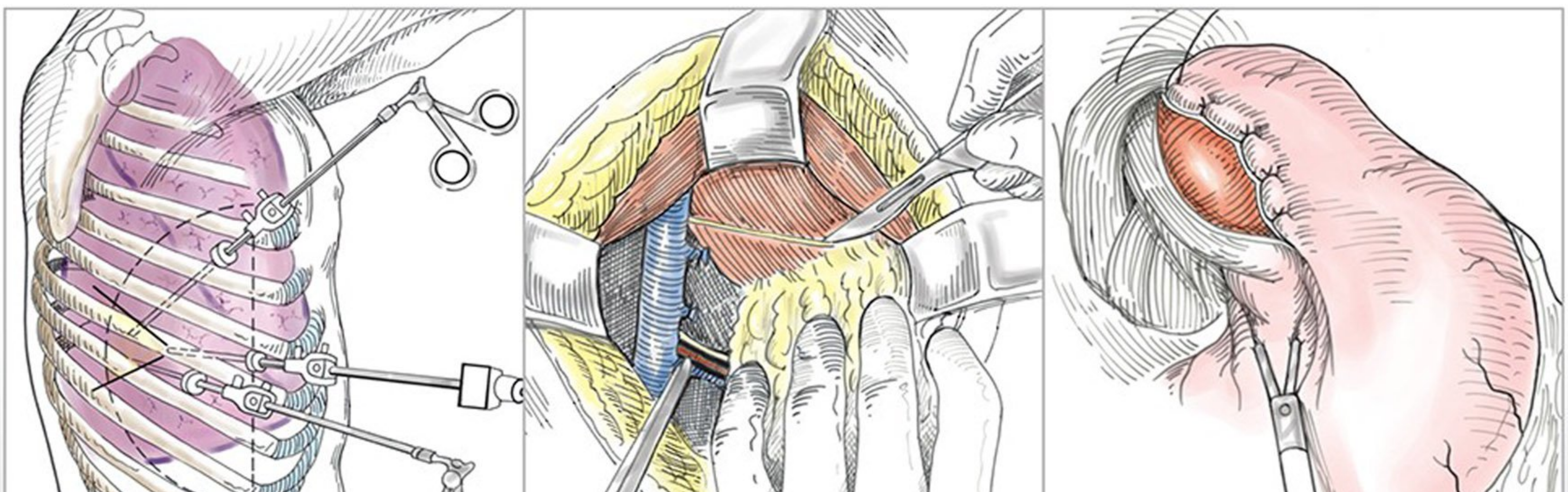
ZOLLINGER'S ATLAS OF SURGICAL OPERATIONS



TENTH EDITION

E. CHRISTOPHER ELLISON
ROBERT M. ZOLLINGER, JR.

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ZOLLINGER'S ATLAS OF SURGICAL OPERATIONS

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CONTENTS

section VIII: genitourinary

section ix: hernia

section x: endocrine

section xi: head and neck

section xii: skin, soft tissue, and breast

section xiii: vascular

section xiv: extremities

PREFACE

Some 75 years ago, this ATLAS was created to document proven and safe operative techniques in common use by general surgeons. Many improvements and changes have occurred in the previous nine editions including use of stapled techniques for gastrointestinal anastomoses and minimally invasive surgery. These two techniques were joined in full flower in the ninth edition wherein what was once considered advanced laparoscopic techniques in the 1990s is now in common use and taught as essential elements in most surgical residency training programs.

In this new 10th edition several important improvements have been made. We have engaged Associate Editors as content experts who have helped identify new procedures that should be included and who have made significant improvements to existing content. Nineteen new surgical operations have been added. These include eight procedures that we think are essential to the practice of general surgery including axillary lymphadenectomy, insertion of a CAPD catheter, fasciotomy, escharotomy, insertion of an inferior vena caval filter, ventral hernia repair using the technique of open component parts separation, ureter repair, and basic thoracoscopy. In addition we have included four additional complex gastrointestinal procedures namely laparoscopic esophageal myotomy, sleeve gastrectomy for morbid obesity, transhiatal esophagectomy and transthoracic esophagectomy. The vascular surgery section now contains new variations on femoral thrombectomy, femorofemoral bypass, saphenous vein laser ablation, and thrombectomy of the superior mesenteric artery. Finally we added laparoscopic hand-assisted donor nephrectomy and kidney transplantation.

A major editorial reorganization has also occurred with the addition of 18 Associate Editors whose special expertise has been channeled into discrete body system–oriented chapters. This reorganization should make it easier to find operations whose titles no longer use roman numerals. The authors and the associate editors have critically reviewed and updated this entire 10th edition. The scientific content of all operative procedures from indications through postoperative care have been made current with significant improvements in about 50 chapters of text and art.

During the preparation of the 10th edition we received valuable input from Brian Belval at McGraw Hill and Donna Sampsill in the Department of Surgery at The Ohio State University. In the ninth edition, color processing and printing technology had advanced such that our medical illustrators, could add color to both old and new plates for improved anatomic clarity in more lifelike or realistic settings. For this 10th edition our medical illustrator, Marita Bitans, has prepared new artwork plates in high definition color with computer-generated graphics that now replace the original pen and ink sketches using white chalk scratch board.

We have also created an online Historical Supplement available at **www.ZollingersAtlas.com** to provide open access to many now historical operations that over the last 70 years have been deleted from succeeding editions of the ATLAS. Many were replaced by newer procedures often involving modern technologies such as stapling, laparoscopy, or minimally invasive image-guided procedures. Others were rarely performed and a few were eliminated because of evolving indications. Additionally, in the past the authors and artists had page limitations imposed by the mechanical construction of the folio-sized ATLAS and the capacity of its binding. That is to say, heavily coated paper stock was needed for quality art reproduction and for the prevention of "strike through" of printed material on the backside of each page. The result was a restriction to about 500 pages—a size reached by the mid-1980s. At that point, the addition of any new or modern procedures such as stapling or laparoscopy required the pruning out of operations that (1) were rarely done—for example, portal/systemic shunts, or (2) were done by the increasing numbers of surgical specialists—for example, thoracic/pulmonary operations.

Furthermore, the authors and the publisher feel that many once popular operations should not be lost, but rather archived in this electronic Historical Supplement of the ATLAS where there are no page limitations. Many of these archived operations are still performed in specialized or complex situations because general surgeons by the nature of their practice, not infrequently encounter one of a kind events that are not in the text books. In these circumstances the surgeon must create an operative solution in real time. These solutions often rely upon general principles and experience, perhaps aided by one of these "old" operations. This may be particularly true in regions where expensive operative equipment such as staplers or disposable laparoscopic instruments are not available.

Today many medical libraries cannot afford to purchase and store all published texts, or even all the major printed medical journals. However, the internet is truly worldwide and accessible to almost all medical/surgical facilities and physicians. We trust this electronic Historical Supplement will help fill in some of the historical surgical technique reference gaps.

As Dr. Cutler graciously allowed his original coauthor to continue on after him, so my father did with me. Now it is my turn. Dr. E. Christopher Ellison has become the new lead principle author who will continue the ATLAS. Dr. Ellison is the other son of the Z-E syndrome. He is the Robert M. Zollinger Professor in the Department of Surgery at the Ohio State University Medical Center. He has accepted the primary responsibility for the ATLAS and its migration back to Columbus and the OSU Department of Surgery, where Dr. Zollinger Senior nurtured the ATLAS for over 40 years. Finally, of additional historic note, all of Dr. Zollinger's papers plus the text and artwork from all earlier editions are now archived in the Medical Heritage Center within the OSU Prior Health Sciences Library where these materials are catalogued and available online.

E. Christopher Ellison, MD
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ASSOCIATE EDITORS

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Section I
BAsICs

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ChapTEr 1

surgical Technique

Asepsis, hemostasis, and gentleness to tissues are the bases of the surgeon's art. Nevertheless, recent decades have shown a shift in emphasis from the attainment of technical skill to the search for new procedures. T e advances in minimally invasive techniques have allowed the surgeon great flexibility in the choice of operative techniques. Nearly all operations may be performed by an open or a minimally invasive laparoscopic technique. T e surgeon must decide which approach is in the best interest of the individual patient. In addition, application of robotic surgery has added a new dimension to the surgical armamentarium. T roughout the evolution of surgery it has been recognized that faulty technique rather than the procedure itself was the cause of failure. Consequently it is essential for the the young, as well as the experienced surgeon, to appreciate the important relationship between the art of performing an operation and its subsequent success. T e growing recognition of this relationship should reemphasize the value of precise technique.

T e technique described in this book emanates from the school of surgery inspired by William Stewart Halsted. T is school, properly characterized as a "school for safety in surgery," arose before surgeons in general recognized the great advantage of anesthesia. Before Halsted's teaching, speed in operating was not only justified as necessary for the patient's safety but also extolled as a mark of ability. Despite the fact that anesthesia afforded an opportunity for the development of a precise surgical technique that would ensure a minimum of injury to the patient, spectacular surgeons continued to emphasize speedy procedures that disregarded the patient's welfare. Halsted first demonstrated that, with careful hemostasis and gentleness to tissues, an operative procedure lasting as long as 4 or 5 hours left the patient in better condition than a similar procedure performed in 30 minutes with the loss of blood and injury to tissues attendant on speed. T e protection of each tissue with the exquisite care typical of Halsted is a dif cult lesson for the young surgeon to learn. T e preoperative preparation of the skin, the draping of the patient, the selection of instruments, and even the choice of suture material are not so essential as the manner in which details are executed. Gentleness is essential in the performance of any surgical procedure.

Young surgeons have dif culty in acquiring this point of view because they are usually taught anatomy, histology, and pathology by teachers using dead, chemically fixed tissues. Hence, students regard tissues as inanimate material that may be handled without concern. T ey must learn that living cells may be injured by unnecessary handling or dehydration. A review of anatomy, pathology, and associated basic sciences is essential in the daily preparation of young surgeons before they assume the responsibility of performing a major surgical procedure on a living person. T e young surgeon is often impressed by the speed of the operator who is interested more in accomplishing a day's work than in teaching the art of surgery. Under such conditions, there is little time for review of technique, discussion of wound healing, consideration of related basic scientific aspects of the surgical procedure, or the criticism of results. Wound complications become a distinct problem associated with the operative procedure. If the wound heals, that is enough. A little redness and swelling in and about wounds are taken as a natural course and not as a criticism of what took place in the operating room 3 to 5 days previously. Should a wound disrupt, it is a calamity; but how often is the suture material blamed, or the patient's condition, and how seldom does the surgeon inquire into just where the operative technique went wrong?

T e following detailed consideration of a common surgical procedure, appendectomy, will serve to illustrate the care necessary to ensure successful results. Prior to the procedure, the verified site of the incision is marked with the surgeon's initials by the operating surgeon. T en the patient is transferred to the operating room and is anesthetized. T e operating table must be placed where there is maximum illumination and adjusted to present the abdomen and right groin. T e light must be focused with due regard for the position of the surgeon and assistants as well as for the type and depth of the wound. T ese details must be planned and directed before the skin is disinfected. A prophylactic antibiotic is administered within 1 hour of the skin incision and, in uncomplicated cases, is discontinued within 24 hours of the procedure.

T e ever-present threat of sepsis requires constant vigilance on the part of the surgeon. Young surgeons must acquire an aseptic conscience and discipline themselves to carry out a meticulous hand-scrubbing technique. A knowledge of bacterial flora of the skin and of the proper method of preparing one's hands before entering the operating room, along with a sustained adherence to a methodical scrub routine, are as much a part of the art of surgery as the many other facets that ensure proper wound healing. A cut, burn, or folliculitis on the surgeon's hand is as hazardous as the infected scratch on the operative site.

T e preoperative preparation of the skin is concerned chiefly with mechanical cleansing. It is important that the hair on the patient's skin is removed with clippers immediately before operation; preferably in the operating suite after anesthetization. T is eliminates discomfort to the patient, affords relaxation of the operative site, and is a bacteriologically sound technique. T ere should be as short a time-lapse as possible between hair removal and incision, thus preventing contamination of the site by a regrowth of organisms or the possibility of a nick or scratch presenting a source of infection. T e skin is held taut to present an even, smooth surface, as the hair is removed with power-driven disposable clippers. T e use of sharp razors to remove hair is discouraged.

Obviously, it is a useless gesture to scrub the skin the night before operation, and to send the patient to the operating room with the site of incision covered with a sterile towel. However, some surgeons prefer to carry out a preliminary preparation in elective operations on the joints, hands, feet, and abdominal wall. Historically, this would involve scrubbing the skin with a cleansing agent several times a day for 2 or 3 days before the surgery. Today the patient may be instructed to shower using a specialized cleansing agent, preferably chlorhexidine gluconate, the evening before and the day of the surgery. Intravenous antibiotics are ordered to be administered within 1 hour of the planned incision.

In the operating room, after the patient has been properly positioned, the lights adjusted, and the proper plane of anesthesia reached, the final preparation of the operative site is begun. An assistant, puts on sterile gloves, and completes the mechanical cleansing of the operative site with sponges saturated in the desired solution. Chlorhexidine gluconate is the ideal cleansing agent. T e contemplated site of incision is treated first; the remainder of the field is cleansed with concentric strokes until all of the exposed area has been covered. As with all tinctures and alcohols used in skin preparation, caution must be observed to prevent skin blisters caused by puddling of solutions at the patient's side or about skin creases. It is important to allow the prep solution to dry completely before draping in order to minimize a fire hazard. T is usually requires 3 minutes with chlorhexidine gluconate. Similarly, electrocardiographic (ECG) and cautery pads should not be wetted. Some surgeons prefer to paint the skin with an iodine-containing solution or a similar preparation.

A transparent sterile plastic drape may be substituted for the skin towels in covering the skin, avoiding the necessity for towel clips at the corners of the field. T is draping is especially useful to cover and wall off an ostomy. T e plastic is made directly adherent to the skin by a bacteriostatic adhesive. After application of the drape, the incision is made directly through the material, and the plastic remains in place until the procedure is completed. When, for cosmetic reasons, the incision must accurately follow the lines of skin cleavage, the surgeon gently outlines the incision with a sterile inked pen before the adhesive plastic drape is applied. T e addition of the plastic to the drape ensures a wide field, that is, surgically, completely sterile, instead of surgically clean as the prepared skin is considered. At the same time, the plastic layer prevents contamination should the large drape sheet become soaked or torn.

Superficial malignancies, as in the case of cancer of the skin, lip, or neck, present a problem in that a routine vigorous mechanical scrub is too traumatic causing irritation or bleeding. Gentle preparation with painting is preferred. Following hair removal with clippers, a germicidal solution should be applied carefully. Similarly, the burned patient must have special skin preparation. In addition to the extreme tissue sensitivity, many times gross soil, grease, and other contaminants are present. Copious flushing of the burned areas with isotonic solutions is important as mechanical cleansing is carried out with a nonirritating detergent.

Injuries such as the crushed hand or the open fracture require extreme care, and meticulous attention to skin preparation must be observed. T e hasty, inadequate preparation of such emergency surgery can have disastrous consequences. A nylon bristle brush and a detergent are used to scrub the area thoroughly for several minutes. Hair is removed by an electric clipper for a wide area around the wound edges. Copious irrigation is essential after the skin is prepared, followed by a single application of a germicide. An antibacterial sudsing cleanser may be useful for cleansing the contaminated greasy skin of the hands or about traumatic wounds.

When the skin has been prepped and the patient has been positioned and draped, then a TIME OUT is done. During this time, all physicians and staff must stop what they are doing and listen and verify the information presented, including the patient's name, scheduled procedure including the correct site, allergies, and whether preoperative antibiotics were administered and when as shown in table 1 of Chapter 3.

T e skin incision is made with a scalpel. T e deeper tissues may be incised with electrocautery using a blended current. Some surgeons prefer electrocautery rather than ligatures to control smaller bleeders. If the energy level is too high, this will produce tissue necrosis potentially devitalizing a larger zone of tissues on either side of its incision.

Some surgeons prefer electrocautery rather than ligatures to control smaller bleeders. Heavy suture materials, regardless of type, are not desirable. Fine silk, synthetics, or absorbable sutures should be used routinely. Every surgeon has his or her own preference for suture material, and new types are constantly being developed. Fine silk is most suitable for sutures and ligatures because it creates a minimum of tissue reaction and stays securely knotted. If a surgeon's knot is laid down and tightened, the ligature will not slip when the tension on the silk is released. A square knot then can be laid down to secure the ligature, which is cut close to the knot. T e knots are set by applying tension on the ligature between a finger held beyond the knot in such a plane that the finger, the knot, and the hand are in a straight line. However, it takes long practice to set the first knot and run down the setting, or final knot, without holding the threads taut. T is detail of technique is of great importance, for it is impossible to ligate under tension when handling delicate tissue or when working in the depths of a wound. When tying vessels caught in a hemostat, it is important that the side of the jaws of the hemostat away from the vessel be presented so that as little tissue as possible is included in the tie. Moreover, the hemostat should be released just as the first knot is tightened, the tie sliding down on tissue not already devitalized by the clamp. One-handed knots and rapidly thrown knots are unreliable. Each knot is of vital importance in the success of an operation that threatens the patient's life.

As the wound is deepened, exposure is obtained by retraction. If the procedure is to be prolonged, the use of a self-retaining retractor is advantageous, since it ensures constant exposure without fatiguing the assistants. Moreover, unless the anesthesia is deep, the constant shifting of a retractor held by an assistant not only disturbs the surgeon but also stimulates the sensory nerves. Whenever a self-retaining retractor is adjusted, the amount of tissue compression must be judged carefully because excessive compression may cause necrosis. Dif culty in obtaining adequate exposure is not always a matter of retraction. Unsatisfactory anesthesia, faulty position of the patient, improper illumination, an inadequate and improperly placed incision, and failure to use instruments instead of hands are factors to be considered when visibility is poor.

Handling tissues with fingers cannot be as manageable, gentle, or safe as handling with properly designed, delicate instruments. Instruments can be sterilized, whereas rubber gloves offer the danger that a needle prick or break may pass unnoticed and contamination may occur. Moreover, the use of instruments keeps hands out of the wound, thus allowing a full view of the field and affording perspective, which is an aid to safety.

After gentle retraction of the skin and subcutaneous tissue to avoid stripping, the fascia is sharply incised with a scalpel in line with its own fibers; jagged edges must be avoided to permit accurate reapproximation. T e underlying muscle fibers may be separated longitudinally with the handle of the knife or electrocautery depending on the type of incision. Blood vessels may be divided between hemostats and ligated. After hemostasis is achieved, the muscle is protected from trauma and contamination by moist gauze pads. Retractors may now be placed to bring the peritoneum into view.

With toothed forceps or hemostat, the operator seizes and lifts the peritoneum. T e assistant grasps the peritoneum near the apex of the tent, while the surgeon releases hold on it. T is maneuver is repeated until the surgeon is certain that only peritoneum free of intra-abdominal tissue is included in the bite of the forceps. A small incision is made between the forceps with a scalpel. T is opening is enlarged with scissors by inserting the lower tip of the scissors beneath the peritoneum for 1 cm and by tenting the peritoneum over the blade before cutting it. If the omentum does not fall away from the peritoneum, the corner of a moist sponge may be placed over it as a guard for the scissors. T e incision should be made only as long as that in the muscle since peritoneum stretches easily with retraction, and closure is greatly facilitated if the entire peritoneal opening is easily visualized. When the incision of the peritoneum is completed, retractors can then be placed to give the optimum view of the abdominal contents. T e subcutaneous fat should be protected from possible contamination by sterile pads or a plastic wound protector. If the appendix or cecum is not apparent immediately, the wound may be shifted about with the retractors until these structures are located.

Although some consider it is customary to pack off the intestines from the cecal region with several moist sponges, we are convinced that the less material introduced into the peritoneal cavity the better. Even moist gauze injures the delicate superficial cells, which thereafter present a point of possible adhesion to another area as well as less of a barrier to bacteria. T e appendix is then delivered into the wound and its blood supply investigated, with the strategic attack in surgery always being directed toward control of the blood supply. T e blood vessels lying in the mesentery are more elastic than their supporting tissue and tend to retract; therefore, in ligating such vessels, it is best to transfix the mesentery with a curved needle, avoiding injury to the vessels. T e vessel may be safely divided between securely tied ligatures, and the danger of its slipping out of a hemostat while being ligated is eliminated. T e appendix is removed by the technique depicted in Chapter 48, and the cecum is replaced in the abdominal cavity. Closure begins with a search for sponges, needles, and instruments, until a correct count is obtained. In reapproximating the peritoneum, a continuous absorbable suture is used.

With the peritoneum closed, the muscles fall together naturally unless they were widely separated. T e fascia overlying the muscles is carefully reapproximated with interrupted sutures and the muscles will naturally realign their positions. Alternatively, some surgeons prefer to approximate the peritoneum, muscle, and fascia in a one-layer closure with interrupted sutures.

Coaptation of the subcutaneous tissues is essential for a satisfactory cosmetic result. Well-approximated subcutaneous tissues permit the early removal of skin sutures and thus prevent the formation of a wide scar. Subcutaneous sutures are placed with a curved needle, large bites being taken through Scarpa's fascia, so that the wound is mounded upward and the skin edges are almost reapproximated. T e sutures must be located so that both longitudinal and cross-sectional reapproximation is accurate. Overlapping or gaping of the skin at the ends of the wound may be avoided readily by care in suturing the subcutaneous layer.

T e skin edges are brought together by interrupted sutures, subcuticular sutures, or metal skin staples. If the subcutaneous tissues have been sutured properly, the skin sutures or staples may be removed on the fifth postoperative day or so. T ereafter, additional support for minimizing skin separation may be provided by multiple adhesive paper strips. T e result is a fine white line as the ultimate scar with less of a "railroad track" appearance, which may occur when skin sutures or staples remain for a prolonged time. To minimize this unsightly scar and lessen apprehension over suture removal, many surgeons approximate the incision with a few subcutaneous absorbable sutures that are reinforced with strips of adhesive paper tape.

Finally, there must be proper dressing and support for the wound. If the wound is closed per primam and the procedure itself has been "clean," the wound should be sealed off for at least 48 hours so it will not be contaminated from without. T is may be done with a dry sponge dressing.

T e time and method of removing skin sutures are important.

Lack of tension on skin sutures and their early removal, by the third to fifth day, eliminate unsightly cross-hatching. In other parts of the body, such as the face and neck, the sutures may be removed in 48 hours if the approximation has been satisfactory. When retention sutures are used, the length of time the sutures remain depends entirely on the cause for their use; when the patients are elderly or cachectic or suffer from chronic cough or the effects of radiation therapy, such sutures may be necessary for as long as 10 to 12 days. A variety of protective devices (bumpers) may be used over which these tension sutures can be tied so as to prevent the sutures from cutting into the skin.

The method of removing sutures is important and is designed to avoid contaminating a clean wound with skin bacteria. After cleansing with alcohol, the surgeon grasps the loose end of the suture, lifts the knot away from the skin by pulling out a little of the suture from beneath the epidermis, cuts the suture at a point that was beneath the skin, and pulls the suture free. Thus, no part of a suture that was on the outside of the skin will be drawn into the subcutaneous tissues to cause an infection in the wound. The importance of using aseptic technique in removing sutures and subsequent dressing under proper conditions cannot be overemphasized. Adhesive paper strips, colloids, or glue, when properly applied, can make skin sutures unnecessary in many areas.

The example of the characteristics of a technique that permits the tissues to heal with the greatest rapidity and strength and that conserves all the normal cells demonstrates that the surgeon's craftsmanship is of major importance to the patient's safety. It emphasizes the fact that technical surgery is an art, which is properly expressed only when the surgeon is aware of its inherent dangers. The same principles underlie the simplest as well as the most serious and extensive operative procedure. The young surgeon who learns the basic precepts of asepsis, hemostasis, adequate exposure, and gentleness to tissues has mastered his or her most difficult lessons. Moreover, once surgeons have acquired this attitude, their progress will continue, for they will be led to a histologic study of wounds, where the real lessons of wound healing are strikingly visualized. They will also be led to a constant search for better instruments until they emerge finally as artists, not artisans.

The surgeon unaccustomed to this form of surgery will be annoyed by the constant emphasis on gentleness and the time-consuming technique of innumerable interrupted sutures. However, if the surgeon is entirely honest and if he or she wishes to close all clean wounds per primam, thus contributing to the patient's comfort and safety, all the principles that have been outlined must be employed. Fine suture material must be utilized—so fine that it breaks when such strain is put on it as will cut through living tissue. Each vessel must be tied securely so that the critically important vessel will always be controlled. Strict asepsis must be practiced. All this is largely a matter of conscience. To those who risk the lives of others daily, it is a chief concern.

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Chapter 2

Anesthesia

Anesthesiology as a special field of endeavor has made clear the many physiologic changes occurring in the patient during anesthesia. The pharmacologic effects of anesthetic agents and techniques on the central nervous system and the cardiovascular and respiratory systems are now better understood. New drugs have been introduced for inhalation, intravenous, spinal, and regional anesthesia. In addition, drugs, such as muscle relaxants and hypotensive or hypertensive agents, are used for their specific pharmacologic effect. Older anesthetic techniques, such as spinal and caudal anesthesia, have been improved by the refinement of the continuous technique and more accurate methods of controlling the distribution of the administered drug. Marked advances in anesthesia have taken place in pulmonary, cardiac, pediatric, and geriatric surgery. Improved management of airway and pulmonary ventilation is reflected in the techniques and equipment available to prevent the deleterious effects of hypoxia and hypercarbia. An increased understanding of the altered hemodynamics produced by anesthesia in the ill patient has resulted in better fluid, electrolyte, and blood replacement preoperatively in patients with a decreased blood volume and electrolyte imbalance, thus allowing many patients once thought to be too ill for surgery, the opportunity for safe operative care.

Although the number of anesthesiologists has increased within recent years, it still is not enough to meet the increased surgical load. Surgeons, therefore, may find that they will be assigned certified registered nurse anesthetists (CRNAs) to administer anesthesia. Although CRNAs have excellent training they must be supervised by a physician. Hence the surgeon must bear in mind that in the absence of a trained anesthesiologist, it is the surgeon who is legally accountable should catastrophe from any cause, compromise the outcome of the surgical procedure. Under these circumstances, the surgeon should be knowledgeable about the choice of anesthetic agents and techniques, and their indications and complications. Further, he or she should be familiar with the condition of the patient under anesthesia by observing the color of blood or viscera, the rapidity and strength of the arterial pulsation, and the effort and rhythm of the chest wall or diaphragmatic respirations. Knowing the character of these conditions under a well-conducted anesthesia, the surgeon will be able readily to detect a patient who is doing poorly.

It is this point of view that has caused us to present in this practical volume the following short outline of modern anesthetic principles. This outline makes no pretense of covering fully the physiologic, pharmacologic, and technical details of anesthesiology, but it offers to the surgeon some basic important information.

GENERAL CONSIDERATIONS The intraoperative role of the anesthesiologist as a member of the surgical team is severalfold, including the assurance of adequate pulmonary ventilation, maintenance of a near-normal cardiovascular system, and conduction of the anesthetic procedure itself. One cannot be isolated from the other.

VENTILATION Preventing the subtle effects of hypoxia is of prime importance to the anesthesiologist. It is well known that severe hypoxia may cause sudden disaster, and that hypoxia of a moderate degree may result in slower but equally disastrous consequences. Hypoxia during anesthesia is related directly to some interference with the patient's ability to exchange oxygen. This commonly is caused by allowing the patient's tongue partially or completely to obstruct the upper airway. Foreign bodies, emesis, profuse secretions, or laryngeal spasm may also cause obstruction of the upper airway. Of these, aspiration of emesis, although rare, represents the greatest hazard to the patient. General anesthesia should not be administered in those patients likely to have a full stomach unless adequate protection of the airway is assured. A common guideline in adults with normal gastrointestinal motility is a 6- to 8-hour interval between the ingestion of solid food and induction of anesthesia. In addition, members of the surgical team should be capable of performing endotracheal intubation. This will reduce the possibility of the patient's asphyxiating, as the endotracheal tube is not always a guarantee of a perfect airway. Other conditions known to produce a severe state of hypoxia are congestive heart failure, pulmonary edema, asthma, or masses in the neck and mediastinum compressing the trachea. As these conditions may not be directly under the anesthesiologist's control, preoperative evaluation should be made by the surgeon, the anesthesiologist, and appropriate consultants. In complex airway cases, the patient may be intubated using topical anesthetics and a flexible fiberoptic bronchoscope that serves as an internal guide for the overlying endotracheal tube.

Before any general anesthetic technique is commenced, facilities must be available to perform positive-pressure oxygen breathing, and suction must be available to remove secretions and vomitus from the airway before, during, and after the surgical procedure. Every effort should be expended to perform an adequate tracheobronchial and oropharyngeal cleansing after the surgical procedure, and the airway should be kept free of secretions and vomitus until the protective reflexes return. With the patient properly positioned and observed, all these procedures will help to reduce the incidence of postoperative pulmonary complications.

CARDIOVASCULAR SUPPORT Fluid therapy during the operative procedure is a joint responsibility of the surgeon and the anesthesiologist. Except in unusual circumstances, anemia, hemorrhage, and shock should be treated preoperatively. During the operation transfusions should be used with caution as there can be significant risks associated with transfusions. Most patients can withstand up to 500 mL of blood loss without difficulty. However, in operative procedures known to require several units of blood, the blood should be replaced as lost as estimated from the quantity of blood within the operative field, the operative drapes, and the measured sponges and suction bottles. The intravascular volume can be expanded by cross-matched packed red blood cells, specifically indicated for their oxygen-carrying capacity, when the hematocrit (Hct) is $\leq$ 23% to 25% or the hemoglobin (Hb) is $\leq$ 7 g/dL. In emergency situations when blood is not available, synthetic colloids (dextran or hydroxyethyl starch solutions), albumin, or plasma may be administered to maintain an adequate expansion of blood volume. All blood products are used with caution because of the possibility of transmitting homologous viral diseases. Infusions of Ringer's lactate (a balanced electrolyte solution), via a secure and accessible intravenous catheter, should be used during all operative procedures, including those in pediatrics. Such an arrangement allows the anesthesiologist to have ready access to the cardiovascular system, and thereby a means of administering drugs or treating hypotension promptly. In addition, large, centrally placed catheters may be used to monitor central venous pressure or even cardiac performance if a pulmonary artery catheter is placed into the pulmonary vasculature. As many modern anesthetic agents may produce vasodilation or depression of myocardial contractility, anesthesiologists may volume load patients with crystalloid solutions. This maintains normal hemodynamic parameters and a good urine output. However, this fluid loading may have serious after effects in some patients; thus the anesthesiologist must monitor the type and volume of fluids given to the patient during the operation and communicate this to the surgeon.

The patient's body position is an important factor both during and after the operation. The patient should be placed in a position that allows gravity to aid in obtaining optimum exposure. The most effective position for any procedure is the one that causes the viscera to gravitate away from the operative field. Proper position on the table allows adequate anatomic exposure with less traumatic retraction. With good muscle relaxation and an unobstructed airway, exaggerated positions and prolonged elevations become unnecessary. The surgeon should bear in mind that extreme positions result in embarrassed respiration, in harmful circulatory responses, and in nerve palsies. When the surgical procedure is concluded, the patient should be returned gradually to the horizontal supine position, and sufficient time should be allowed for the circulatory system to become stabilized. When an extreme position is used, extremity wrappings should be applied and the patient should be returned to the normal position in several stages, with a rest period between each one. Abrupt changes in position or rough handling of the patient may result in unexpected circulatory collapse. After being returned to bed, the patient should be positioned for safe respiration. The patient is observed for unobstructed breathing and stable hemodynamic parameters until he or she is sufficiently alert.

Anesthesia in the aged patient is associated with an increased morbidity and mortality. Degenerative diseases of the pulmonary and cardiovascular systems are prominent, with the individual being less likely to withstand minor insults to either system. Sedatives and narcotics should be used sparingly in both the preoperative and postoperative periods. Regional or local anesthesia should be employed in this age group whenever feasible. This form of anesthesia decreases the possibility of serious pulmonary and cardiovascular system complications and at the same time decreases the possibility of serious mental disturbance that can occur following general anesthesia. Induction and maintenance of anesthesia can be made smoother by good preoperative preparation of the respiratory tract. This begins with cessation of smoking prior to admission and continues with vigorous pulmonary care that may involve positive-pressure aerosol therapy and bronchodilators. A detailed cardiac history in preoperative workup will uncover patients with borderline cardiac failure, coronary insuf ciency, or valvular disease, who require specialized drug treatment and monitoring.

ANESTHETICS As most patients are anxious in the preoperative period, premedication with an anxiolytic agent is often given in the preoperative holding area. Once upon the operating table, the patient is preoxygenated before being induced rapidly and smoothly with an intravenous hypnotic and narcotic.

Induction of a full general anesthesia requires airway control with either a laryngeal mask airway (LMA) or an endotracheal tube, whose placement may require transient muscle paralysis.

Muscle relaxants such as succinylcholine or nondepolarizing neuromuscular blocking agents should be used for those operations requiring muscular looseness if it is not provided by the anesthetic agent. By the use of these drugs, adequate muscular relaxation can be obtained in a lighter plane of anesthesia, thereby reducing the myocardial and peripheral circulatory depression observed in the deeper planes of anesthesia. In addition, the protective reflexes, such as coughing, return more quickly if light planes of anesthesia are maintained. Finally, however, it is important to note that the mycin-derivative antibiotics may interact with curare-like drugs so as to prolong their effect with inadequate spontaneous respiration in the recovery area and may lead to extended respiratory support.

When the maximum safe dosages of local anesthetic agents are exceeded, the incidence of toxic reactions increases. T ese reactions, which are related to the concentration of the local anesthetic agent in the blood, may be classified as either central nervous system stimulation (i.e., nervousness, sweating, and convulsions) or central nervous system depression (i.e., drowsiness and coma). Either type of reaction may lead to circulatory collapse and respiratory failure. Resuscitative equipment consisting of positive-pressure oxygen, intravenous fluids, vasopressors, and an intravenous barbiturate should be readily available during all major operative procedures using large quantities of local anesthesia. T e intensity of anesthesia produced by the local anesthetic agents depends on the concentration of the agent and on the size of the nerve. As the size of the nerve to be anesthetized increases, a higher concentration of anesthetic agent is utilized. Since the maximum safe dose of lidocaine (Xylocaine) is 300 mg, it is wise to use 0.5% lidocaine when large volumes are needed.

T e duration of anesthesia can be prolonged by the addition of epinephrine to the local anesthetic solution. Although this prolongs the anesthetic effect and reduces the incidence of toxic reactions, the use of epinephrine is not without danger. Its concentration should not exceed 1:100,000; that is, 1 mL of 1:1,000 solution in 100 mL of local anesthetic agent. After the operative procedure has been completed and the vasoconstrictive effect of the epinephrine has worn off, bleeding may occur in the wound if meticulous attention to hemostasis has not been given. If the anesthetic is to be injected into the digits, epinephrine should not be added because of the possibility of producing gangrene by occlusive spasm of these end arteries, which do not have collaterals. Epinephrine is also contraindicated if the patient has hypertension, arteriosclerosis, and coronary or myocardial disease.

In any surgical practice, occasions arise when the anesthesiologist should refuse or postpone the administration of anesthesia. Serious thought should be given before anesthesia is commenced in cases of severe pulmonary insuf ciency; with elective surgery in the patient with myocardial infarction less than 6 months prior; severe unexplained anemia; with inadequately treated shock; in patients who recently have been or are still on certain drugs such as monoamine oxidase (MAO) inhibitors and certain tricyclic antidepressants that may compromise safe anesthesia; and, finally, in any case in which the anesthesiologist feels he or she will be unable to manage the patient's airway, such as Ludwig's angina, or when there are large masses in the throat, neck, or mediastinum that compress the trachea.

CARDIAC MORBIDITY AND MORTALITY Cessation of effective cardiac activity may occur at any time during an anesthetic or operative procedure performed under local or general anesthesia. Many etiologic factors have been cited as producing cardiac dysfunction; however, acute or prolonged hypoxia is undoubtedly the most common cause. In a few instances, undiagnosed cardiovascular disease such as severe aortic stenosis or myocardial infarction has been the cause of cardiac standstill. Many sudden cardiac complications relate to anesthetic technique and they are often preceded by warning signs long before the catastrophe actually occurs. Common anesthetic factors include overdosage of anesthetic agents, either in total amount of drug or in speed of administration; prolonged and unrecognized partial respiratory obstruction; inadequate blood replacement with delay in treating hypotension; aspiration of stomach contents; and failure to maintain constant vigilance over the anesthetized patient's cardiovascular system. T e last factor is minimized by the use of the precordial or intraesophageal stethoscope, a continuous electrocardiogram, end-tidal CO_2, and oxygen saturation monitoring.

Mortality and morbidity from cardiac events can be minimized further by having all members of the surgical team trained in the immediate treatment of sudden cardiac collapse. Successful treatment of sudden cardiac collapse depends upon immediate diagnosis and the institution of therapy without hesitation. Diagnosis is established tentatively by the absence of the pulse and blood pressure as recognized by the anesthesiologist and confirmed by the surgeon's palpation of the arteries or observation of the absence of bleeding in the operative field. T e Advanced Cardiac Life Support protocols developed by the American College of Cardiology provide a reasonable guide to resuscitation. It is imperative that external cardiac compression and the establishment of a clear and unobstructed airway be instituted immediately. Intravenous administration of epinephrine is appropriate. If adequate circulation is being produced, a pulse should be palpable in the carotid and brachial arteries. Many times, oxygenated blood being circulated through the coronary arteries by external compression will be suf cient to start a heart in asystole. If the heart is fibrillating, it should be defibrillated. Defibrillation may be accomplished by electrical direct current, which is the preferred method. If all of these resuscitative measures are unsuccessful, then thoracotomy with direct cardiac compression or defibrillation may be considered in an equipped and staffed operating room setting.

T e treatment of a patient revived after a cardiopulmonary arrest is directed toward maintaining adequate cardiopulmonary ventilation and perfusion, and preventing specific organ injuries such as acute renal tubular necrosis or cerebral edema. T is may involve vasoactive drugs, steroids, diuretics, or hypothermia.

CHOICE OF ANESTHESIA T e anesthesiologist's skill is the most important factor in the choice of anesthesia. T e anesthesiologist should select the drugs and methods with which he or she has had the greatest experience. T e effects of the drugs are modified by the speed of administration, total dose, the interaction of various drugs used, and the technique of the individual anesthesiologist. T ese factors are far more important than the theoretical effects of the drugs based on responses elicited in animals. With anesthetic agents reported to have produced hepatocellular damage, certain precautions should be observed. T is is particularly important in patients who have been administered halogenated anesthetic agents in the recent past, or who give a history suggestive of hepatic dysfunction following a previous anesthetic exposure. Further, the halogenated anesthetic agents should be used cautiously in patients whose occupations expose them to hepatocellular toxins or who are having biliary tract surgery.

T e following factors about the proposed operation must be considered: its site, magnitude, and duration; the amount of blood loss to be expected; and the position of the patient on the operating table. T e patient should then be studied to ascertain his or her ability to tolerate the surgical procedure and the anesthetic. Important factors are the patient's age, weight, and general condition as well as the presence of acute infection, toxemia, dehydration, and hypovolemia. Hence, there is a dual evaluation: first, of the overall state of the patients' vital organ systems and, second, of the superimposed hazards of the disease.

T e patient's previous experience and prejudices regarding anesthesia should be considered. Some patients dread losing consciousness, fearing loss of control; others wish for oblivion. Some patients, or their friends, have had unfortunate experiences with spinal anesthesia and are violently opposed to it. An occasional individual may be sensitive to local anesthetics or may have had a prolonged bout of vomiting following inhalation anesthesia. Whenever possible, the patient's preference regarding the choice of anesthesia should be followed. If that choice is contraindicated, the reason should be explained carefully and the preferred procedure should be outlined in such a way as to remove the patient's fears. If local or spinal anesthesia is selected, psychic disturbance will be minimized and the anesthetic made more effective if it is preceded by adequate premedication.

PRELIMINARY MEDICATION If possible, the patient should be visited by the anesthesiologist prior to the operation. T e anesthesiologist should have become acquainted with the patient's condition and the proposed operation. He or she must evaluate personally the patient's physical and psychic state and, at this time, should inquire about the patient's previous anesthetic experience and about drug sensitivity. T e anesthesiologist should question the patient about drugs taken at home and be sure that medicines requiring continued administration, such as beta-blockers or insulin, are continued. Further inquiry should be made concerning drugs (such as corticosteroid drugs, antihypertensive drugs, MAO inhibitors, and tranquilizers) that may have an interaction with the planned anesthesia. If the patient is taking any of these drugs, proper precautions should be taken to prevent an unsatisfactory anesthetic and surgical procedure.

Preoperative medication is frequently a part of the anesthetic procedure. T e choice of premedication depends on the anesthetic to be used. Dosage should vary with the patient's age, physical state, and psychic condition. Premedication should remove apprehension, reduce the metabolic rate, and raise the threshold to pain. Upon arriving in the operating suite, the patient should be unconcerned and placid.

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Chapter

3

Preoperative Preparation and Postoperative Care

For centuries the surgeon's chief training was in anatomy, almost to the exclusion of other aspects of the art. Only in the 20th century did the increasing scope of surgery and unremitting efforts to reduce the number of deaths and complications to a minimum lead inevitably to the realization that a sound understanding of physiology is as important as a thorough grounding in anatomic relationships. In the 21st century, there is increasing interest in evidence-based preoperative and postoperative care and the application of scientific knowledge and compassion to restore the patient to a normal physiologic state and equilibrium as readily as possible after minor or major surgery. T e discipline of surgical critical care represents the ultimate merging of the art of surgery with the science of physiology.

PREOPERATIVE PREPARATION T e surgeon of the 21st century is concerned not only with the proper preoperative preparation of the patient and technical conduct of an operative procedure but also with the preparation of the operating room and an understanding of the problems created by illness in the patient as a whole. Because of the complexities of a patient population with many medical comorbid conditions, preoperative preparation may require a team approach. It is important for the surgeon to understand potential complications and their prevention and recognition. In the ideal situation, the preoperative preparation of the patient begins the ambulatory setting prior to admission. T e surgeon assesses the patient and determines the need for surgery for the specific diagnosis. T e surgeon advises the patient on the benefits and risks of the procedure in general as well as those that are specific to the operation being recommended. Informed consent is more than a signature on a piece of paper: it is a process of discussion and a dialogue between the surgeon and patient in which the patient has the opportunity to ask questions. T e surgeon should also include a discussion of the possible use of blood products, and if deemed appropriate, advise the patient about autologous blood donation. In assessing the patient's condition it is important to identify major health issues. Pulmonary pathology including chronic obstructive pulmonary disease and asthma should be identified. Any departure from the norm disclosed by the history, physical examination, or the various procedures enumerated below may call for further specialty referral and treatment in concert with the patient's primary physician. Likewise, history of a myocardial infarction, valvular heart disease, or a previous coronary intervention may suggest the need for cardiac clearance and assessment by a cardiologist. Finally most patients undergoing major procedures are seen prior to surgery by an anesthesiologist. T is is especially important if they are class III or IV according to the American Society of Anesthesiologist (ASA). Written or verbal communication with the referring physician and primary care physician is important in order to facilitate continuity of care.

In many situations, the primary care physician may be engaged to help ready the patient for surgery. T e primary physician may then set in motion diagnostic and therapeutic maneuvers that improve control of the patient's diseases, thus optimizing his or her status for anesthesia and surgery. Even simple "oral and respiratory prophylaxis," for example, the ordering of dental care and treatment of chronic sinusitis or chronic bronchitis, can be beneficial. Restriction of smoking combined with expectorants for a few days may alleviate the chronic productive cough that is so likely to lead to serious pulmonary complications. T e surgeon should supervise any special diets that may be required, apprise the family and patient of the special requirements, and instill in the patient that peace of mind and confidence which constitutes the so-called psychologic preparation. T e patient should inform the surgeon of any food or drug idiosyncrasies, thus corroborating and supplementing the surgeon's own observations concerning the patient as an operative risk.

It is helpful to require the patient to cough to determine whether his or her cough is dry or productive. In the presence of the latter, consultation with pulmonary medicine may be helpful and surgery may be delayed for the improvement that will follow discontinuance of smoking and the institution of repeated daily pulmonary physical therapy and incentive spirometry in addition to expectorants and bronchodilating drugs as indicated. In the more serious cases, the patient's progress should be documented with formal pulmonary function tests, including arterial blood gases. Patients with other chronic lung problems should be evaluated in a similar manner.

In general, electrocardiograms are routinely obtained, especially after the age of 50. A stress test, radionuclide imaging scan, or ultrasound echo test may be useful for screening, while coronary angiogram, carotid Doppler ultrasounds, or abdominal vascular scans may be performed if significant vascular disease is present or requires correction before an elective general surgery operation.

Standard preoperative considerations include antibiotic prophylaxis and preventive measures for venous thromboembolism. In addition, some surgeons have the patient bathe with antiseptic soap the day prior to the operation. If any special diet or bowel preparation is necessary, the patient is so advised and given the necessary instructions or prescriptions. Intravenous antibiotics should be ordered to be administered within 1 hour prior to the incision. Some antibiotics have specific administration requirements. T e surgeon may consult with the hospital pharmacy concerning the optimal timing of antibiotic administration for vancomycin, gentamicin, or other less commonly employed antibiotic preparations.

Hospitalized patients are frequently more ill than those seen in an ambulatory setting. In this setting, the surgical team works with the medical team to bring the patient into physiologic balance prior to surgery. Recommendations of pulmonary and cardiac consultants should be followed to improve the patient's risk for surgery. T e hospitalized patient may be separated from his or her family and may be depressed or have anxiety. T e surgeon's reassurance and confident manner can help the patient overcome some of the psychologic stress of illness.

Particularly for the hospitalized patient, assessment of nutritional status with measurement of albumin and prealbumin or other markers, pulmonary and cardiac function is necessary. If the patient is malnourished, then this should optimally be corrected prior to surgical intervention if the condition permits. Enteral feedings are preferred. In some cases with oropharyngeal obstruction, a percutaneous endoscopic gastrostomy may be performed to provide access. Feeding with prepared formulas may be necessary. If gastrointestinal access cannot be obtained, total parenteral nutrition (TPN) may be necessary. Although about 1 g of protein per kilogram of body weight is the average daily requirement of the healthy adult, it is frequently necessary to double this figure to achieve a positive nitrogen balance and protect the tissues from the strain of a surgical procedure and long anesthesia. T e administered protein may not be assimilated as such unless the total caloric intake is maintained well above basal requirements. If calories are not supplied from sugars and fat, the ingested protein will be consumed by the body like sugar for its energy value.

If for any reason the patient cannot be fed via the gastrointestinal tract, parenteral feedings must be utilized. On occasion, a deficient oral intake should be supplemented by parenteral feedings to ensure a daily desirable minimal level of 1,500 calories. Water, glucose, salt, vitamins, amino acids, trace minerals, and intravenous fats are the elements of these feedings. Accurate records of intake and output are indispensable. Frequent checks on the liver, renal, and marrow functions along with blood levels of protein, albumin, blood urea nitrogen, prothrombin, and hemoglobin are essential to gauge the effectiveness of the treatment. One must be careful to avoid giving too much salt. T e average adult will require no more than 500 mL of normal saline each day unless there is an abnormal loss of chlorides by gastrointestinal suction or fistula. Body weight should be determined daily in patients receiving intravenous fluids. Since each liter of water weighs approximately 1 kg, marked fluctuations in weight can give warning of either edema or dehydration. A stable body weight indicates good water and calorie replacement.

In catabolic states of negative nitrogen balance and inadequate calorie intake, usually due to the inability to eat enough or to a disrupted gastrointestinal tract, intravenous TPN using a central venous catheter can be lifesaving. Ordinarily, a subclavian or jugular catheter site is used. At present, these solutions contain a mixture of amino acids as a protein source and carbohydrates for calories. Fat emulsions provide more calories (9 calories per gram versus 4 for carbohydrates or protein) and lessen the problems of hyperglycemia. In general, the TPN solutions contain 20% to 25% carbohydrate as glucose plus 50 g of protein source per liter. To this are added the usual electrolytes plus calcium, magnesium, phosphates, trace elements, and multiple vitamins, especially vitamins C and K. Such a solution offers 1,000 calories per liter and the usual adult receives 3 L per day. T is provides 3,000 calories, 150 g of protein, and a mild surplus of water for urinary, insensible, and other water losses. Any component of the TPN solution can be given in insuf cient or excessive quantities, thus requiring careful monitoring. T is should include daily weights, intake and output balances, urinalysis for sugar spillage, serum electrolytes, blood sugar and phosphate, hematocrit, and liver function tests with prothrombin levels in specific instances. Other than catheter-related problems, major complications include hyperglycemia with glucosuria (solute diuresis) and hyperglycemic nonketotic acidosis from overly rapid infusion. Reactive hypoglycemia or hypophosphatemia (refeeding syndrome) may occur after sudden discontinuance of the infusion (catheter accident).

Another major complication involves infection, and strict precautions are needed in preparing the solutions and handling the infusion bottles, lines, and catheters in order to prevent related blood stream infections. Guidelines from the CDC for the prevention of catheter-related blood stream infections should be followed. Prior to insertion standard hand hygiene procedures are followed. During insertion maximal sterile barrier precautions are employed. T e skin is prepared with a > 0.5% chlorhexidine preparation. If there is a contraindication to chlorhexidine then tincture of iodine, an iodophor or 70% alcohol can be used as alternatives prior to catheter insertion or with dressing changes. T e dressing used to cover the central venous catheter is with sterile gauze, or sterile transparent, semipermeable dressing. Topical antibiotic ointment is avoided, except for dialysis catheters, because the potential to promote fungal infection and antimicrobial resistance. T e catheter is replaced if the dressing becomes damp, loosened, or visibly soiled. In the adult, for short-term use central venous catheters gauze dressings are replaced every 2 days and for transparent dressings every 7 days. T e same guidelines apply to children unless there is risk of catheter dislodgement which may be considered. T ere is evidence that central venous lines should be routinely replaced in order to avoid related bold stream infections. If the patient is not receiving blood products or fat emulsions, administration sets that are used continuously, including secondary sets and add-on devices should be changed no more frequently than at 96-hour intervals, but at least every 7 days. Fungemia or gram-negative septicemia should be guarded against, and ideally the catheter system should not be violated for drawing blood samples or for infusion of other solutions. Sepsis does not contraindicate the use of intravenous nutrition, but chronic septicemia without obvious etiology is the indication for removal and culturing of these catheters.

Vitamins are not routinely required by patients who have been on a good diet and who enter the hospital for an elective surgical procedure. Vitamin C is the one vitamin usually requiring early replacement, since only a limited supply can be stored in the body at any one time. In some instances (severe burns are one example), massive doses of 1 g daily may be needed. Vitamin B complex is advantageously given daily. Vitamin K is indicated if the prothrombin time is elevated. T is should be suspected whenever the normal formation of vitamin K in the bowel is interfered with by gastric suction, jaundice, the oral administration of broad-spectrum antibiotics, starvation, or prolonged intravenous alimentation. Objective evidence of improved nutrition may be documented with rising serum protein concentrations, especially albumin, prealbumin, and transferrin, or with the return of a positive skin test for immunocompetence. Certainly if the patient's condition requires urgent treatment, surgery should not be delayed to correct preoperative malnutrition, and the surgeon should plan methods of postoperative nutrition including the possible placement of a feeding jejunostomy or planning on TPN.

Blood transfusions may be needed to correct severe anemia or to replace deficits in circulating blood volume. Properly spaced preoperative transfusions can do more to improve the tolerance for major surgery in poor-risk patients than any other measure in preparation. Blood should be given if the patient is anemic. Such deficits have often been found even when the hemoglobin and hematocrit are normal, as they will be when both plasma volume and red cell volume are contracted concurrently. T is situation has been dramatically termed "chronic shock," since all the normal defenses against shock are hard at work to maintain the appearance of physiologic equilibrium in the preoperative period. If the unsuspecting surgeon fails to uncover the recent weight loss and, trusting the hemoglobin, permits the patient to be anesthetized with a depleted blood volume, vasoconstriction is lost and vascular collapse may promptly ensue. T e hemoglobin level should be brought to approximately 10 g/dL or the hematocrit to 30% before elective surgery in which a significant blood loss is anticipated or if the patient has limited cardiopulmonary reserve.

Time for the restoration of blood volume and caution are both necessary, especially in older people. If the initial hemoglobin is very low, the plasma volume must be overexpanded. Packed red cells are specifically needed rather than whole blood. Each 500 mL of blood contains 1 g of salt in its anticoagulant. As a result, cardiac patients may have some dif culty with multiple transfusions from the salt or plasma loading, and diuretics can be very helpful. T ere has also been some concern about the potassium in blood stored a week or more. T is should never prevent a needed transfusion, but it is a consideration in massive transfusions in emergency situations.

Patients requiring treatment for acute disturbances of the blood, plasma, or electrolyte equilibrium present a somewhat different problem. Immediate replacement is in order, preferably with a solution that approximates the substances being lost. In shock from hemorrhage, replacement should be made with electrolyte solutions plus blood, although plasma substitutes, such as dextran or hydroxyethyl starch solutions, can provide emergency aid in limited amounts (up to 1,000 mL) until blood or plasma is available. In severe burns, plasma, blood, and normal saline or lactated Ringer's solution are in order. In vomiting, diarrhea, and dehydration, water and electrolytes will often suf ce. In many of these patients, however, there is a loss of plasma that is easy to overlook. For instance, in peritonitis, intestinal obstruction, acute pancreatitis, and other states in which large internal surfaces become inflamed, much plasma-rich exudate may be lost, with no external sign to warn the surgeon until the pulse or blood pressure becomes seriously disturbed. Such internal shifts of fluid have been called "third space" losses. T ese losses may require albumin plus electrolyte solutions for proper replacement. It is because of these internal losses that many cases of peritonitis or bowel obstruction may require colloid replacement during their preoperative preparation.

In all such acute imbalances, a minimum of laboratory determinations will include serum or plasma sodium, potassium, chloride, bicarbonate, glucose, and urea nitrogen. Calcium, magnesium, and liver function tests may be useful, while arterial blood gases with pH, bicarbonate concentration Po_2 and Pco_2 enable accurate and repeated evaluation of the respiratory and metabolic components involved in an acidosis or alkalosis. Systemic causes of metabolic acidosis or alkalosis must be corrected. In either case, potassium may be needed. It should be given in suf cient quantity to maintain a normal serum level but only after the urine output is adequate to excrete any excess. Although the laboratory data are useful, the key to adequate replacement therapy is found in the patient's clinical course and in his or her intake–output record. Evidence of restoration is found in a clearing mentation, a stable blood pressure, a falling pulse rate and temperature curve, improved skin turgor, and an increase in urine output.

Antibiotic agents have proved their usefulness in preparing the patient whose condition is complicated by infection or who faces an operation where infection is an unavoidable risk. For procedures on the large bowel, preparation with certain oral preparations combining nonabsorbable antibiotics, purgatives, and zero-residue high-nitrogen diets will reduce the presence of formed stool and diminish the bacterial counts of the colon and theoretically result in safer resections of the lower bowel. In jaundiced patients and in others seriously ill with liver disease, cleansing and minimizing bacterial metabolism within the bowel may provide the necessary support through a major operative intervention. Decompression of an obstructed, septic biliary tree from above by percutaneous transhepatic catheterization or from below by endoscopic retrograde cholangiopancreatography (ERCP) provides bile for culture and antibiotic sensitivity studies. T ese maneuvers may also buy time for further preoperative resuscitation that lessens the risk of an urgent operation. T e beneficial action of the antibiotics must not give the surgeon a false sense of security, however, for in no sense are they substitutes for good surgical technique and the practice of sound surgical principles.

T e many patients now receiving endocrine therapy require special consideration. If therapeutic corticosteroid or adrenocorticotropic hormone (ACTH) has been administered within the preceding few months, the same drug must be continued before, during, and after surgery. T e dose required to meet the unusual stress on the day of operation is often double or triple the ordinary dose. Hypotension, inadequately explained by obvious causes, may be the only manifestation of a need for more corticosteroids. Some later dif culties in wound healing may be anticipated in patients receiving these drugs.

Preoperative management of diabetes requires special consideration. Guidelines change periodically so the surgeon should consult the institution's practice guideline reference or the endocrinologist or primary care physician for assistance. Some general considerations as recommended at the Ohio State University Medical Center are outlined below. First morning procedures are preferred. T e HbA1c should be reviewed (i.e., for intermediate/high risk). If poor glycemic control is identified (HbA1c > 9%), the patient should be referred to the primary physician or endocrinologist for medication adjustment. T e surgeon may consider postponing nonemergent surgery or procedures until medication adjustments are made. T e patient should be instructed to hold all metformin-containing products 1 day prior to surgery. If the patient has inadvertently taken metformin and will undergo any procedure that will compromise renal function, the surgeon may consider **canceling** the case. If the patient will **not** undergo a procedure that may impair renal function, it is **not necessary to cancel** the case. If the patient uses other oral or noninsulin injectable diabetes medications (Symlin, Byetta) the morning of the procedure, withholding of these medications should be discussed with the primary care physician, endocrinologist, and anesthesiologist if possible. Likewise, short-acting insulin (lispro, aspart, glulisine) may be held the morning of the procedure unless the patient uses correction dosing in the fasting state. Adjustments in basal insulin (NPH, glargine, and detemir) should be made by the primary physician or endocrinologist. For morning surgery the evening dose of NPH or lente insulin may be reduced by 20% and the morning dose by 50%. For once a day basal insulin (glargine, detemir), the dose of the evening before or the morning of may be reduced by 20%. For split-mixed insulin (70/30, 75/25, 50/50), the prior evening dose may be reduced by 20% and the morning of dose by 50%. During continuous infusion of insulin with a pump, one may consider a 20% reduction in basal rates to begin at midnight prior to the scheduled surgery. For procedures lasting 3 hours or less, the infusion may be continued. For procedures lasting more than 3 hours, the continuous infusion should be discontinued and intravenous insulin infusion started according to the institutional protocol and/or according to the recommendations of the endocrinologist.

T e patient's normal blood pressure should be reliably established by multiple preoperative determinations as a guide to the anesthesiologist. An accurate preoperative weight can be a great help in managing the postoperative fluid balance.

Well-prepared surgeons will assure themselves of a more than adequate supply of properly cross-matched blood and blood products if a coagulopathy is anticipated. In all upper abdominal procedures, the stomach should be decompressed and kept out of the way. It has a tendency to fill with air during the induction of anesthesia, but this may be minimized by inserting a nasogastric tube prior to operation or after endotracheal intubation. In cases of pyloric obstruction, emptying the stomach will not be easy; nightly lavages with a very large Ewalt tube may be required. A Foley catheter may be used to keep the bladder out of the way during pelvic procedures. Postoperatively, this can be a great help in obtaining accurate measurements of urine volume at hourly intervals, particularly when there has been excessive blood loss or other reason to expect renal complications. In general, a good hourly urine output of 40 to 50 mL per hour indicates satisfactory hydration and an adequate effective blood volume for perfusion of vital organs. Finally, the surgeon should forewarn the nursing staff of the expected condition of the patient after operation. T is will assist them in having necessary oxygen, aspirating apparatus, special equipment or monitors, and so forth at the patient's bedside upon his or her return from the recovery room.

T e anesthesiologist should interview each patient prior to operation. In those with serious pulmonary or constitutional diseases in need of extensive surgery, the choice of anesthesia is an exacting problem with serious consequences. Hence, the surgeon, the anesthesiologist, the primary physician, and appropriate consulting specialists may want to confer in advance of surgery in these complicated cases.

In scheduling the procedure, the surgeon will consider the specific equipment needed. T is may include but not be limited to electrocautery or other energy sources, special scopes such as a choledochoscope, intraoperative ultrasound, grafts or prosthetics, and the need for fluoroscopy. In addition, one might consider the method of postoperative pain control. Is an epidural appropriate for postoperative pain management, or will a patient-controlled analgesic pump suf ce? If the former is considered, the anesthesia team should be made aware as additional time would need to be factored for placement so as not to delay the procedure. In addition, the decision for invasive monitoring should be made in collaboration with anesthesia. Finally, if any consultants are anticipated to be needed at surgery, such as a urologist for placement of a ureteral stent, these arrangements should be established prior to the day of the operation.

OPERATIVE MANAGEMENT T e surgical and anesthesia teams and nursing have the responsibility of ensuring the safety of the patient during the operative procedure. On the day of surgery prior to the operation, the key responsibility of the surgeon is to mark the site or side of the surgery. T e use of surgical checklists may be helpful in improving patient safety. T e outline shown in table 1 is based on the World Health Organization (WHO) Guidelines for Safe Surgery (2009).

Before induction of anesthesia, the nurse and an anesthesia team member confirm that: (1) the patient has verified his or her identity, the surgical site, procedure, and has signed an informed consent; (2) the surgical site has been marked; (3) the patient's allergies are identified, accurate, and communicated to the team members; (4) the patient's airway and risk of aspiration have been assessed and, if needed, special equipment for intubation procured; (5) blood is available if the anticipated blood loss is greater than 500 mL; and (6) a functional pulse oximeter is placed on the patient. Best safety practices in the operating room include taking a timeout. Before the skin incision is made, the entire team takes a timeout. T is means they stop what they are doing and focus on the safety of the patient. During this timeout the team orally confirms: (1) all team members by name; (2) the patient's identity, surgical site, and procedure; (3) that prophylactic antibiotics have been administered $\leq$ 60 minutes before the operation; (4) special equipment is available; (5) imaging results for the correct patient are displayed; and (6) review of anticipated surgical and anesthesia critical events including sterility of the equipment and availability and whether there is an anticipated fire safety hazard. At the completion of the procedure and prior to the patient leaving the operating room, the team orally confirms: (1) the procedure as recorded; (2) correct sponge, needle, and instrument counts if applicable; (3) the specimen is correctly labeled, including the patient's name; (4) any issues with equipment that need to be addressed; and (5) key concerns for the postoperative management of the patient. A debriefing

TABLE 1 CHECKLIST FOR SAFE SURGERY

1. **Sign In (Before Induction)**—Performed Together by Surgeon, Nursing and Anesthesia
   - Team Members Introduce Themselves by Name and Role
   - Patient Identification
     Procedure
     Site and Side
     Confirmed Consent
     Blood Band
     Allergies
   - Confirmation of Site Marking, when applicable
   - Anesthesia Assessment
     Anesthesia Machine Check
     Monitors functional?
     Difficult Airway?
     Suction Available?
     Patient's ASA status
   - Blood Available
     Anticipated Blood Loss Risk
     Equipment Available
2. **Time Out (Before Skin Incision)**—Initiated/Led by Surgeon
   - Confirm Team Members/Introduce Themselves
   - Operation To Be Performed
   - Anticipated Operative Course
   - Site of Procedure
   - Patient Positioning
   - Allergies
   - Antibiotics Given—Time
   - Imaging Displayed
3. **Sign Out (Procedure Completed)**—Performed by OR Team
   - Performed Procedure Recorded
   - Body Cavity Search Performed
   - Uninterrupted Count
     Sponges
     Sharps
     Instruments
   - Counts Correct
     Sponges
     Sharps
     Instruments
   - Specimens Labeled
   - Team Debriefing

with the team is helpful in reinforcing safe practices and correcting any process issues in future cases. If the patient is being admitted to an intensive care unit (ICU) bed, then there needs to be written and oral communication with the receiving team concerning the above.

POSTOPERATIVE CARE Postoperative care begins in the operating room with the completion of the operative procedure. The objective, like that of preoperative care, is to maintain the patient in a normal state. Ideally, complications are anticipated and prevented. This requires a thorough understanding of those complications that may follow surgical procedures in general and those most likely to follow specific diseases or procedures.

The unconscious patient or the patient still helpless from a spinal anesthesia requires special consideration, having to be lifted carefully from table to bed without unnecessary buckling of the spine or dragging of flaccid limbs. The optimum position in bed will vary with the individual case.

Patients who have had operations about the nose and mouth should be on their sides with the face dependent to protect against aspiration of mucus, blood, or vomitus. Major shifts in position after long operations are to be avoided until the patient has regained consciousness; experience has shown that such changes are badly tolerated. In some instances, the patient is transferred from the operating table directly to a permanent bed which may be transported to the patient's room. After the recovery of consciousness, most patients who have had abdominal operations will be more comfortable with the head slightly elevated and the thighs and knees slightly flexed. The usual hospital bed may be raised under the knees to accomplish the desired amount of flexion. If this is done, the heels must also be raised at least as high as the knees, so that stasis of blood in the calves is not encouraged. Patients who have had spinal anesthesia ordinarily are kept in bed for several hours to minimize postanesthetic headache and orthostatic hypotension.

Postoperative pain is controlled by the judicious use of narcotics. New techniques include the continued infusion of preservative-free morphine (Duramorph) into an epidural catheter which is left in place for several days or the use of a patient-controlled analgesia (PCA) intravenous infusion system containing morphine or meperidine. It is a serious error to administer too much morphine. This will lower both the rate and amplitude of the respiratory excursions and thus encourage pulmonary atelectasis. Antiemetic drugs minimize postoperative nausea and potentiate the pain relief afforded by narcotics. Some newer antihistamines also sedate effectively without depressing respirations. On the other hand, patients should be instructed to make their pain known to the nurses and to request relief. Otherwise, many stoic individuals, unaccustomed to hospital practice, might prefer to lie rigidly quiet rather than disturb the busy staff. Such voluntary splinting can lead to atelectasis just as readily as does the sleep of morphia.

Although postoperative care is a highly individual matter, certain groups of patients will have characteristics in common. The extremes of life are an example. Infants and children are characterized by the rapidity of their reactions; they are more easily and quickly thrown out of equilibrium with restriction of food or water intake; they are more susceptible to contagious diseases that may be contracted during a long hospitalization. Conversely, the healing processes are swifter, and there is a quicker restoration to normal health. The accuracy of their fluid replacement is a critical matter, since their needs are large and their little bodies contain a very small reserve. Infants require 100 to 120 mL of water for each kilogram of body weight each day; in dehydration, twice this amount may be allowed.

The calculation of fluid needs in infants and children has been related to body surface area. Pocket-sized tables are available for the quick determination of surface area from age, height, and weight. In this system, from 1,200 to 1,500 mL of fluid per square meter are provided for daily maintenance. Parenteral fluids should contain the principal ions from all the body compartments (sodium, chloride, potassium, calcium) but not in high or "normal" concentrations. Solutions containing electrolytes at about half isotonic strength and balanced for all the ions are now available. Those containing only dextrose in water are best avoided. Colloids, such as blood or albumin, are indicated in severely depleted infants and whenever acute losses occur, just as in adults. Ten to 15 mL per kilogram of body weight may be given slowly each day.

The body weight should be followed closely. Very small infants should be weighed every 8 hours, and their orders for fluid therapy reevaluated as often. Infants and children have a very low tolerance for overhydration. Since accidents can happen everywhere, the flask for intravenous infusion hanging above an infant should never contain more water than the child could safely receive if it all ran in at once—about 20 mL per kilogram of body weight.

Elderly patients likewise demand special considerations. The elderly population is rapidly expanding in numbers; and with age, their medical diseases and treatments become more complex. The aging process leaves its mark on heart, kidneys, liver, lungs, and mind. Response to disease may be slower and less vigorous; the tolerance for drugs is usually diminished; and serious depletions in the body stores may require laboratory tests for detection. Awareness of pain may be much decreased or masked in the aged. A single symptom may be the only clue to a major complication. For this reason, it is often wise to listen carefully to the elderly patient's own appraisal of his or her progress, cater to any idiosyncrasies, and vary the postoperative regimen accordingly. Elderly patients know better than their physicians how to live with the infirmities of age. For them, the routines that have crept into postoperative care can become deadly. Thoracotomy and gastric tubes should be removed as soon as possible. Immobilizing drains, prolonged intravenous infusions, and binders should be held to a minimum. Early ambulation is to be encouraged. Conversely, if an elderly patient is not doing well, the surgeon should have a low threshold to place such an at-risk senior in an ICU after a complicated operation. In this setting, the patient will be monitored more frequently than on the floor; also, critical pulmonary, hemodynamic, and metabolic treatments may be pursued more aggressively.

As long as a postoperative patient requires parenteral fluids, accurate recordings of the intake and output and daily body weight are essential for scientific regulation of water and electrolytes. Then the amount and type of fluid to be given each day should be prescribed individually for each patient. Intake should just equal output for each of the important elements: water, sodium, chloride, and potassium. For each of these, a certain loss is expected each day in the physiology of a normal person. In table 2, these physiologic losses are listed in part A. There are two major sources of loss requiring replacement in every patient receiving intravenous fluids:

TABLE 2 INTRAVENOUS FLUID REPLACEMENT FOR SOME COMMON EXTERNAL LOSSES

	mEq per Liter			IV Replacement with			
	Na^+	Cl^-	K^+	Volume of Water	Saline or L/R	Dex/W	Add K^+
A. Physiologic							
Skin, lungs	0	0	0	800 mL	—	800 mL	—
Good urine flow	40	50	30	1,200 mL	500 mL	700 mL	Optional
B. Pathologic							
Heavy sweating	50	60	5	350 mL/°C fever	½ either	½	—
Gastric suction	60	90	10	mL for mL output	½ saline	½	Add 30 mEq/L
Bile	145	100	41	mL for mL output	1 either	—	—
Pancreatic juice	140	75	4	mL for mL output	1 either	—	—
Bowel (long tube)	120	100	10	mL for mL output	1 either	—	Add 30 mEq/L
Diarrhea	140	100	30	mL for mL output	1 either	—	Add 30 mEq/L

(1) vaporization from skin and lungs, altered modestly by fever, but with a net average of about 800 mL per day in an adult; and (2) urine flow, which should lie between 1,000 and 1,500 mL daily. (In the normal stool, the loss of water and electrolytes is insignificant.) About 2,000 mL of water per day satisfy the normal physiologic requirements. It is a common error to administer too much salt in the form of normal saline in the immediate postoperative period. Normal losses are more than satisfied by the 4.5 g available in 500 mL of normal saline or a balanced electrolyte solution such as lactated Ringer's (L/R) solution. Many patients do well on less unless there is pathologic fluid loss from suction or drainage. T e remainder of the normal parenteral intake should be glucose in water, as the nutritional requirements of the patient dictate.

To the physiologic output must be added, for replacement purposes, any other loss of body fluids that may result from disease. Some common sources for pathologic external losses are listed in part B of table 2. In any of these losses, appropriate replacement depends upon an accurate intake–output record. If perspiration or fistulae are seeping large quantities of fluid on dressings or sheets, these may be collected and weighed. T ese fluids should be replaced volume for volume. All of these losses are rich in electrolyte content, and their replacement requires generous quantities of saline and electrolytes, in contrast to the very small amounts needed for normal physiologic replacement. Selection of the appropriate intravenous solutions may be made from a knowledge of the average electrolyte content in the source of the loss. table 2 provides some of these data and suggests formulae by which intravenous restitution may be made. T us, 1,000 mL of nasogastric suction output may be effectively replaced by 500 mL of saline plus 500 mL of dextrose and water with extra potassium chloride (KCl) added. Approximations of the formulae to the closest 500 mL are usually satisfactory in the adult. However, when losses arise from the gastrointestinal system below the pylorus, some alkaline lactate or bicarbonate solutions will eventually be necessary. When large volumes are being replaced, the adequacy of the therapy should be checked by daily weighing and by frequent measurement of serum electrolyte concentrations. When 3 to 6 L or more of intravenous fluids are required daily, the precise selection of electrolytes in this fluid becomes very important. T e day should be broken into 8- or 12-hour shifts, with new orders for the fluid volume and electrolyte mixture at the start of each time interval. T ese new estimates are based upon repeated and updated measurements of body weight, input and output data, serum electrolytes, hematocrit, and the electrolyte composition of abnormal fluid losses and urine. T e old principle of dividing the problem into smaller segments will improve the ability to conquer it.

T e administration of potassium requires special consideration. Although this is an intracellular ion, its concentration in the plasma must not be raised above 6 mEq/L during any infusion, or serious cardiac arrhythmias may result. Ordinarily, when the kidneys are functioning properly, any excess potassium is quickly excreted and dangerous plasma levels are never reached. Small quantities of potassium should be added to the intravenous infusion only after good postoperative urine flow has been established. T ere are huge intracellular stores of this ion, so that there need be no rush about giving it. On the other hand, pathologic fluid losses from the main intestinal stream—the stomach or bowel—are rich in potassium. After a few days of such losses, suf cient depletion can occur to produce paralytic ileus and other disturbances. T erefore, it is best to give potassium generously, once the urine output is clearly adequate, and to monitor its level with plasma electrolyte tests or the height of the T wave in the electrocardiogram in urgent situations.

Surgeons should interest themselves in the details of the patient's diet after surgery. Prolonged starvation is to be avoided. On the first day, the diet may need to be restricted to clear liquids, such as tea. Fruit juices may increase abdominal distention and are best omitted until the third postoperative day. In a convalescence proceeding normally, a 2,500-calorie diet with 100 g of protein may often be started on the second or third postoperative day. Weighing should continue at twice-weekly intervals after diet is resumed. Weight portrays the nutritional trend and may stimulate more ef cient feeding or a search for hidden edema in the case of too rapid a gain.

Ordinarily, constant gastrointestinal suction will be employed after operations upon the esophagus or resections of the gastrointestinal tract and in the presence of peritonitis, ileus, or intestinal obstruction. If ileus or intestinal obstruction appears postoperatively, a nasogastric tube may be used for decompression of the stomach and indirectly the small bowel. T e long Cantor tube is rarely used for distal decompression, as it cannot be easily passed into the small bowel. T e tube is usually kept in place for 2 to 5 days and removed as normal bowel function returns. T is will be evidenced by resumption of peristalsis, the passage of flatus, and the return of appetite. When it is anticipated that gastrointestinal suction will be needed for a more prolonged time, a gastrostomy placed at operation may provide gratifying comfort to the patient. It has proved ef cient in maintaining suction and keeping distention to a minimum, particularly in the elderly patient with chronic lung disease, whose nasopharyngeal space must be kept as clear of contamination as possible. Feeding by way of a jejunostomy catheter or a gastrostomy tube may also be of value, particularly in the patient who is unable to swallow or who has dif culty in maintaining an adequate caloric intake.

No set rule can be laid down for the particular time at which a patient is permitted out of bed. T e tendency at present is to have the patient ambulatory at the earliest possible moment, and most patients may be allowed out of bed on the first day after the operation. A longer period of rest may be essential to patients who have recently been in shock or who suffer from severe infection, cardiac insuf ciency, cachexia, severe anemia, or thrombophlebitis. T e principle of early ambulation has unquestionably speeded up the recovery period, accelerated the desire and tolerance for food, and probably decreased the incidence and severity of respiratory complications.

T e surgeon should distinguish between ambulation and sitting in a chair; the latter actually may favor deep venous thrombosis. Every surgeon should establish a method of assisting patients out of bed and should teach these principles to those responsible for the bedside care. On the evening of the operation, the patient is encouraged to sit on the edge of the bed, kick his or her legs, and cough. Such patients are urged to change their position in bed frequently and move their legs and feet. T e following day, the patient is turned on the side (wound side down) with the hips and knees flexed. T is brings the knees to the edge of the bed, and an assistant then helps raise the patient sideways to a sitting position as the feet and lower legs fall over the side of the bed. T e patient then swings the legs and moves feet to the floor, stands erect, breaths deeply, and coughs several times. Following this, the patient takes 8 or 10 steps and sits in a chair for 10 minutes, then returns to bed by a reversal of the foregoing steps. Once the patient has been up, he or she is encouraged at first to get up twice daily and later on to be up and walking as much as health and strength condition permit.

A sudden decrease in vital capacity may signal an impending pulmonary complication or an inflammatory process (abscess) adjacent to the diaphragm. Likewise, electrolyte imbalance, abdominal distention, or tenderness may decrease the vital capacity. Incentive spirometry is a helpful adjunct, particularly for those patients who will not or cannot breathe well for themselves. Frequent deep breathing and coughing in the postoperative period assist in clearing the bronchial tree of fluid collection, whereas ultrasonic or nebulized mists may be needed to loosen dried secretions. In such patients, pulmonary physical therapy with clapping, positive-pressure inhalation with bronchodilators, and postural drainage may be required. Daily examination with palpation of the calves and popliteal and adductor regions should be performed by the surgical team. Increase in calf circumference may be due to the edema of an otherwise unsuspected deep venous thrombosis (DVT). T e onset of phlebitis has been clearly related to slowed venous return from the lower extremities during operation and postoperative immobility. Venous stasis can be reduced by wearing elastic stockings, elastic wrappings, or sequential compression stockings to the calves. In high-risk patients, including those with a history of DVT, perioperative anticoagulation should be considered.

With the occurrence of a DVT, anticoagulant therapy should be instituted at once, so that disabling or fatal pulmonary embolism may be avoided. T rombosis is to be considered always as a potential complication; it appears to be more common in elderly and obese individuals, in infective states, and in malignant disease. Early ambulation has not eradicated this dreaded complication, and a sudden cardiopulmonary collapse several uneventful days after surgery may signal a pulmonary embolus from silent DVT.

Disruption of abdominal wounds is fortunately infrequent. It is more common in patients who have extensive surgery for carcinoma or obstructive jaundice. Contributing factors may be vitamin C deficiency, hypoproteinemia, steroid use, vomiting, abdominal distention, wound infection, or a need to cough excessively if preoperative tracheobronchial toilet was not well accomplished. The disruption is rarely recognized before the 7th day and is exceedingly rare after the 17th and 18th days. A sudden discharge from the wound of a large amount of orange serum is pathognomonic of dehiscence. Investigation may disclose an evisceration with a protruding loop of bowel or merely lack of healing of the walls of the wound. The proper treatment consists of replacing the viscera under sterile conditions in the operating room and closing the wound by through-and-through interrupted inert sutures of heavy size (as described in Chapter 10).

The surgeon must assume the responsibility for all untoward events occurring in the postoperative period. This attitude is necessary for progress. Too often surgeons are content to explain a complication on the basis of extraneous influences. Although the surgeon may feel blameless in the occurrence of a cerebral thrombosis or a coronary occlusion, it is inescapable that the complication did not arise until the operation was performed. Only as surgeons recognize that most sequelae of surgery, good and bad, are the direct results of preoperative preparation, of performance of the operative procedure, or of postoperative care will they improve his or her care of the patient and while attempting to prevent all avoidable complications.

CHAPTER

4

Ambulatory Surgery

Ambulatory or outpatient surgery is applicable to relatively few chapters in this Atlas. However, the repair of inguinal, femoral, and small umbilical hernias, breast biopsies, excision of skin tumors, and many plastic procedures are commonly performed in an ambulatory setting. In addition, many gynecologic procedures as well as certain orthopedic, otolaryngologic, and other procedures are performed in this area. T e decision for or against ambulatory surgery may depend on the facilities available, as well as on the presence of an in-house anesthesiologist, recovery room, and observational unit. If all of these are available, some surgeons will also perform minimally invasive or laparoscopic procedures. Many patients tend to feel reassured by plans for ambulatory surgery, which in the majority of instances does not involve hospital admission. Obviously, the guidelines for this approach may well be altered by the patient's age and any changes in physical status.

T e surgeon is responsible for making the specific decision for or against ambulatory surgery provided that the patient finds it acceptable. T e attitude of the patient, the nature of the surgical problem, the depth of family support that will be available postoperatively, and the type of facility in which the procedure is to be performed must all be taken into consideration. Hospital guidelines usually indicate the procedures found to be appropriate and acceptable to that particular institution as defined in their credentialing of operative privileges and procedures. T e surgeon may perform very minor surgical excisions in a properly equipped office and more extensive procedures in a freestanding facility or one associated with a hospital that provides anesthesiologists, equipment, and personnel competent to handle unexpected emergencies.

Since the general surgeon will depend upon the use of local anesthesia for many patients undergoing ambulatory surgery, it is important to be familiar with the limitations on the amount of each local anesthetic that can be safely injected. A review of the nerve supply to the area involved is advisable. Although reactions to local anesthetics are relatively uncommon, the signs and symptoms, which may include convulsive seizures, should be recognized, and preparation should be made for the early administration of some type of anticonvulsant.

Anesthesiologists tend to triage patients into several categories as defined by the American Society of Anesthesiologists (ASA). In ASA category I are patients who have no organic, physiologic, biochemical, or psychiatric disorders. T e pathologic process being operated upon is localized and not systemic. In ASA category II, patients have a mild to moderate systemic disturbance caused either by the condition to be treated or by other pathophysiologic processes. Examples are mild diabetes or treated hypertension. Some would add all neonates under 1 month of age and all octogenarians. ASA category III includes patients with severe disturbances or disorders from whatever cause. Examples include those with diabetes requiring insulin or patients with angina pectoris. T e presence of an anesthesiologist is essential in the majority of patients in ASA categories II and III.

Ambulatory surgery requires that the final physical evaluation of the patient by the surgeon be performed as near the date of the procedure as practical. Many ambulatory surgery centers start this process by having the patient fill out a checklist like those shown in figures 1 and 2. T is information is reviewed by the surgeon, the admitting nurse, and the anesthesiologist. T e patient is assigned to the proper category. ASA categories I and II patients are generally excellent candidates for ambulatory surgery, whereas ASA category III patients should be carefully selected in consultation with the anesthesiologist.

T e period between the examination and the performance of a procedure may be as long as 2 to 4 weeks, but in the winter months, a shorter period may be desirable because of the frequency of upper respiratory disorders. Patients should be informed that the development of even suggestive symptoms of an upper respiratory infection is a possible indication for postponing the elective procedure.

Patients may also be required to have blood studies, which often vary with age or organ system impairment. A sickle cell screen is done if clinically indicated, and a hematocrit is usually sufficient for ASA category I patients under the age of 40. T ereafter, renal function tests (BUN or creatinine) and blood glucose tests are added followed by an electrocardiogram (especially in males) and a chest radiograph. ASA category III patients who have cardiovascular disease, insulin-dependent diabetes, and specific organ system diseases such as those involving kidneys, liver, or lung require thorough medical and surgical evaluation before being scheduled for an ambulatory operation. Medical control of the diseases must be optimized, and a preprocedure consultation with the anesthesiologist may be appropriate.

PREANESTHETIC EVALUATION

NAME ______ PHONE # ______

PROPOSED OPERATION ______ SURGEON ______

DATE OF PROPOSED OPERATION ______ AGE ______ HT ______ WT ______

PLEASE CHECK (✓) EACH QUESTION YES OR NO. IF YOU DO NOT UNDERSTAND ANY QUESTION, PLEASE PLACE A QUESTION MARK (?) IN THE "YES" OR "NO" COLUMN.

RECENT OR PRESENT ILLNESS	YES	NO	REMARKS
A COLD IN PAST 2 WEEKS			
BRONCHITIS OR CHRONIC COUGH			
ASTHMA, HAY FEVER			
CROUP			
PNEUMONIA. TUBERCULOSIS OTHER LUNG INFECTION			
PULMONARY EMBOLUS			
EMPHYSEMA			
SHORTNESS OF BREATH			
ANY OTHER LUNG TROUBLE			
DO YOU SMOKE? HOW MUCH? DATE OF LAST CHEST X-RAY			
HEART FAILURE			
HEART MURMUR			
HIGH BLOOD PRESSURE			
LOW BLOOD PRESSURE			
CHEST PAIN, ANGINA			
HEART ATTACK(S)			
PALPITATIONS: IRREGULAR OR FAST HEARTBEAT			
DATE OF LAST EKG			
BACK OR NECK PAIN OR INJURY			
SLIPPED DISC, SCIATICA			
CONVULSIONS, EPILEPSY			
STROKE OR DIZZINESS			
NERVE OR MUSCLE WEAKNESS			
THYROID TROUBLE			
DIABETES			
LOW BLOOD SUGAR			
ANEMIA			
SICKLE CELL ILLNESS, BLEEDING OR CLOTTING PROBLEMS			
BLOOD TRANSFUSIONS?			
INFANT DEVELOPMENT PROBLEMS, DOWN'S SYNDROME, PREMATURITY, SLOW GROWTH AND DEVELOPMENT			

Figure 1 Preanesthetic evaluation.

T e presence of an anesthesiologist provides guidance for the control of anxiety in children and adults alike by appropriate preoperative medication. Sedation with midazolam (Versed) can provide a short interval of pleasant forgetfulness while the local anesthetic is being injected. Analgesia may be needed; standard narcotics (like meperidine) and short-acting synthetic ones (like fentanyl) are effective. Should the patient require a limited general anesthesia, thiopental plus nitrous oxide or continuous infusion of propofol (Diprivan) offers the advantage of rapid emergence. Among the conduction anesthesia techniques, a short-duration spinal is possible, but epidural infusions are preferred as the patients need not await return of motor function to their legs and urinary bladder.

T e rigid routines of a major operating room in a busy hospital are adhered to in the ambulatory surgical setting. A careful, detailed record of the procedure, the anesthesia, and the recovery period is made.

In many instances, the resulting scar is quite important. Distortion of the skin and subcutaneous tissues by the injection of the local anesthetic agent must be recalled because the incision adheres to the direction of the lines of skin cleavage. T e avoidance of administering epinephrine along with the anesthetic agent decreases the incidence of postoperative bleeding or discoloration of the wound from delayed oozing. T e skin incision should be of sufficient length to ensure adequate exposure. While electrocoagulation can be used, individual ligation of active bleeding vessels is better. T e type of suture material, as well as the type of suturing, need not vary from the traditional technique of the surgeon.

All specimens removed must be submitted for microscopic evaluation by the pathologist. Patients should be informed of any abnormal findings, unless it seems more judicious to inform the next of kin, with a full written statement of the reasons for doing this on the patient's record.

Closure of the skin should be done very carefully, whether the procedure is for cosmetic purposes or for the local excision of a benign tumor. Some believe subcutaneous closure is less painful than clips or sutures that penetrate the skin. Others prefer to use adhesive strips that tend to take the

RECENT OR PRESENT ILLNESS		YES	NO	REMARKS
LIVER TROUBLE: HEPATITIS, JAUNDICE, CIRRHOSIS				
STOMACH TROUBLE, ULCERS, HIATAL HERNIA, GALL BLADDER				
KIDNEY TROUBLE, STONES, INFECTION, DIALYSIS				
MENTAL OR EMOTIONAL ILLNESS				
OTHER ILLNESS NOT MENTIONED				
FEMALES: ARE YOU PREGNANT?				
DO YOU DRINK ALCOHOL?				
USE OTHER RECREATIONAL DRUGS?				
LIST PREVIOUS SURGERIES:	DATE			
DATE OF MOST RECENT ANESTHETIC TYPE				
HAVE YOU HAD ANY UNUSUAL REACTION TO ANESTHESIA?				
HAS ANY BLOOD RELATIVE HAD AN UNUSUAL REACTION TO ANESTHESIA?				
DO YOU HAVE DENTURES OR LOOSE TEETH, CAPS, CROWNS OR BRIDGES?				
DO YOU WEAR CONTACT LENSES, HEARING AID, OR A PHYSICAL PROSTHESIS?				
ARE YOU ALLERGIC TO ANY MEDICATIONS? (LIST)				
ARE YOU TAKING (OR HAVE YOU RECENTLY TAKEN) MEDICATIONS?				
FOR BLOOD PRESSURE				
DIURETICS (WATER PILLS)				
DIGITALIS, DIGOXIN, LANOXIN (OTHER HEART MEDICINE)				
CANCER CHEMOTHERAPY				
TRANQUILIZERS, SLEEPING TABS, SEDATIVES, ANTIDEPRESSANTS				
BLOOD THINNERS, ANTICOAGULANT				
EYE DROPS				
PAIN PILLS OR SHOTS				
STEROIDS, CORTISOL, MEDROL, PREDNISONE				
INSULIN (WHAT KIND?)				
OTHER				

I HAVE ANSWERED THE QUESTIONS CONCERNING MY HEALTH TO THE BEST OF MY KNOWLEDGE.

SIGNED ______________________ DATE ____________

____

RELATIONSHIP (IF OTHER THAN PATIENT)

Figure 2 Patient checklist.

GENERAL HOMEGOING POSTOPERATIVE INSTRUCTIONS

TO: ______________________ FOLLOWING: ____________

DOCTOR'S NAME: ______________________ PHONE NUMBER: ____________

PLEASE OBSERVE THE FOLLOWING INSTRUCTIONS TO INSURE A SAFE RECOVERY FROM YOUR SURGERY.

DIET:

1. Drink water, apple juice or carbonated beverages as tolerated.
2. Eat small amounts of foods such as Jell-O, soup, crackers, as tolerated. Progress to normal diet if you are not nauseated.
3. Avoid alcoholic beverages for 24 hours.

MEDICATIONS:

1. Take as directed.
2. If pain is not relieved by your medication, call your physician.
3. Dizziness is not unusual.
4. Avoid drugs for allergies, nerves or sleep for 24 hours.

ACTIVITIES:

1. Rest at home; limit activity; do not engage in sports or heavy work until your doctor gives you permission.
2. ALLOW 24 HOURS BEFORE:
   — driving or operating hazardous machinery (sewing machine, drills, etc.).
   — signing important papers.
   — making significant decisions.
3. Children having had surgery should not be left unattended.

WOUND/DRESSING:

1. Observe area for bleeding; if dressing becomes soaked or fresh bright red bleeding occurs, apply pressure and call your doctor at once.
2. Do not change dressing until instructed by your doctor.
3. Keep incisional area clean and dry.

If you are concerned and are unable to reach your doctor, go to the hospital's emergency room.

Call your doctor's office for follow-up appointment.

These instructions have been explained to the patient, family or friend and a copy has been given to same.

Patient Signature: ____________________

Date: ____________ Nurse Signature: ____________________

Figure 3 General homegoing postoperative instructions.

tension off the line of closure. The dressing should be as simple as possible, unless a compression dressing is desired. Most dressings can be removed in 2 or 3 days and bathing resumed.

It should be suggested that upon their return home, patients will find a few hours in bed desirable while the effects of the drugs administered are diminished. They should be instructed to find the position most likely to give postoperative comfort. For example, the patient undergoing repair of an inguinal hernia should have less discomfort if the knee on the operated side is moderately flexed over a pillow. Some will be more comfortable with support for the scrotum with an ice cap placed intermittently over the area of the incision.

The patient undergoing ambulatory surgery should take plenty of fluids for several days. A mild cathartic is helpful in counteracting the effect of any preoperative narcotics, as well as reducing tension on the wound from straining at stool. Stool softeners (like mineral oil) may prove to be useful if prolonged inactivity or narcotic use is anticipated.

Written instructions like those shown in figure 3 should be reviewed with the patient and particularly with the responsible family member who is taking the patient home. An informed caregiver at home is an essential part of the ambulatory surgery experience. If a relative or a caregiver is not available, then consideration should be given to overnight observation of the patient. These instructions should cover the areas of medications, diet, activities, and wound care. The feeling of relief that "it is over" does not permit the patient to test the strength of the surgical closure or the stability of recovery from the anesthetic or any drugs that may have been given. Most patients are cautioned to refrain from driving, operating hazardous machinery, or making important decisions for 24 hours. They should be instructed how to reach the surgeon and be given the telephone number of the hospital emergency department in case of an urgent emergency. A follow-up telephone call by the ambulatory surgery center or the surgeon on the day after operation serves to verify that recovery is proceeding satisfactorily. Most patients greatly appreciate this evidence of concern. A written appointment time for return evaluation and checkup is given.

Patients having ambulatory surgery do surprisingly well, and most seem to prefer this approach to the long-established tradition of hospitalization. It must be admitted that this approach places more preoperative responsibility on the patient, as well as on the surgeon, to meet all the requirements for the performance of a procedure. The patient must take the time not only to be evaluated by the surgeon but to have all the laboratory and radiographic examinations taken care of in advance. Since the tests and the physician's final evaluation may precede the day of operation by several weeks, the patient must take responsibility to inform the surgeon of any special developments, such as a change in condition or the occurrence of an upper respiratory infection.

The period of recovery before the patient can return to work depends on the extent and type of surgical procedure. It is hoped that ambulatory surgery will shorten the period of disability and ensure more prompt correction of the indications for operation.

Section II

SURGICAL ANATOMY

CHAPTER 5

Arterial Blood Supply to the Upper Abdominal Viscera

T e stomach has a very rich anastomotic blood supply. T e largest blood supply comes from the celiac axis **(1)** by way of the left gastric artery **(2)**. T e blood supply to the uppermost portion, including the lower esophagus, is from a branch of the left inferior phrenic artery **(3)**. T e left gastric artery divides as it reaches the lesser curvature just below the esophagogastric junction. One branch descends anteriorly **(2a)** and the other branch posteriorly along the lesser curvature. T ere is a bare area of stomach wall, approximately 1 to 2 cm wide, between these two vessels which is not covered by peritoneum. It is necessary to ligate the left gastric artery near its point of origin above the superior surface of the pancreas in the performance of a total gastrectomy. T is also applies when 70% or more of the stomach is to be removed. Ligation of the artery in this area is commonly done in the performance of gastric resection for malignancy so that complete removal of all lymph nodes high on the lesser curvature may be accomplished.

A lesser blood supply to the uppermost portion of the stomach arises from the short gastric vessels **(4)** in the gastrosplenic ligament. Several small arteries arising from the branches of the splenic artery course upward toward the posterior wall of the fundus. T ese vessels are adequate to ensure viability of the gastric pouch following ligation of the left gastric artery as well as of the left inferior phrenic artery. If one of these vessels predominates, it is called the posterior gastric artery; its presence becomes significant in radical gastric resection. Mobilization of the spleen, following division of the splenorenal and gastrophrenic ligaments, retains the blood supply to the fundus and permits extensive mobilization at the same time. T e blood supply of the remaining gastric pouch may be compromised if splenectomy becomes necessary. T e body of the stomach can be mobilized toward the right and its blood supply maintained by dividing the thickened portion of the splenocolic ligament up to the region of the left gastroepiploic artery **(5)**. Further mobilization results if the splenic f exure of the colon, as well as the transverse colon, is freed from the greater omentum. T e greater curvature is ordinarily divided at a point between branches coming from the gastroepiploic vessels **(5, 6)** directly into the gastric wall.

T e blood supply to the region of the pylorus and lesser curvature arises from the right gastric artery **(7)**, which is a branch of the hepatic artery **(8)**. T e right gastric artery is so small that it can hardly be identified when it is ligated with the surrounding tissues in this area.

One of the larger vessels requiring ligation during gastric resection is the right gastroepiploic artery **(6)** as it courses to the left from beneath the pylorus. It parallels the greater curvature. T e blood supply to the greater curvature also arises from the splenic artery **(9)** by way of the left gastroepiploic artery **(5)**.

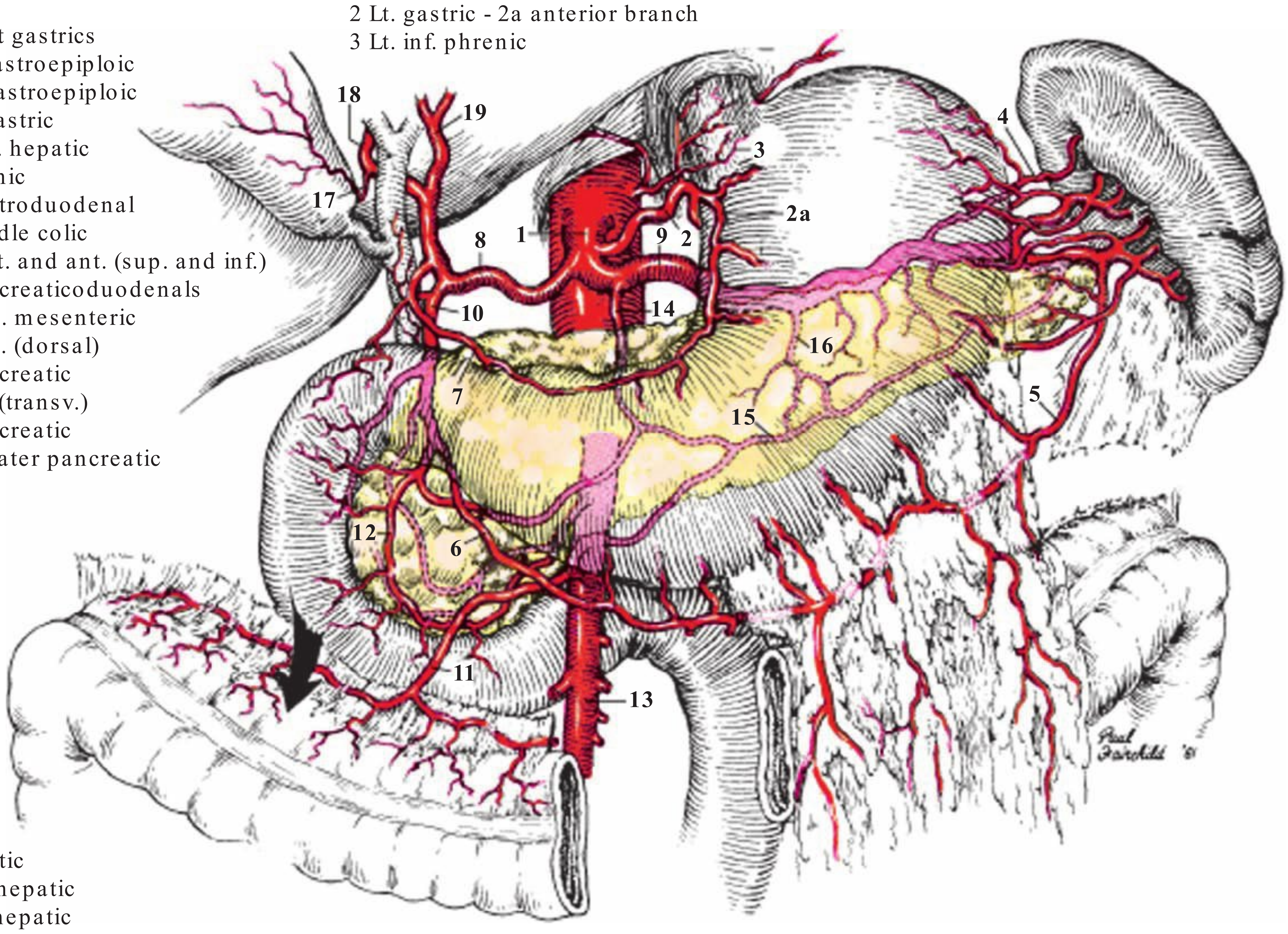
Relatively few key arteries need to be ligated to control the major blood supply to the pancreas. When the duodenum and head of the pancreas are to be resected, it is necessary to ligate the right gastric artery **(7)** and the gastroduodenal artery **(10)** above the superior surface of the duodenum. T e possibility of damaging the middle colic vessels **(11)**, which arise from the superior mesenteric artery and course over the head of the pancreas, must always be considered. T is vessel may be adherent to the posterior wall of the antrum of the stomach, and it may course over the second part of the duodenum, especially if the hepatic f exure of the colon is anchored high in the right upper quadrant. T e anterior and posterior branches of the inferior pancreaticoduodenal artery **(12)** are ligated close to their points of origin from the superior mesenteric artery **(13)**. Additional branches directly to the third portion of the duodenum and upper jejunum also require ligation.

T e body and tail of the pancreas can be extensively mobilized with the spleen. T e splenic artery located beneath the peritoneum over the superior surface of the pancreas should be ligated near its point of origin **(9)**. T e dorsal pancreatic artery **(14)** arises from the splenic artery near its point of origin and courses directly into the body of the pancreas. Following the removal of the spleen, the inferior surface of the body and tail of the pancreas can be easily mobilized without division of major arteries. When the body of the pancreas is divided, several arteries will require ligation. T ese include the inferior (transverse) pancreatic artery **(15)** arising from the splenic artery and the greater pancreatic artery **(16)**.

T e blood supply to the spleen is largely from the splenic artery arising from the celiac axis. Following ligation of the splenic artery, there is a rich anastomotic blood supply through the short gastric vessels **(4)**, as well as the left gastroepiploic artery **(5)**. T e splenic artery is usually serpentine in contour, as it courses along the superior surface of the pancreas just beneath the peritoneum. Following division of the gastrosplenic vessels, it is advantageous to ligate the splenic artery some distance from the hilus of the spleen. T e gastric wall should not be injured during the division of the short gastric vessels high in the region of the fundus. Small blood vessels entering the tail of the pancreas require individual ligation, especially in the presence of a large spleen and accompanying induration in the region of the tail of the pancreas.

T e colon has been displaced inferiorly as indicated by the arrow to allow visualization of the Gastric, Hepatic, Pancreatic and Duodenal vessels. T e blood supply to the gallbladder is through the cystic artery **(17)**, which usually arises from the right hepatic artery **(18)**. In the triangular zone bounded by the cystic duct joining the common hepatic duct and the cystic artery, Calot's triangle, there are more anatomic variations than are found in any other location. T e most common variations in this zone, which is no larger than 3 cm in diameter, are related to the origin of the cystic artery. It most commonly arises from the right hepatic artery **(18)** after the latter vessel has passed beneath the common hepatic duct. T e cystic artery may arise from the right hepatic artery more proximally and lie anterior to the common hepatic duct. Other common variations include origin of the cystic artery from the left hepatic artery **(19)**, the common hepatic artery **(8)**, or the gastroduodenal artery **(10)**; additionally, these cystic arteries may have uncommon relationships to the biliary ductal system. T e variations in the hepatoduodenal ligament are so numerous that nothing should be ligated or incised in this area until definite identification has been made. ■

1 Celiac axis
2 Lt. gastric - 2a anterior branch
3 Lt. inf. phrenic
4 Short gastrics
5 Lt. gastroepiploic
6 Rt. gastroepiploic
7 Rt. gastric
8 Com. hepatic
9 Splenic
10 Gastroduodenal
11 Middle colic
12 Post. and ant. (sup. and inf.) pancreaticoduodenals
13 Sup. mesenteric
14 Sup. (dorsal) pancreatic
15 Inf. (transv.) pancreatic
16 Greater pancreatic



17 Cystic
18 Rt. hepatic
19 Lt. hepatic

CHAPTER

6

Venous and Lymphatic Supply to the Upper Abdominal Viscera

T e venous blood supply of the upper abdomen parallels the arterial blood supply. T e portal vein **(1)** is the major vessel that has the unique function of receiving venous blood from all intraperitoneal viscera with the exception of the liver. It is formed behind the head of the pancreas by the union of the superior mesenteric **(2)** and splenic **(3)** veins. It ascends posterior to the gastrohepatic ligament to enter the liver at the porta hepatis. It lies in a plane posterior to and between the hepatic artery on the left and the common bile duct on the right. T is vein has surgical significance in cases of portal hypertension. When portacaval anastomosis is performed, exposure is obtained by means of an extensive Kocher maneuver. Several small veins **(4)** from the posterior aspect of the pancreas enter the sides of the superior mesenteric vein near the point of origin of the portal vein. Care must be taken to avoid tearing these structures during the mobilization of the vein. Once hemorrhage occurs, it is difficult to control.

T e coronary (left gastric) vein **(5)** returns blood from the lower esophageal segment and the lesser curvature of the stomach. It runs parallel to the left gastric artery and then courses retroperitoneally downward and medially to enter the portal vein behind the pancreas. It anastomoses freely with the right gastric vein **(6)**, and both vessels drain into the portal vein to produce a complete venous circle. It has a significance in portal hypertension in that the branches of the coronary vein, along with the short gastric veins **(7)**, produce the varicosities in the fundus of the stomach and lower esophagus.

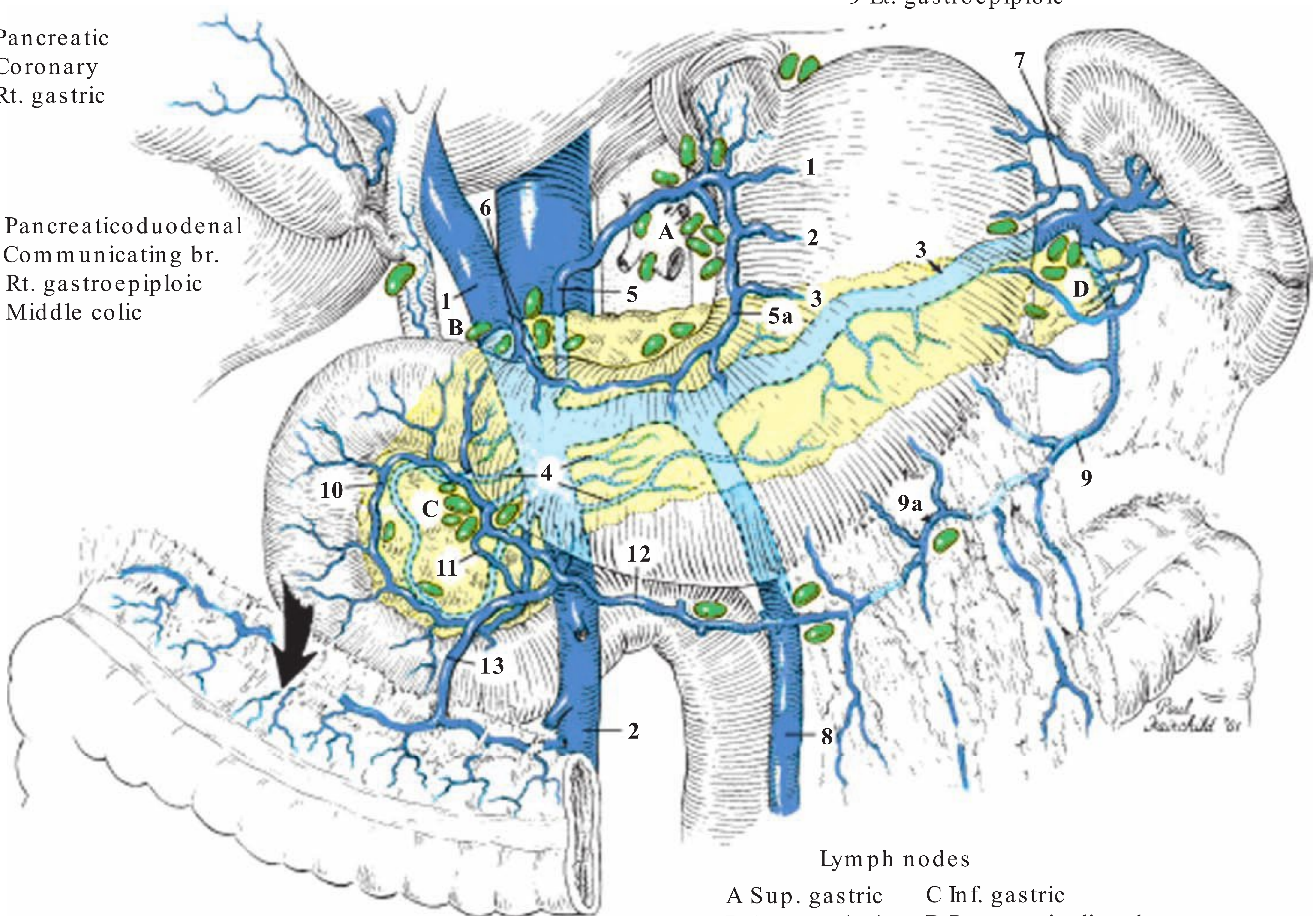
T e other major venous channel in the area is the splenic vein **(3)**, which lies deep and parallel to the splenic artery along the superior aspect of the pancreas. T e splenic vein also receives venous drainage from the greater curvature of the stomach and the pancreas, as well as from the colon, through the inferior mesenteric vein **(8)**. When a splenorenal shunt is performed, meticulous dissection of this vein from the pancreas with ligation of the numerous small vessels is necessary. As the dissection proceeds, the splenic vein comes into closer proximity with the left renal vein where anastomosis can be performed. T e point of anastomosis is proximal to the entrance of the inferior mesenteric vein.

T e colon has been displaced inferiorly as indicated by the arrow to allow visualization of the portal vein in the hepatoduodenal ligament and the venous drainage of stomach, head of the pancreas, and duodenum. T e venous configuration on the gastric wall is relatively constant. In performing a conservative hemigastrectomy, venous landmarks can be used to locate the proximal line of resection. On the lesser curvature of the stomach, the third branch **(5a)** of the coronary vein down from the esophagocardiac junction is used as a point for transection. On the greater curvature of the stomach the landmark is where the left gastroepiploic vein **(9)** most closely approximates the gastric wall **(9a)**. Transection is carried out between these two landmarks **(5a, 9a)**.

T e anterior and posterior pancreaticoduodenal veins **(10)** produce an extensive venous network about the head of the pancreas. T ey empty into the superior mesenteric or hepatic portal vein. T e anterior surface of the head of the pancreas is relatively free of vascular structures, and blunt dissection may be carried out here without difficulty. T ere is, however, a small anastomotic vein **(11)** between the right gastroepiploic **(12)** and the middle colic vein **(13)**. T is vein, if not recognized, can produce troublesome bleeding in the mobilization of the greater curvature of the stomach, as well as of the hepatic f exure of the colon. T e pancreaticoduodenal veins have assumed new importance with the advent of transhepatic venous sampling and hormonal assays for localization of endocrine-secreting tumors of the pancreas and duodenum.

In executing the Kocher maneuver, no vessels are encountered unless the maneuver is carried inferiorly along the third portion of the duodenum. At this point the middle colic vessels **(13)** cross the superior aspect of the duodenum to enter the transverse mesocolon. Unless care is taken in doing an extensive Kocher maneuver, this vein may be injured.

T e lymphatic drainage of the upper abdominal viscera is extensive. Lymph nodes are found along the course of all major venous structures. For convenience of reference, there are four major zones of lymph node aggregations. T e superior gastric lymph nodes **(A)** are located about the celiac axis and receive the lymphatic channels from the lower esophageal segment and the major portion of the lesser curvature of the stomach, as well as from the pancreas. T e suprapyloric lymph nodes **(B)** about the portal vein drain the remaining portion of the lesser curvature and the superior aspect of the pancreas. T e inferior gastric subpyloric group **(C)**, which is found anterior to the head of the pancreas, receives the lymph drainage from the greater curvature of the stomach, the head of the pancreas, and the duodenum. T e last major group is the pancreaticolienal nodes **(D)**, which are found at the hilus of the spleen and drain the tail of the pancreas, the fundus of the stomach, and the spleen. T ere are extensive communications among all these groups of lymph nodes. T e major lymphatic depot, the cisterna chyli, is found in the retroperitoneal space. T is communicates with the systemic venous system by way of the thoracic duct into the left subclavian vein. T is gives the anatomic explanation for the involvement of Virchow's node in malignant diseases involving the upper abdominal viscera. ■


1 Portal
2 Sup. mesenteric
3 Splenic
4 Pancreatic
5 Coronary
6 Rt. gastric
7 Short gastric
8 Inf. mesenteric
9 Lt. gastroepiploic
10 Pancreaticoduodenal
11 Communicating br.
12 Rt. gastroepiploic
13 Middle colic
5a
9a
A
B
C
D
Lymph nodes
A Sup. gastric
B Suprapyloric
C Inf. gastric
D Pancreaticolienal

CHAPTER 7

Anatomy of the Large Intestine

Because of its embryologic development from both the midgut and hindgut, the colon has two main sources of blood supply: the superior mesenteric **(1)** and the inferior mesenteric arteries **(2)**. The superior mesenteric artery **(1)** supplies the right colon, the appendix, and small intestine. The middle colic artery **(3)** is the most prominent branch of the superior mesenteric artery. It arises after the pancreaticoduodenal vessels (see Chapter 5). The middle colic artery branches into a right and left division. The right division anastomoses with the right colic **(4)** and the ileocolic **(5)** arteries. The left branch communicates with the marginal artery of Drummond **(6)**. The middle and right colic and ileocolic arteries are doubly ligated near their origin when a right colectomy is performed for malignancy. The ileocolic artery reaches the mesentery of the appendix from beneath the terminal ileum. Angulation or obstruction of the terminal ileum should be avoided following the ligation of the appendiceal artery **(7)** in the presence of a short mesentery.

The inferior mesenteric artery arises from the aorta just below the ligament of Treitz. Its major branches include the left colic **(8)**, one or more sigmoid branches **(9, 10)**, and the superior hemorrhoidal artery **(11)**. Following ligation of the inferior mesenteric artery at its origin, the viability of the colon is maintained through the marginal artery of Drummond **(6)** by way of the left branch of the middle colic artery.

The third blood supply to the large intestine arises from the middle and inferior hemorrhoidal vessels. The middle hemorrhoidal vessels **(12)** arise from the internal iliac (hypogastric) **(13)**, either directly or from one of its major branches. They enter the rectum along with the suspensory ligament on either side. These are relatively small vessels, but they should be ligated.

The blood supply to the anus is from the inferior hemorrhoidal **(14)** vessels, a branch of the internal pudendal artery **(15)**. In low-lying lesions wide excision of the area is necessary with ligation of the individual bleeders as they are encountered.

The venous drainage of the right colon parallels the arterial supply and drains directly into the superior mesenteric vein **(1)**. The inferior mesenteric vein, in the region of the bifurcation of the aorta, deviates to the left and upward as it courses beneath the pancreas to join the splenic vein. High ligation of the inferior mesenteric vein **(16)** should be carried out before extensive manipulation of a malignant tumor of the left colon or sigmoid in order to avoid the vascular spread of tumor cells.

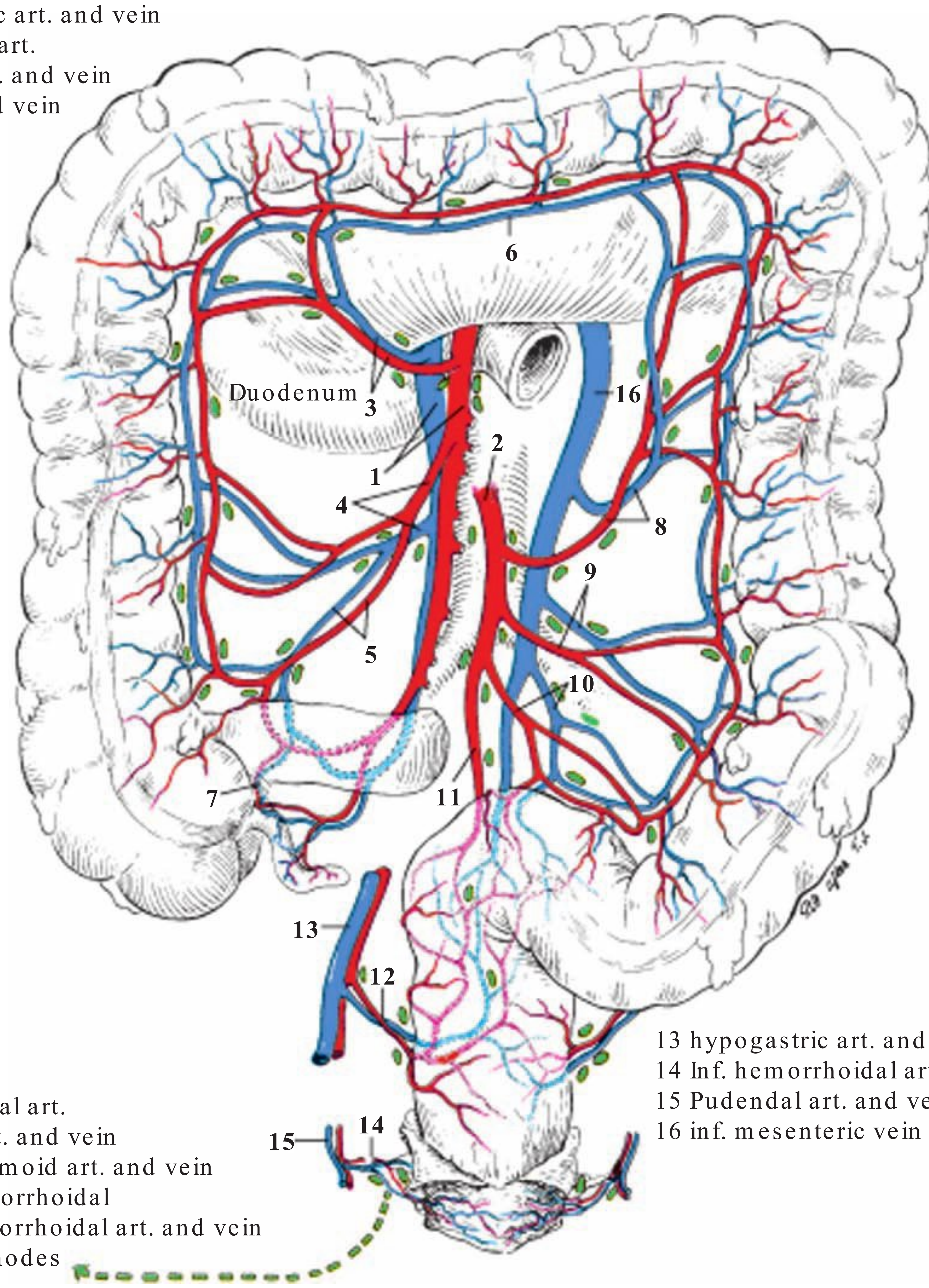
The right colon can be extensively mobilized and derotated to the left side without interference with its blood supply. The mobilization is accomplished by dividing the avascular lateral peritoneal attachments of the mesentery of the appendix, cecum, and ascending colon. Blood vessels of a size requiring ligation are usually present only at the peritoneal attachments of the hepatic and splenic flexures. The transverse colon and splenic flexure can be mobilized by separating the greater omentum from its loose attachment to the transverse colon (see Chapter 26). Traction on the splenic flexure should be avoided lest troublesome bleeding could result from a tear in the adjacent splenic capsule. The abdominal incision should be extended high enough to allow direct visualization of the splenic flexure when it is necessary to mobilize the entire left colon. The left colon can be mobilized toward the midline by division of the lateral peritoneal attachment. There are few, if any, vessels that will require ligation in this area.

The descending colon and sigmoid can be mobilized medially by division of the avascular peritoneal reflection in the left lumbar gutter. The sigmoid is commonly quite closely adherent to the peritoneum in the left iliac fossa. The peritoneal attachment is avascular, but because of the proximity of the spermatic or ovarian vessels, as well as the left ureter, careful identification of these structures is required. Following the division of the peritoneal attachment and the greater omentum, further mobilization and elongation of the colon can be accomplished by division of the individual branches **(8, 9, 10)** of the inferior mesenteric artery. This ligation must not encroach on the marginal vessels of Drummond **(6)**.

The posterior wall of the rectum can be bluntly dissected from the hollow of the sacrum without dividing important vessels. The blood supply of the rectum is in the mesentery adjacent to the posterior rectal wall. Following division of the peritoneal attachment to the rectum and division of the suspensory ligaments on either side, the rectum can be straightened with the resultant gain of considerable distance (Chapter 57). The pouch of Douglas, which may initially appear to be quite deep in the pelvis, can be mobilized well up into the operative field.

The lymphatic supply follows the vascular channels, especially the venous system. Accordingly, all of the major blood supplies of the colon should be ligated near their points of origin. These vessels should be ligated before a malignant tumor is manipulated. Complete removal of the lymphatic drainage from lesions of the left colon requires ligation of the inferior mesenteric artery **(2)** near its point of origin from the aorta.

Low-lying malignant rectal lesions may extend laterally along the middle hemorrhoidal vessels **(12)** as well as along the levator ani muscles. They may also extend cephalad along the superior hemorrhoidal vessels **(11)**. The lymphatic drainage of the anus follows the same pathway but may include spread to the superficial inguinal lymph nodes **(17)**. The lower the lesion, the greater the danger of multiple spread from the several lymphatic systems involved. ■



1 Sup. mesenteric art. and vein
2 Inf. mesenteric art.
3 Middle colic art. and vein
4 Rt. colic art. and vein
5 Ileocolic art. and vein
6 marginal vessels of Drummond
7 Appendiceal art.
8 Lt. colic art. and vein
9 and 10 Sigmoid art. and vein
11 Sup. hemorrhoidal
12 Mid. hemorrhoidal art. and vein
13 hypogastric art. and vein
14 Inf. hemorrhoidal art. and vein
15 Pudendal art. and vein
16 inf. mesenteric vein
17 Inguinal nodes

CHAPTER 8

Anatomy of the Abdominal Aorta and Inferior Vena Cava

T e various vascular procedures that are carried out on the major vessels in the retroperitoneal area of the abdominal cavity make familiarity with these structures essential. Likewise, surgery of the adrenal glands and the genitourinary system invariably involves one or more of the branches of the abdominal aorta and inferior vena cava.

T e blood supply to the adrenals is complicated and different on the two sides. T e superior arterial supply branches from the inferior phrenic artery **(1)** on both sides. T e left adrenal receives a branch directly from the adjacent aorta. A similar branch also may pass behind the vena cava to the right side, but the more prominent arterial supply arises from the right renal artery. T e major venous return **(3)** on the left side is directly to the left renal vein. On the right side, the venous supply may be more obscure, as the adrenal is in close proximity to the vena cava and the venous system **(2)** drains directly into the latter structure.

T e celiac axis **(A)** is one of the major arterial divisions of the abdominal aorta. It divides into the left gastric, splenic, and common hepatic arteries. Immediately below this is the superior mesenteric artery **(B)**, which provides the blood supply to that portion of the gastrointestinal tract arising from the foregut and midgut. T e renal arteries arise laterally from the aorta on either side. T e left renal vein crosses the aorta from the left kidney and usually demarcates the upper limits of arteriosclerotic abdominal aneurysms. T e left ovarian (or spermatic) vein **(13)** enters the left renal vein, but this vessel on the right side **(5)** drains directly into the vena cava.

In removing an abdominal aortic aneurysm, it is necessary to ligate the pair of ovarian (or spermatic) arteries **(4)**, as well as the inferior mesenteric artery **(C)**. In addition, there are four pairs of lumbar vessels that arise from the posterior wall of the abdominal aorta **(14)**. T e middle sacral vessels will also require ligation **(12)**. Because of the inflammatory reaction associated with the aneurysm, this portion of the aorta may be intimately attached to the adjacent vena cava.

T e blood supply to the ureters is variable and difficult to identify. T e arterial supply **(6, 7, 8)** arises from the renal vessels, directly from the aorta, and from the gonadal vessels, as well as from the hypogastric arteries **(11)**. Although these vessels may be small and their ligation necessary, the ureters should not be denuded of their blood supply any further than is absolutely necessary.

T e aorta terminates by dividing into the common iliac arteries **(9)**, which in turn divide into the external iliac **(10)** and the internal iliac (hypogastric) **(11)** arteries. From the bifurcation of the aorta, the middle sacral vessel **(12)** descends along the anterior surface of the sacrum. T ere is a concomitant vein that usually empties into the left common iliac vein at this point **(12)**.

T e ovarian arteries **(4)** arise from the anterolateral wall of the aorta below the renal vessels. T ey descend retroperitoneally across the ureters and through the infundibulopelvic ligament to supply the ovary and salpinx **(15)**. T ey terminate by anastomosing with the uterine artery **(16)**, which descends in the broad ligament. T e spermatic arteries and veins follow a retroperitoneal course before entering the inguinal canal to supply the testis in the scrotum.

T e uterine vessels **(16)** arise from the anterior division of the internal iliac (hypogastric) arteries **(11)** and proceed medially to the edge of the vaginal vault opposite the cervix. At this point, the artery crosses over the ureter ("water under the bridge") **(17)**. T e uterine vein, in most instances, does not accompany the artery at this point but passes behind the ureter. In a hysterectomy, the occluding vascular clamps must be applied close to the wall of the uterus to avoid damage to the ureter. T e uterine vessels then ascend along the lateral wall of the uterus and turn laterally into the broad ligament to anastomose with the ovarian vessels.

T e lymphatic networks of the abdominal viscera and retroperitoneal organs frequently end in lymph nodes found along the entire abdominal aorta and inferior vena cava. Lymph nodes about the celiac axis **(A)** are commonly involved with metastatic cancer arising from the stomach and the body and tail of the pancreas. T e para-aortic lymph nodes, which surround the origin of the renal vessels, receive the lymphatic drainage from the adrenals and kidneys.

T e lymphatic drainage of the female genital organs forms an extensive network in the pelvis with a diversity of drainage. T e lymphatic vessels of the ovary drain laterally through the broad ligament and follow the course of the ovarian vessels **(4, 5)** to the preaortic and lateroaortic lymph nodes on the right and the precaval and laterocaval lymph nodes on the left. T e fallopian tubes and the uterus have lymphatic continuity with the ovary, and communication of lymphatics from one ovary to the other has also been demonstrated.

Lymphatics of the body and fundus of the uterus may drain laterally along the ovarian vessels in the broad ligament with wide anastomoses with the lymphatics of the tube and ovary. Lateral drainage to a lesser extent follows a transverse direction and ends in the external iliac lymph nodes **(18)**. Less frequently, tumor spread occurs by lymphatic trunks, which follow the round ligament from its insertion in the fundus of the uterus to the inguinal canal and end in the superf cial inguinal lymph nodes **(22)**.

T e principal lymphatic drainage of the cervix of the uterus is the preureteral chain of lymphatics, which follow the course of the uterine artery **(16)** in front of the ureters and drain into the external iliac **(18)**, the common iliac **(19)**, and obturator lymph nodes. Lesser drainage is by way of the retroureteral lymphatics, which follow the course of the uterine vein, pass behind the ureter, and end in the internal iliac (hypogastric) lymph nodes **(20)**. T e posterior lymphatics of the cervix, less constant than the other two, follow an anteroposterior direction on each side of the rectum to end in the para-aortic lymph nodes found at the aortic bifurcation **(21)**.

T e lymphatics of the prostate and bladder, like those of the cervix, are drained particularly by nodes of the external iliac chain **(18)** and occasionally also by the hypogastric **(20)** and common iliac lymph nodes **(19)**. ■