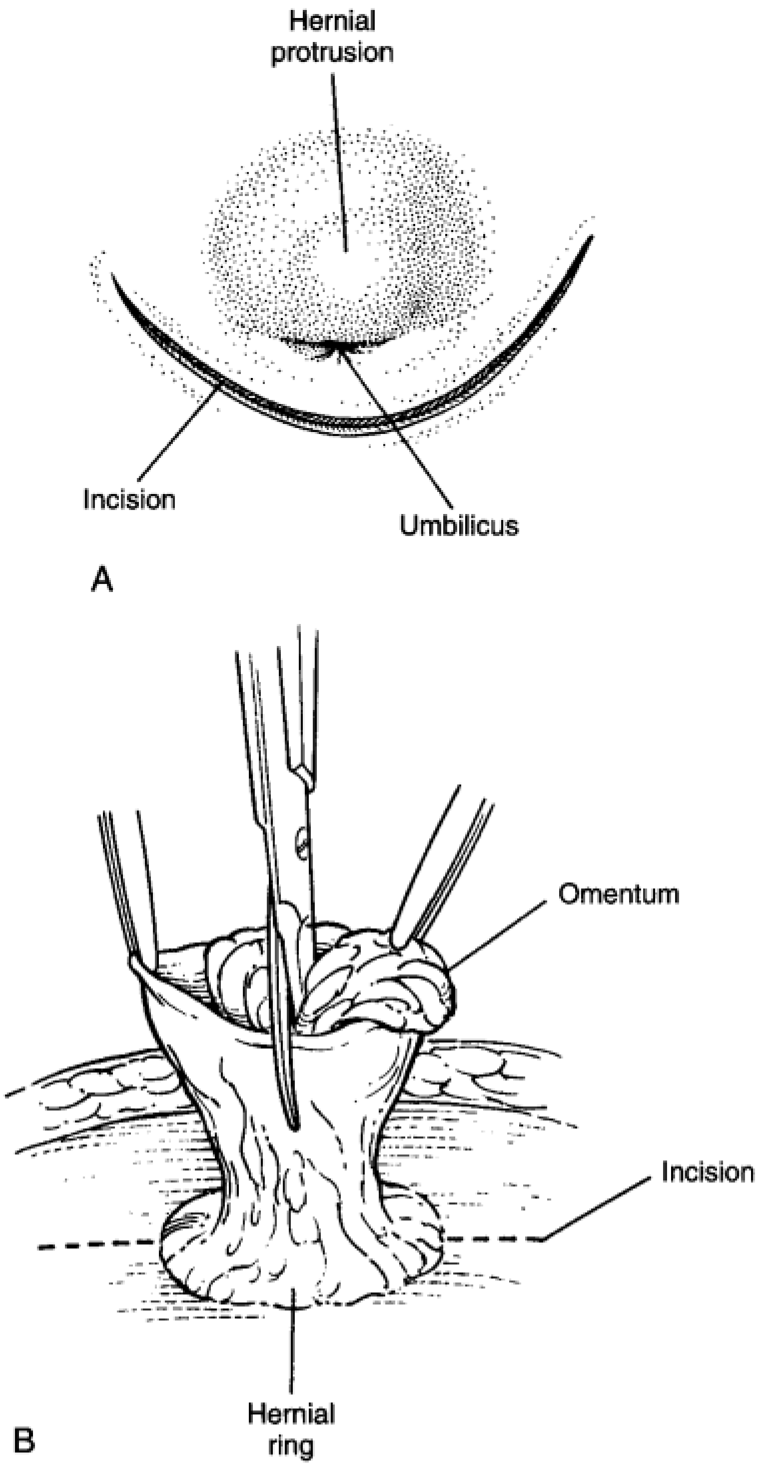


Figure 15-1 *A*, A periumbilical incision is made. *B*, The hernia sac is dissected down to the level of the fascia. The content of the sac is inspected.



ESOPHAGUS/STOMACH/DUODENUM/SMALL BOWEL

Chapter 16 - Transabdominal Nissen Fundoplication

EMBRYOLOGY AND ANATOMY

See Chapter 19 .

PREOPERATIVE PREPARATION

Before the decision is made to perform an antireflux procedure, the presence of gastroesophageal reflux with all accompanying complications such as reflux esophagitis or stricture formation must be confirmed. The preoperative barium swallow must be reviewed for the presence of a shortened esophagus, esophageal stricture, or abnormal gastric emptying. 24-hour pH monitoring is useful in correlating the patient's pain with episodes of gastric reflux. Because the patient may have been on prolonged H_2 receptor antagonists or proton pump inhibitors, gastric achlorhydria may allow bacterial overgrowth, and thus perioperative antibiotics should be administered.

Operative Procedure

POSITION

The patient is placed in a supine position and undergoes general anesthesia with endotracheal intubation. The anesthesiologist should be requested to place a nasogastric tube. A Foley catheter is also inserted, and sequential compression devices are placed over the lower extremities.

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INCISION

A midline incision from the xiphoid process extending 2 to 3 cm distal to the umbilicus is made.

EXPOSURE AND OPERATIVE TECHNIQUE

Initially, a thorough exploration is performed to exclude any coincident pathology. The stomach and the duodenum are meticulously evaluated for the presence of active ulceration or scars from healed ulcers. The gallbladder is palpated for presence of cholelithiasis.

The patient is placed in the reverse Trendelenburg position, and an upper hand retractor system is arranged to allow the costal margins to be elevated. In addition, a Balfour abdominal wall retractor is placed to provide exposure. If the left lobe of the liver is enlarged or extends far to the left side, the left triangular ligament is divided sharply with electrocautery. The left lobe can thus be folded and retracted away from the esophageal hiatus. The peritoneal covering over the esophageal hiatus is identified and grasped with a long Schnidt clamp. This peritoneal reflection is incised transversely and extended to the left across the whole gastrophrenic ligament and to the right as far as the gastrohepatic ligament. The vagal trunk and branches are identified and preserved. The esophagus is dissected free from its surrounding areolar tissue for a length of approximately 6 cm using a combination of blunt digital dissection and electrocautery. A large Penrose drain is passed around the esophagus to provide traction. If feasible, the posterior vagus trunk should be separated from the esophagus and thus excluded from the fundal wrap. The Penrose drain is retracted downward to determine if adequate gastric fundus is available for the wrap. If the fundus is believed to be inadequate for the wrap, the first two or three short gastric vessels are clamped, divided, and ligated with 2-0 silk sutures. The anesthesiologist is asked to withdraw the nasogastric tube and replace it with a 40 Fr Maloney esophageal dilator.

First, the esophageal hiatus is inspected; if this is believed to be enlarged, the two diaphragmatic crura are approximated with interrupted 2-0 silk sutures. At completion of repair of the esophageal hiatus, it should allow easy passage of one finger through it. With the right hand, the gastric fundus is passed behind the esophagus and grasped with two long Babcock clamps (Fig. 16–1 *A*). Before commencing the wrap, the operator removes the Penrose drain. The fundal wrap should measure approximately 3 to 4 cm in length. The wrap is begun by placing 2-0 silk interrupted seromuscular sutures that include seromuscular bites of the two fundal folds and the esophagus. About four of these sutures are placed at approximately 1-cm intervals and tied down snugly (Fig. 16–1 *B*). To create a floppy Nissen fundoplication, two fingers should easily pass between the wrap and the esophagus. To stabilize the fundal sleeve, two more sutures should be placed at the bottom edge of the fundal wrap and the anterior wall of the stomach.

Figure 16-1 *A*, The mobilized gastric fundus is passed behind the distal esophagus. *B*, The fundal wrap is constructed by placing at least four sutures, taking bites of the two fundal folds and the esophagus.

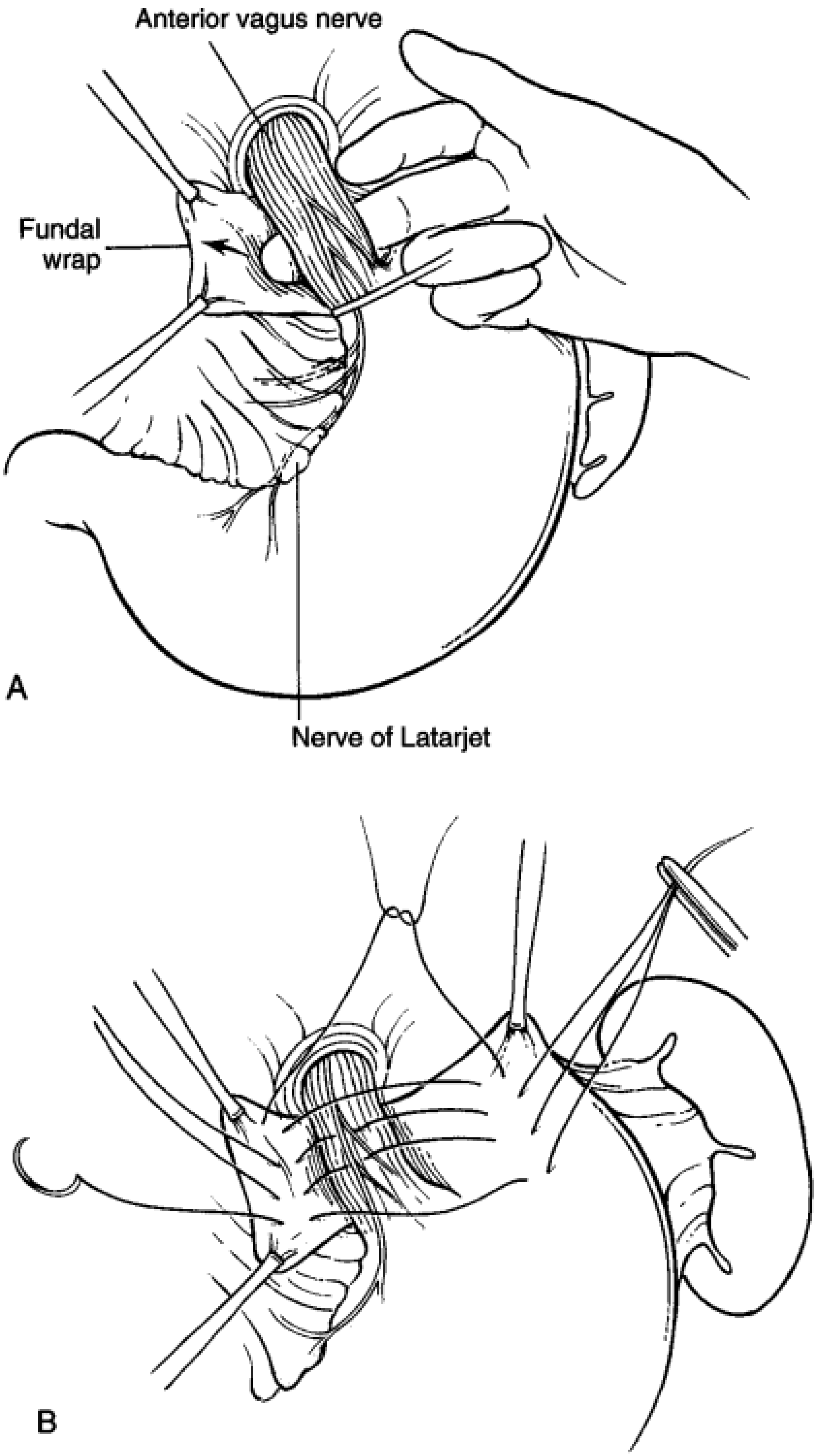


Figure 17‑1 The stomach is grasped to provide traction while the short gastric vessels are divided commonly with a harmonic scalpel. A Penrose drain is placed around the abdominal esophagus.

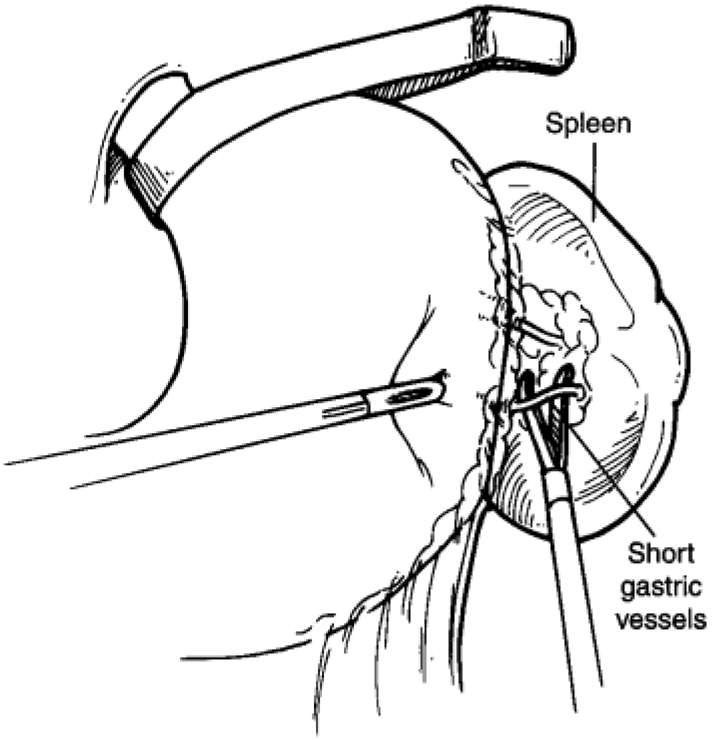


Figure 18-1 Midline incision used for performing vagotomy and drainage procedures.

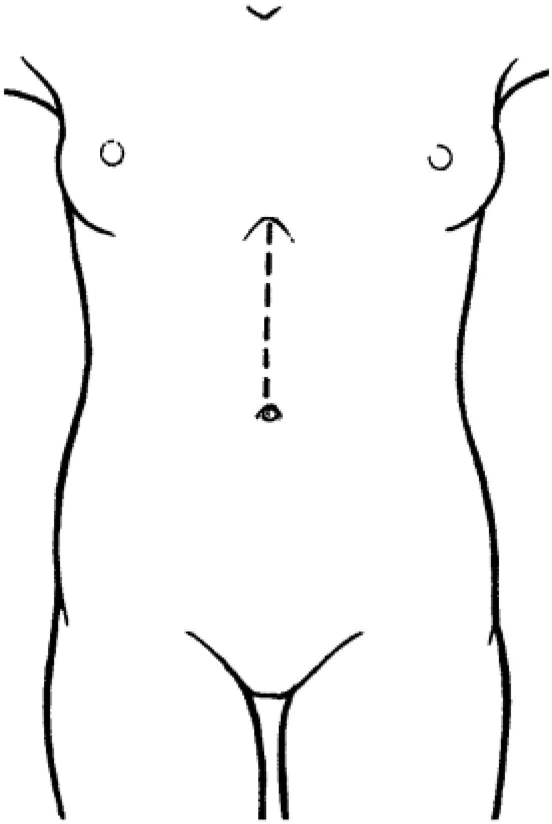


Figure 18-2 The left lobe of the liver is retracted to expose the esophageal hiatus. The distal esophagus is mobilized at the hiatus to reveal the anterior vagal trunk. Two fingers are passed behind the esophagus to locate the posterior vagal trunk. *Inset*, The posterior vagal trunk is divided.

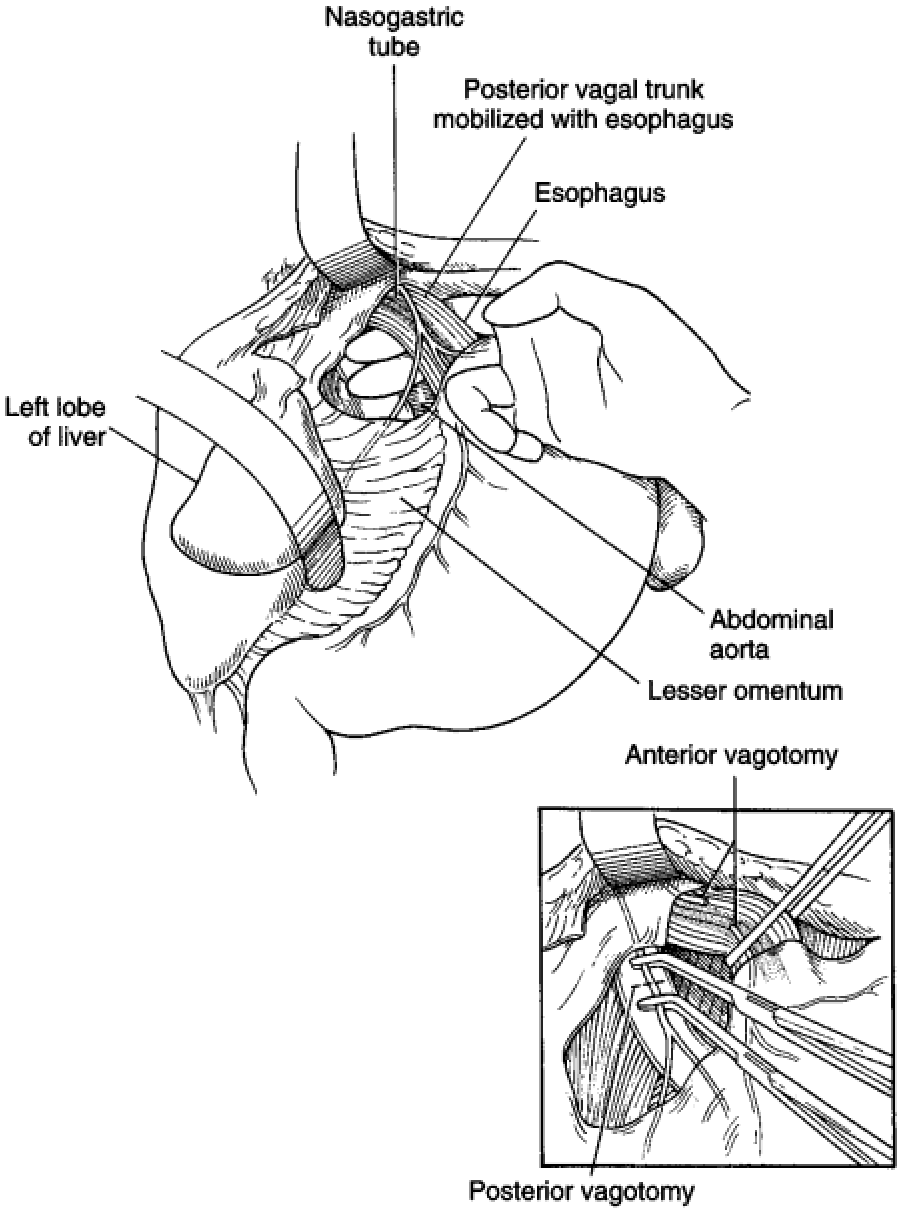


Figure 18-3 Antrectomy followed by Billroth I gastroduodenostomy has been performed. The "angle of sorrow" where anastomotic leak can occur is shown.

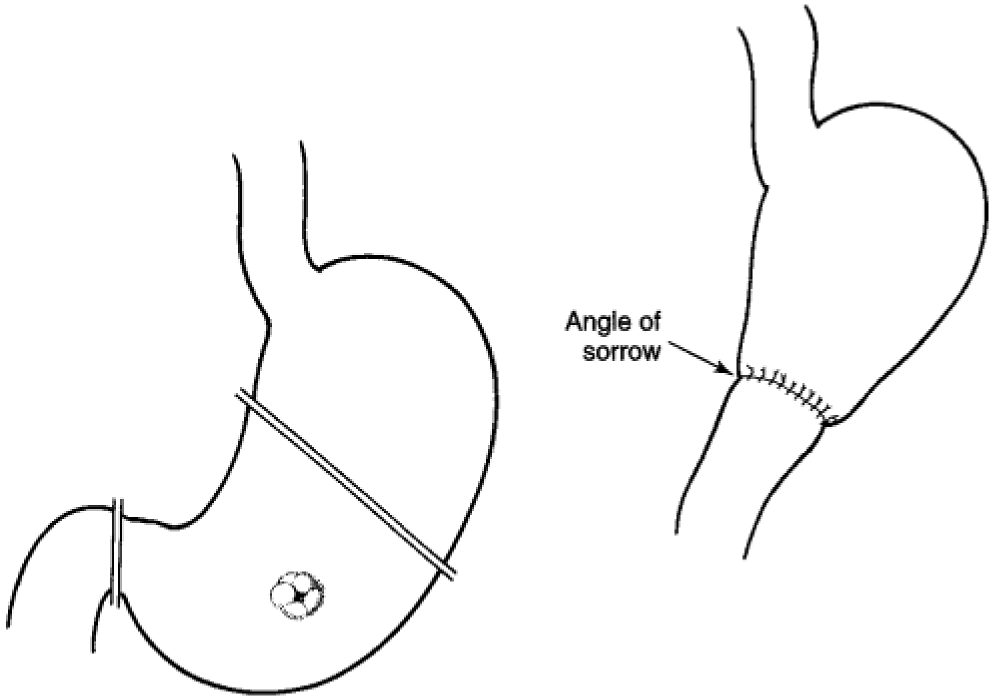


Figure 18-4 Billroth II gastrojejunostomy after either a distal or subtotal gastrectomy.

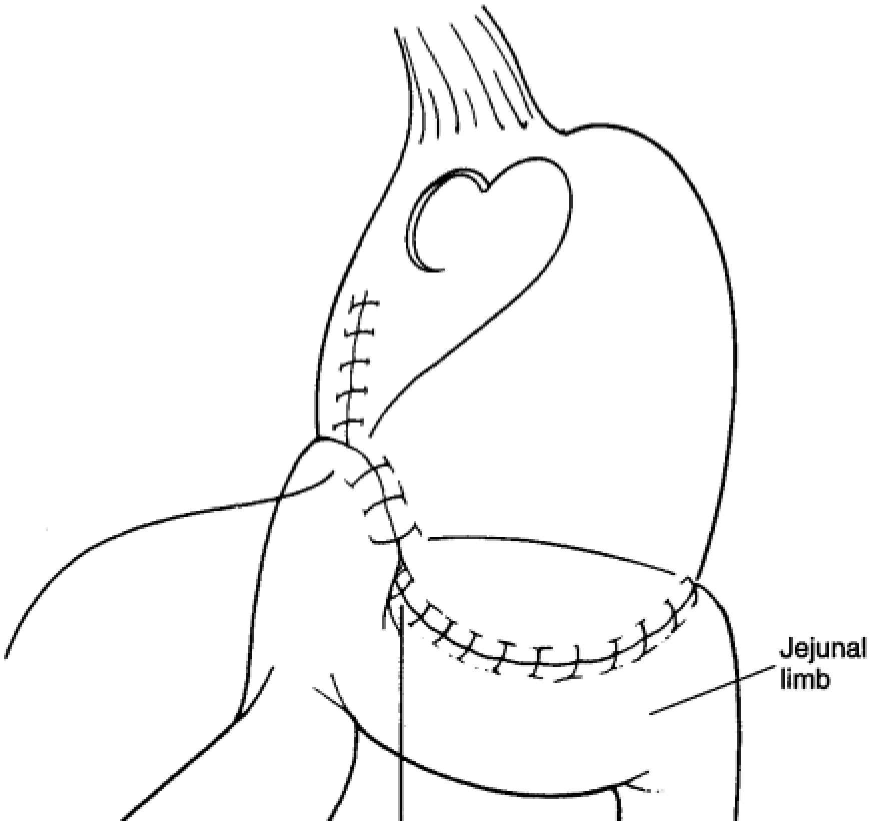


Figure 19-1 The various levels of transection of the stomach needed to perform a total, subtotal, or distal gastrectomy. The level of jejunal transection needed to construct a Roux-en-Y jejunal limb is shown.

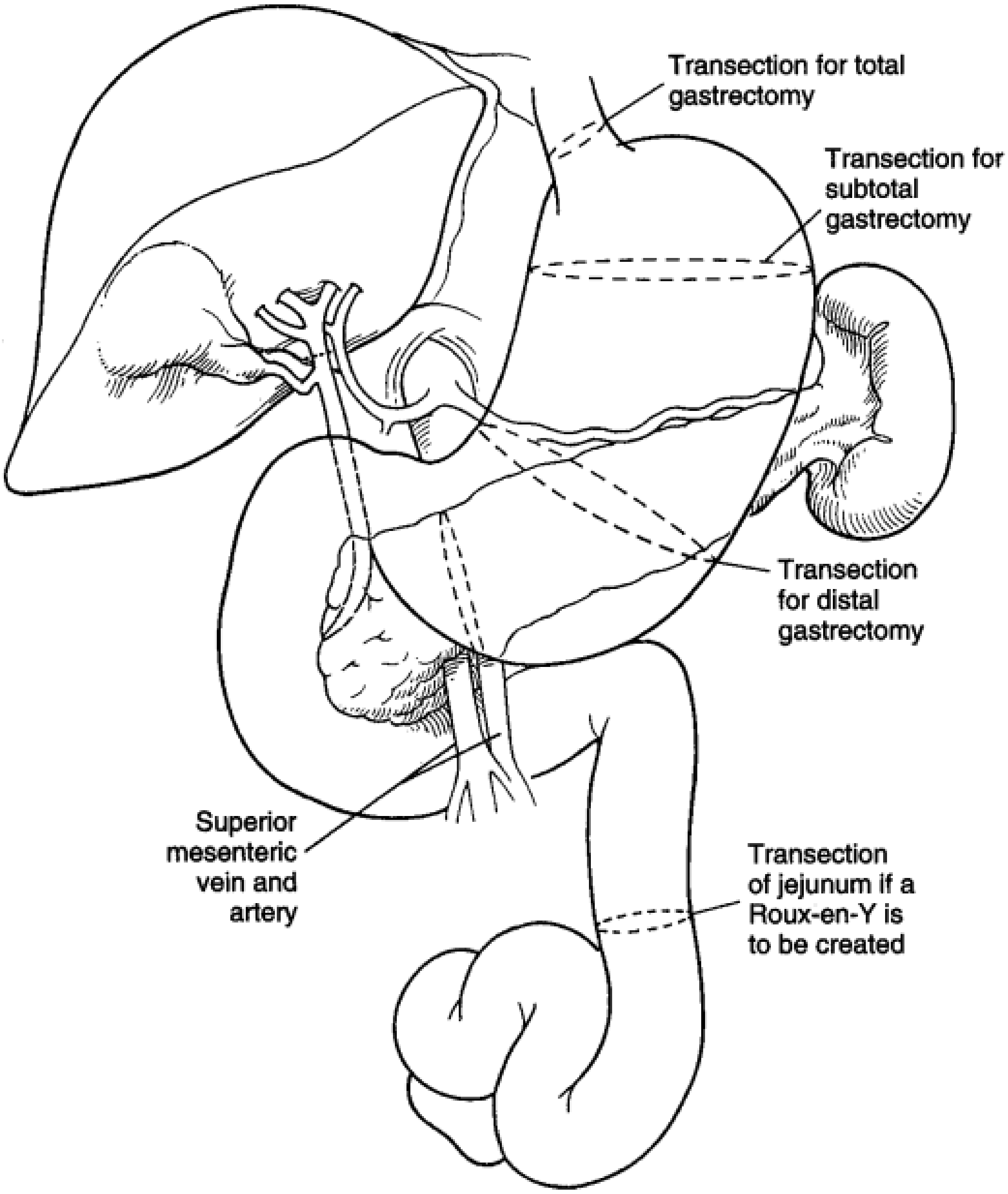


Figure 19-2 Construction of a stapled end-to-side esophagojejunal anastomosis. *A*, The anvil is passed into the esophagus and the purse-string suture is tied. *B*, The completed end-to-side esophagojejunal anastomosis.

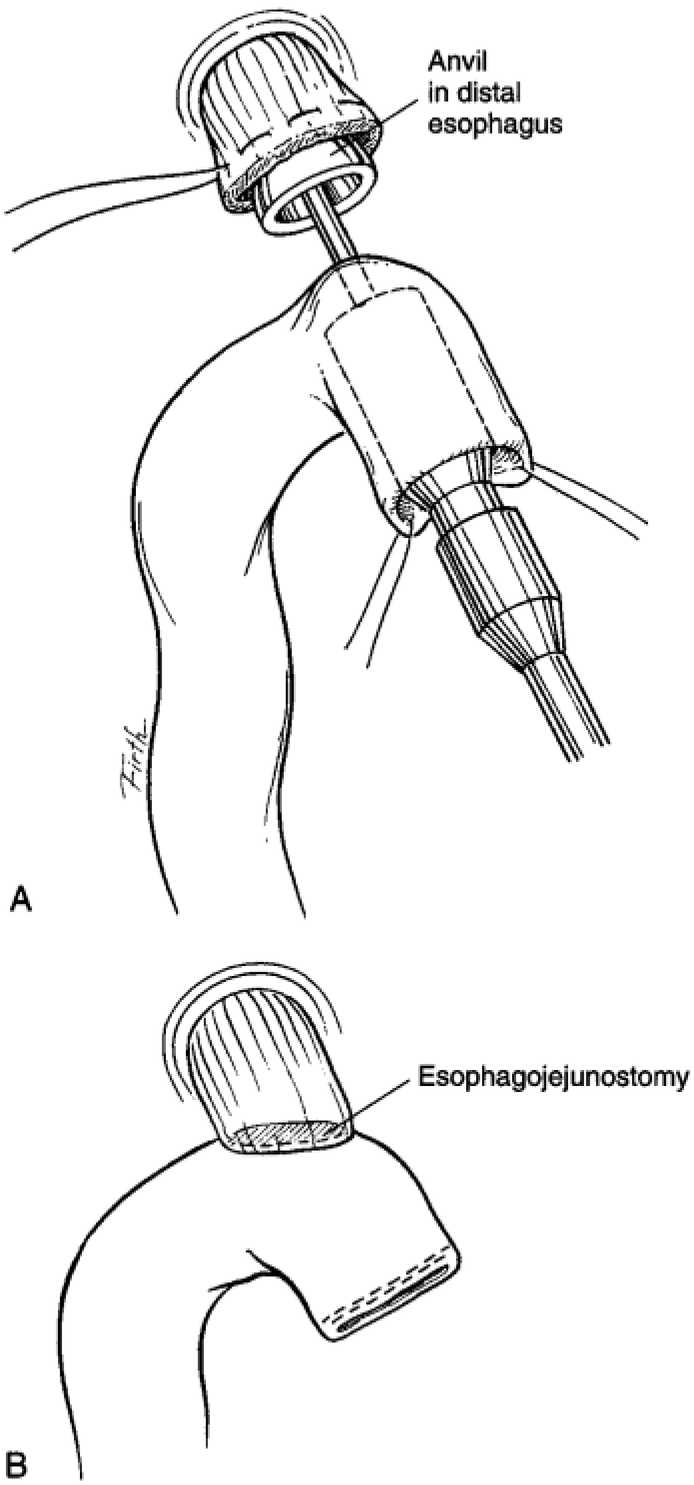


Figure 19-3 Billroth II gastrojejunostomy after either a distal or subtotal gastrectomy.

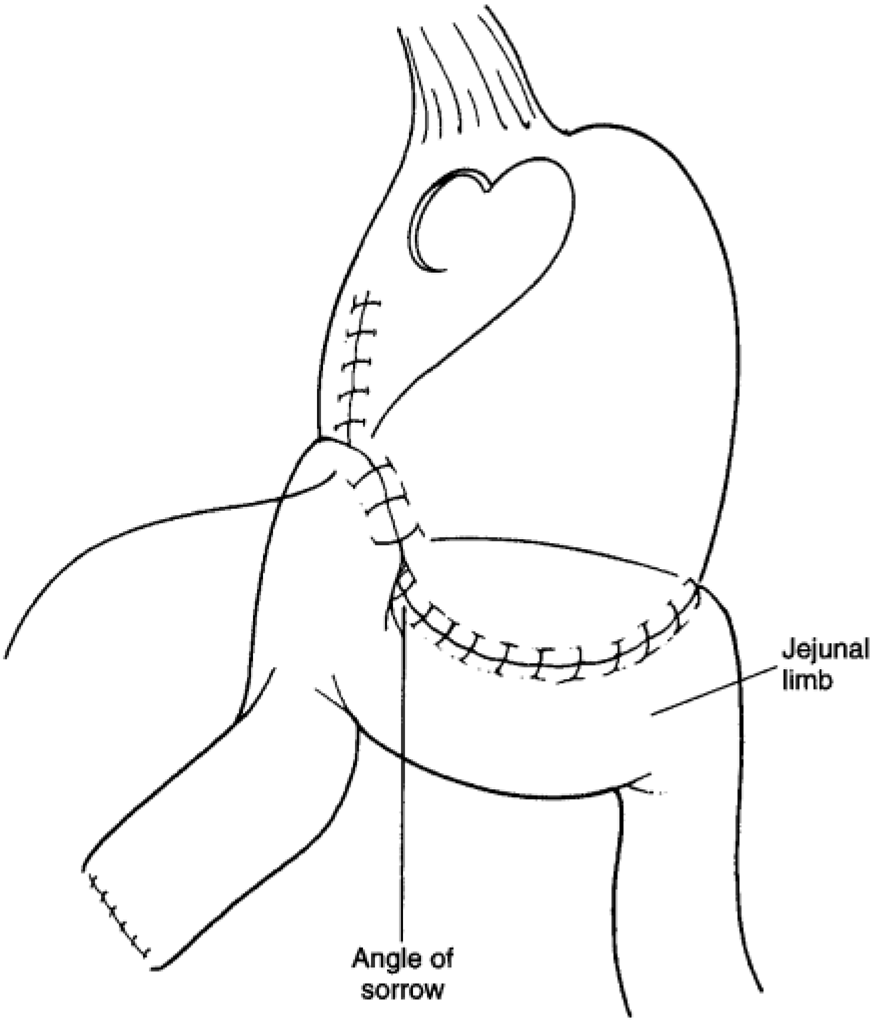


Figure 20-1 *A*, The inner purse-string suture is tied down after the gastrostomy tube is passed into the stomach. *B*, The second, outer purse-string suture is tied. *C*, Cross-section shows the gastrostomy tube being brought out through the anterior abdominal wall, and the anterior stomach wall is sutured to the peritoneum.

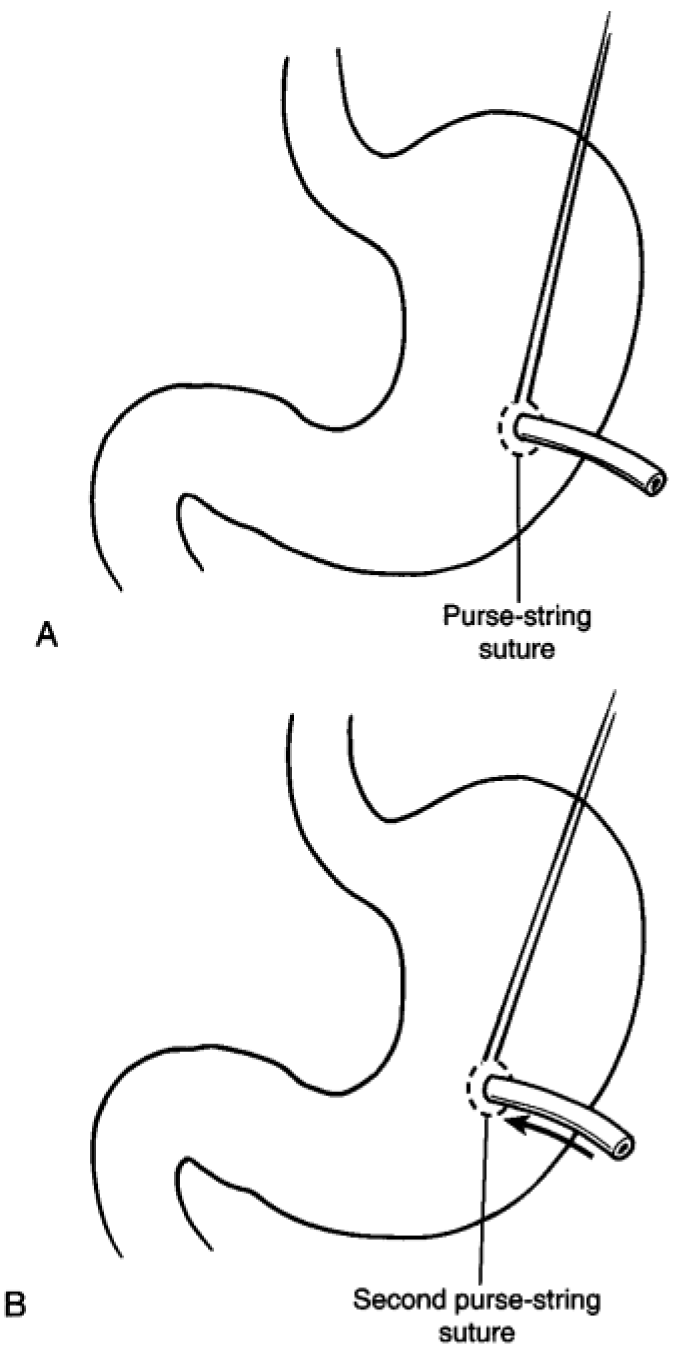


Figure 20-1 *A*, The inner purse-string suture is tied down after the gastrostomy tube is passed into the stomach. *B*, The second, outer purse-string suture is tied. *C*, Cross-section shows the gastrostomy tube being brought out through the anterior abdominal wall, and the anterior stomach wall is sutured to the peritoneum.

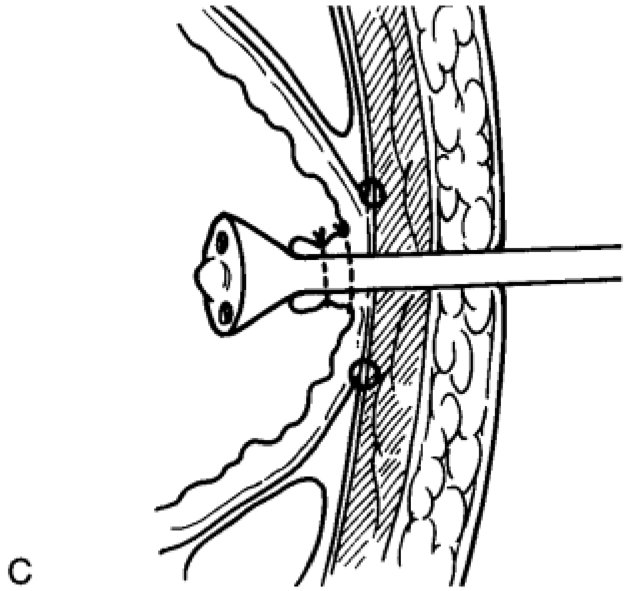


Figure 21-1 *A*, Technique of performing a Graham patch. Multiple seromuscular 2-0 or 3-0 silk sutures are placed adjacent to the edges of the perforated ulcer. *B*, A segment of omentum is placed over the perforation, and the sutures are tied down.

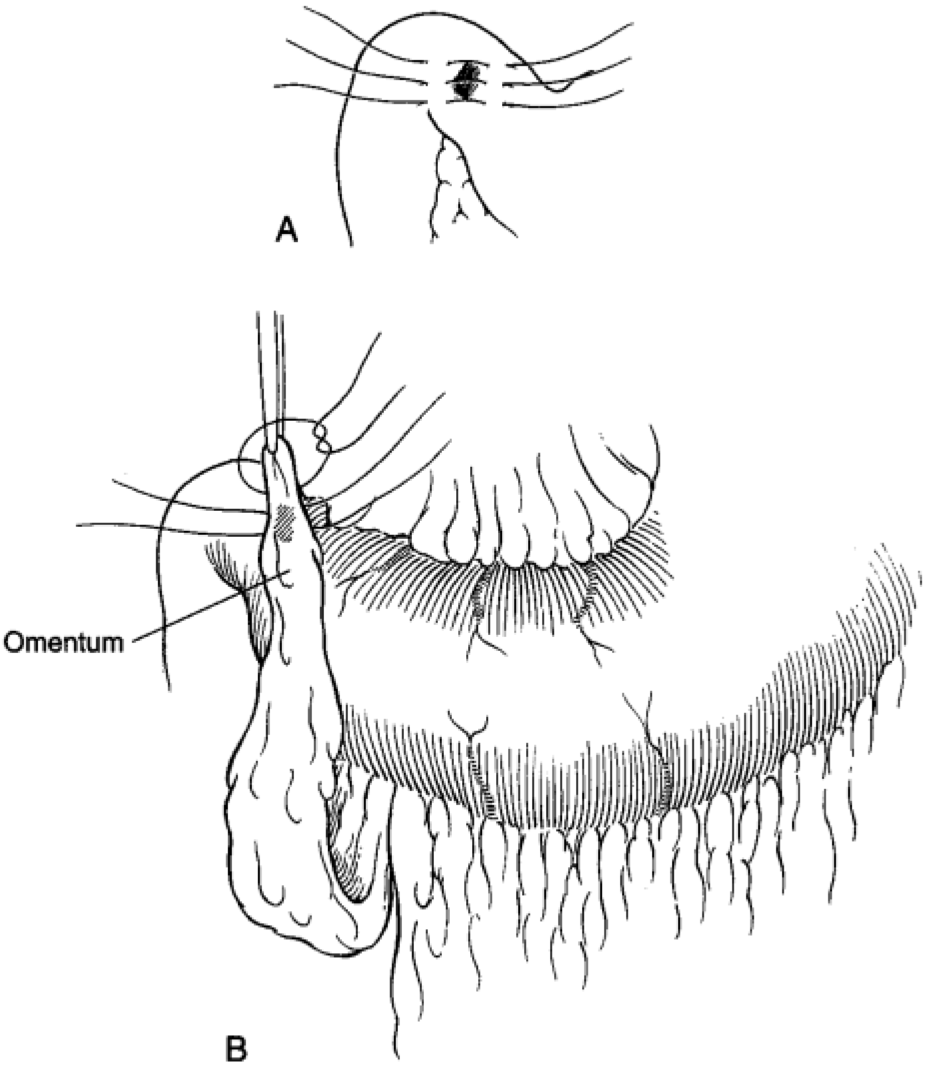


Figure 22-1 Hemorrhage from a duodenal ulcer is controlled with sutures placed above and below the bleeding point.

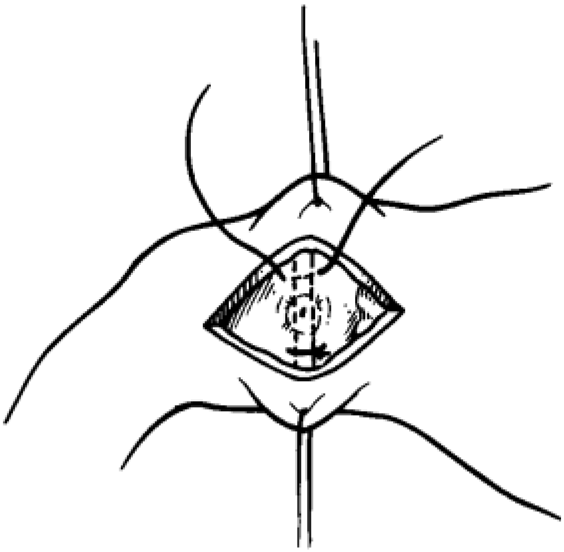


Figure 23-1 *A*, The small bowel is divided proximally and distally with a GIA-60 stapler, and the mesenteric vessels are divided and ligated. *B*, After the anastomosis is complete, the mesenteric defect is closed to avoid internal hernia.

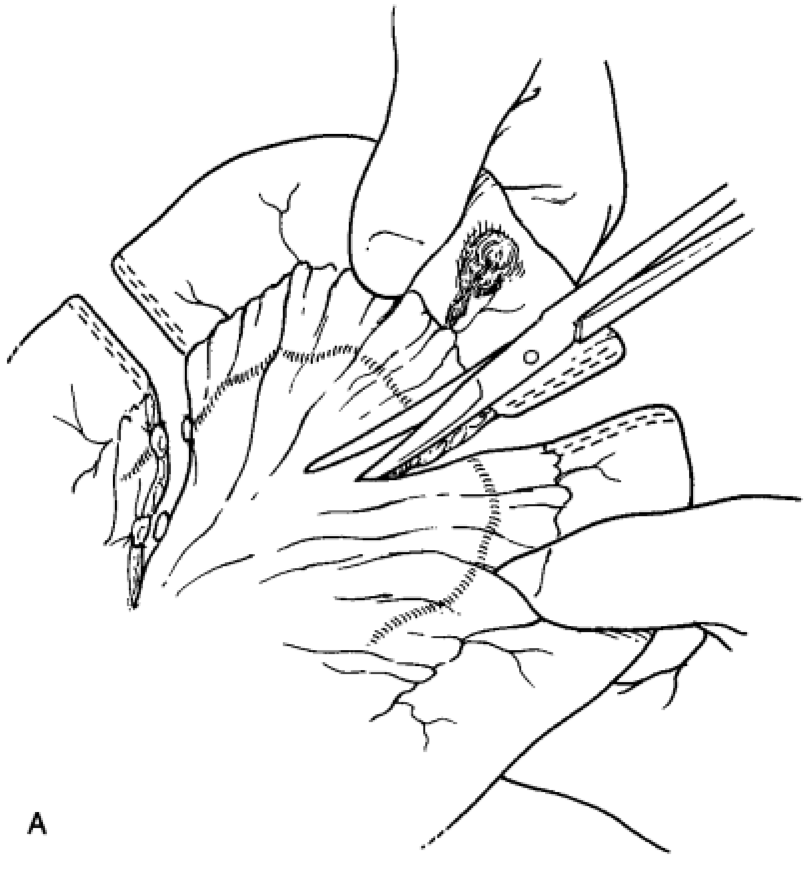
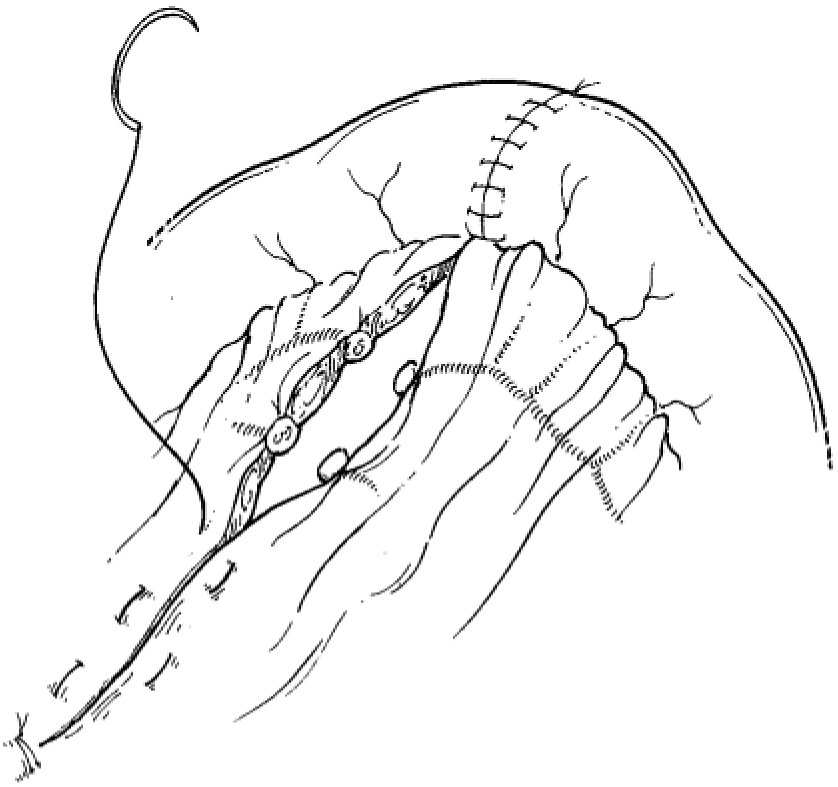


Figure 23-1 *A*, The small bowel is divided proximally and distally with a GIA-60 stapler, and the mesenteric vessels are divided and ligated. *B*, After the anastomosis is complete, the mesenteric defect is closed to avoid internal hernia.



HEPATOBILIARY SYSTEM

Chapter 24 - Open Cholecystectomy

EMBRYOLOGY

The liver diverticulum is derived from the distal end of the foregut and grows into the septum transversum. The connection between the hepatic diverticulum and the foregut (which develops into duodenum) elongates and narrows to form the bile ducts. The gallbladder and the cystic duct develop from a ventral outgrowth that emerges from the bile duct. The biliary tree passes through a solid stage that is followed by recanalization. The gallbladder initially is a hollow organ but becomes solid due to proliferation of epithelial cells. Later, recanalization occurs, and failure of this process leads to atresia of the gallbladder.

RELEVANT SURGICAL ANATOMY

The gallbladder is a pear-shaped organ about 7.5 to 10 cm in length. It lies within a fossa on the inferior aspect of the right lobe of the liver. Anatomically it can be divided into a fundus, body, infundibulum, and neck. The fundus extends beyond the edge of the liver and comes in contact with the anterior abdominal wall at the level of the tip of the ninth rib. The infundibulum sags down toward the duodenum at Hartmann's pouch, where gallstones often become impacted. Originating from the neck of the gallbladder is the cystic duct, which joins the common hepatic duct in a variable fashion. The surgically important triangle of Calot is formed by the common hepatic duct on the left, the cystic duct on the right, and the liver above.

The common hepatic duct is formed by the union of the right and the left main bile ducts outside the confines of the liver. It is 2 to 3 cm long and lies entirely within the portal fissure. The common bile duct (CBD) is formed by the union of the common hepatic duct and the cystic duct. It measures approximately 8 cm in length (range, 5–15 cm), and its course is as follows:

- One third in the lesser omentum: It lies anterior to the portal vein with the hepatic artery on the left.
- One third behind the first part of duodenum: It lies anterior to the portal vein, with the gastroduodenal artery on the left.
- One third behind the head of pancreas: It lies over the inferior vena cava.

Behind the head of the pancreas the CBD is joined by the main pancreatic duct to form a common channel known as the ampulla of Vater. The ampulla opens on the posteromedial aspect of the second part of the duodenum. This opening, known as the duodenal papilla, is located approximately 10 cm from the pylorus. This papilla will normally allow passage of a 3-mm dilator. On cholangiography the normal diameter of the CBD ranges from 8 mm to 1 cm, whereas on ultrasonography it is 6 cm.

The blood supply of the gallbladder is derived from the cystic artery, which is most commonly a branch of the right hepatic artery, and lies within the triangle of Calot. The cystic artery tethers the gallbladder and can be felt as a taut string when the gallbladder is retracted laterally. The blood supply of the extrahepatic bile ducts originates from the superior pancreaticoduodenal artery, hepatic artery, and cystic artery. The veins from the gallbladder drain directly into the liver or into the hepatic vein via the pericholedochal plexus.

The foramen of Winslow is an important anatomic landmark for performing the Pringle maneuver. Its relations are as follows: (1) anteriorly, the free border of the lesser omentum; (2) posteriorly, the inferior vena cava and the right adrenal gland; (3) superiorly, the caudate process of the liver; and (4) inferiorly, the horizontal part of the hepatic artery and below it the second part of the duodenum.

PREOPERATIVE PREPARATION

Apart from assessment of the cardiopulmonary systems to evaluate the patient’s ability to withstand open cholecystectomy, special circumstances should be addressed. If the patient is jaundiced, in addition to the baseline laboratory investigations, liver function tests, hepatitis profile, and a coagulation profile should be obtained. If there is a history of fluctuating jaundice in male patients, Gilbert disease must be excluded. If endoscopic retrograde cholangiopancreatography or percutaneous transhepatic cholangiography has been performed, the results should be reviewed.

Prophylactic antibiotics should be administered, especially for high-risk patients with the following parameters: age older than 70 years and a history of diabetes mellitus, jaundice, CBD stones/stricture, biliary tree malignancy, or steroid usage.

Operative Procedure

POSITION

The patient undergoes general anesthesia with endotracheal intubation. A nasogastric tube is inserted. The patient is placed in a supine position on an x-ray operative table and arranged for ultra-operative fluoroscopy. The patient is prepped and draped. The surgeon should stand on the right side of the table.

INCISIONS

If it is an elective procedure and no other pathology is suspected, it would be appropriate to use a Kocher (oblique right upper quadrant) incision. If on laparotomy other pathology is discovered, a Kocher incision can be extended into a bilateral subcostal incision.

Kocher Incision

A subcostal incision is made. The anterior rectus sheath is incised and the rectus muscle identified. A Rochester-Pean clamp is placed under the muscle, which is divided with electrocautery. The assistant should be ready to clamp epigastric vessels within the rectus muscle, and these vessles are ligated with 2-0 silk sutures. Next, the posterior sheath is incised, and the preperitoneal fat is separated digitally or with hemostats. The peritoneum is grasped with two hemostats and incised to open the peritoneal cavity. The falciform ligament can be spared if the exposure is adequate, but in most cases it is divided and ligated with 2-0 absorbable sutures.

Midline Incision

The linea alba, identifiable by the crisscrossing of the fascial fibers, is incised, and the preperitoneal fat is identified. The peritoneum is grasped up with two hemostats and incised after it has been ensured that no bowel has been inadvertently included with the peritoneal lining. The opening is extended with the use of electrocautery.

EXPOSURE AND OPERATIVE TECHNIQUE

First, a careful exploration is performed to exclude unrecognized pathology, with special reference to "Saint's triad," which is defined by the presence of gallstones, hiatus hernia, and diverticular disease. Other common causes of upper abdominal pain that should be excluded include peptic ulcer, carcinoma of the stomach, carcinoma of the pancreas, and chronic pancreatitis.

Exposure of the gallbladder is achieved through the following steps:

1. Elevate the head of the bed to 15 degrees, which allows the gallbladder to descend into the field of operation.

2. The operator places his or her hand over the liver on the right side to break the suction between the diaphragm and liver, therefore allowing the liver to descend.
3. Using moist laparotomy pads, the operator should (1) pack the hepatic flexure down, (2) pack off the lesser curvature of the stomach to the left, (3) place wet laparotomy pads and use a Deaver or Harrington retractor medial to the gallbladder to retract the liver, and (4) use an additional laparotomy pad to pack off the small intestine and duodenum and have the assistant retract the duodenum.

The above steps are extremely important in facilitating the remainder of the procedure.

Any adhesions present between the gallbladder and the adjacent structures are carefully and sharply divided. The cystic duct and the gallbladder are gently palpated to feel for any stones. The operator should avoid inadvertently dislodging any stones into the CBD. After Hartmann's pouch has been identified, it is grasped with a Rochester-Pean clamp and retracted laterally to place the cystic duct on tension (Fig. 24–1). An additional Rochester-Pean clamp is placed near the fundus to provide traction during dissection. The assistant should retract the duodenum downward

Figure 24-1 The gallbladder is grasped with two clamps and retracted laterally to expose the triangle of Calot.

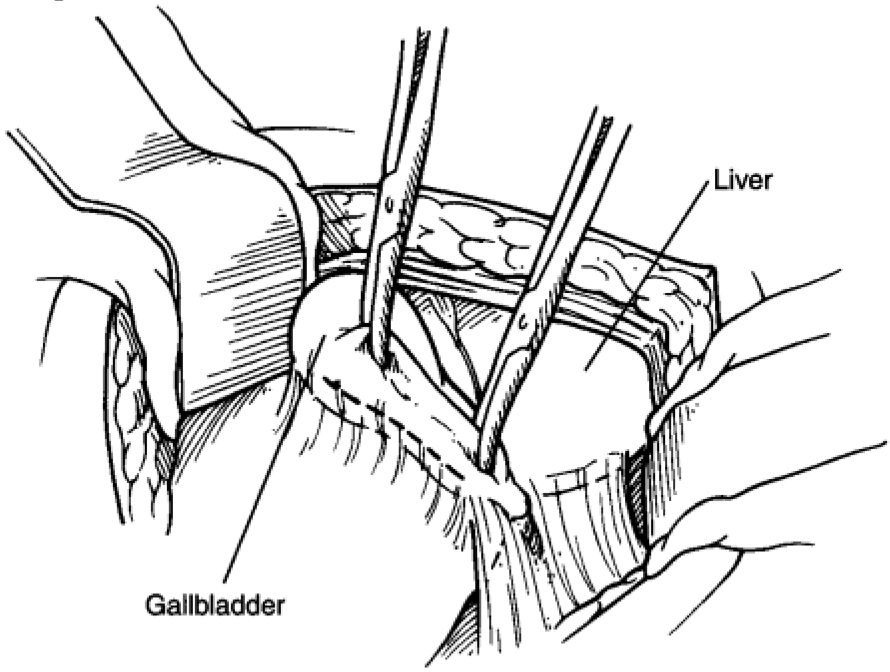


Figure 25-1 *A*, The fundus and the Hartmann pouch of the gallbladder are grasped and retracted to visualize triangle of Calot. The cystic artery has been divided. Hemoclips have been placed across the cystic duct. *B*, The resected gallbladder is retrieved.

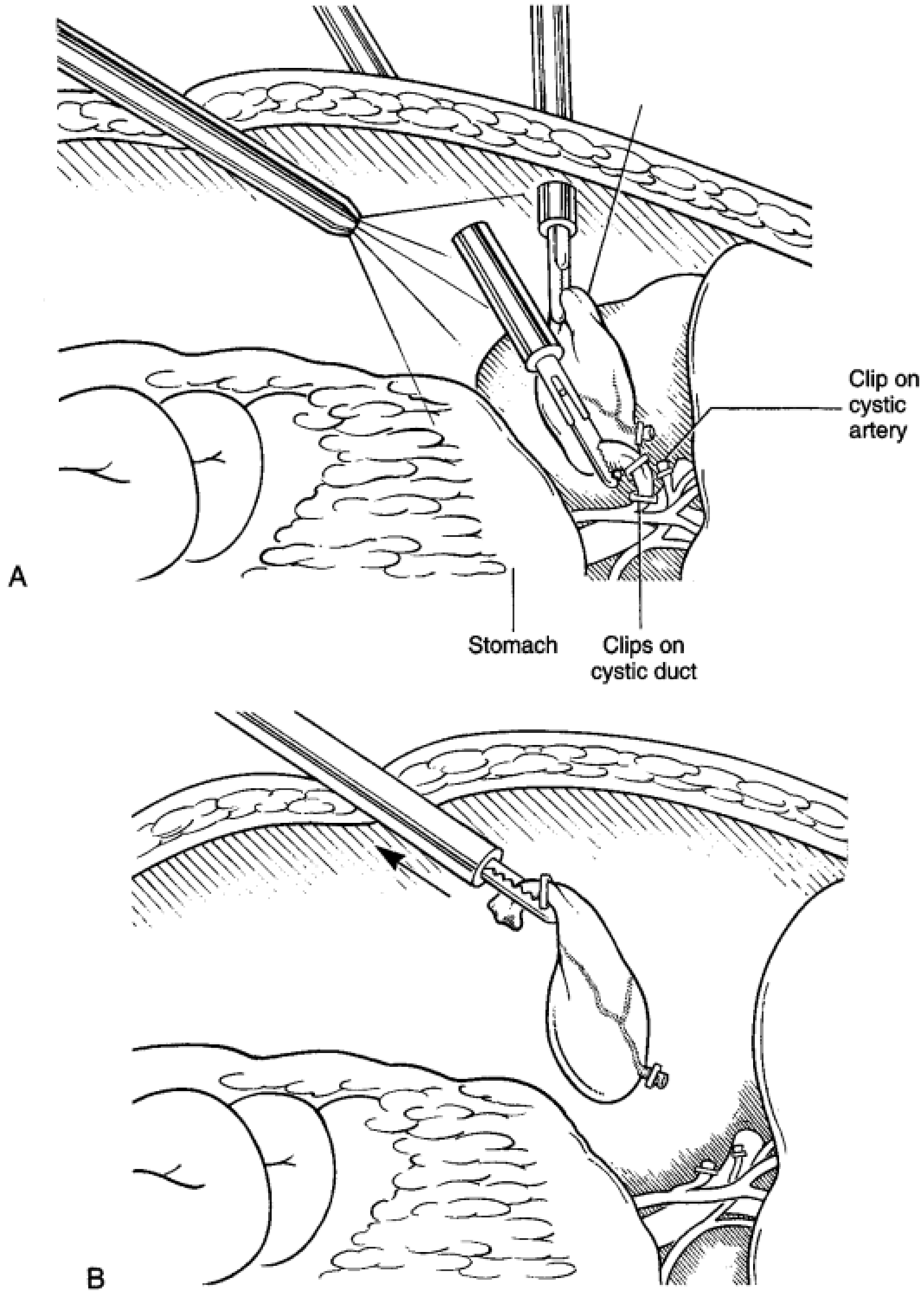


Figure 26-1 The distribution of the portal and hepatic veins. Cantlie's line extends from the gallbladder to the inferior vena cava.

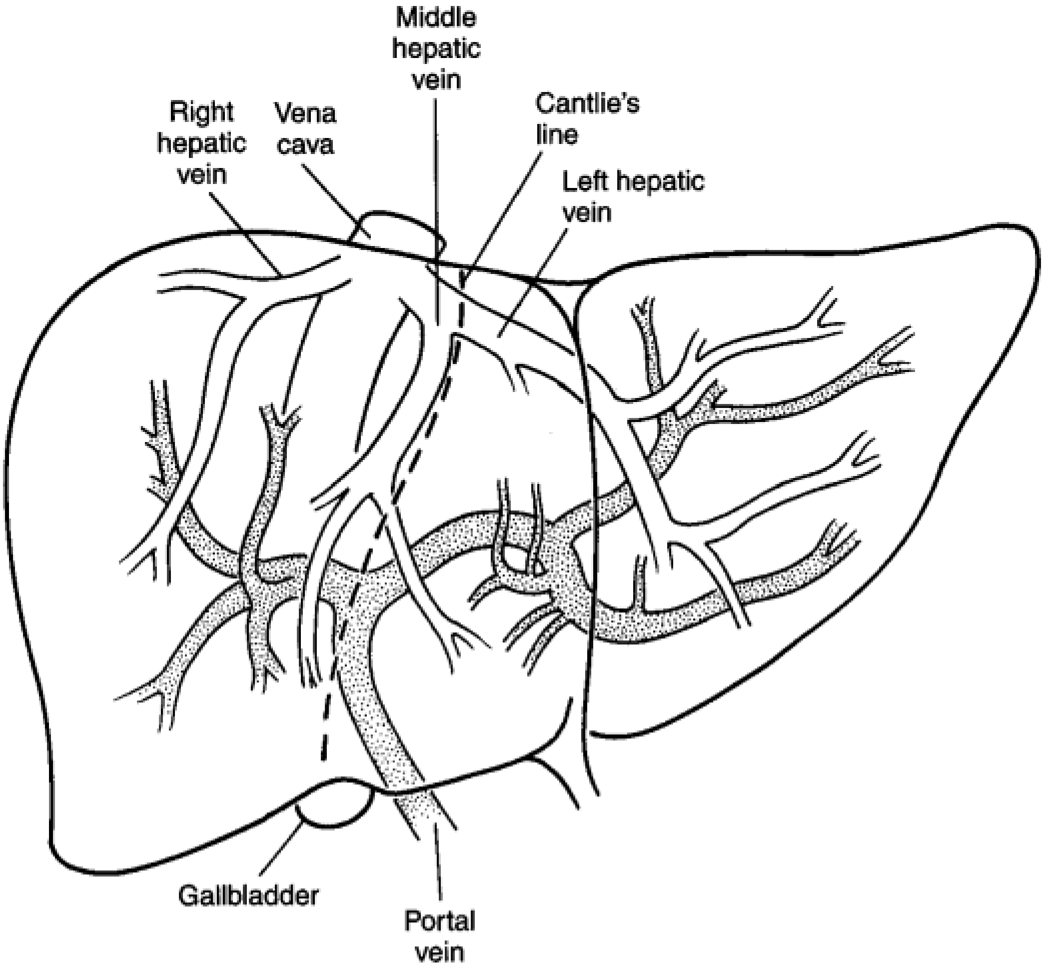


Figure 26-2 Subdivisions of the liver are based on Couinaud's nomenclature.

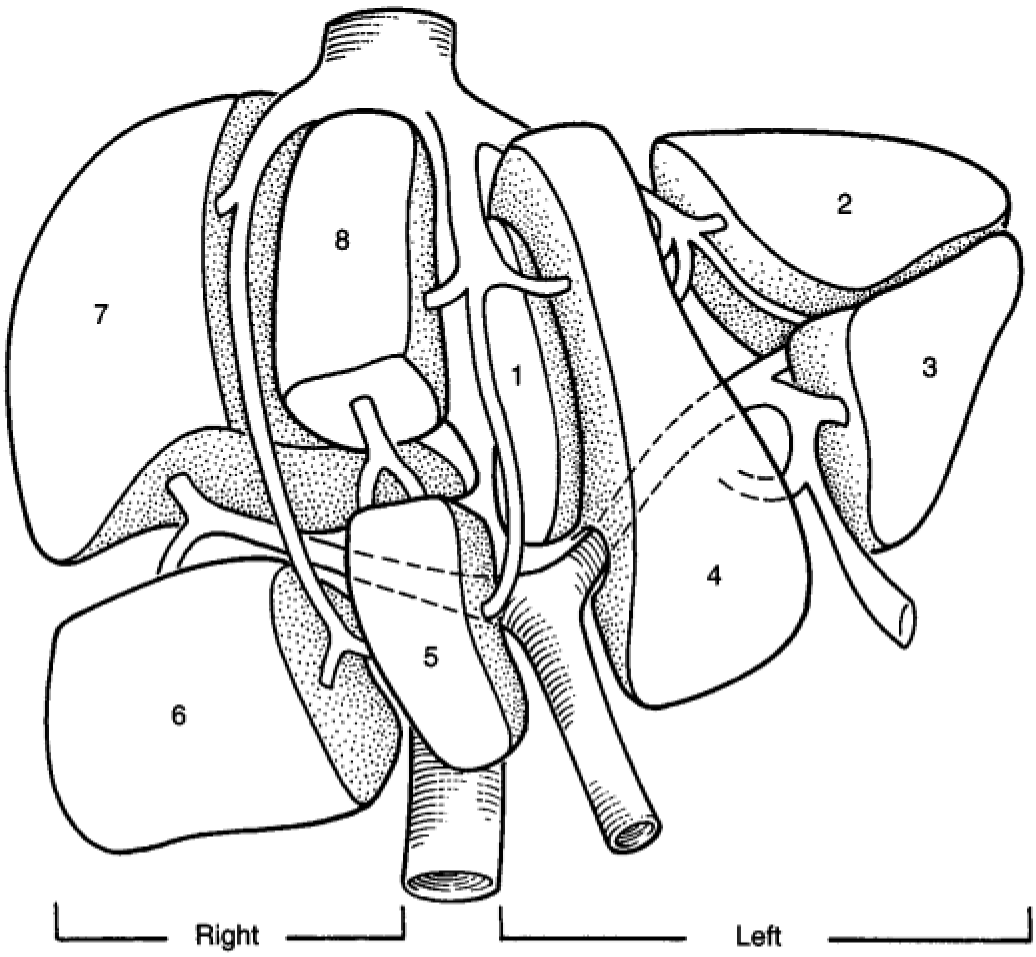


Figure 26-3 Completion of right hepatic lobectomy. The divided and suture ligated right hepatic vein is seen.

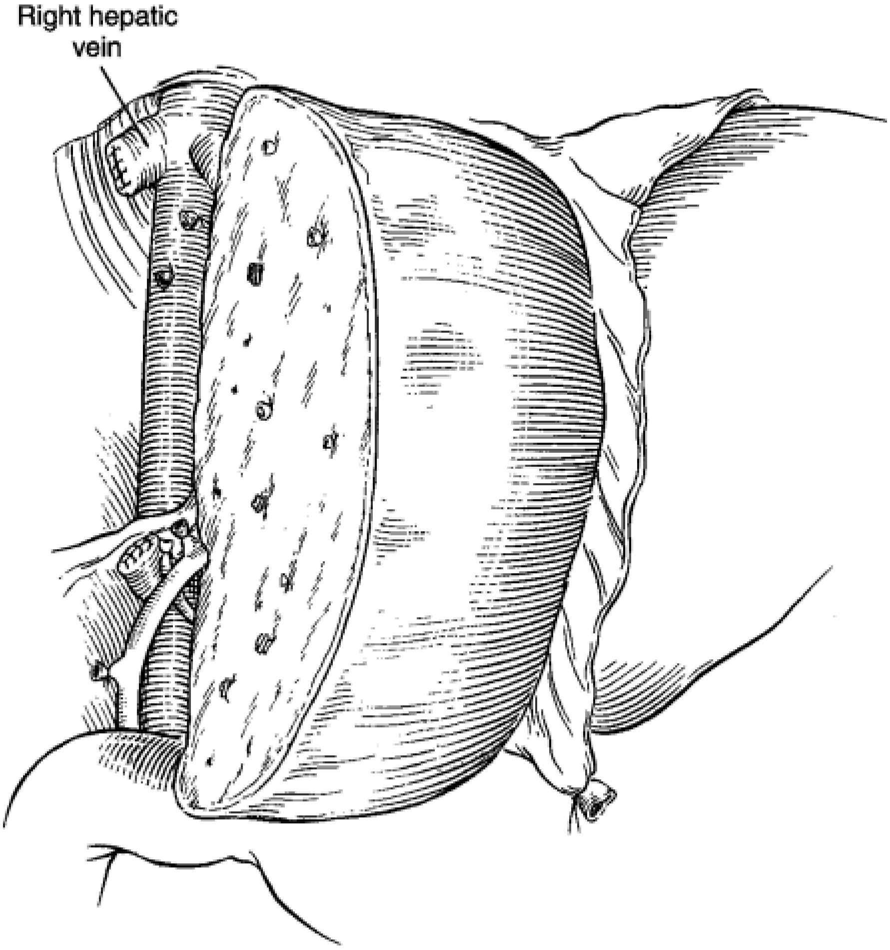


Figure 26-4 Completion of the left hepatic lobectomy. The divided and ligated left hepatic vein is shown.

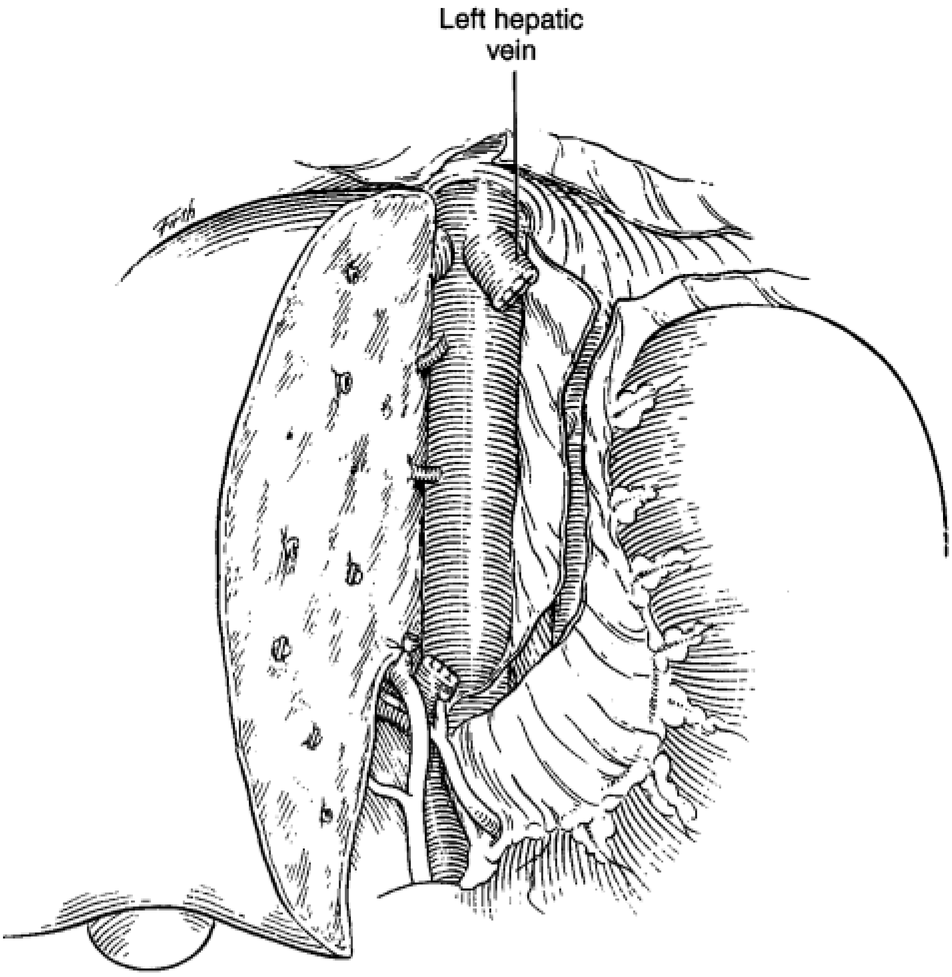


Figure 27-1 The transected end of the common bile duct is sutured to the side of a jejunal limb.

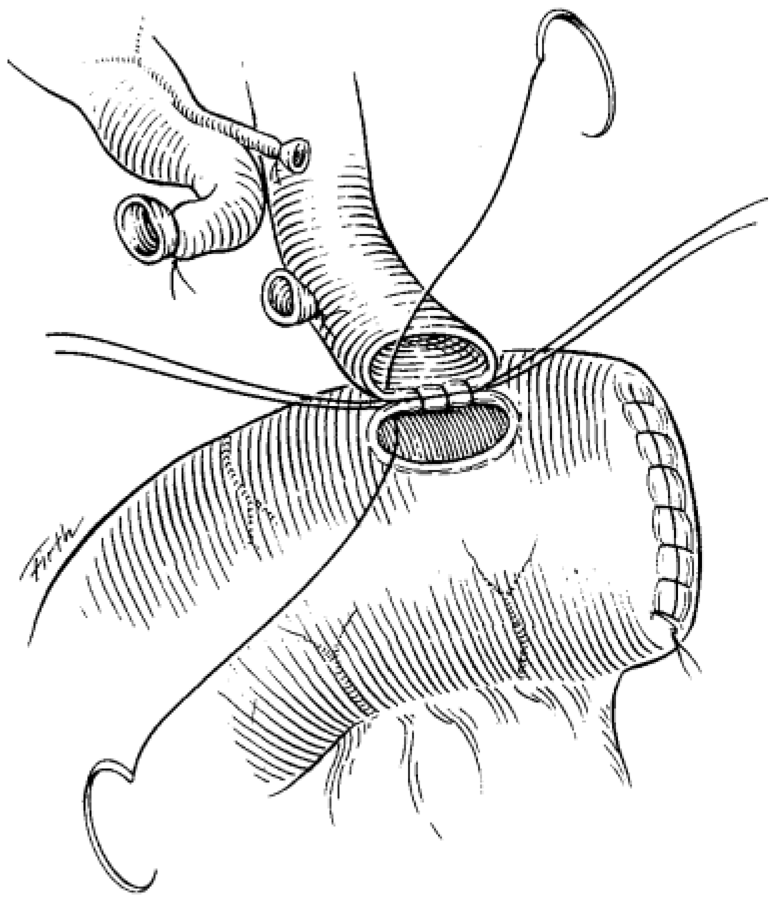
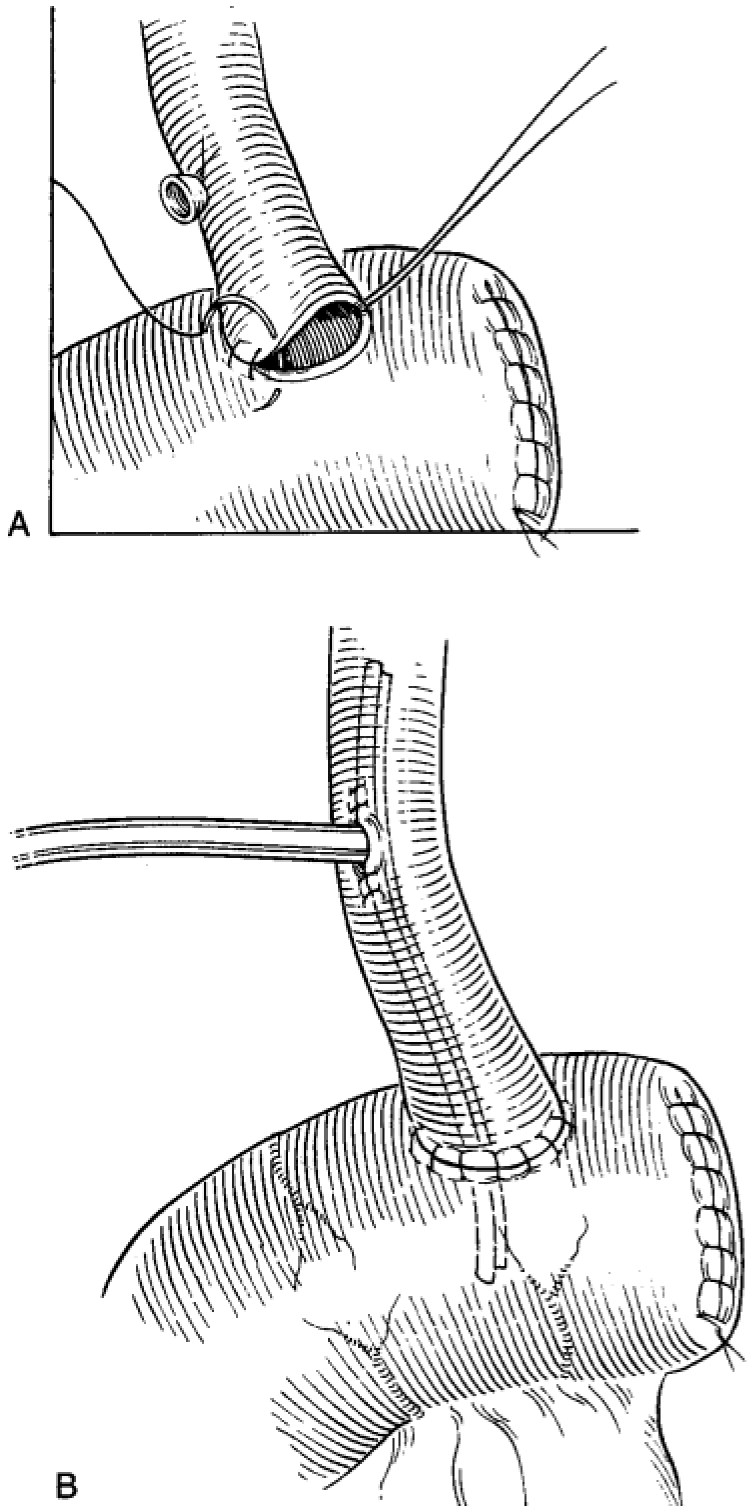


Figure 27-2 *A,* The anterior layer of the anastomosis is completed. *B*, The anastomosis is protected with a T-tube as a stent.



PANCREAS

Chapter 28 - Pancreatico-duodenectomy (Whipple Procedure)

EMBRYOLOGY

The ectodermal epithelium of the duodenum gives rise to two pancreatic buds. In the ventral mesentery is the ventral pancreatic bud, and opposite it is the larger dorsal pancreatic bud lying within the dorsal mesoderm. Because of the retroperitoneal location of the duodenum, the dorsal pancreas comes to lie on the posterior body wall in the retroperitoneal position and within the concavity of the duodenum. The ventral pancreas comes to lie adjacent to the larger dorsal bud due to the rotation of the stomach and the migration of the liver toward the dorsal body wall.

Once both the ventral and dorsal pancreas lie in the C-shaped concavity of the duodenum, they fuse. The ventral bud forms the uncinate process, whereas the bulk of the pancreas is derived from the dorsal bud. The main pancreatic duct (duct of Wirsung) is formed by the distal part of the dorsal duct and the entire ventral pancreatic duct. The proximal part of the dorsal pancreatic duct either obliterates or persists as the accessory pancreatic duct (duct of Santorini).

ANATOMY

The pancreas is a retroperitoneal organ that measures approximately 15 cm in length and weighs approximately 80 g. It is a soft and lobulated organ that extends from the C-loop of the duodenum to the hilum of

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the spleen. For descriptive purposes, the pancreas is divided into a head, neck, body, and tail.

The head of the pancreas lies within the C-loop of the duodenum and inferiorly bears an uncinate process that passes to the left behind the superior mesenteric vessels. This relationship is important when encountering tumors in this region and during their resection while performing a pancreaticoduodenectomy. The neck of the pancreas lies at the level of the portal vein and origin of the superior mesenteric artery. The body is a triangular segment of pancreas that travels upward and to the left. Finally, the tail of the pancreas travels upward within the splenorenal ligament to reach the splenic hilum.

There are important anatomic relationships to the pancreas that have surgical relevance. These are described according to the different segments of the pancreas. The superior, lateral, and inferior borders of the head of the pancreas are embraced by the C-loop of the duodenum. Structures that lie anterior to the pancreatic head include the pylorus and the transverse colon. Posteriorly, the head is near the inferior vena cava and the common bile duct. The uncinate process of the head of the pancreas is crossed anteriorly by the superior mesenteric vessels. The neck lies in front of the origin of the portal vein; lying anterior to this are the pylorus and the gastroduodenal artery. Immediately above the body of the pancreas is the celiac axis; the tortuous splenic artery runs along its upper border. The splenic vein lies along the posterior surface of the body of the pancreas. At the inferior border the two leaves of the transverse mesocolon are attached. The anterior surface of the body of the pancreas is covered by the peritoneum of the lesser sac.

The main pancreatic duct (the duct of Wirsung) traverses the main body of the pancreas and joins the common bile duct, entering the posteromedial aspect of the second part of the duodenum at the ampulla of Vater, which is surrounded by the sphincter of Oddi. The accessory pancreatic duct (the duct of Santorini) drains the upper part of the head of the pancreas and opens approximately 2 cm proximal to the main duct.

The arterial supply of the pancreas is derived from the branches of the celiac axis and the superior mesenteric artery. The head of the pancreas and the C-loop of the duodenum are intimately supplied by the pancreaticoduodenal arcades. The superior and inferior pancreaticoduodenal arteries are derived from the gastroduodenal artery and the middle colic arteries, respectively. Both the superior and inferior pancreaticoduodenal arteries branch into anterior and posterior branches, which create an arterial arcade around the head of the pancreas. Ligation of these vessels during resection of the head of the pancreas would lead to duodenal necrosis because the head of the pancreas and the C-loop of the duodenum share this blood supply. Consequently, during the Whipple procedure both the head of the pancreas and the C-loop of the duodenum must be resected.

The splenic artery provides numerous branches to the pancreas, including the dorsal pancreatic artery. There are numerous collaterals between the small branches derived from the splenic artery and the dorsal and transverse pancreatic arteries. Therefore, ligation of the splenic artery does not require splenectomy, but ligation of the splenic vein does.

The venous drainage of the pancreas parallels the arterial supply and includes the portal, the splenic, and both the superior and inferior mesenteric veins. As indicated earlier, the superior mesenteric vein and the splenic vein join behind the neck of the pancreas to form the portal vein. The lymphatic drainage is along the lymph nodes situated adjacent to the arteries that supply the pancreas. These lymph nodes eventually drain into the celiac and superior mesenteric lymph nodes.

PREOPERATIVE PREPARATION

In addition to the routine assessment of the cardiac, respiratory, and renal function of the patient, it is vital to review the high-resolution spiral computed tomography scan of the abdomen and pelvis with 3-mm cuts through the pancreas. Attention is paid to the presence of local invasion of adjacent vessels, particularly the superior mesenteric vessels and the portal vein. Major vessel occlusion and/or encasement, liver metastases, or enlarged celiac axis lymph nodes are ominous signs of incurable disease. Chest x-ray is also reviewed. If the patient is noted to have sepsis related to jaundice, preoperative biliary drainage may be advisable. Preoperative tissue diagnosis of a pancreatic mass is unnecessary if it is considered resectable by computed tomographic findings.

Operative Procedure

POSITION

The patient is placed in the supine position. General anesthesia is achieved with endotracheal intubation. A nasogastric tube and a Foley catheter and sequential pneumatic compression devices are placed. Perioperative antibiotics are administered. The abdomen is shaved, prepped, and draped in the usual manner. The procedure begins initially with a diagnostic laparoscopy. If there is no overt evidence of peritoneal, omental, or liver metastasis, the surgeon can proceed with exploratory laparotomy.

INCISION

A right subcostal incision extending toward the left side is made and carried down through the subcutaneous tissue and anterior rectus sheath. The rectus muscle and the posterior rectus sheath are divided with electrocautery.

EXPOSURE AND OPERATIVE TECHNIQUE

The ligamentum teres is divided between clamps and ligated with 2-0 silk. The falciform ligament is divided to the level of the inferior vena cava, thus allowing bimanual palpation of the liver. A thorough exploration is again undertaken, with particular attention to the presence of any peritoneal implants or periaortic or celiac axis lymphadenopathy. Liberal biopsies of suspicious peritoneal implants and enlarged lymph nodes that are beyond the limits of normal resection should be performed, because these contraindicate resection. The transverse colon is lifted, and the mesocolon is palpated just medial to the ligament of Treitz, because invasion in this region would involve the middle colic vessels, thus necessitating segmental colon resection.

Once evidence of distant metastasis has been excluded, the next step is to determine whether the primary tumor is resectable; this is done by excluding invasion of the adjacent vascular structures (inferior vena cava, superior mesenteric vessels, portal vein, and aorta) by the tumor. Adequate exposure is essential, and the use of a self-retaining abdominal retractor facilitates the procedure. Mobilization of the right colon and the hepatic flexure is begun to provide access to the second part of the duodenum. A wide Kocher maneuver is performed, and the duodenum and pancreas are elevated off the inferior vena cava until the left border of the abdominal aorta can be palpated. The Kocher maneuver is extended by continuing mobilization of the third portion of the duodenum until the superior mesenteric vein is encountered. The gastrocolic ligament is divided just inferior to the gastroepiploic arcade to gain access to the lesser sac. To improve access to the anterior surface of the pancreatic head, the right gastroepiploic vein is divided as it crosses the neck of the pancreas to enter the superior mesenteric vein. The middle colic vein is identified and followed down to its confluence with the superior mesenteric vein, which was previously identified during the extensive Kocher maneuver. The anterior surface of the superior mesenteric vein is dissected under direct vision. Using a Cushing vein retractor, the neck of the pancreas is lifted, and entering this avascular plane, the superior mesenteric vein is traced proximally to its confluence with the portal vein.

Once sufficient inferior dissection has been performed, the superior aspect of the dissection is commenced. This portion of the procedure is greatly facilitated by first performing a cholecystectomy. The peritoneal reflection over the hepatoduodenal ligament is carefully opened, and the common bile duct and common hepatic artery are carefully dissected and vessel loops are placed around them. The adipose and nodal tissues in this region are dissected toward the specimen. The gastroduodenal artery is identified and ligated in continuity to facilitate access to the portal vein at the superior aspect of the pancreas. Exposing the interface between the bile duct and the portal vein facilitates the process of adequately assessing resectability, and this can be achieved by dividing the common hepatic duct.

Even if the tumor is unresectable, the divided common hepatic duct can be used to construct the choledochojejunostomy. Thus, division of both

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the gastroduodenal artery and the common hepatic duct untethers the first portion of the duodenum, which can now be retracted, thus allowing further dissection, under direct vision, of the anterior surface of the portal vein from the superior aspect. Such exposure will eliminate the need for blind finger dissection to assess the plane between the neck of the pancreas and the portal vein. Palpation behind the head of the pancreas is necessary to determine if the tumor has invaded the uncinate process, the posterior aspect of the portal vein, or the superior mesenteric artery (Fig. 28–1).

At this point if there is no evidence of encroachment of the tumor to the major regional vessels, a decision to proceed with formal resection is made. To ensure adequate regional lymphadenectomy, tissues over the

Figure 28-1 The gastric antrum, common hepatic duct, and gastroduodenal artery have been divided. To assess resectability, the surgeon is performing careful digital exploration by placing the index finger between the pancreatic neck and the portal vein. SMA, superior mesenteric artery; SMV, superior mesenteric vein.

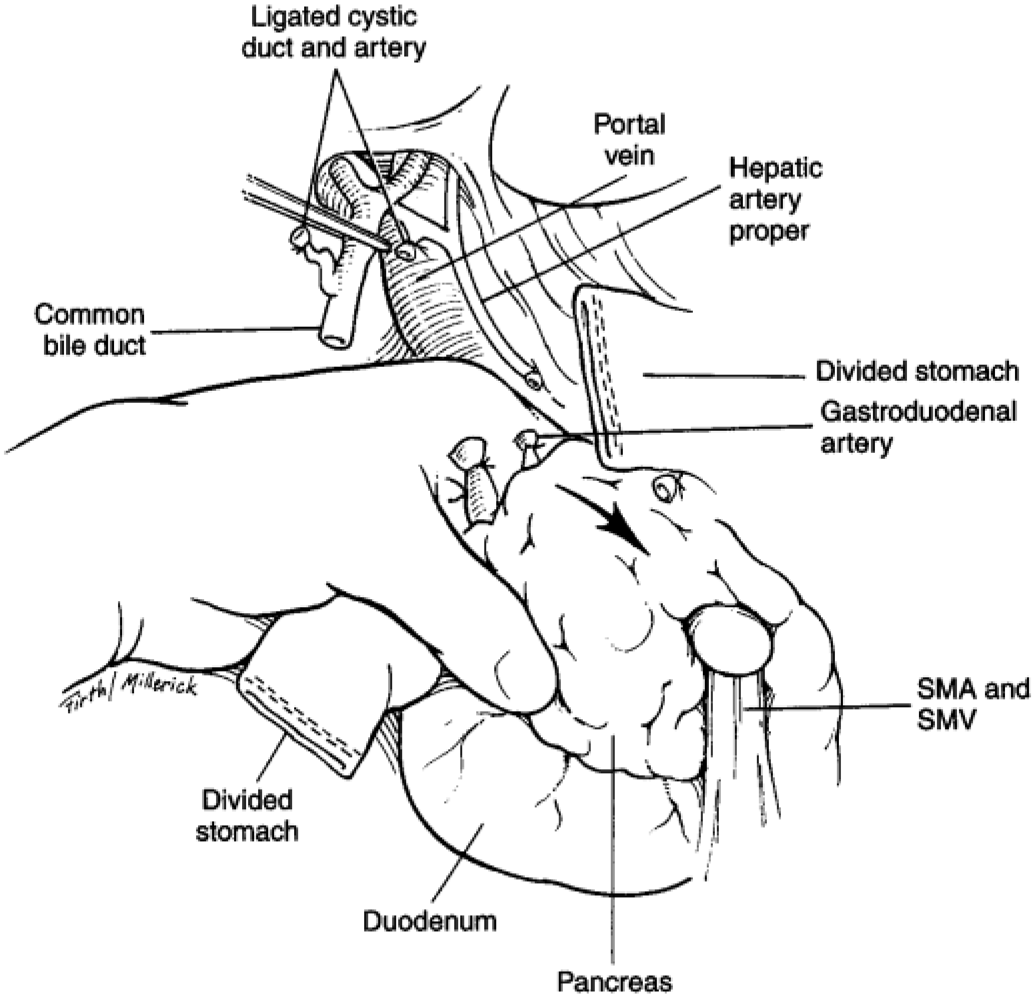


Figure 28-2 The ligament of Treitz is sharply divided and the jejunum is transected with a GIA-60 linear stapler.

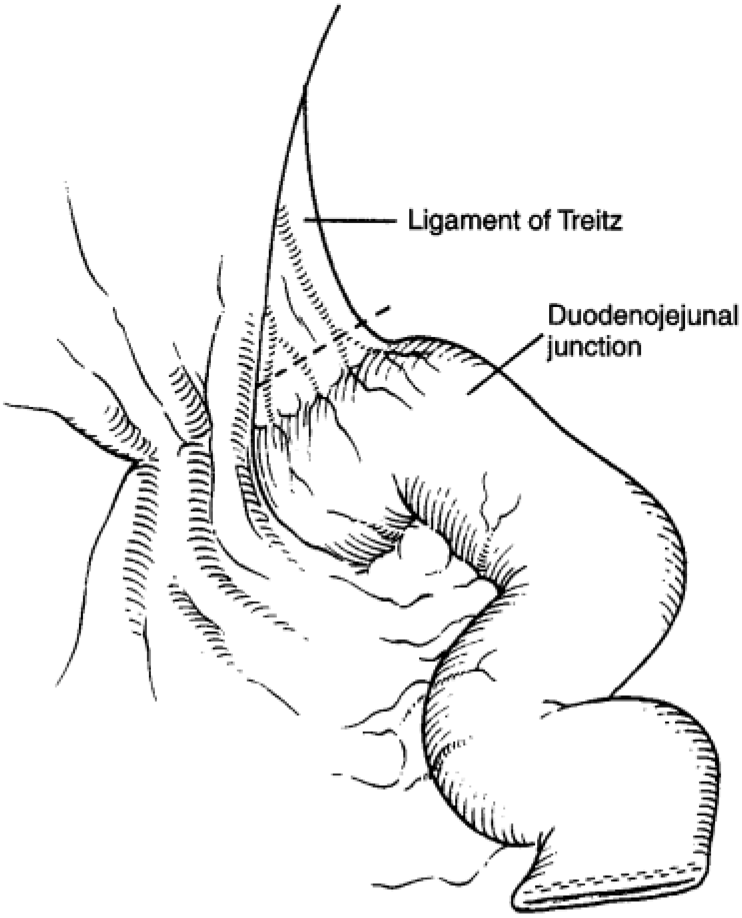


Figure 28-3 The resected specimen contains the gastric antrum, duodenum, head of the pancreas, distal common bile duct, and proximal jejunum.

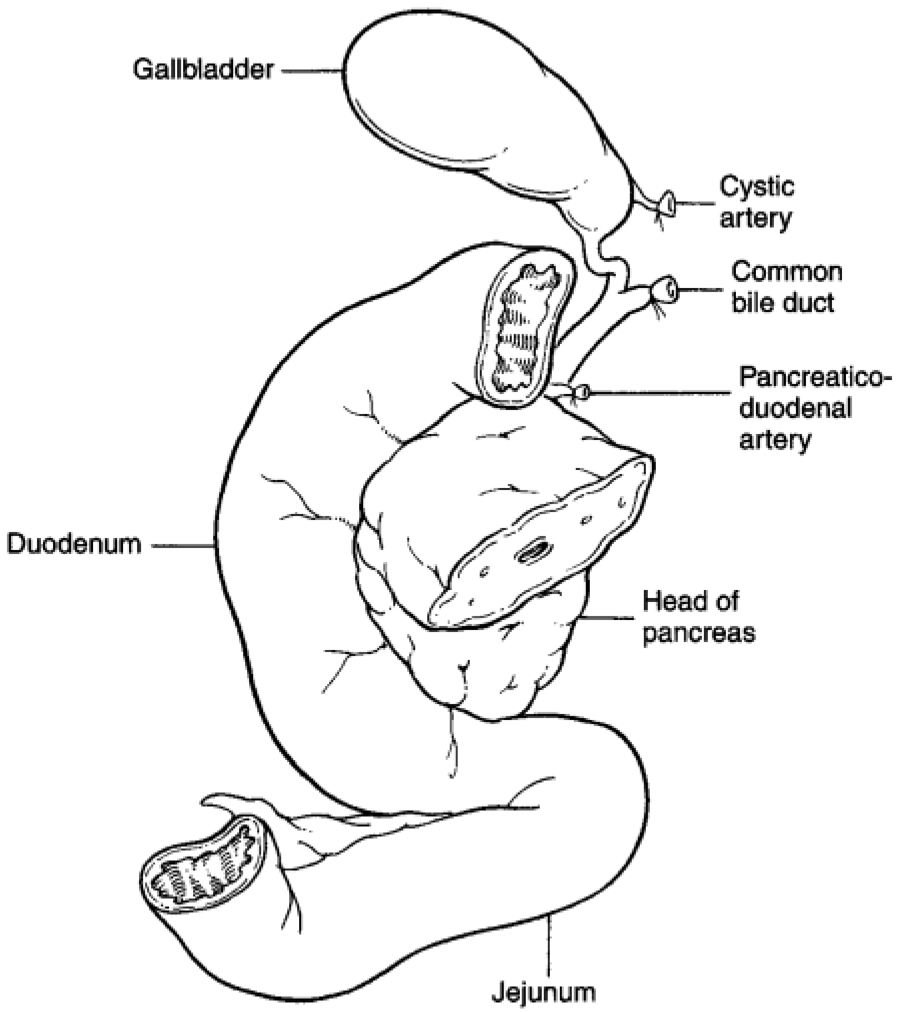
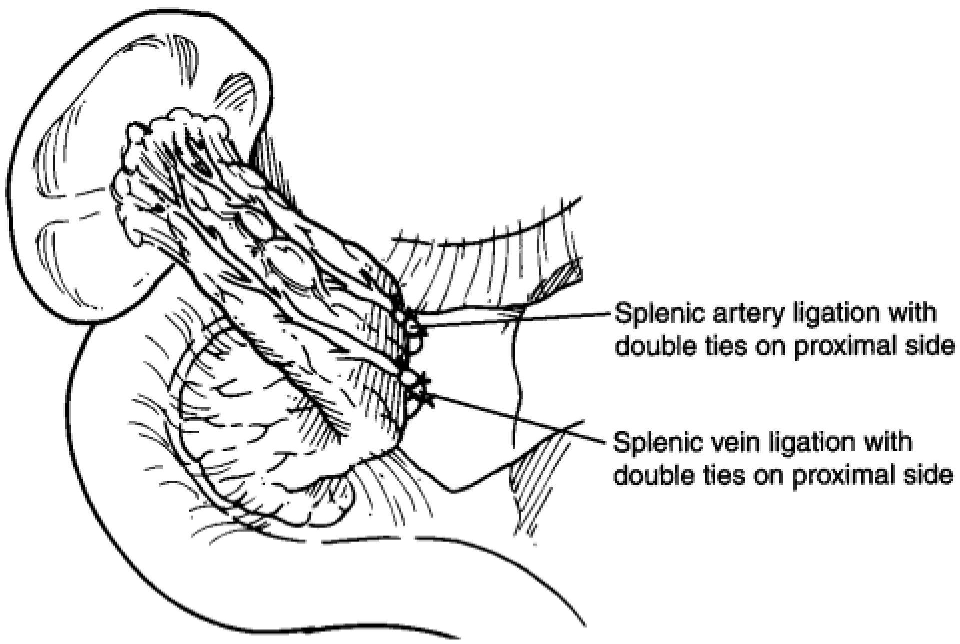


Figure 29-1 The spleen and the pancreas are mobilized medially. The splenic vessels are ligated in continuity and divided.



SPLEEN

Chapter 30 - Splenectomy

EMBRYOLOGY

The spleen develops from a mass of mesenchymal cells located within the dorsal mesentery. As it enlarges it becomes lobulated and projects into the greater sac. The notch on the anterior border of the spleen is the remnant of this fetal lobulation. Embryologic development of the spleen assists in understanding of the ligament attachments present in the adult. As the stomach rotates, the left surface of the dorsal mesentery fuses with the posterior body wall over the left kidney; this explains the development of the splenorenal ligament. Dorsal mesentery between the spleen and the stomach represents the gastrosplenic ligament.

ANATOMY

The spleen is an ovoid lymphoid organ that resides in the left upper quadrant. It weighs approximately 200 g and measures approximately 12 cm long, 8 cm wide, and 4 cm thick. The long axis of the spleen lies along the tenth rib. The spleen has two surfaces: the outer diaphragmatic surface and the medial visceral surface that bears the hilum. The anterior border has a notch that can be palpable when the spleen is enlarged. The spleen has several ligaments, and their names indicate their connections. The splenorenal ligament contains the splenic vessels and the tail of the pancreas. The gastrosplenic ligament contains several short gastric vessels. Some of the other minor ligaments surrounding the spleen include the splenocolic ligament, the splenophrenic ligament, the pancreaticosplenic ligament, and the phrenosplenic fold, which lies anterior to the gastrosplenic ligament.

The blood supply of the spleen originates from the splenic artery, which is a branch of the celiac axis. The splenic artery is a very tortuous vessel that runs along the upper border of the pancreas to reach the splenic hilum, where it divides into several branches. The venous drainage of the spleen flows into the splenic vein. The splenic vein lies along the posterior surface of the pancreas and joins the superior mesenteric vein to form the portal vein. The lymphatic drainage of the spleen is along the splenic artery via the superior pancreatic nodes to the celiac group of para-aortic nodes.

The incidence of accessory spleens varies from 10% to 30%. Most of these are present at the splenic hilum or near the tail of the pancreas. However, accessory spleens can be found in other areas such as the omentum, the splenocolic ligament, and along the path of the splenic artery. In approximately two thirds of patients only one accessory spleen is present, and in another 15% to 20% two such accessory spleens are present.

Operative Procedure

POSITION

The patient is placed in a supine position. After induction of anesthesia and endotracheal intubation, a nasogastric tube and Foley catheter are placed. A prophylactic dose of antibiotics is administered, and external pneumatic compression devices are placed on the lower extremities.

INCISION

The incision used depends on the size of the spleen, whether emergency access to the abdomen is required, and whether there is an underlying coagulation disorder. In emergent cases and in patients with a large spleen, a midline incision is preferred. Small spleens can be accessed via a left subcostal incision.

EXPOSURE AND OPERATIVE TECHNIQUE

A thorough exploration of the abdomen is performed, with particular attention directed to identifying accessory spleens and palpating the gallbladder for calculi. A self-retaining Balfour retractor is then placed, and the assistant lifts the left costal margin with a large Richardson retractor to expose the structures in the left upper quadrant.

The spleen is gently grasped with the palm of the hand and displaced medially toward the incision. This places the avascular lateral peritoneal attachments (splenorenal and splenophrenic ligaments) under tension, and they are incised with Metzenbaum scissors or electrocautery (Fig. 30–1). This dissection usually does not lead to significant bleeding unless collaterals from existing portal hypertension are present, in which case they must be ligated. Division of the lateral peritoneal ligaments allows the spleen to be drawn farther toward the surgeon. Dry laparotomy pads are placed in the splenic bed for hemostasis and to facilitate elevation

Figure 30-1 The spleen is grasped and the lateral peritoneal ligaments are divided. The splenocolic ligaments have been divided to release the splenic flexure.

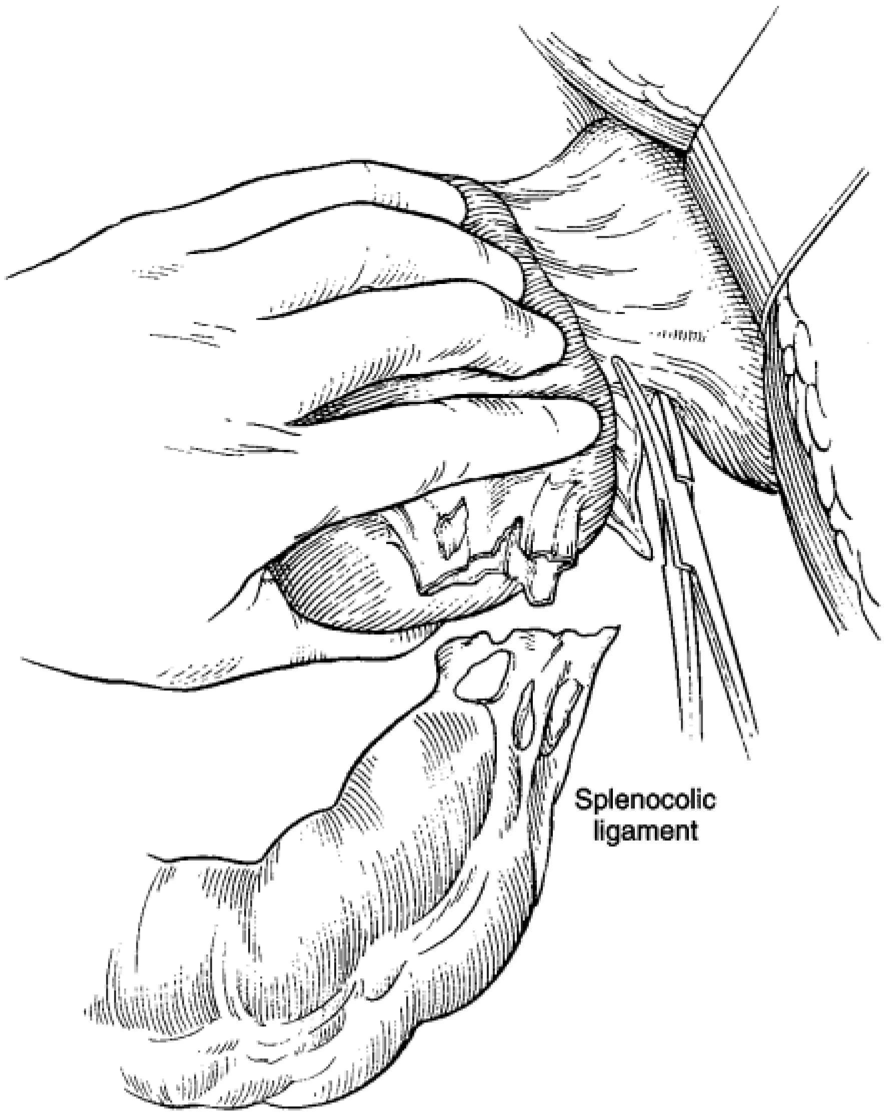


Figure 30-2 After complete mobilization of the spleen, the vessels at the hilum are clamped and divided, avoiding injury to the tail of the pancreas.

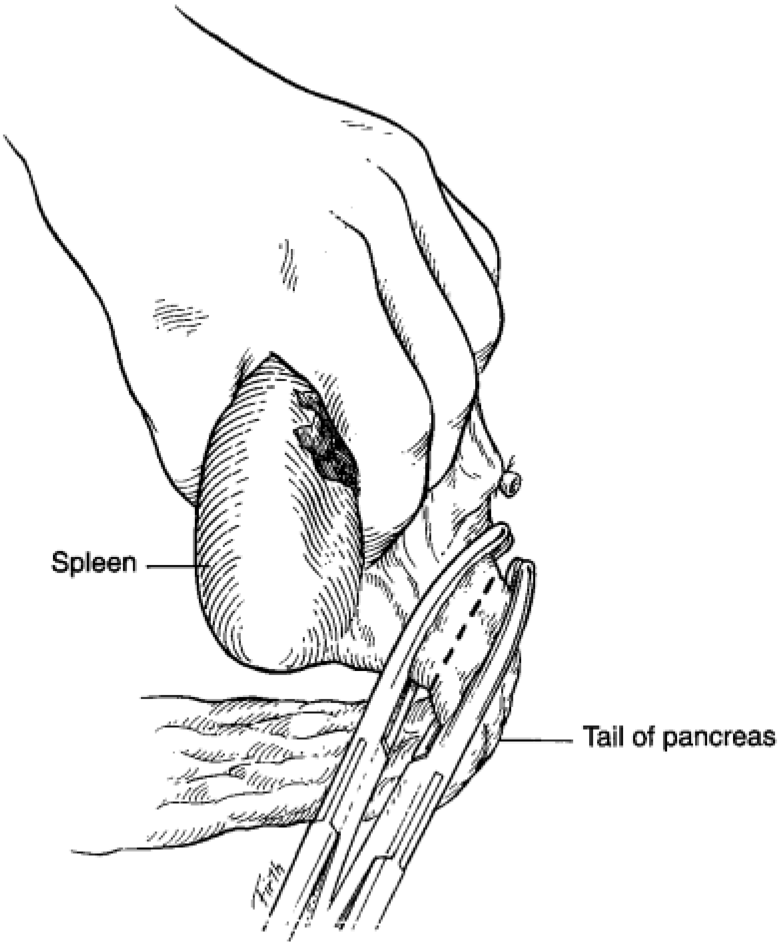
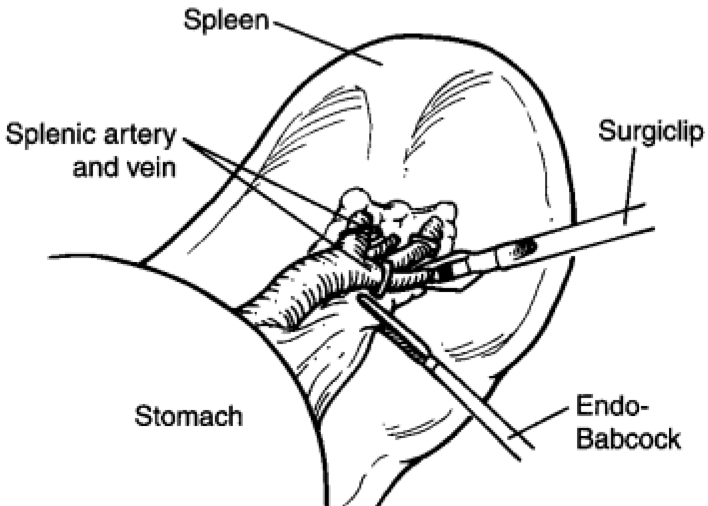


Figure 31 - 1 The hilar vessels are exposed and can be transected with an endovascular stapler.



LARGE BOWEL/ANORECTUM

Chapter 32 - Appendectomy

EMBRYOLOGY

During the early developmental stage, the appendix is the caudal extension of the cecum and possesses the same caliber. The right wall of the cecum grows rapidly downward and begins to displace the appendix medially and closer to the ileocecal area.

ANATOMY

The appendix varies in length from 8 to 14 cm and arises from the posteromedial surface of the cecum, where all three taeniae coli meet. The position of the appendix can vary considerably among patients. It can be located in the pelvis, behind or along the lateral border of the cecum, or anterior or posterior to the distal ileum. The appendix possesses a complete peritoneal covering and has its own mesoappendix, which is attached to the mesentery of the distal ileum. Contained within the mesoappendix is the appendicular artery, which is a branch of the posterior cecal artery. Venous drainage of the appendix is via the appendicular vein, which drains into the posterior cecal vein. The nerve supply of the appendix is derived from both sympathetic and vagal fibers. Visceral pain from the appendix is conducted by the afferent sympathetic fibers that enter at the T10 spinal level.

PREOPERATIVE PREPARATION

Once a diagnosis of acute appendicitis is entertained and a decision is made to explore the patient, it is imperative to resuscitate the patient adequately with intravenous fluids. Intravenous antibiotics should be administered. In young patients, minimal investigations are required if the clinical picture is strongly suspicious for appendicitis. If a mass is palpable in the right

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lower quadrant, computed tomography of the abdomen and pelvis can be valuable to assess for the presence of either an appendiceal abscess or a malignant tumor arising from the cecum, appendix, or small bowel. Depending on the expertise of the radiographer, often an ultrasound can be used for visualization of the thickened appendix.

Operative Procedure

POSITION

The patient is placed in the supine position and undergoes general anesthesia with endotracheal intubation. While the patient is anesthetized and the abdominal musculature relaxed, it is advisable to carefully examine the abdomen to ascertain the presence of right lower quadrant masses. If there is any uncertainty about the diagnosis of appendicitis, especially in females, a lower midline incision can be made. Alternatively, the procedure may initially begin with diagnostic laparoscopy. If, however, the clinical suspicion for appendicitis is high, the direct approach to the appendix via the right lower quadrant is made.

INCISION

McBurney's point, located one third of the distance from the anterior superior iliac spine to the umbilicus, is identified. A transverse skin incision (Rocky-Davis incision) is made at McBurney's point (Fig. 32–1 *A*). The skin incision should be long enough to allow the appendectomy to be performed without unnecessary excessive retraction of the anterior abdominal musculature and skin.

EXPOSURE AND OPERATIVE TECHNIQUE

The skin incision is carried through the subcutaneous tissue until the external oblique fascia is exposed. A small incision is made in the external oblique fascia along the line of its fibers. The superior and the inferior edges of this opening are grasped with curved Kelly clamps. This incision is sharply extended with slightly open Metzenbaum scissors along the direction of the fibers (Fig. 32–1 *B*). The underlying fibers of the internal oblique muscle are identified and split with a curved Kelly clamp and retracted with Army-Navy or Richardson retractors.

Next, the transversus abdominis muscle is identified and split and the Richardson retractors adjusted to expose the peritoneum. The operator grasps the peritoneum with curved Kelly clamps, carefully verifying that intra-abdominal viscera have not been inadvertently grasped. With a no. 15 scalpel, a small incision is made in the peritoneum. Suction catheters and culture swabs should be available in case purulent fluid is encountered when the peritoneal cavity is entered. If this is the case, some fluid should be obtained for bacteriologic culture and the rest aspirated to limit any contamination of the wound edges. The edges of the peritoneum are

Figure 32-1 *A*, The transverse incision is placed at McBurney's point. *B*, The external oblique fascia is incised and the underlying muscles are split. *C,* After the mesoappendix has been divided, a purse-string suture using an absorbable suture can be placed to invert the base of the appendix.

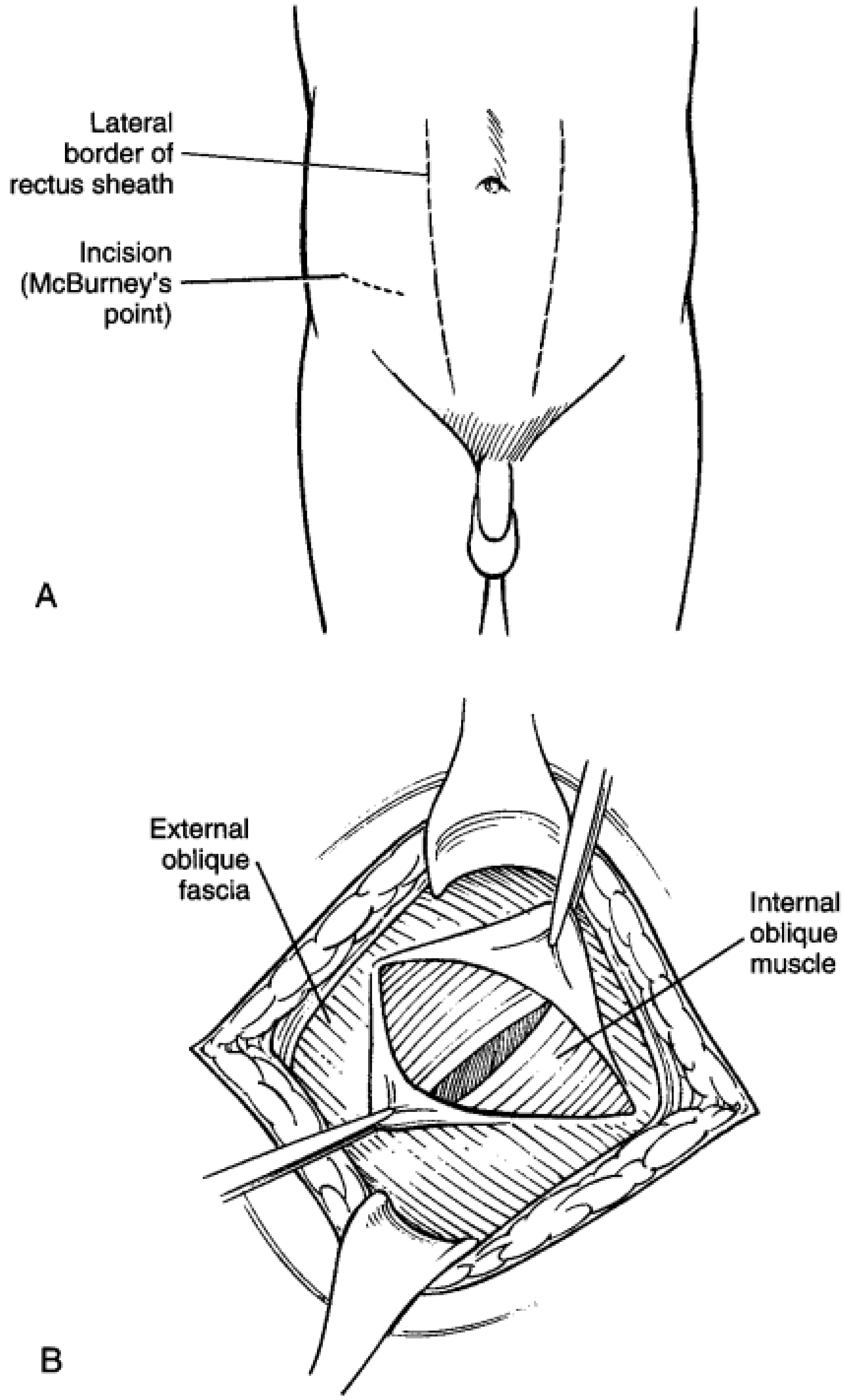


Figure 32-1 *A*, The transverse incision is placed at McBurney's point. *B*, The external oblique fascia is incised and the underlying muscles are split. *C,* After the mesoappendix has been divided, a purse-string suture using an absorbable suture can be placed to invert the base of the appendix.

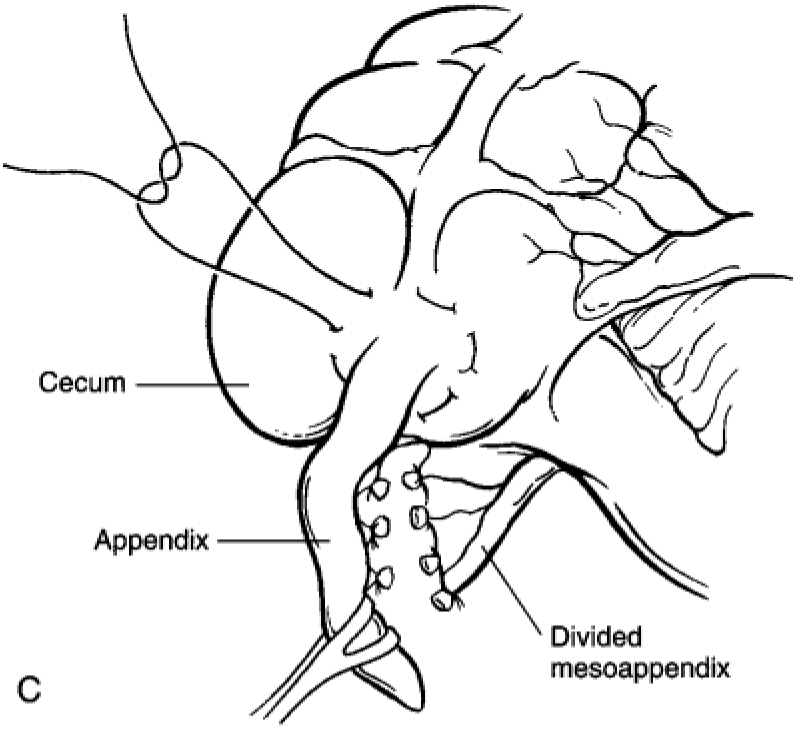


Figure 33 - 1 The mesoappendix is dissected close to the base of the appendix and then divided with an endovascular stapler.

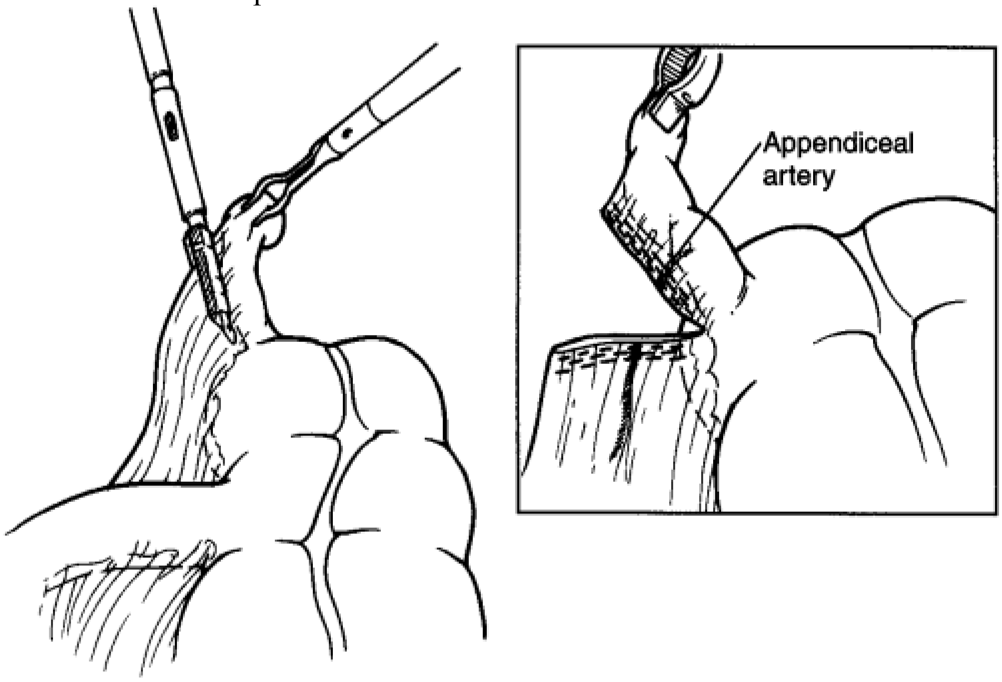
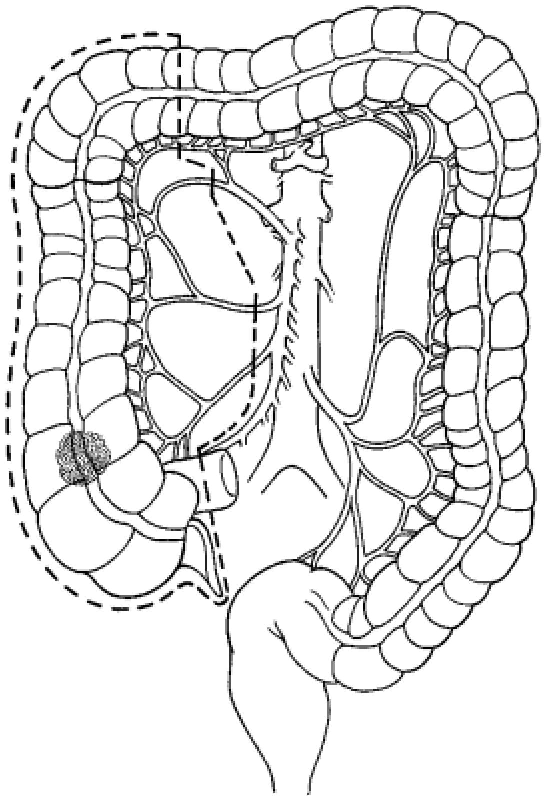


Figure 34 - 1 The various types of colon resections performed; dashed lines indicate the extent of large bowel removed. *A*, Right hemicolectomy; *B*, extended right colectomy. *C*, Transverse colectomy; *D*, left colectomy. *E*, Extended left colectomy; *F*, sigmoid colectomy.



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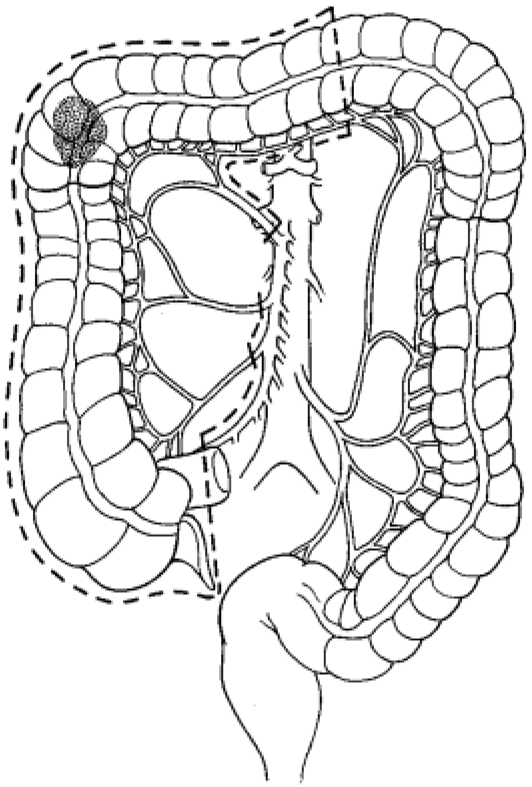

B

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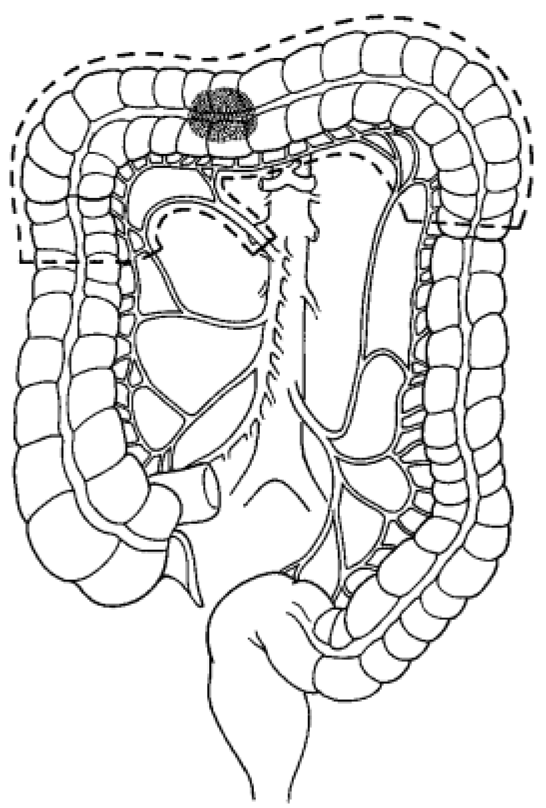

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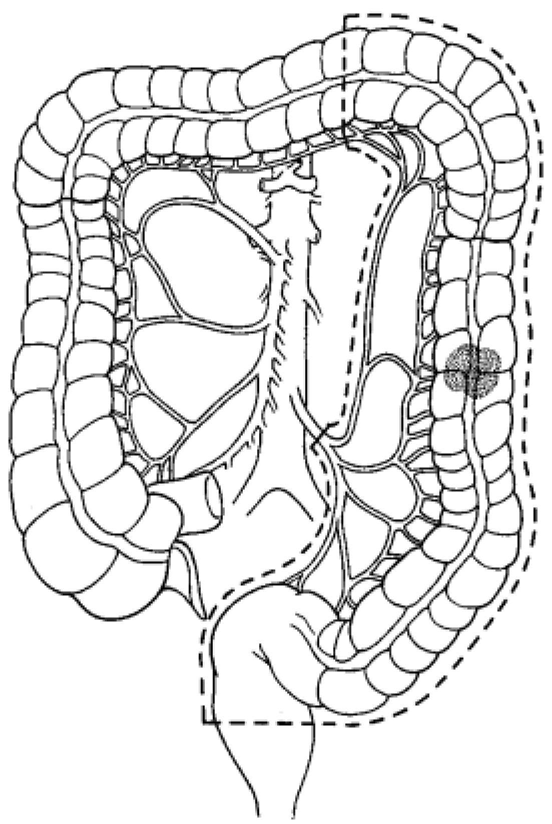

D

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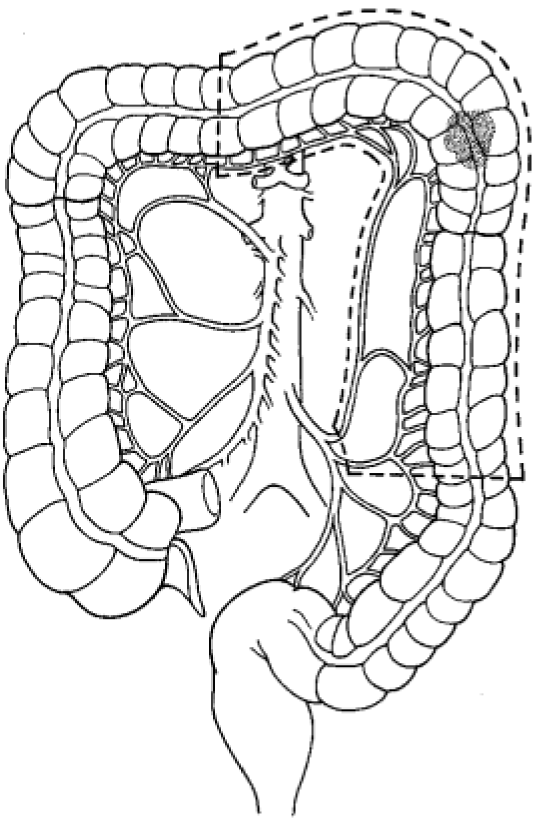

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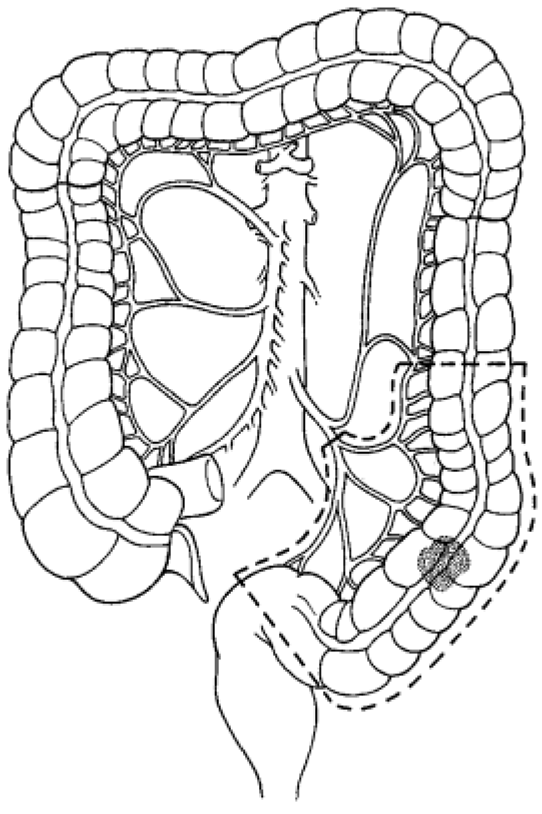


F

Figure 34-2 *A*, After division of the vessels in the mesocolon, soft clamps are placed across the bowel, which is then divided with a linear GIA stapler. *B*, Bowel anastomosis is being performed with a hand-sewn technique.

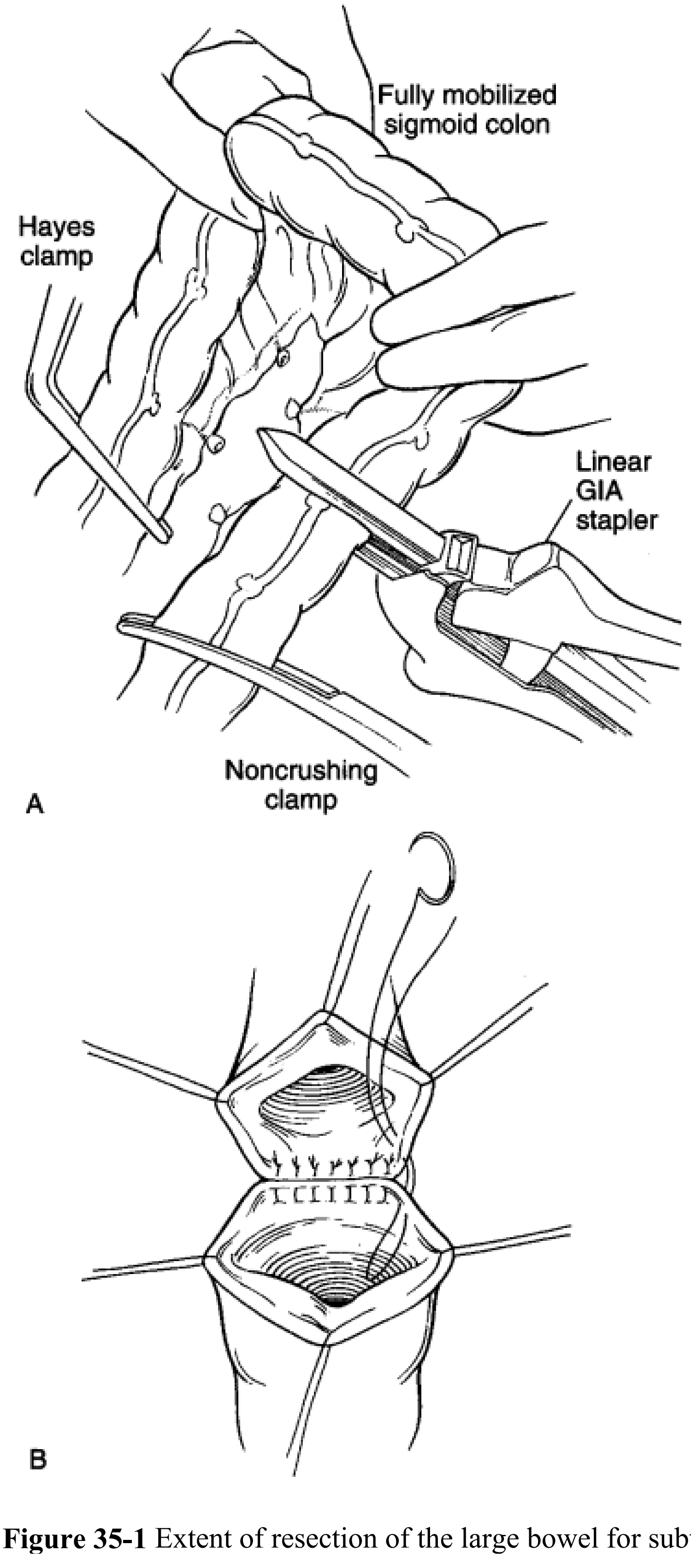


Figure 35-1 Extent of resection of the large bowel for subtotal colectomy (dashed lines).

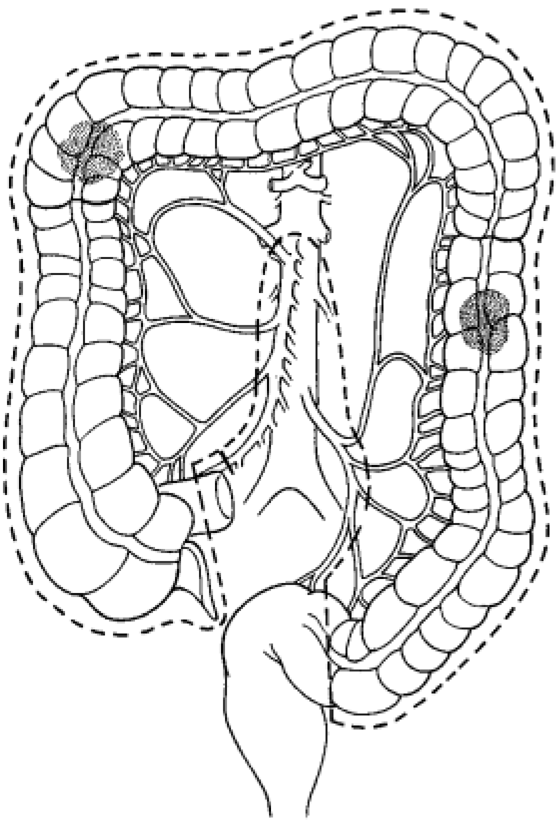


Figure 35-2 *A*, The terminal ileum is folded and an enterotomy is made at the apex of the J-pouch. *B*, Creation of the side-to-side anastomosis with a GIA stapler. *C*, Placement of a purse-string suture around the enterotomy.

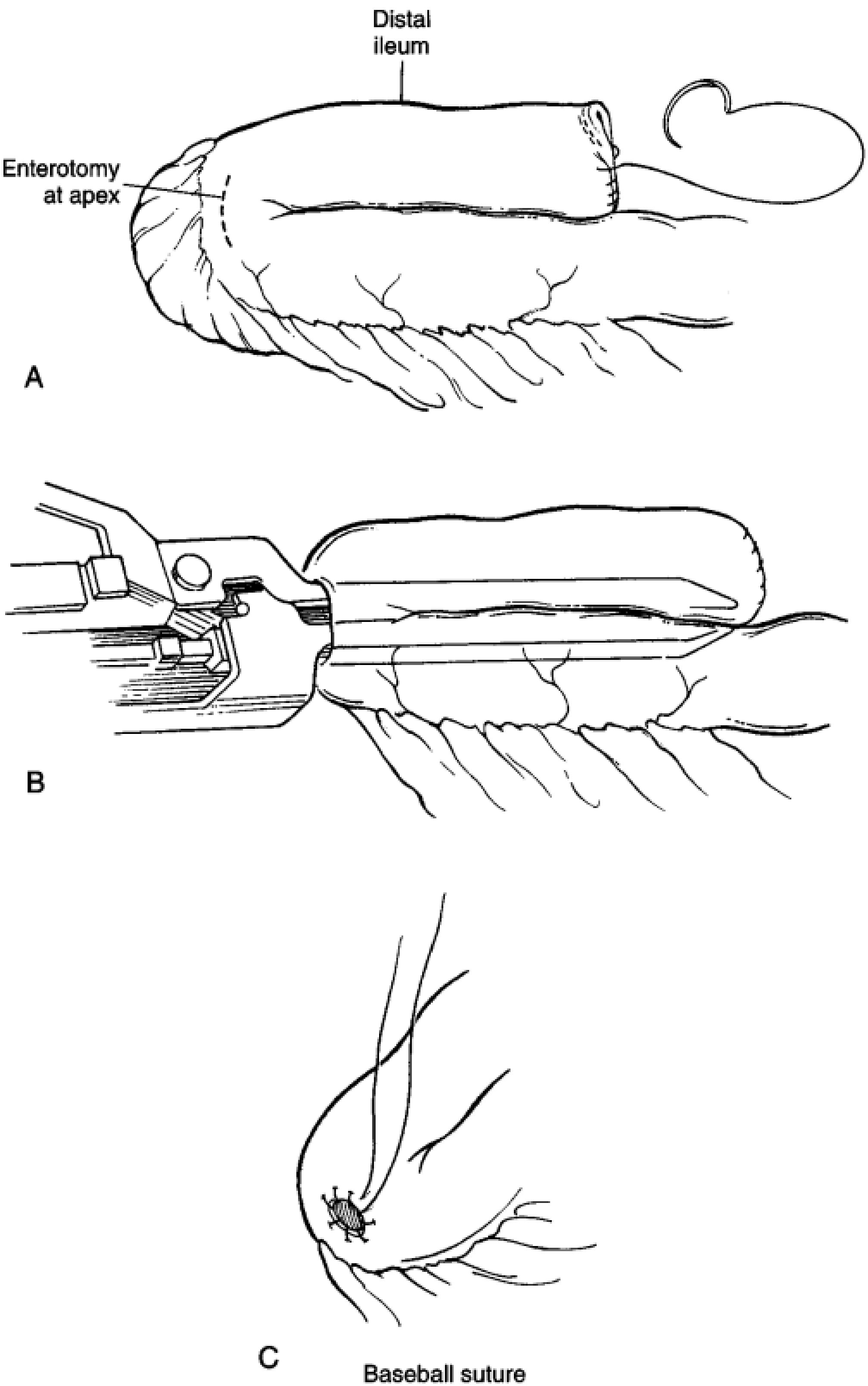


Figure 36-1 Sagittal view of the pelvis demonstrating the plane of dissection for rectal resection.

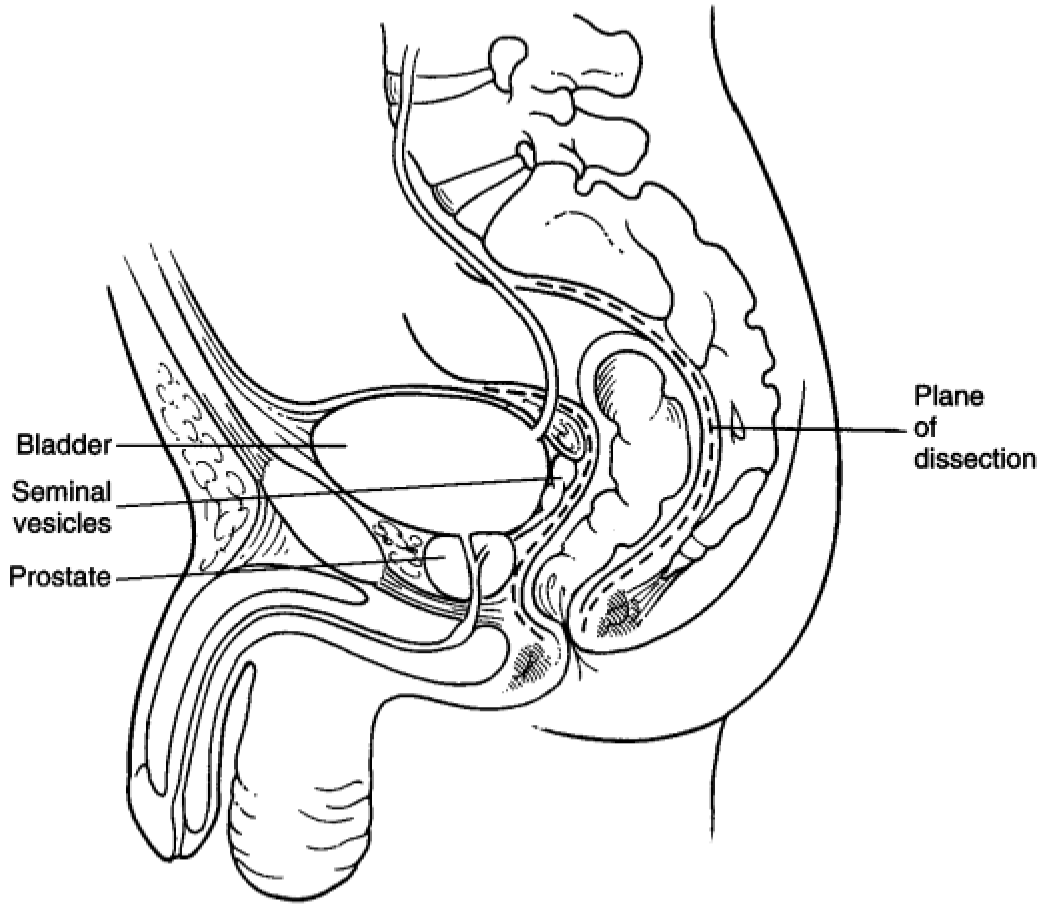


Figure 36-2 *A*, After a low anterior resection the stapling device is used for the anastomosis. *B*, The completed anastomosis with a double staple line.

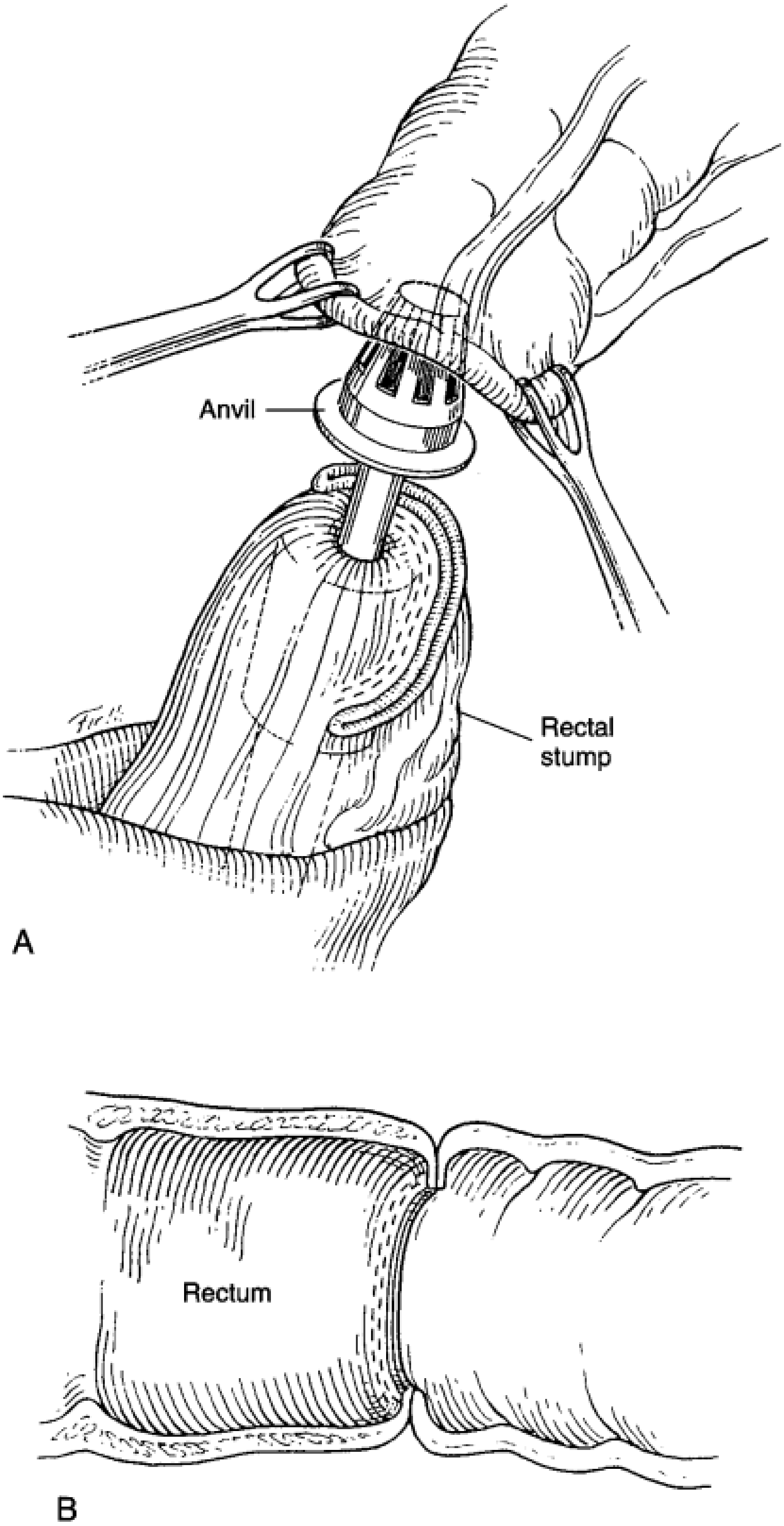


Figure 36-3 *A*, Incision for the perineal dissection when performing abdominoperineal dissection. *B*, The levator muscles are being divided with Metzenbaum scissors.

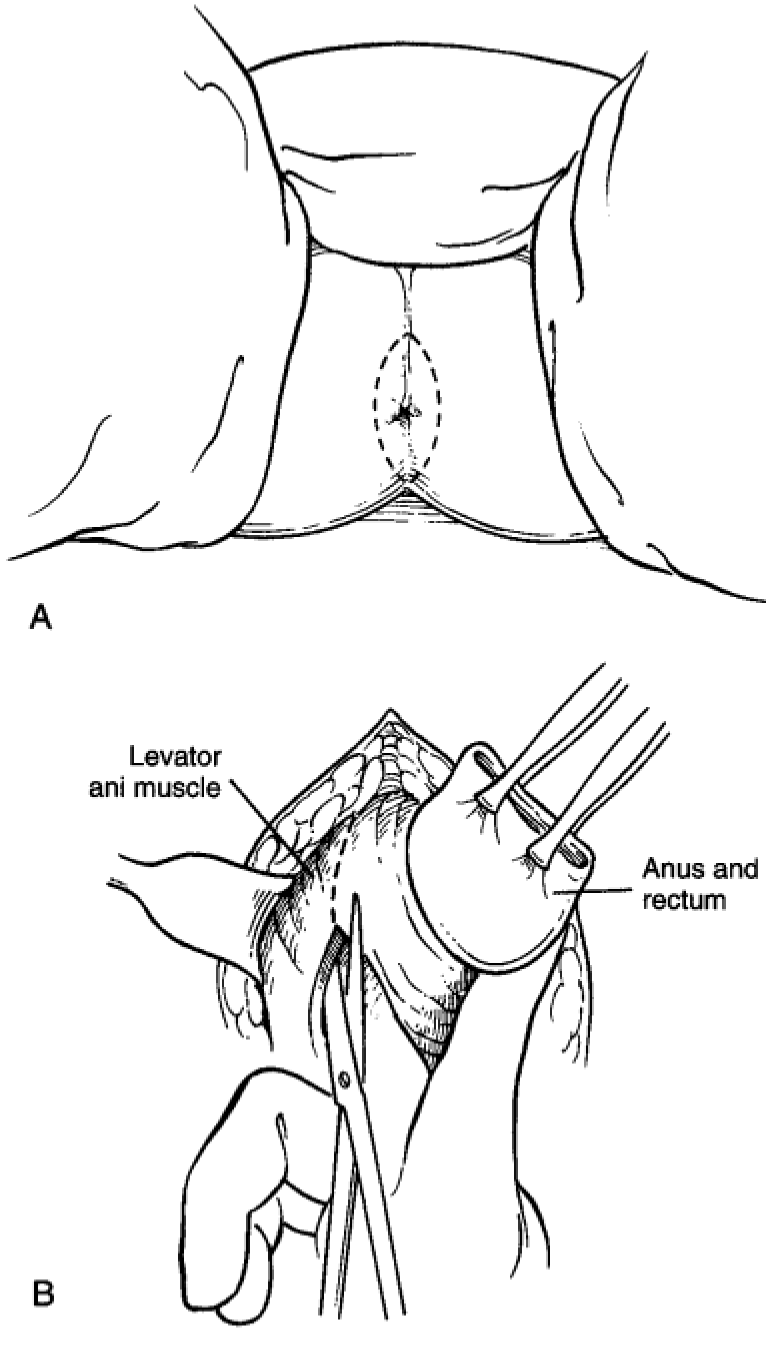


Figure 37-1 *A*, The loop of bowel is brought through a circular defect created in the anterior abdominal wall. *B*, The edges of the bowel wall are approximated to the skin.

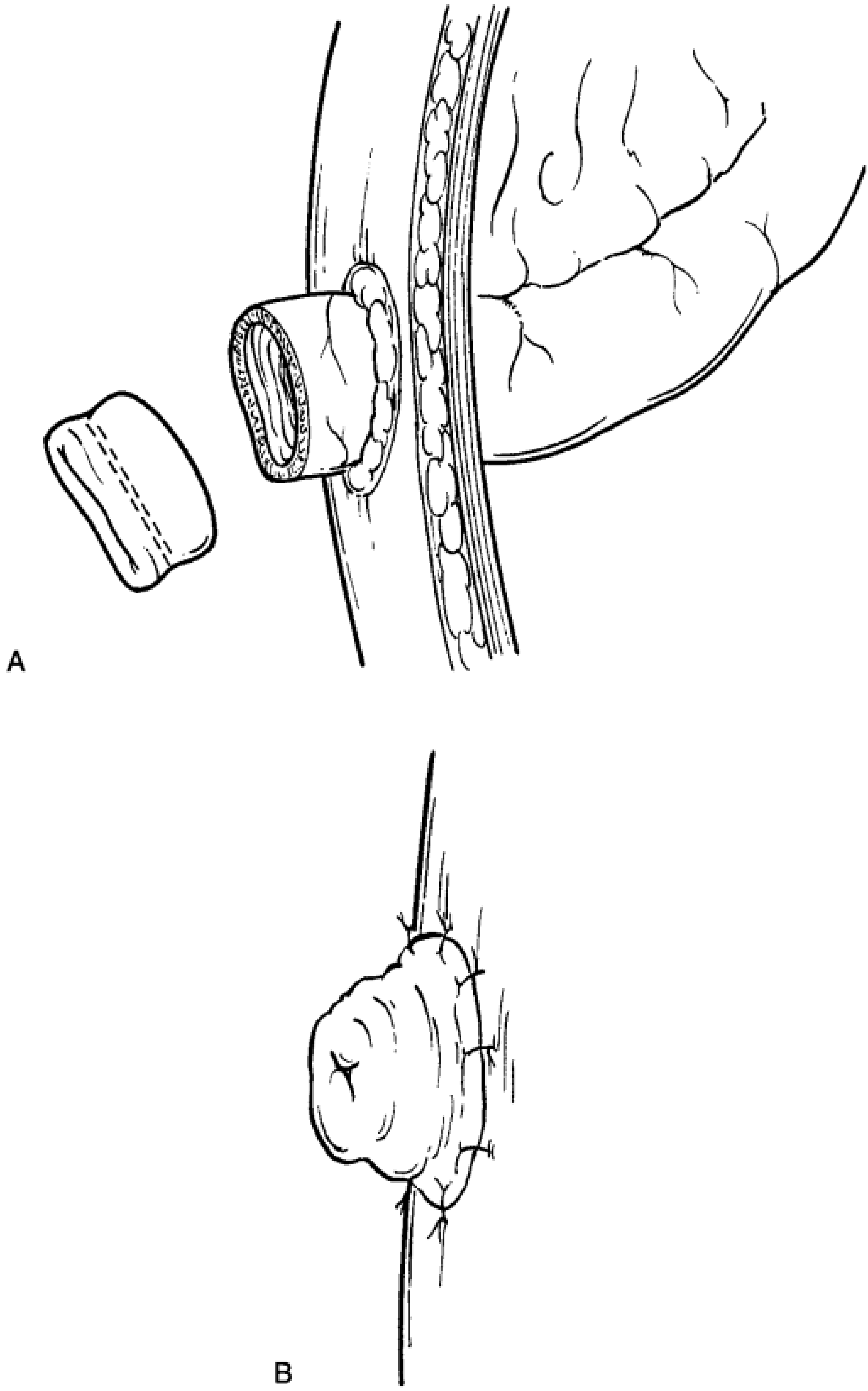
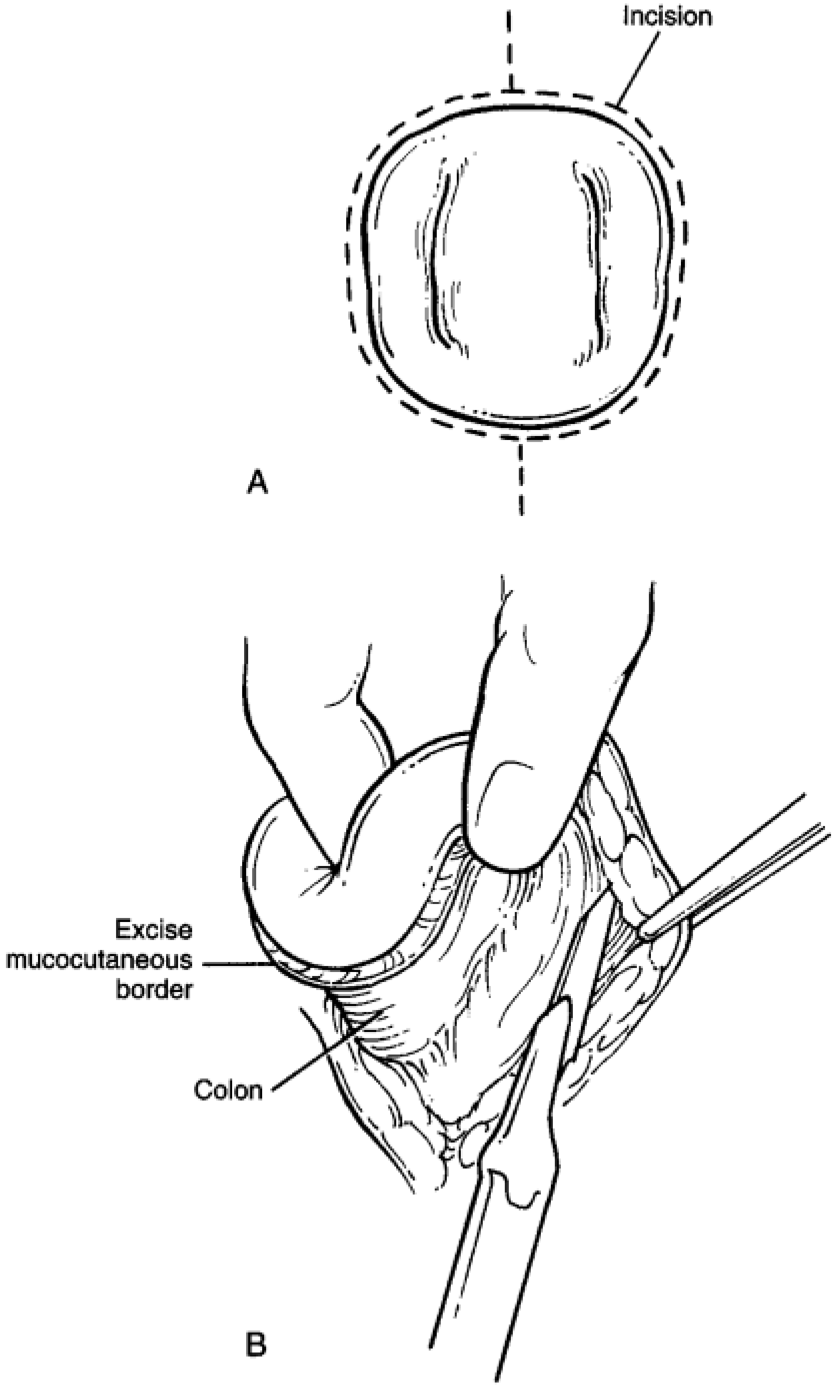


Figure 37-2 *A*, A circumferential incision is made at the mucocutaneous junction. *B*, The loop of bowel is dissected free from the subcutaneous tissue and the fascia. *C*, The anterior layer of the bowel anastomosis is being performed.



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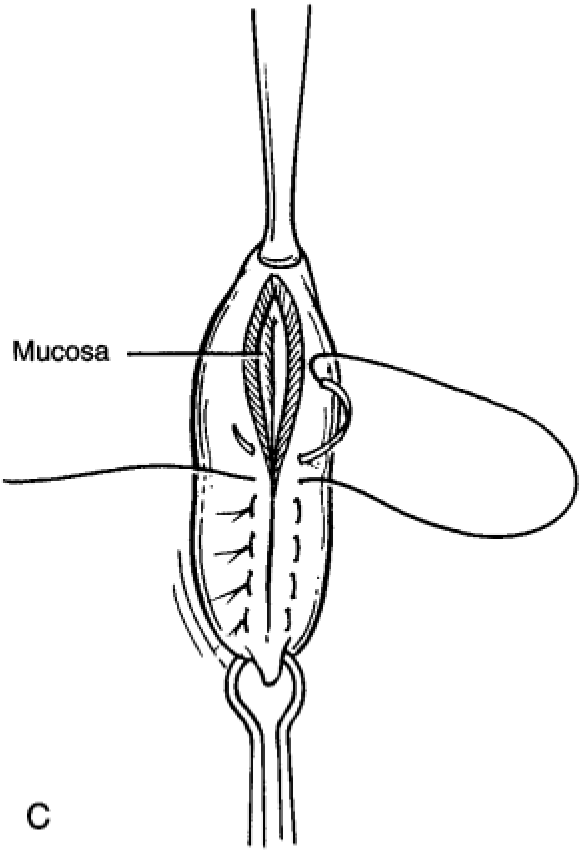
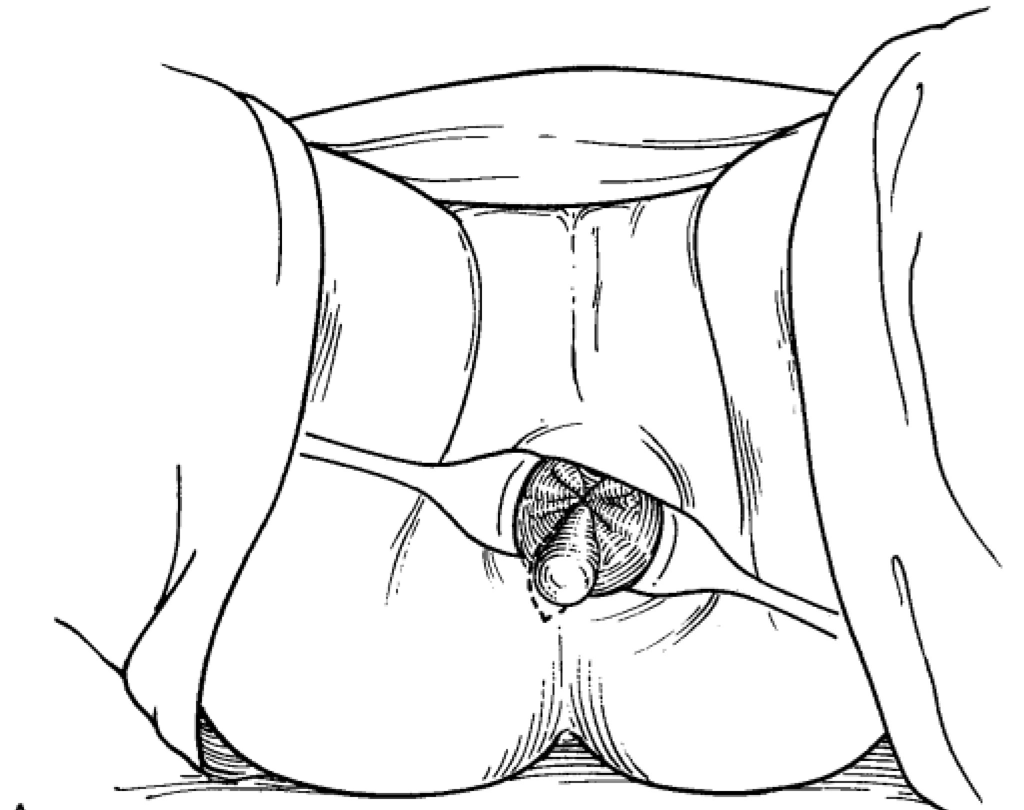


Figure 38-1 *A*, Hemorrhoidal tissues are identified. The mucosa is incised on each side of the hemorrhoid and extended outward toward the anoderm. *B*, The anoderm and the hemorrhoidal mass are elevated off the transverse fibers of the internal sphincter muscle. *C*, The mucosa is approximated with continuous 3-0 absorbable sutures, leaving 2 to 3 mm of the anoderm left open for drainage.



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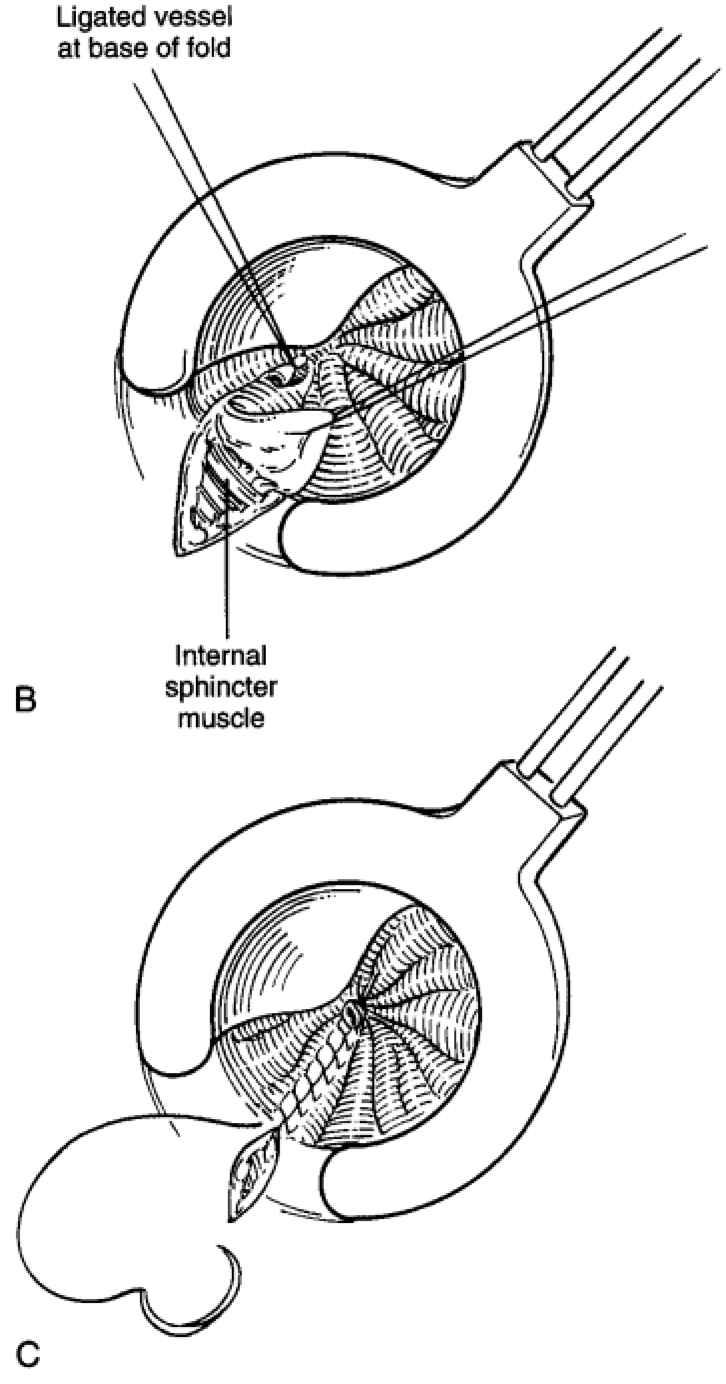

Vascular Surgery

Chapter 39 - Repair of Abdominal Aortic Aneurysm

EMBRYOLOGY

Clusters of angiogenic cells form bilaterally on the lateral sides of the splanchnic mesoderm, close to the midline. These clusters acquire a lumen and form the paired longitudinal vessels, called dorsal aortae. Initially these are continuation of the endocardial heart tubes, but with rotation of the cardiogenic plate, the proximal portion of the dorsal aortae becomes arched. During development, the dorsal aortae fuse to form a single vessel just caudal to the branchial arches. Several intersegmental arterial branches carry blood to the somites and their derivatives. In the abdomen, most of the dorsal segmental arteries become the lumbar arteries, but the fifth pair of intersegmental arteries becomes the common iliac arteries. The caudal portion of the dorsal aorta becomes the median sacral artery.

ANATOMY

The aorta enters the abdominal cavity through the diaphragm at the level of the 12th thoracic vertebra. It lies anterior to the vertebral bodies and bifurcates into two common iliac arteries at the level of the fourth lumbar vertebra. Lying on its right side is the inferior vena cava. The cisterna chyli lies between the aorta and the inferior vena cava at the level of the diaphragm. On the left side lies the left sympathetic trunk. From above and downward, the aorta is covered anteriorly by the peritoneal lining of the lesser sac, the pancreas and the splenic vein, the left renal vein, the third part of the duodenum, and the loops of small bowel.

The branches of the abdominal aorta can be divided into the following groups:

- Anterior vessel branches: celiac axis, superior mesenteric artery, and inferior mesenteric artery
- Lateral vessel branches: suprarenal arteries, renal arteries, and gonadal arteries
- Parietal branches: the phrenic arteries and four paired lumbar arteries
- Three terminal branches: one median sacral artery and two common iliac arteries at the level of the sacroiliac joints dividing into the internal and external iliac arteries

PREOPERATIVE PREPARATION

Once the decision has been made to electively repair an abdominal aortic aneurysm, pulmonary, renal, and cardiac function must be thoroughly evaluated. Pulmonary function tests are obtained, and preoperative therapy, including bronchodilators, is insti-tuted if needed. Cessation of smoking is encouraged, and the patient is taught incentive spirometry. If there is clinical evidence of cardiac dysfunction, cardiac echocardiography and thallium stress tests are obtained to assess perfusion and ventricular function. Baseline, complete blood count, electrolytes, blood urea nitrogen, creatinine, and coagulation pro-files are performed routinely. If a transabdominal aortic aneurysm repair is contemplated, the patient should be prepped with a modified Condon-Nichol bowel preparation.

Prophylactic antibiotics are administered. If preoperative cardiac work-up reveals ventricular dysfunction, the patient can be admitted preoperatively for insertion of Swan-Ganz catheter and optimization of cardiac function.

ANESTHESIA

The patient undergoes general anesthesia. An epidural catheter can be placed for postoperative pain management. A urinary bladder catheter, a nasogastric tube, and radial arterial lines are placed.

Operative Procedure

POSITION

The patient is placed in the supine position with both arms abducted at 90 degrees to allow access for the anesthesiologist. The lower chest, abdomen, and groin are scrubbed, prepped, and draped in sterile fashion.

INCISION

A vertical midline incision extending from the xiphoid to pubis is made.

EXPOSURE AND OPERATIVE TECHNIQUE

The abdominal cavity is entered in the usual fashion, and a thorough exploration is performed to exclude any unexpected lesions, particularly gastrointestinal malignancies. The patient is placed in a slight Trendelenburg position, and a self-retaining retractor system is arranged. The omentum and the transverse colon are retracted upward, and the small bowel is carefully packed in the right upper quadrant with the use of moist towels and appropriate retractors.

The peritoneal covering over the anterior surface of the aorta is opened using Metzenbaum scissors, and the opening is extended over both iliac arteries. Circumferential dissection is not required and is in fact not advised, because it may lead to injuries to the inferior vena cava and the iliac veins. Both ureters are identified and protected from injury. The extent of the aneurysm and the status of the iliac arteries are assessed, and a decision is made to proceed with either a simple tube graft or an aortic bifurcation graft.

The anesthesiologist is instructed to administer a 5000-unit bolus of intravenous heparin. After this, the iliac arteries are cross-clamped to prevent distal embolization. Attention is now directed to exposing the neck of the aneurysm proximally. Division of the ligament of Treitz and the inferior duodenal attachments greatly facilitates this procedure. This dissection is continued until the left renal vein is exposed. The renal vein can be retracted upward to expose the neck of the aneurysm. If necessary, the renal vein can be transected close to the inferior vena cava if the neck of the aneurysm extends beneath this vein. Dividing the renal vein close to the vena cava preserves drainage through the gonadal and adrenal veins. The inferior mesenteric artery is identified, is carefully dissected, and can be divided if necessary. If the inferior mesenteric artery is large and a major contributor to the blood supply of the left colon, it may need to be reimplanted.

After informing the anesthesiologist, the operator cross-clamps the aorta in an anteroposterior direction (Fig. 39–1 *A*). A longitudinal arteriotomy is made along the aneurysm, and the aortic wall is opened like a book with horizontal incisions proximally and distally. The contents of the aneurysm, which includes atheromatous material and clots, are bluntly but meticulously extracted. Bleeding from paired lumbar arteries is controlled with figure-of-eight sutures using 2-0 polypropylene monofilament sutures (Fig. 39–1 *B*). Because the posterior wall of the aneurysm is left undisturbed, bleeding from lumbar veins is minimized. Normally, if the distal aorta is not aneurysmal, a tube graft is an appropriate choice. If the aneurysm extends to the level of the bifurcation, the common iliac arteries are prepared in a similar fashion, leaving the posterior wall intact. Likewise, if the distal aorta and the iliac vessels are aneurysmal, a standard aortobifemoral graft should be chosen. In this case the orifices of both iliac arteries are closed from within using 2-0 polypropylene

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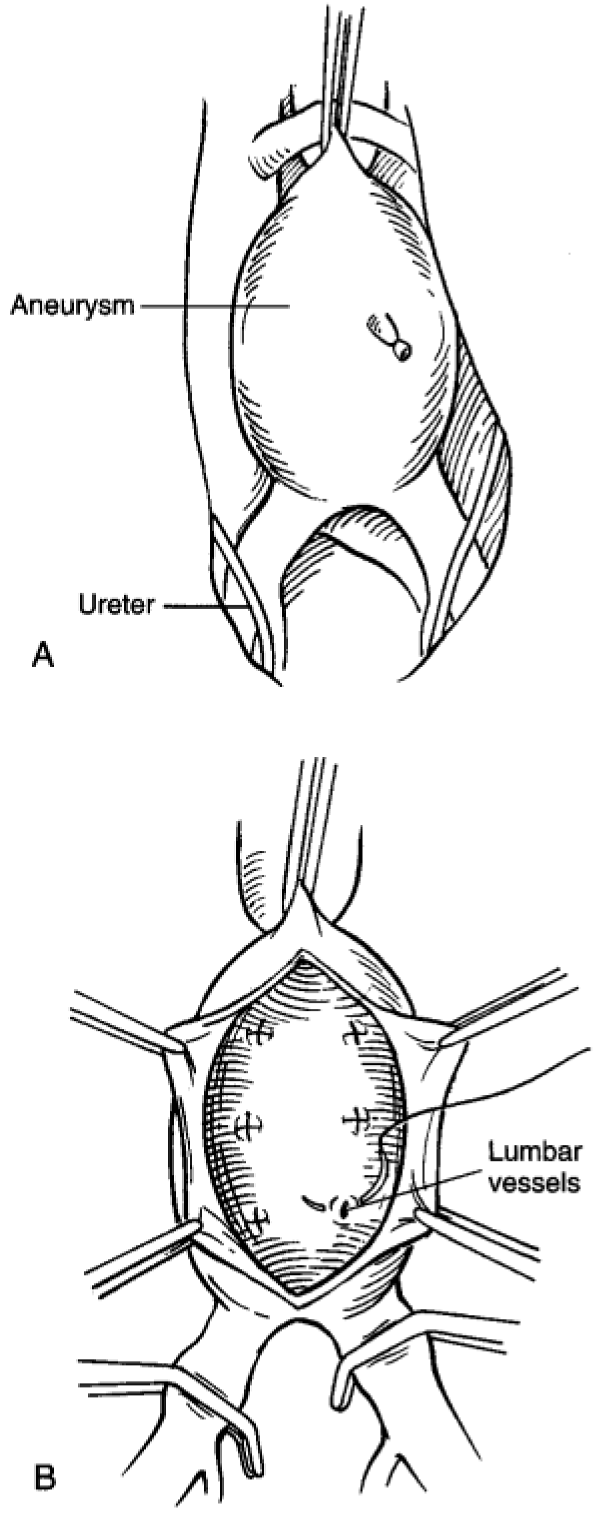
Figure 39-1 *A*, The neck of the aneurysm is cross-clamped below the renal vein. *B*, Bleeding from the lumbar arteries is controlled with figure-of-eight sutures. *C*, After the aneurysm is opened like a book, the graft is sutured. The renal vein can be seen retracted upward.



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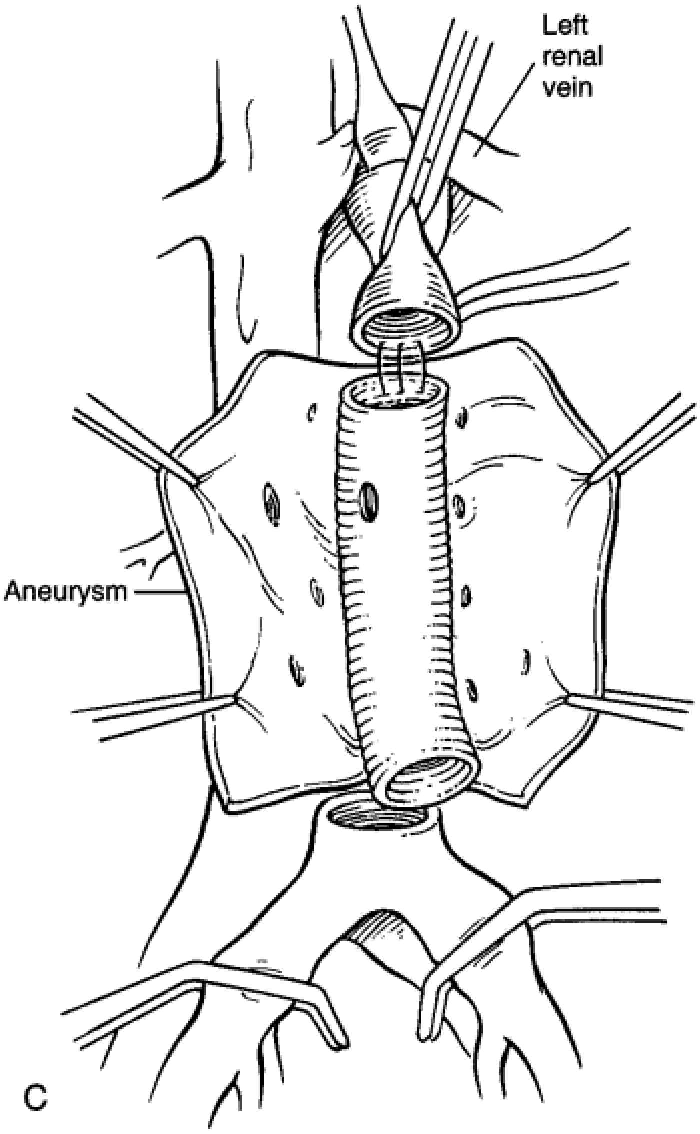


Figure 40 - 1 Incisions used for exposure of the femoral and popliteal vessels to perform femoropopliteal bypass.

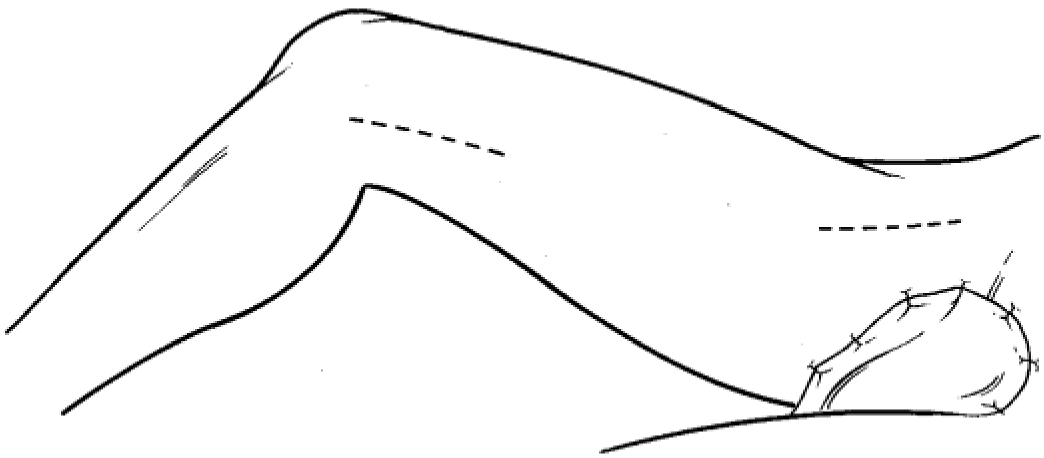


Figure 40 - 2 *A*, Exposed common femoral artery and its branches, superficial and profunda femoris artery. *B*, Exposure of the popliteal artery.

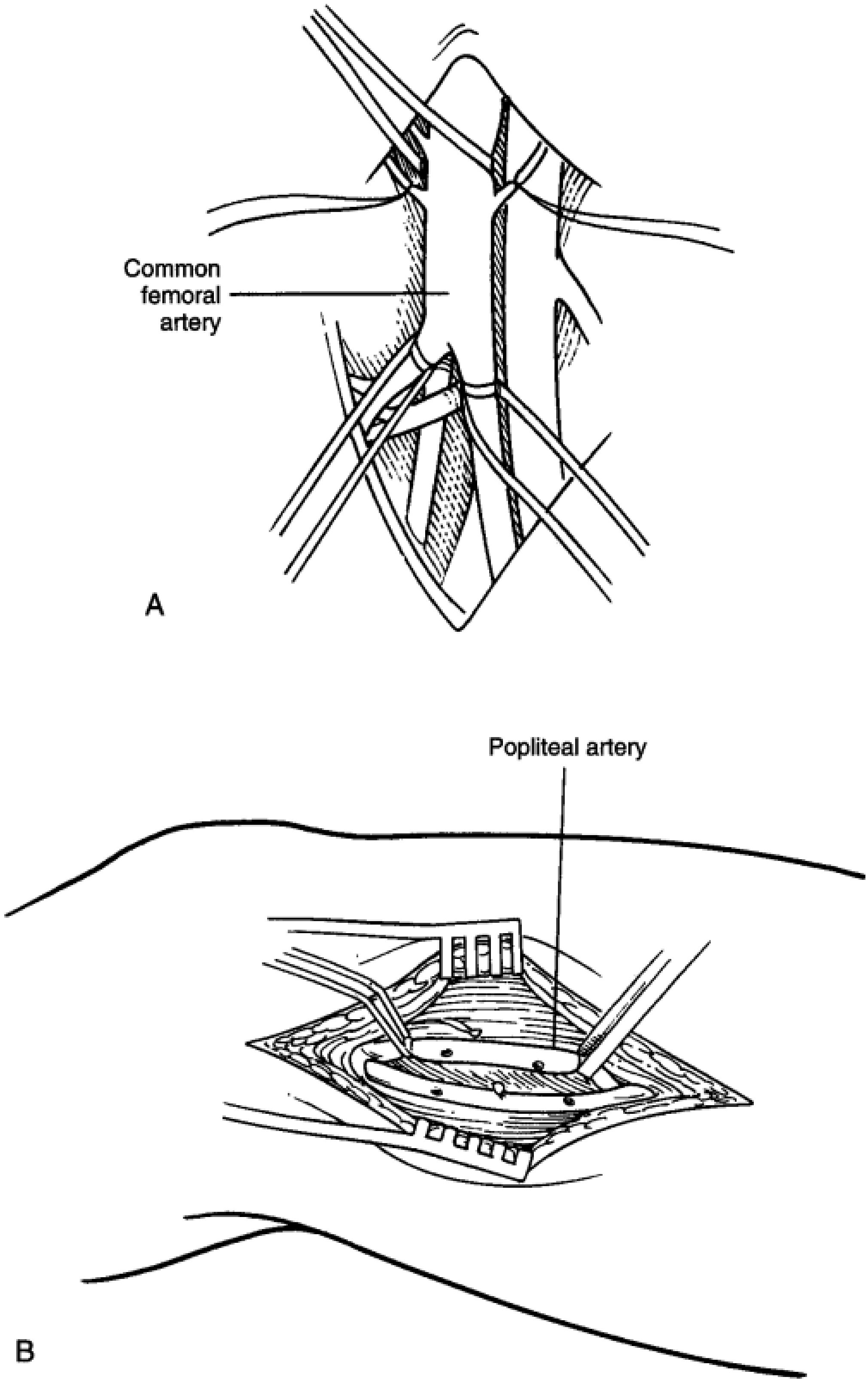


Figure 40-3 Completed femoropopliteal bypass showing the end-to-side proximal and distal anastomoses.

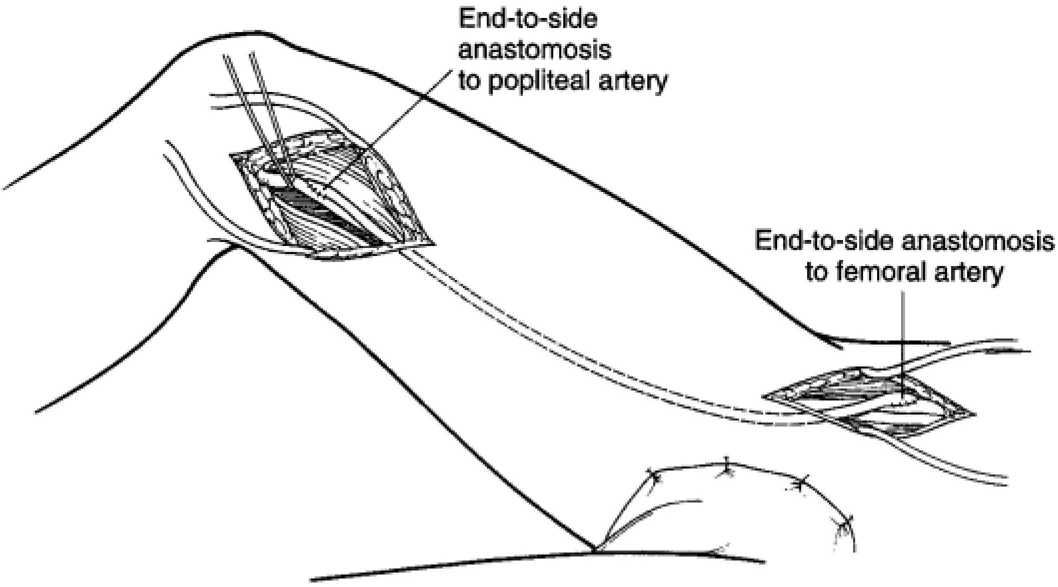


Figure 41 - 1 *A*, Saphenofemoral junction with tributaries entering the proximal aspect of the greater saphenous vein. *B*, The olive head of the Goldman stripper emerging through the open end of the greater saphenous vein in the groin.

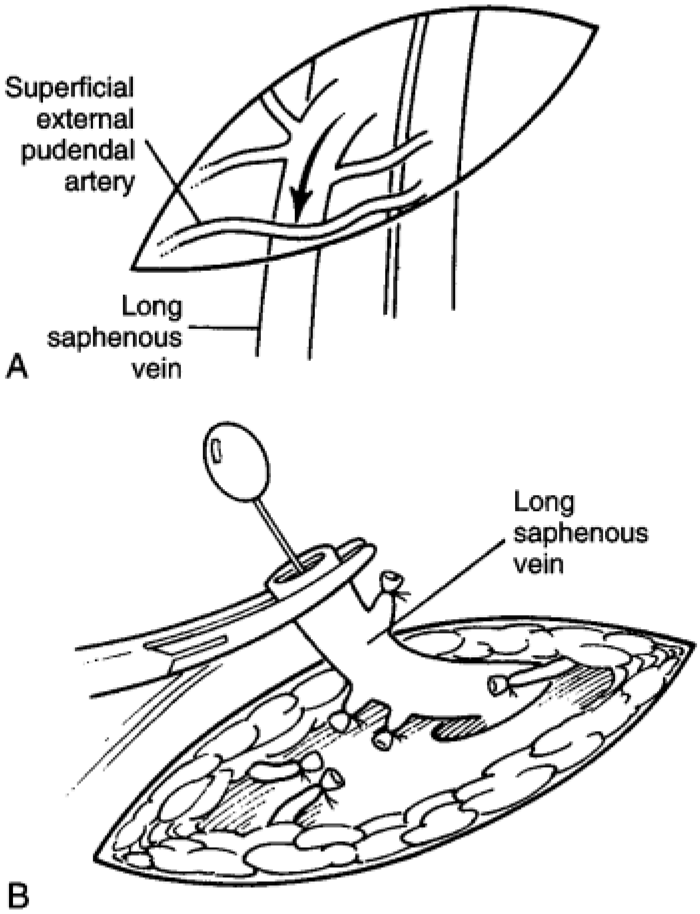


Figure 41 - 2 Through small stab incisions the varicosed veins are lifted out of the wound and avulsed.

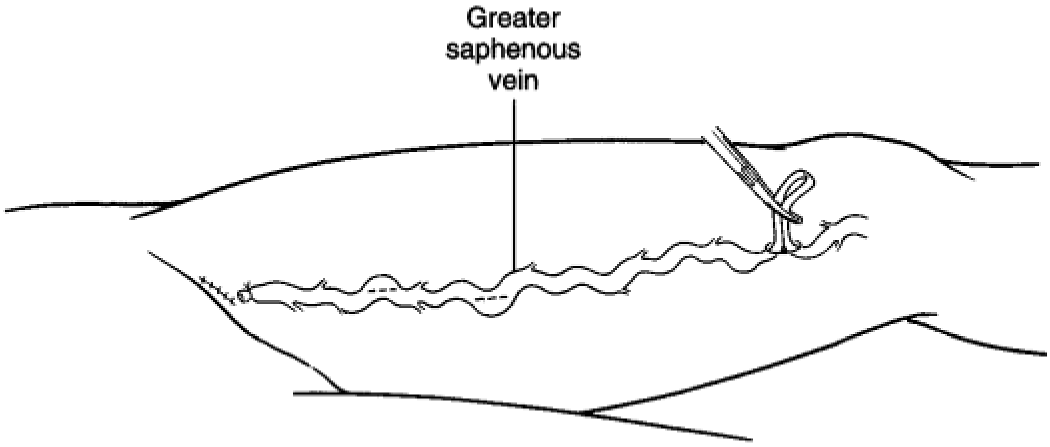


Figure 42-1 Cross-section of the lower extremity at the level of the thigh (*A*) and calf (*B*).

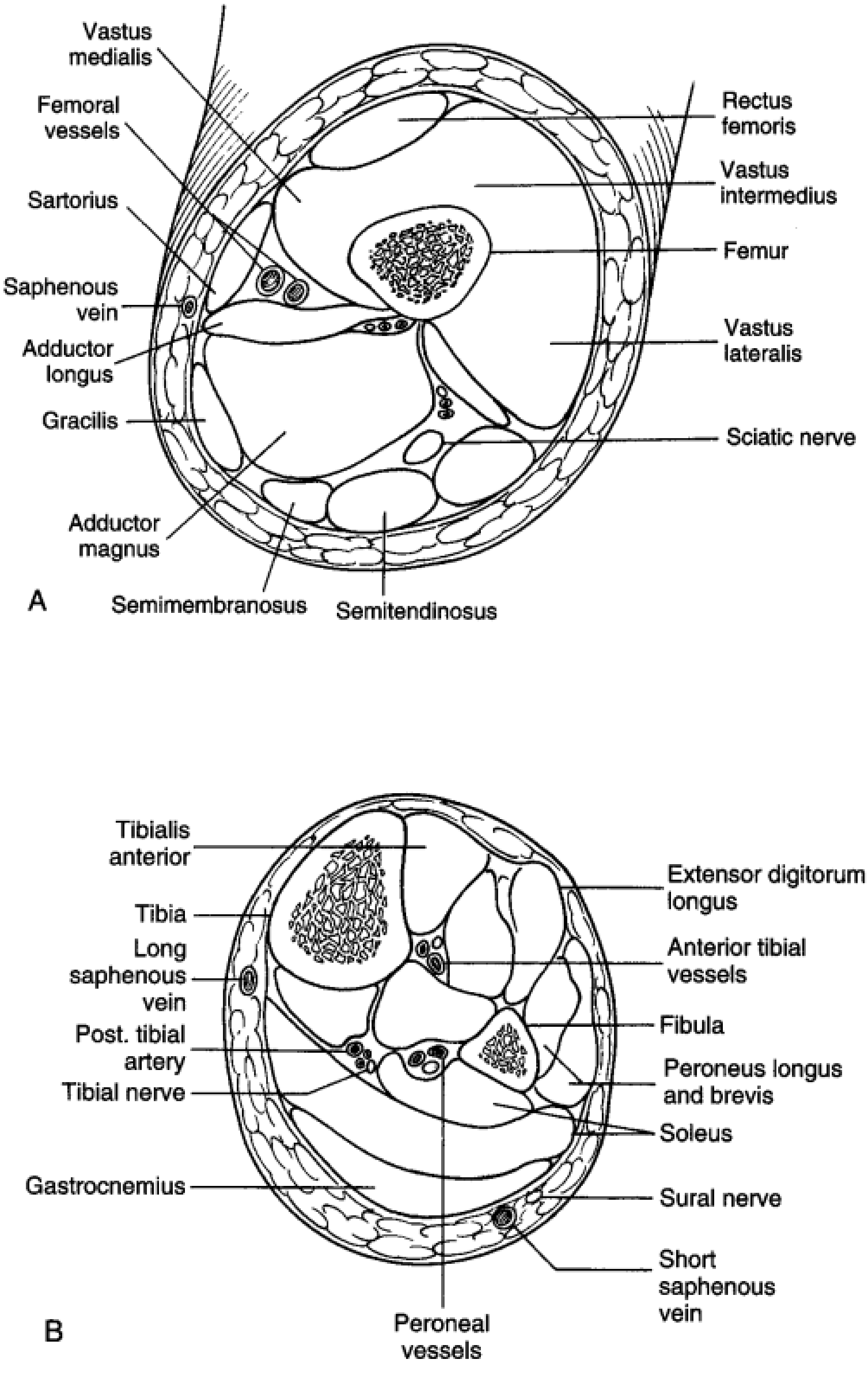


Figure 42-2 Incisions used for above-knee and below-knee amputations.

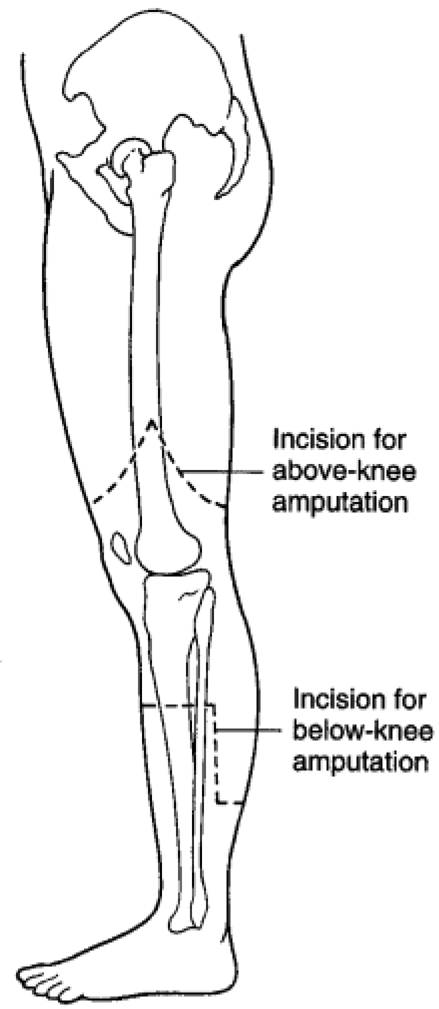
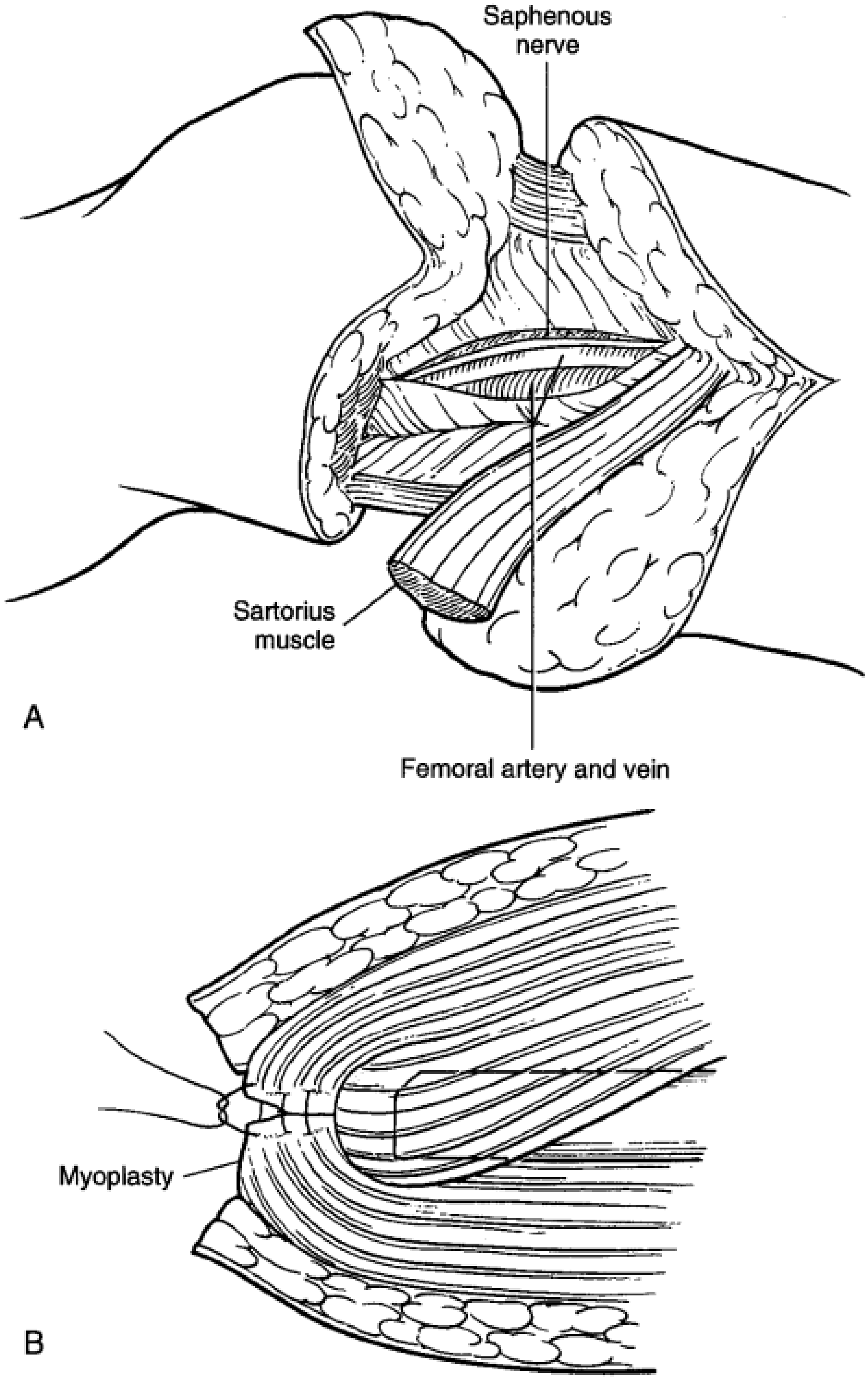


Figure 42-3 *A*, Identification of the femoral vessels and saphenous nerve after division of the sartorius muscle. *B*, Approximation of the divided muscles. *C*, Skin closure with interrupted mattress suture after placement of a closed suction drain.



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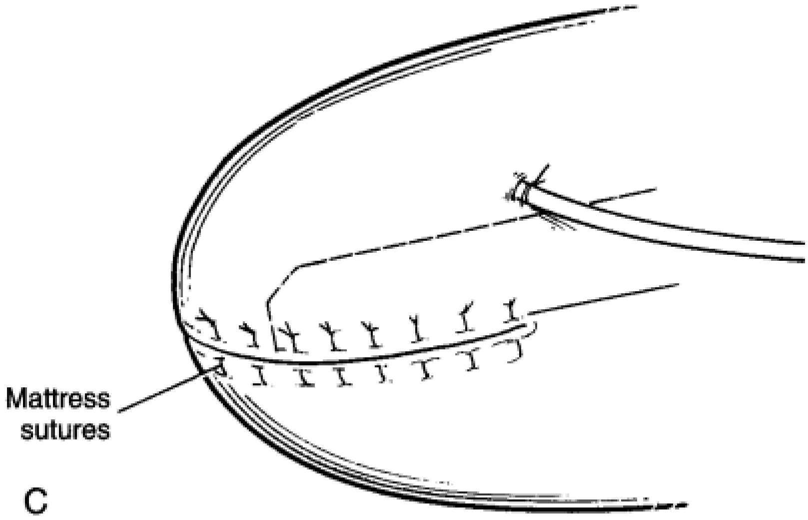


Figure 42-4 *A*, An anterior bevel of 45 degrees cut in the divided tibia. *B*, Division of the posterior tibial vessels after the tibia and fibula have been divided. *C*, Skin closure of the stump.

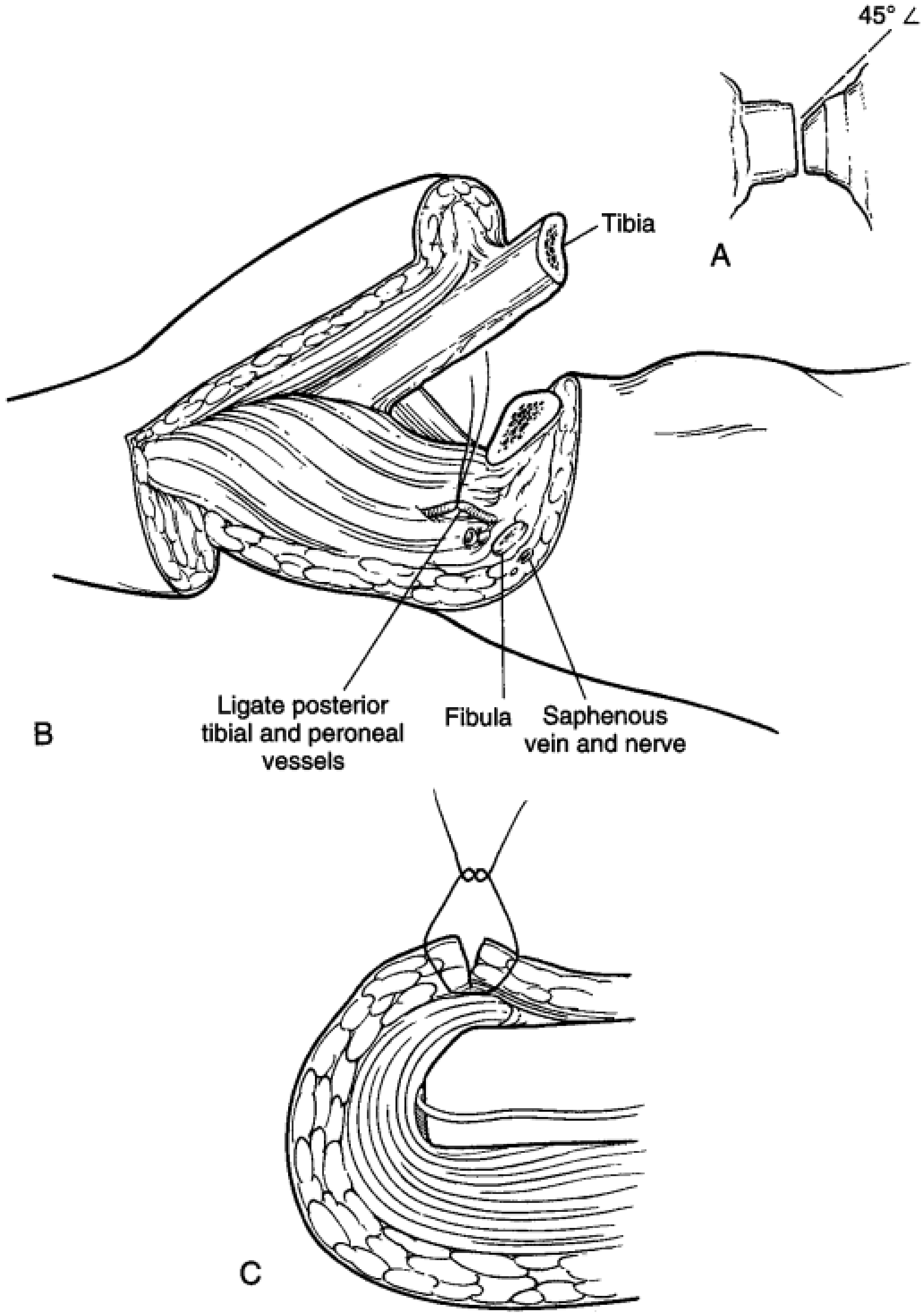


Figure 43-1 Standard incision along the anterior border of the sternocleidomastoid (SCM) muscle.

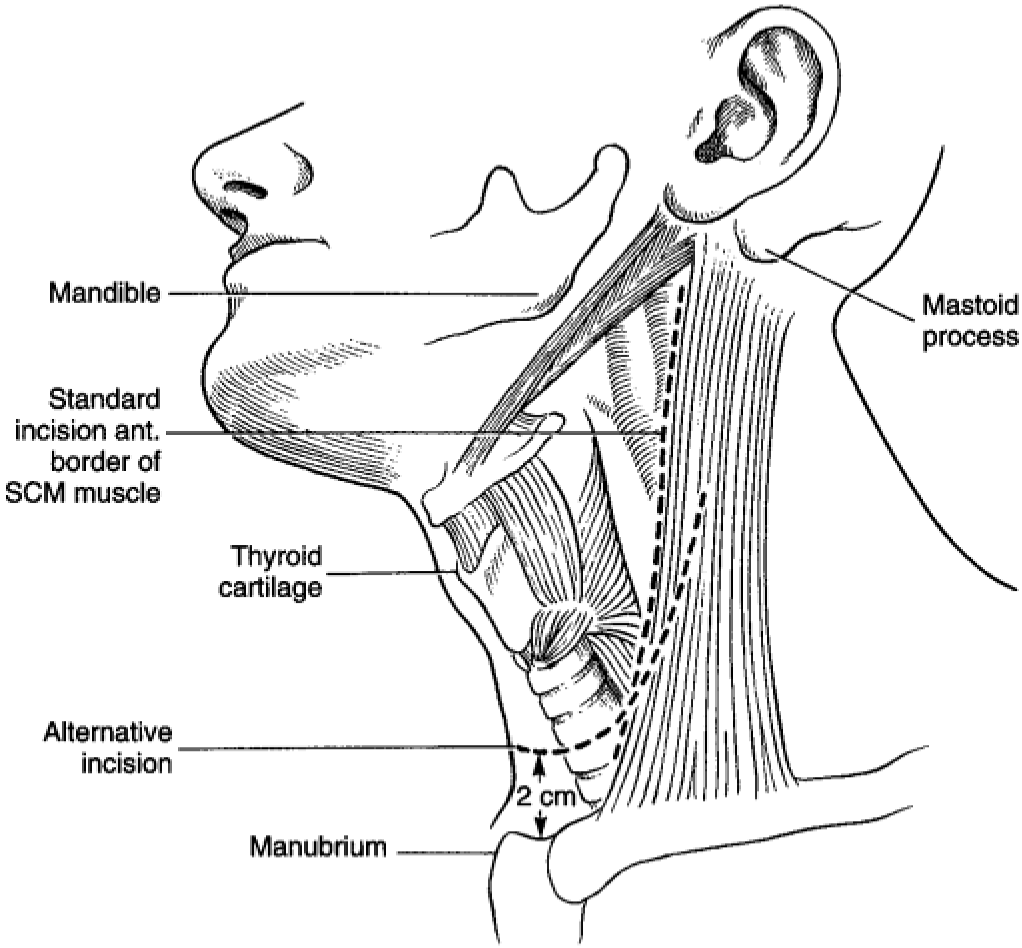


Figure 43-2 The common carotid and both the internal and external carotid arteries are carefully exposed. The hypoglossal nerve with the divided ansa hypoglossi and the vagus nerve can be seen.

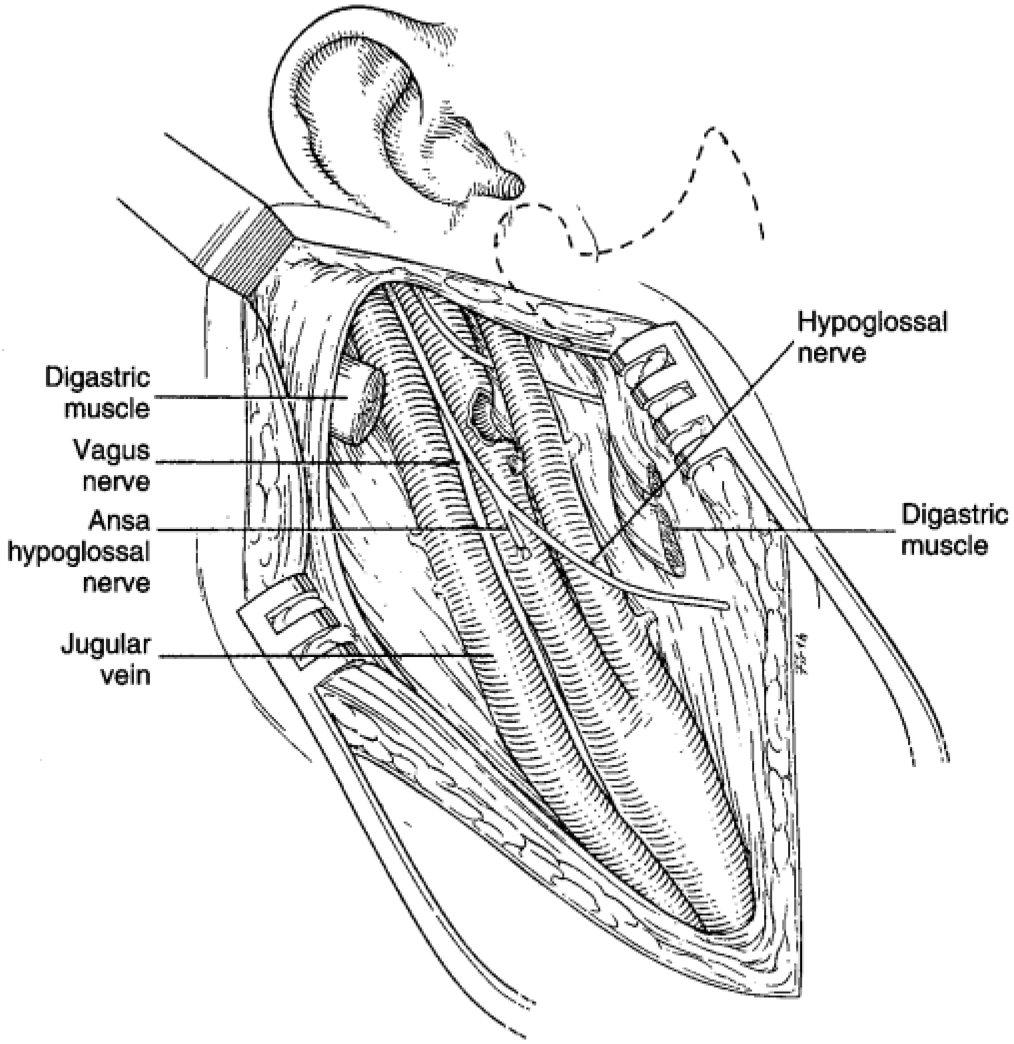


Figure 44-1 *A*, Common femoral artery and the terminal branches are controlled with vascular clamps. A Fogarty embolectomy catheter is passed proximally through the arteriotomy.

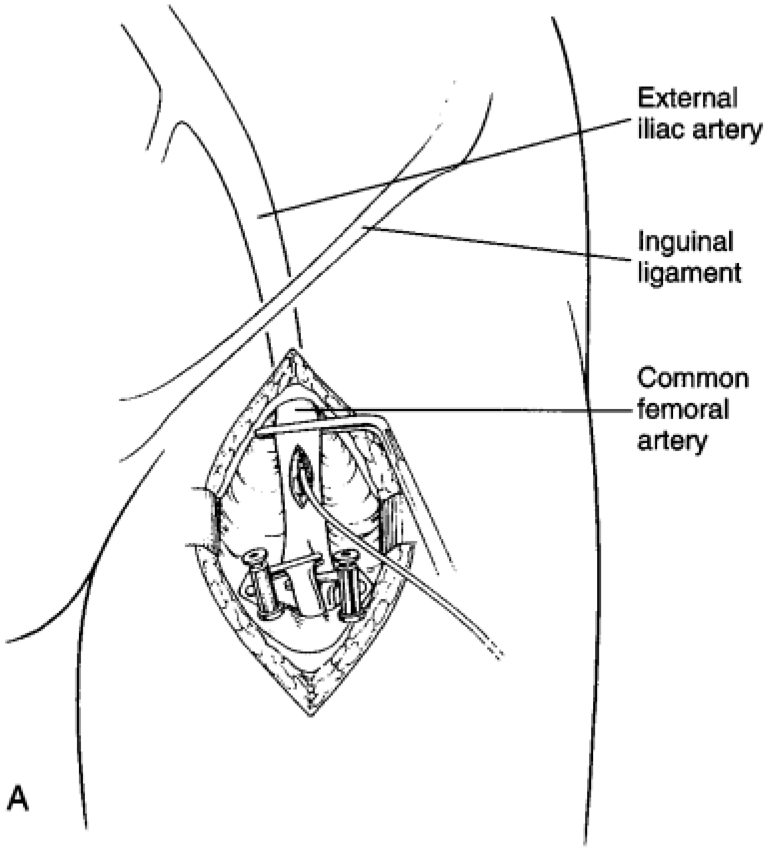
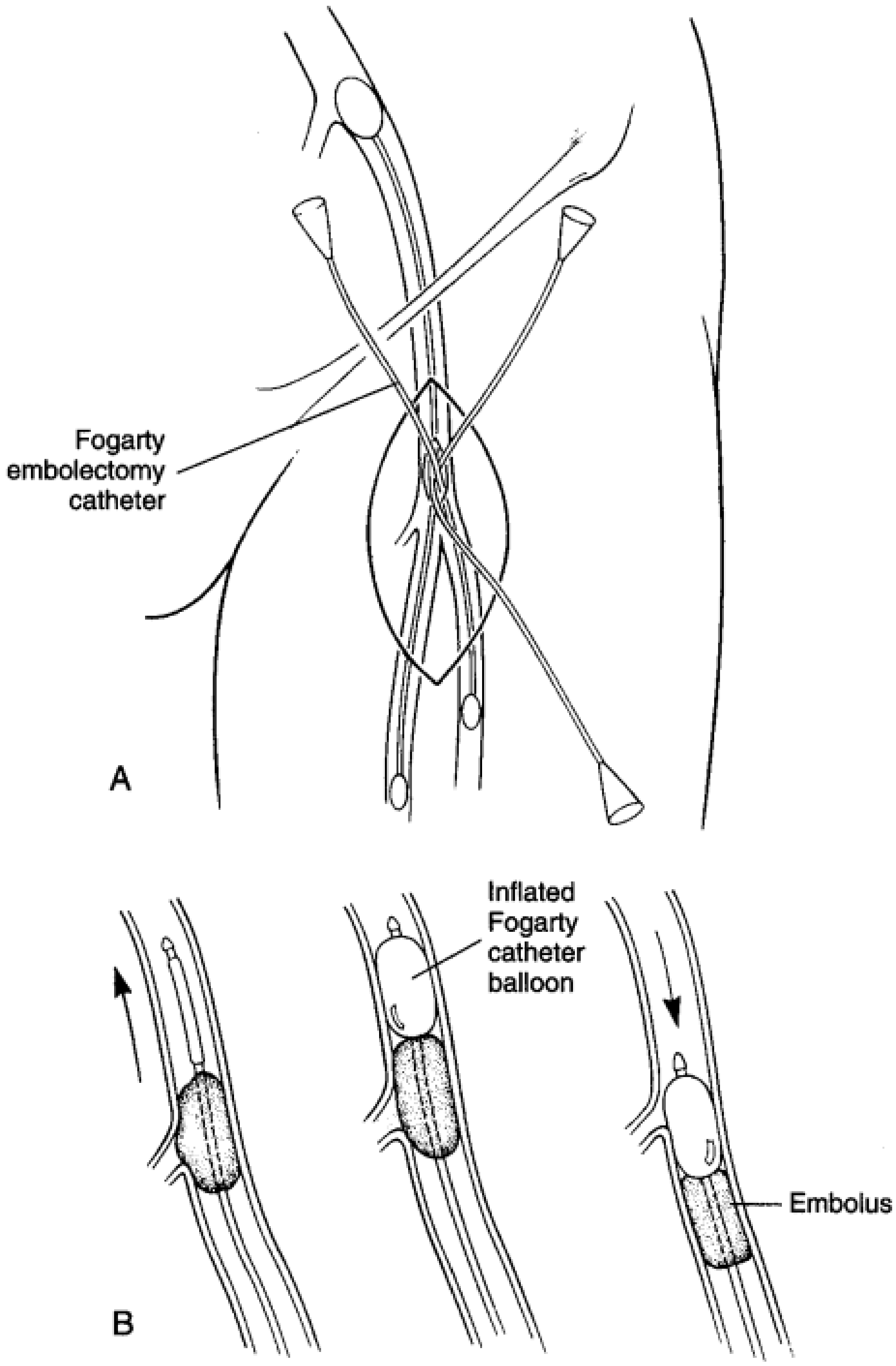


Figure 44-2 *A*, Fogarty embolectomy catheters of various sizes should be available to perform embolectomy. *B*, The balloon is inflated and the catheter is withdrawn to dislodge and remove the embolus.



Urology

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Chapter 45 - Nephrectomy

EMBRYOLOGY

The genitourinary system is derived from the intermediate mesoderm and shows three stages of development:

1. *Pronephros:* Develops during the third week but is a nonfunctional system, and by the fourth week all the indications of the pronephric system have disappeared.
2. *Mesonephros:* Develops during the fourth week and replaces the vestigial pronephros. It functions as an interim structurally simple kidney until the permanent kidneys are formed from the metanephros (see below).
3. *Metanephros:* Develops during the fifth week of gestation and forms the permanent kidney, which arises in the lower lumbar and sacral regions.

At the terminal end of the mesonephric duct, an outgrowth called the ureteric bud appears and ascends along the pathway by which the mesonephric duct had descended. The ureteric bud penetrates the metanephros (condensation of mesoderm), which forms the metanephric cap. The distal end of the ureteric bud subsequently dilates, forming the primitive pelvis. Simultaneously, the primitive pelvis splits into cranial and caudal portions that divide and further subdivide to give rise to major and minor calyces. At the blind end of the minor calyces, collecting ducts are formed. At the distal end of the collecting ducts there is a metanephric tissue cap that under the influence of the tubule moves laterally to form renal vesicles. At the medial end, the vesicle becomes associated with the collecting tubule and breaks into it. The lateral end is invaginated by a small capillary

loop, thus forming Bowman's capsule. The rest of the vesicle forms the proximal and distal convoluted tubules and the loop of Henle, thus resulting in a functioning kidney. The metanephros, which is initially located in the kidney, later ascends to a more cranial position—the ascent of the kidney. This migration is thought to occur due to diminution of the body curvature and the increased growth in the lumbar and the sacral regions. The metanephros derives its blood supply from the common iliac artery and subsequently directly from the aorta as the kidney ascends. The lower vessels degenerate, although they may persist as supernumerary renal arteries. Initially, the renal hilum is directed ventrally, but as the kidney ascends it rotates medially and the hilum points anteromedially.

ANATOMY

Both kidneys are retroperitoneal organs that lie on the posterior abdominal wall. The kidney and the associated structures are outlined in Figure 45–1 . Each kidney lies obliquely, with the upper pole being nearer to the midline than the lower pole. Because of the presence of the liver on the right side, the right kidney is located slightly lower than the

Figure 45-1 Anatomy of the kidney and the associated structures.

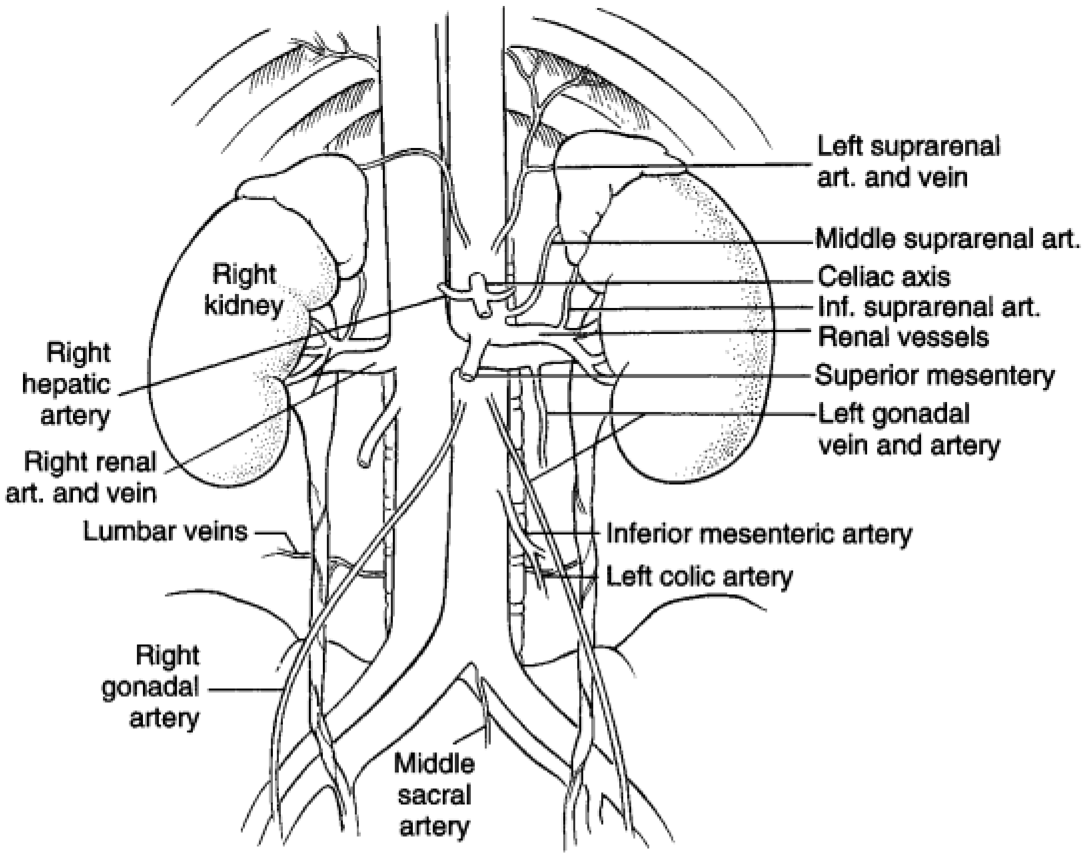


Figure 45-2 *A*, Flank incision for simple nephrectomy showing the latissimus dorsi and external oblique muscles to be divided. *B*, Hilar dissection showing a vessel loop elevating the renal vein to provide access to the renal artery. *C*, Technique of ligating the vessels in continuity and placing a transfixion suture.

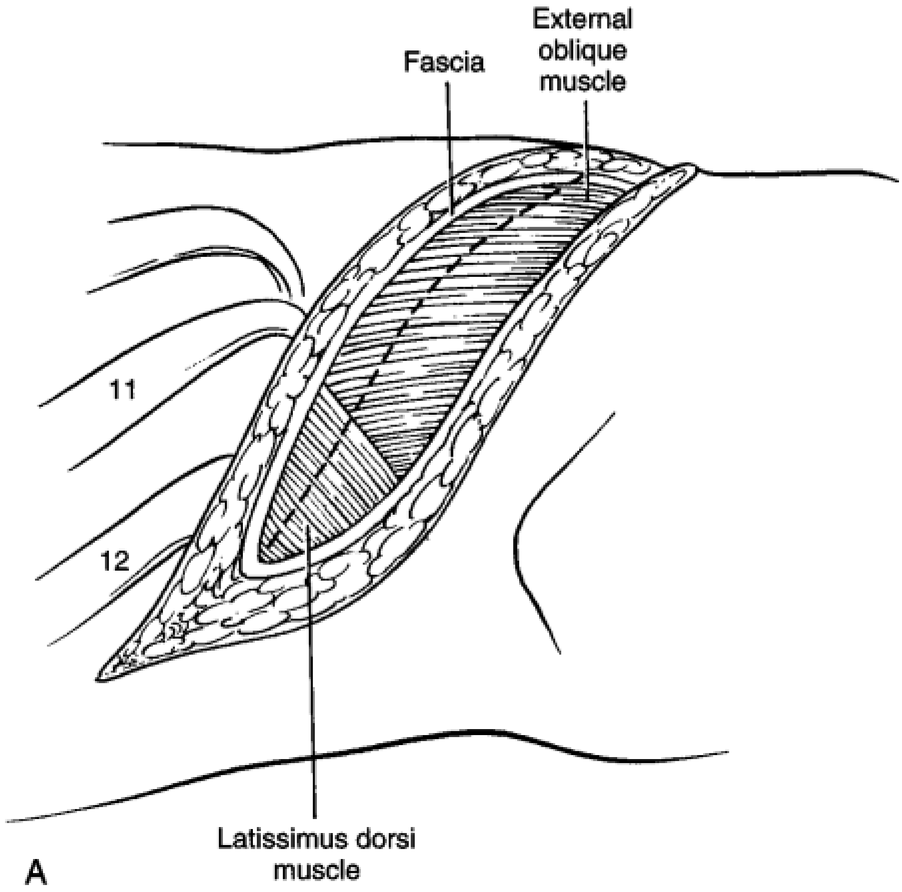


Figure 45-2 *A*, Flank incision for simple nephrectomy showing the latissimus dorsi and external oblique muscles to be divided. *B*, Hilar dissection showing a vessel loop elevating the renal vein to provide access to the renal artery. *C*, Technique of ligating the vessels in continuity and placing a transfixion suture.

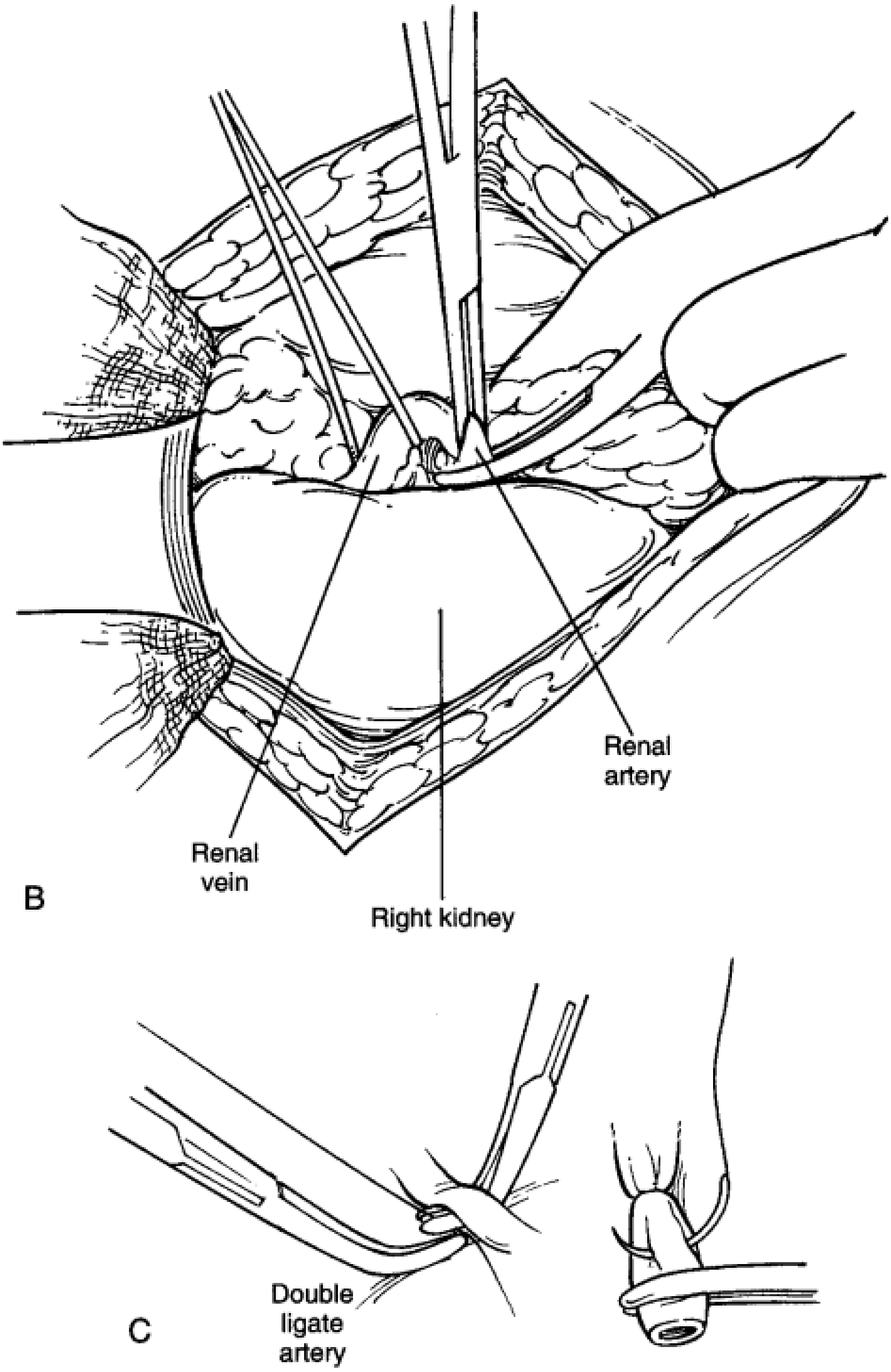


Figure 46-1 The spermatic cord is clamped at the level of the internal ring and then the testis delivered from the scrotum into the wound.

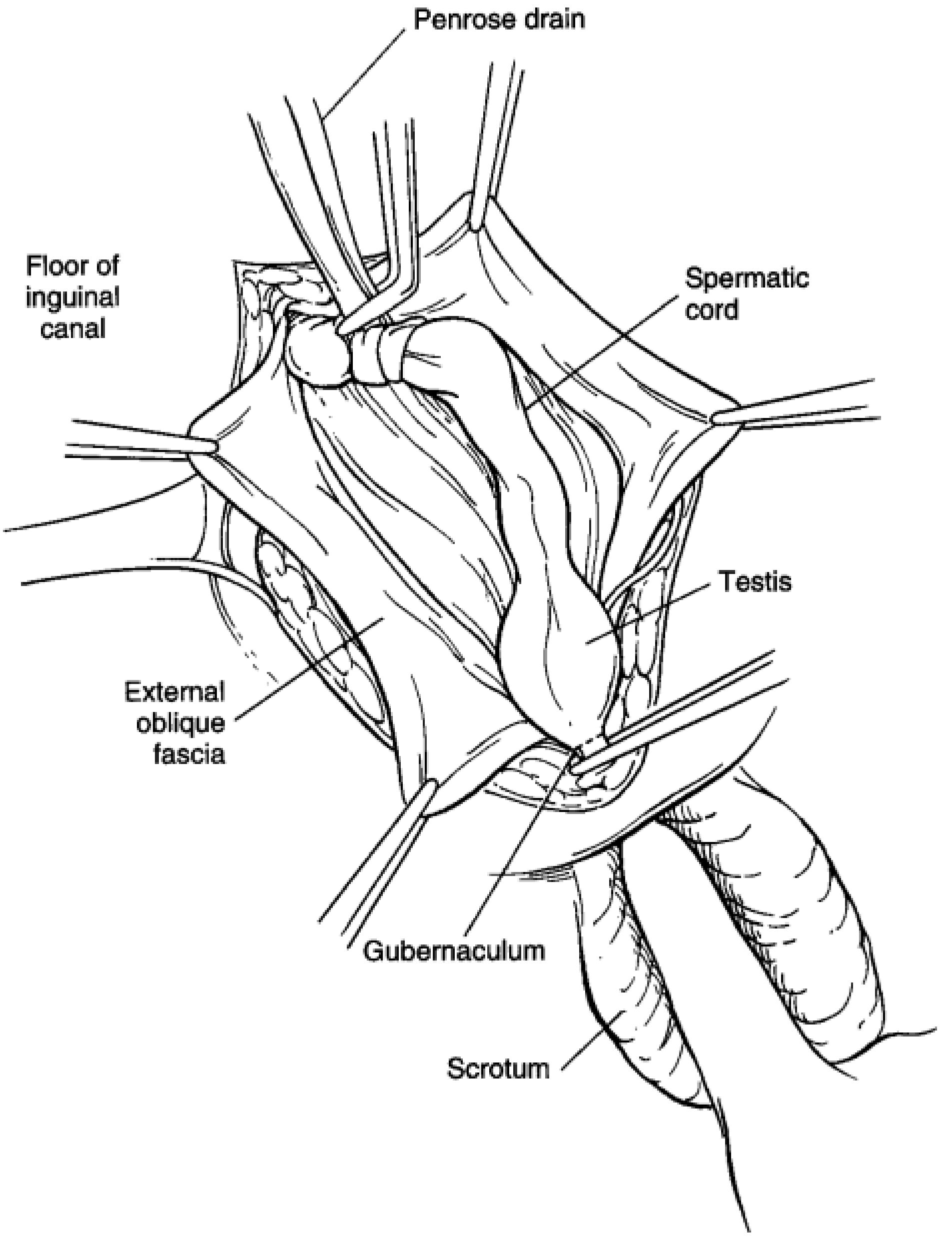


Figure 47 - 1 Incision used for orchidopexy.

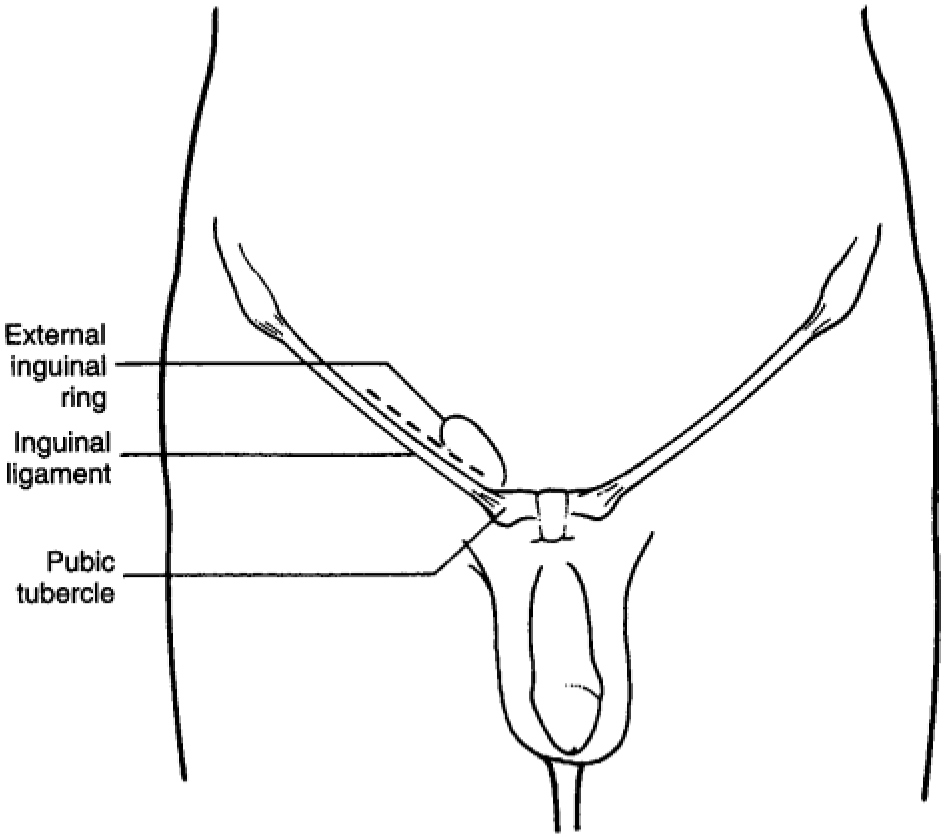


Figure 47-2 Mobilized testis and the spermatic cord seen within the inguinal canal.

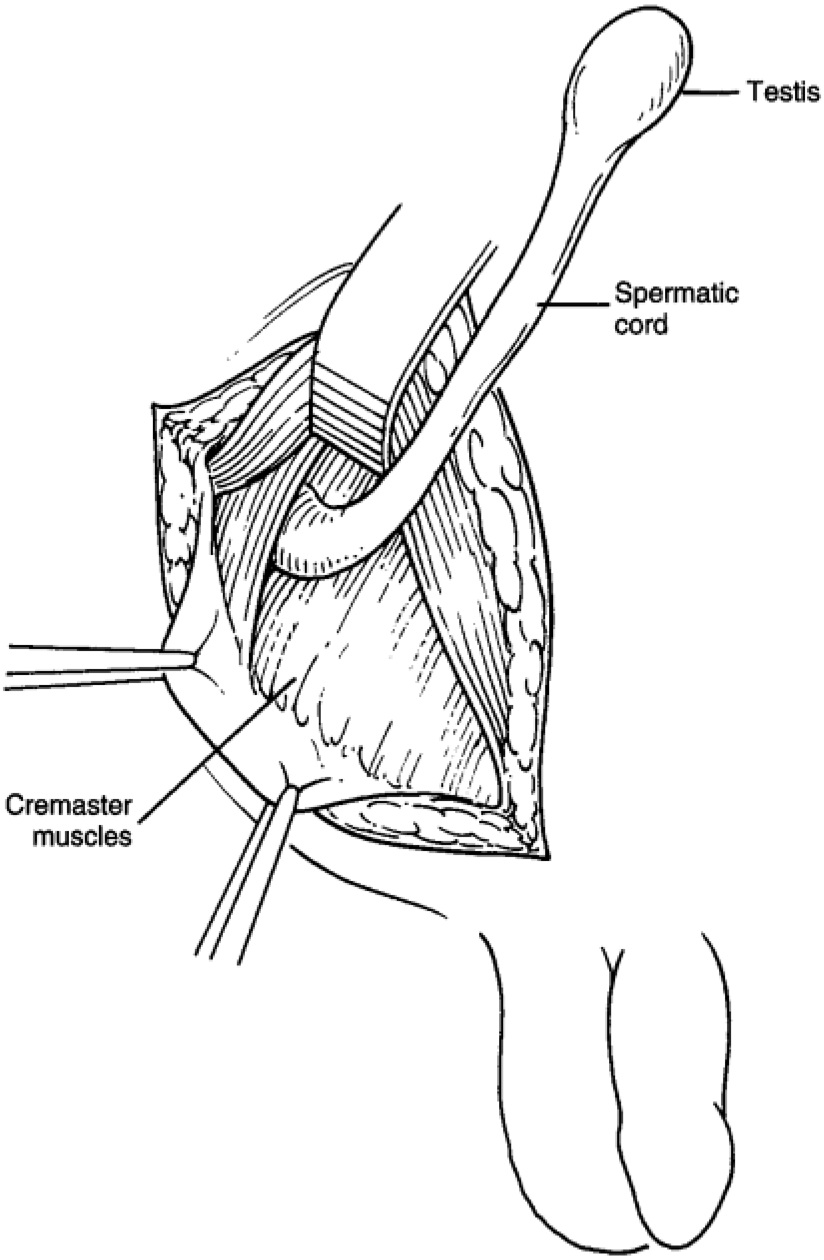


Figure 47-3 *A*, A finger is passed into the scrotum though the inguinal wound. *B*, The testis is anchored in a subdartos pouch.

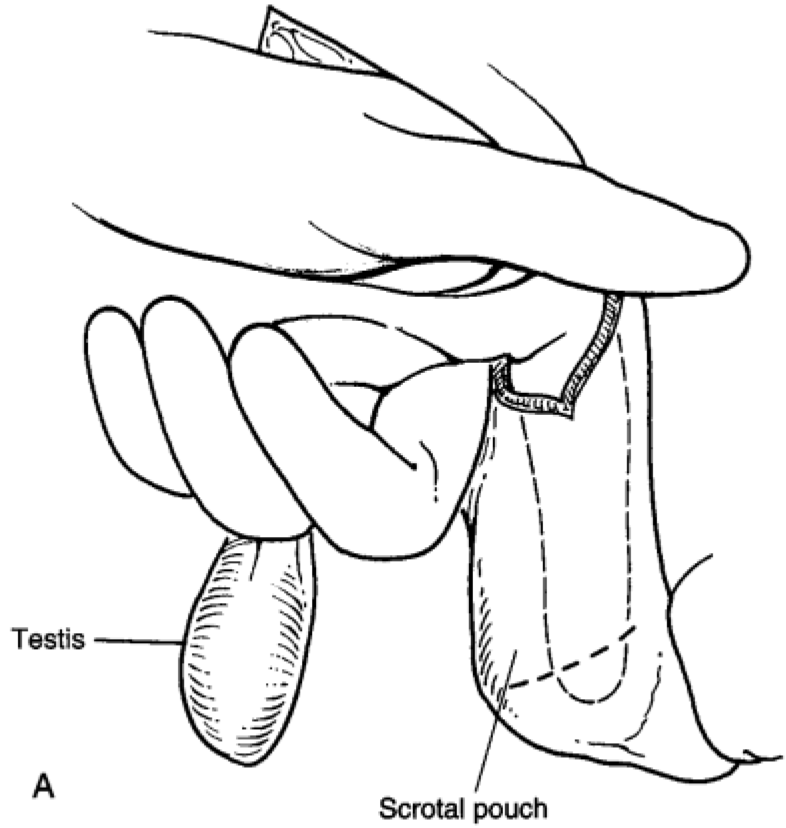


Figure 47-3 *A*, A finger is passed into the scrotum though the inguinal wound. *B*, The testis is anchored in a subdartos pouch.

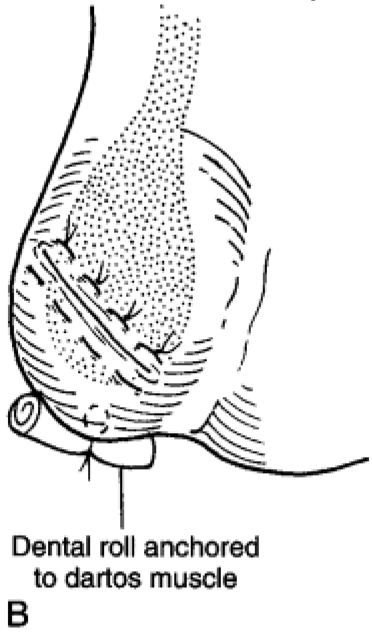


Figure 48-1 *A*, The lateral pedicle of the bladder has been divided and ligated. The left ureter has been tunneled under the sigmoid mesocolon to lie adjacent to the right ureter. *B*, The ends of the ureters are spatulated and then sutured together.

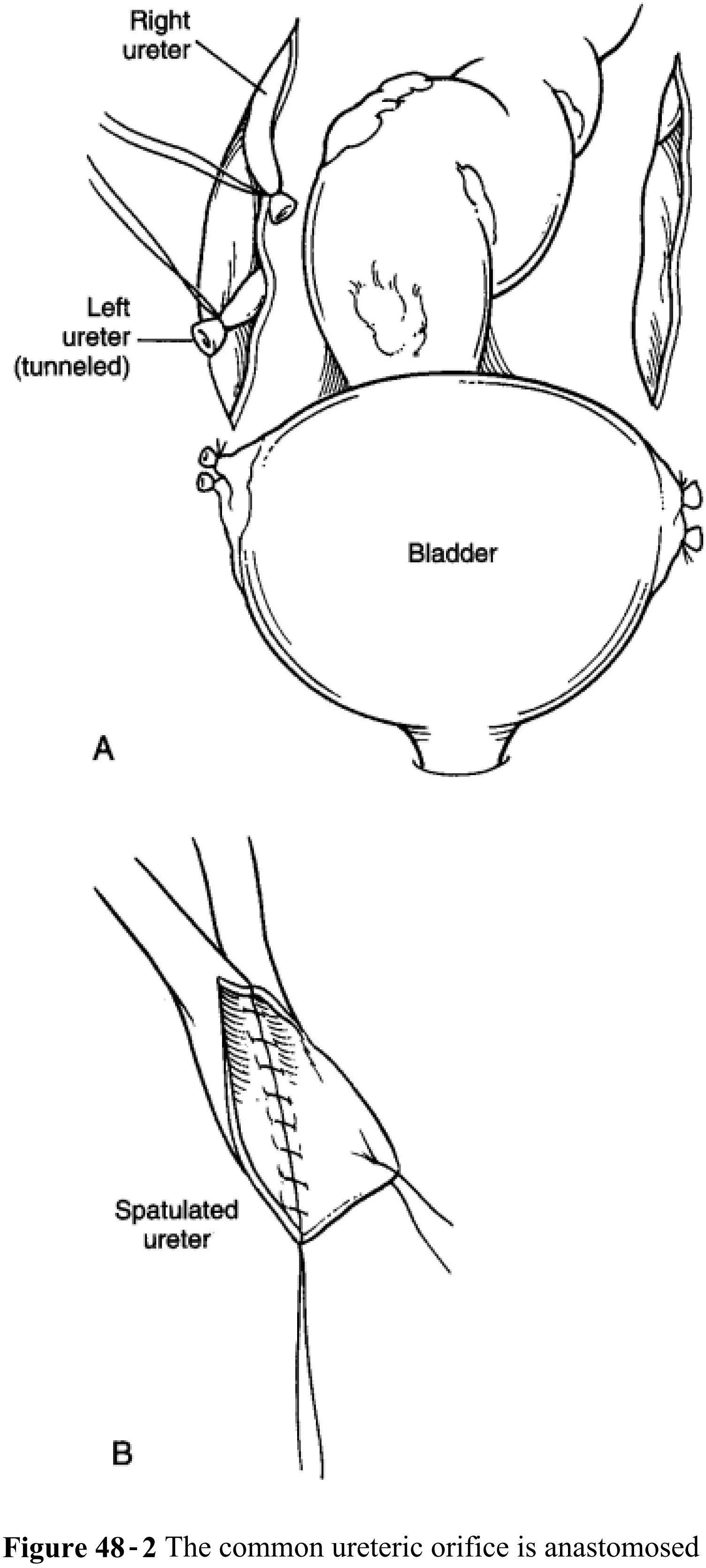


Figure 48-2 The common ureteric orifice is anastomosed to the ileal loop with stents in place. The ileal loop is brought through the anterior abdominal wall as Brook's ileostomy.

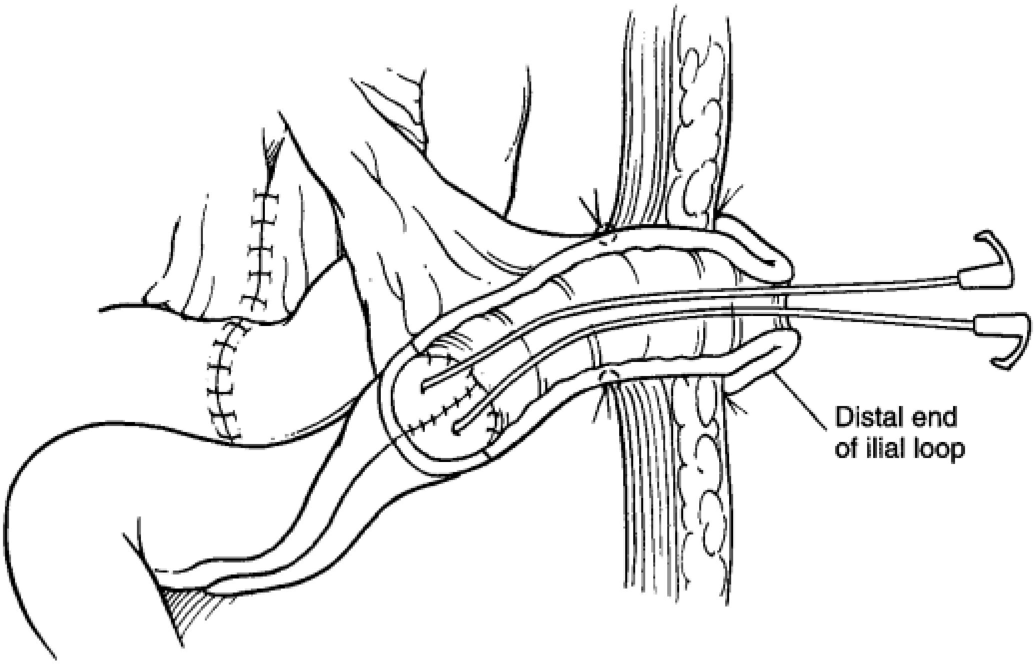
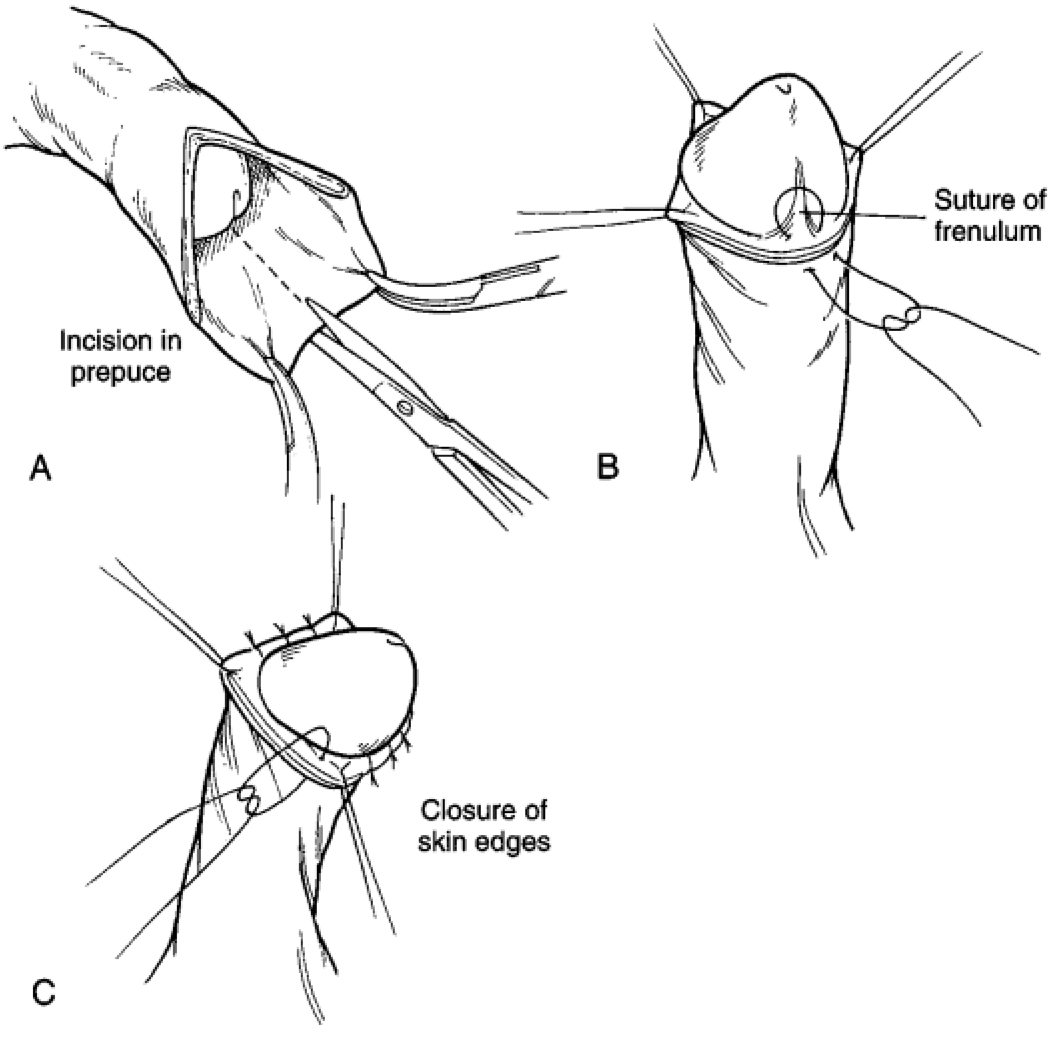


Figure 49-1 *A*, With a fine-curved scissors, a dorsal slit is made down to the level of the coronal sulcus. *B*, The frenular vessel is ligated with 3-0 absorbable suture. *C*, The skin is aligned to the mucosa, and these two layers are sutured together with interrupted 3-0 absorbable suture such as plain catgut.



Gynecology

Chapter 50 - Total Abdominal Hysterectomy

EMBRYOLOGY

The müllerian or paramesonephric duct arises as a longitudinal invagination of the coelomic epithelium on the anterolateral surface of the urogenital ridge. Caudally, the two müllerian ducts grow in the medial direction and fuse together in the midline to form the uterine canal, which continues to grow in a caudal direction. At the point where it comes in contact with the posterior wall of the urogenital sinus (pelvic part), it causes a small swelling, called the müllerian tubercle. The fused common duct gives rise to the body and cervix of the uterus. The horizontal part of the müllerian duct just proximal to the fusion develops into the uterine tubes.

Shortly after formation, the müllerian tubercle begins to proliferate to form the sinovaginal bulb (vaginal plate). This solid plate encircles the caudal end of the fused müllerian ducts and increases in length. The vaginal plate develops a lumen at its caudal end, and by the fifth month of development the entire plate has canalized. The part surrounding the caudal end of the uterus (i.e., cervix) forms the vaginal fornices. The lumen of the vagina remains separated from that of the urogenital sinus by a thin tissue plate, known as the hymen.

ANATOMY

The uterus is a pear-shaped organ lying within the pelvic cavity between the rectum posteriorly and the bladder anteriorly. In its usual anteverted position, the uterus is directed forward with its long axis at 90 degrees

to the vagina. The uterus is divided into a fundus, body, and cervix. The segment of the uterus that lies above the entry of the fallopian tube is known as the fundus. The body is the main part of the uterus and has a cavity, which is triangular in the coronal section. The body of the uterus is continuous inferiorly with the cervix. The convex cervical canal communicates superiorly with the cavity of the uterine body with the vagina through the external os. The entire uterus is covered with peritoneal lining except anteriorly, where at the level of the internal os the peritoneum passes forward onto the superior surface of the bladder. The peritoneum drapes laterally over the fallopian tubes and passes laterally to the lateral pelvic wall to form the broad ligaments of the uterus. The uterus is supported primarily by the levator ani muscles and by three paired ligaments: the uterosacral, the lateral cervical (cardinal), and the pubocervical ligaments. The round ligament of the uterus is a remnant of the gubernaculum and extends from the superolateral angle of the uterus through the broad ligament and the internal ring to end in the labium majus.

The uterus receives its blood supply from the uterine artery, a branch of the internal iliac artery that runs medially in the base of the broad ligament and crosses above the ureter at the level of the internal os. The artery then extends, within the broad ligament, along the lateral border of the uterus to anastomose with the ovarian artery. Venous drainage is via the uterine and internal iliac veins. Lymphatic drainage is primarily to the external and common iliac nodes. However, some lymphatics vessels also drain along the round ligament to the superficial inguinal nodes, and others drain with the ovarian vessels into the para-aortic nodes. The nerve supply of the uterus is derived from branches of the pelvic plexus.

PREOPERATIVE PREPARATION

The cardiovascular and respiratory systems must be adequately evaluated. Perioperative antibiotics are administered. General anesthesia is provided with endotracheal intubation. A nasogastric tube and Foley catheter are inserted. If preoperative work-up reveals an extensive pelvic inflammatory process that may make identification of the ureters difficult, perioperative placement of ureteral stents should be considered. Because the vagina will be entered during the procedure, it is cleansed with dilute Betadine solution. Perioperative administration of 5000 units of heparin subcutaneously and the use of sequential pneumatic compression devices are recommended for prevention of deep vein thrombosis.

Operative Procedure

POSITION

The patient is usually placed in the supine position, and because access to the vagina from below may be required, the legs are placed on stirrups.

INCISION

A low midline incision extending from the pubis to just above the umbilicus is made, and the abdominal cavity is entered.

EXPOSURE AND OPERATIVE TECHNIQUE

After a systematic exploration of the abdominal cavity, the patient is placed in the Trendelenburg position. A self-retaining retractor system is placed for exposure. The small bowel is packed superiorly to provide adequate exposure of the pelvic structures. Straight Kocher clamps are placed across the cornual portion of the uterus such that they occlude the round ligament, fallopian tube, and uterine and ovarian vessels. Using these clamps the uterus is retracted upward, thus placing the structures within the broad ligament under tension. The round ligament is divided, and the proximal end is ligated with 0-0 silk sutures. These sutures are tagged with a hemostat to provide lateral traction (Fig. 50–1 *A*).

Once the round ligament has been divided, the peritoneum over the anterolateral aspect of the broad ligament is incised along the uterus and parallel to the fallopian tubes to expose the underlying avascular area. At

Figure 50-1 *A*, The round ligament and the fallopian tubes have been divided. Clamps are placed at the cornu of the uterus for traction. The relationship of the ureter to the uterine artery arising from the hypogastric artery can be seen. *B*. The plane of dissection between the uterus and the bladder is shown in sagittal section. *C*, Posterior view of the uterus demonstrating the uterosacral ligament.

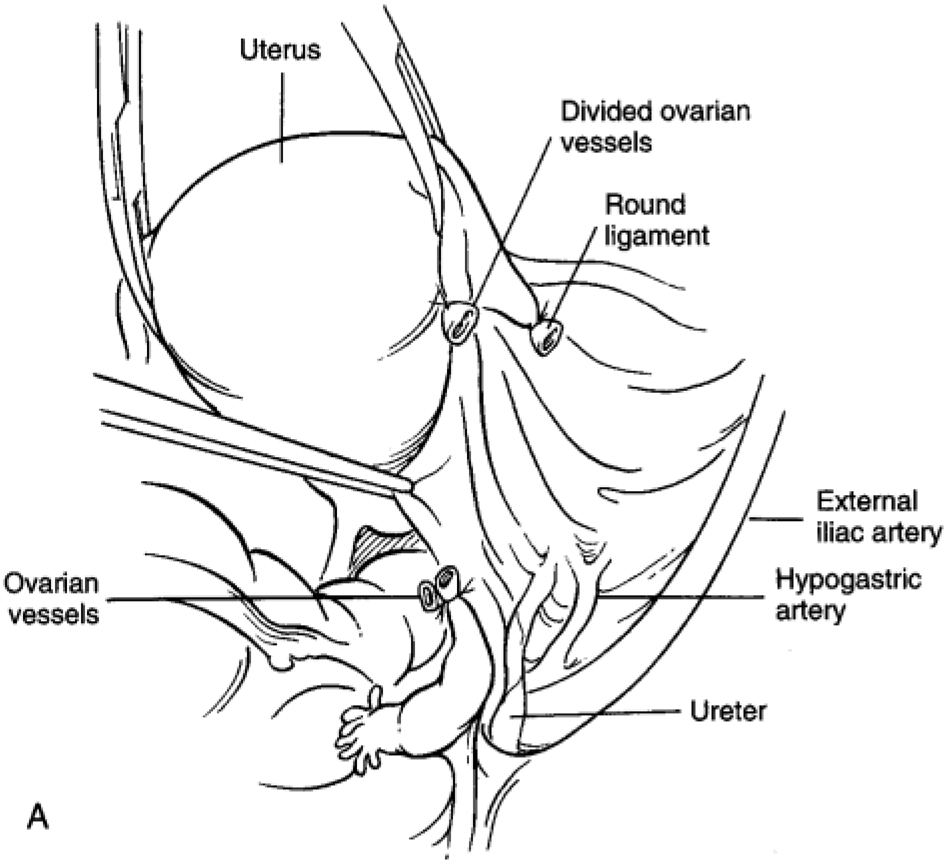
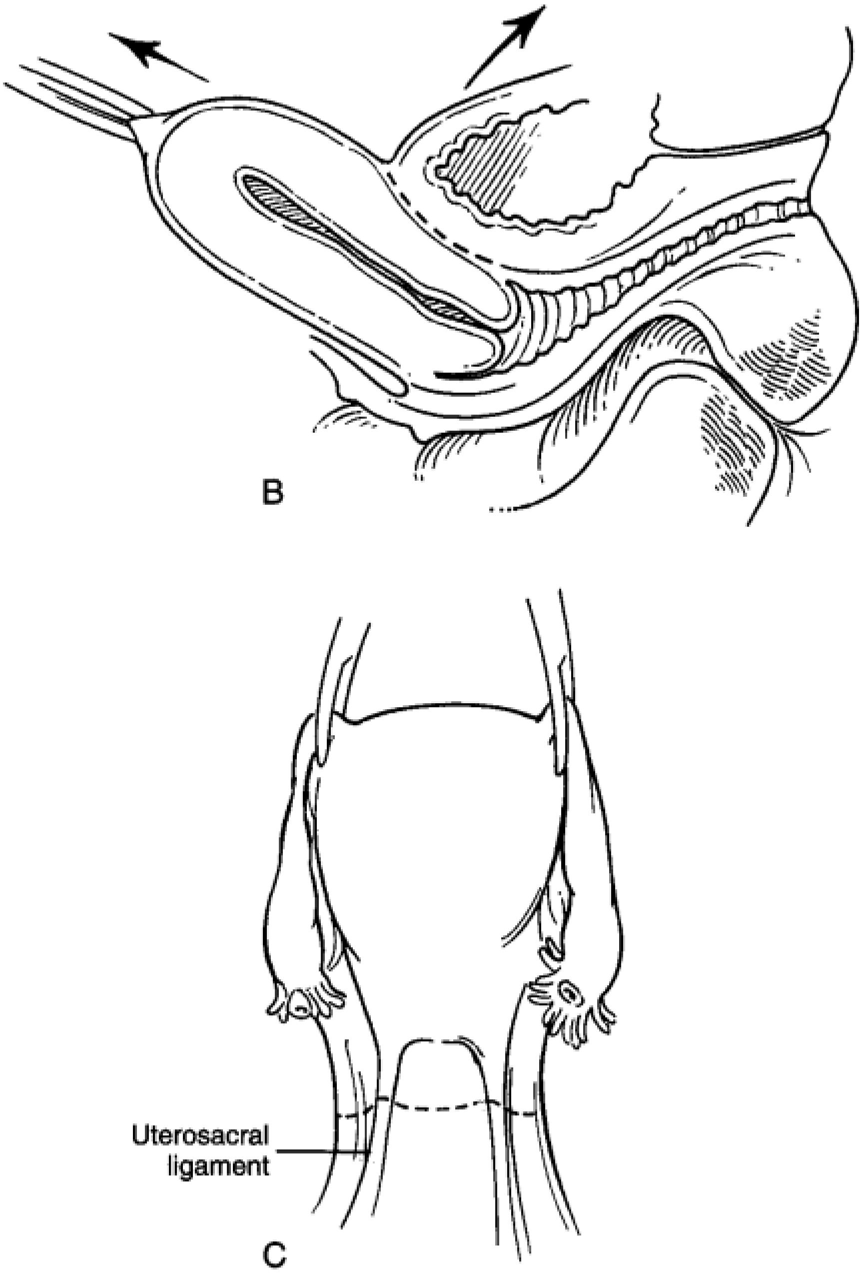


Figure 50-1 *A*, The round ligament and the fallopian tubes have been divided. Clamps are placed at the cornu of the uterus for traction. The relationship of the ureter to the uterine artery arising from the hypogastric artery can be seen. *B*. The plane of dissection between the uterus and the bladder is shown in sagittal section. *C*, Posterior view of the uterus demonstrating the uterosacral ligament.



this stage the ovarian vessels are carefully dissected with a Mixter right-angle clamp, ligated with 0-0 silk sutures, and divided. Alternatively, the vascular pedicle can be secured with an endovascular linear stapler. If the ovaries are to be preserved, the fallopian tubes are divided and ligated, leaving the ovarian vessels intact (see Fig. 50–1 *A*). Next, the ureter is exposed on both sides, from the pelvic brim down to the level of the uterine artery within the pelvis.

Attention is now directed to mobilizing the bladder away from the anterior surface of the uterus, cervix, and upper vagina (Fig. 50–1 *B*). This dissection is initiated by first dividing the vesicouterine peritoneum that joins the lateral openings previously made in the peritoneum of the broad ligaments. With the use of sharp electrocautery dissection, the areolar tissue between the endopelvic fascia and the bladder is divided. During the anterior dissection the cervix is intermittently palpated to gauge the length of the distal dissection. At the level of the cervix, on the lateral aspect, the uterine artery can be seen traveling medially to the cervix. Here the previously exposed ureters can be seen passing beneath the uterine artery.

When the anterior dissection has been completed, the uterus is retracted upward and anteriorly. Next the posterior peritoneal covering of the broad ligament is incised on both sides and extended into peritoneum of the rectovaginal cul-de-sac. With electrocautery the strong uterosacral ligaments are divided (Fig. 50–1 *C*); this allows clear visualization of the cardinal ligaments containing the transverse portion of the uterine artery. While keeping the ureters under view, the cardinal ligaments are clamped on both sides and divided. The proximal part of the cardinal ligament is suture ligated with 2-0 silk sutures. Blind clamping in this region is a frequent cause for iatrogenic injury to the ureters. With the cardinal and the uterosacral ligaments divided on each side, the uterus is retracted upward and anteriorly while simultaneously posterior and downward traction is applied on the rectum. This maneuver facilitates identification of the plane between the uterus and the rectum, and the plane is carefully developed to the level of the posterior vaginal fornices.

When the circumferential dissection of the uterus at the level of the cervix has been completed, this area is carefully examined to ensure that the upper part of the vagina has been carefully cleared from the bladder, rectum, and ureters. The uterus can now be removed by dividing the vaginal wall close to the cervix. The resulting vaginal cuff is grasped with Allis clamps and closed with a continuous 2-0 absorbable suture. To ensure support for the vagina after hysterectomy, approximating the pubocervical fascia to the endopelvic fascia anteriorly and the uterosacral ligaments posteriorly restores the upper pelvic diaphragm. Laterally the cardinal ligament is also included. The pelvis is examined to ensure that the ureters, bladder, and rectum have not been injured during the dissection. The pelvis is then re-peritonealized with continuous 3-0 absorbable sutures without leaving any defects that could cause postoperative small bowel obstruction. If complete closure is not feasible, it is wise to avoid re-peritonealizing the pelvis. If the peritoneum is to be reapproximated, the ureters must be identified during each passage of the needle through the two leaves of peritoneum.

CLOSURE

The linea alba is closed with continuous 1-0 monofilament nonabsorbable sutures. The skin is approximated with staples.