Left Colon Swing for Esophageal Replacement

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Esophageal resection and replacement is required for a variety of malignant and benign disorders of the esophagus. Reconstituting the ability to swallow after esophagectomy represents a fundamental challenge to the thoracic surgeon, and a variety of technical options are available. With increasing experience, the approach to resection of esophageal malignancy is to perform near total esophagectomy with anastomosis of the replacement conduit to the cervical esophagus. Reasons for this include the following:

1. Adequate proximal tumor clearance.
2. Less morbidity or cervical anastomotic leak. (Although leaks from anastomoses of the cervical esophagus are more frequent than those involving the thoracic esophagus, they usually result in a cutaneous fistula, which heals spontaneously by secondary intention.)
3. The functional result appears to be superior with the use of a longer conduit along with a higher anastomosis. Less redundancy of the conduit facilitates emptying, and the greater distance of the anastomosis from the abdomen appears to decrease the tendency toward reflux and associated potential complications such as peptic stricture.

The latter two considerations are functional, and obviously, therefore, apply to esophageal resection and reconstruction for end-stage benign disease as well. Rarely, such as for cancers of the proximal esophagus, a more radical resection (pharyngolaryngoesophagectomy) is required so that the replacement conduit must reach the pharynx. Based on these considerations, the main options for esophageal replacement at the neck level (either to the cervical esophagus or less commonly to the pharynx) are the tubularized stomach, or a long segment of left colon.

Interestingly, early efforts at esophageal replacement around the turn of the century focused mainly on the colon as the replacement conduit. In 1911, Kelling[1] and Vulliet[2] independently proposed the concepts and basis for the use of the colon as an esophageal substitute. Von Hacker[3] achieved successful implementation of colon bypass of the esophagus in 1914. These early efforts led to the colon being the esophageal replacement conduit of choice over many decades. In the more recent past, increasing experience has been gained with the stomach being used as the esophageal substitute. Although certain centers have adhered to use of the colon as the preferential conduit for esophageal replacement,[4] currently this represents a minority view. In general, the frequency of the use of the colon as an esophageal substitute is declining, and in most programs the colon is used only when the stomach is not available or is unsatisfactory.[5,6] A very basic comparison of stomach versus left colon graft is summarized in Table 1.

Patient Selection

In general, the indication for using a left colon graft for esophageal replacement after total or near-total esophageal resection occurs when the stomach is not available. Typically, this is due to remote gastric surgery such as gastrectomy for ulcer disease or tumor. Occasionally, the colon may be used as a "fallback" conduit because of necrosis of the gastric conduit after esophagectomy. Preferential use of the colon as a deliberate alternative to the stomach is rarely indicated for malignant disease. Such preferential use of the colon is best confined for esophageal resections for end-stage benign disease in the young and otherwise healthy patient in whom there is a normal or near-normal life expectancy. Not uncommonly, this becomes necessary in esophagectomy after multiple failed previous surgeries for benign pathology. Nowadays, truly end-stage esophageal pathology not amenable to a surgical repair is quite infrequent.

TABLE 1. Comparison of Stomach Versus Left Colon as *Esophageal Substitutes*

Characteristics	Stomach	Left Colon
Length	Excellent	Excellent
Blood Supply	Excellent and reliable	Usually adequate, perhaps less reliable
Preoperative Evaluation	Minimal	Greater (colonoscopy mesenteric angiogram)
Preoperative Preparation	Virtually none	Mechanical and antibiotic bowel preparation
Operative Time and Complexity	Less	Greater
No. of Anastomoses	One	Three
Emptying	"Passive" (gravity)	Mainly by gravity; perhaps minimal peristalsis
Potential Late Problems	Reflux → peptic stricture (worse with low *anastomosis*)	1. Redundancy → poor emptying. 2. Intolerance of colonic mucosa to acid → ulceration.

Contraindications to the use of the left colon graft are simple. These include:

1. Significant colonic pathology. This includes significant diverticular disease and its complications, colon carcinoma, or significant polyposis.
2. Situations in which the integrity of the vascular pedicle and/or the marginal arterial blood supply of the colon graft have been altered. Such destruction of the vascular integrity may be the consequence of prior major abdominal surgery, particularly repair of abdominal aortic aneurysm, or in older patients with significant atherosclerosis, in whom occlusive lesions can involve the inferior mesenteric artery.

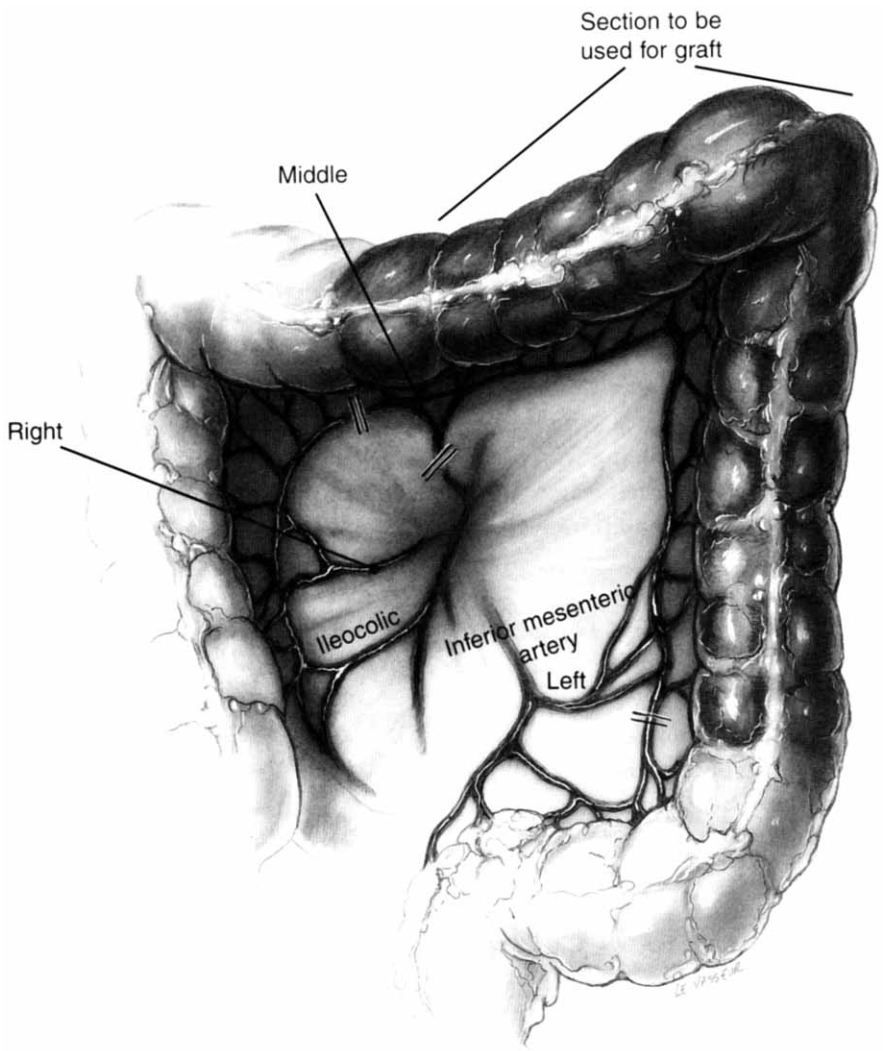
Preoperative Evaluation and Preparation

Evaluation of the colon as a potential conduit for esophageal replacement starts with a careful history to elicit any potential symptoms of colonic disease. Colonoscopy is an important part of the preoperative evaluation and has significant advantages over air-contrast barium enema for assessment of the colonic mucosa in that isolated adenomatous polyps can be resected during the course of the examination. Visceral angiography, including selective examination of the celiac axis, as well as the superior and inferior mesenteric arteries, is another essential part of the preoperative evaluation of the colon graft. Angiography verifies patency of the inferior mesenteric and left colic arteries, the continuity of the marginal artery, as well as the anatomy of the middle colic vessels.

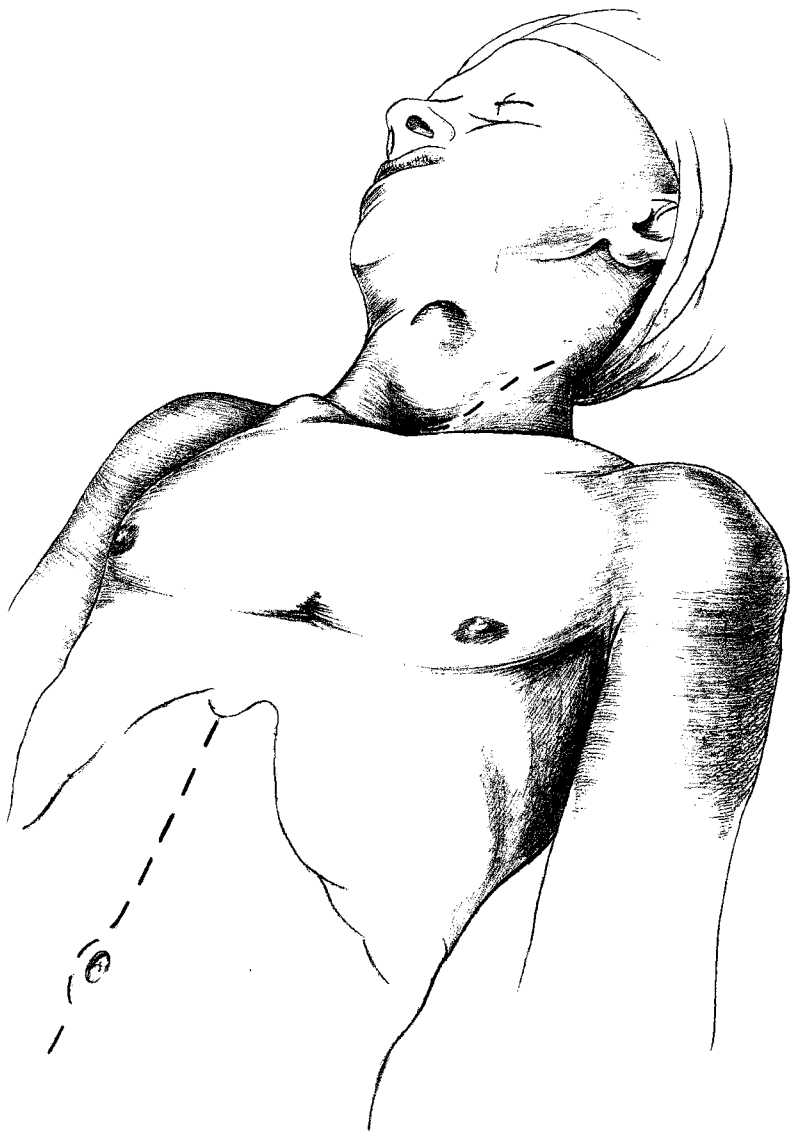
A formal mechanical and antibiotic bowel preparation must be conducted before the colon interposition procedure. Mechanical cleansing of the bowel is achieved by restricting the patient's oral intake to clear liquids for 48 hours before the operation. The patient is then instructed to ingest Go-Lytely (Braintree Laboratories, Braintree, ME) on the afternoon before the procedure. Tap water enemas are administered on the night before surgery until the effluent is clear. The author's preference for antibiotic preparation adheres to a fairly standard protocol, which entails the administration of neomycin and erythromycin by mouth (1 g of each at 1:00 PM, 2:00 PM, and 11:00 PM on the day before surgery). A broad-spectrum antibiotic is given intravenously on the operating table at the start of the procedure.

The remainder of the preoperative evaluation is similar to that for any patient undergoing a major thoracic surgical procedure. This entails preoperative evaluation of pulmonary function tests and cardiac status.

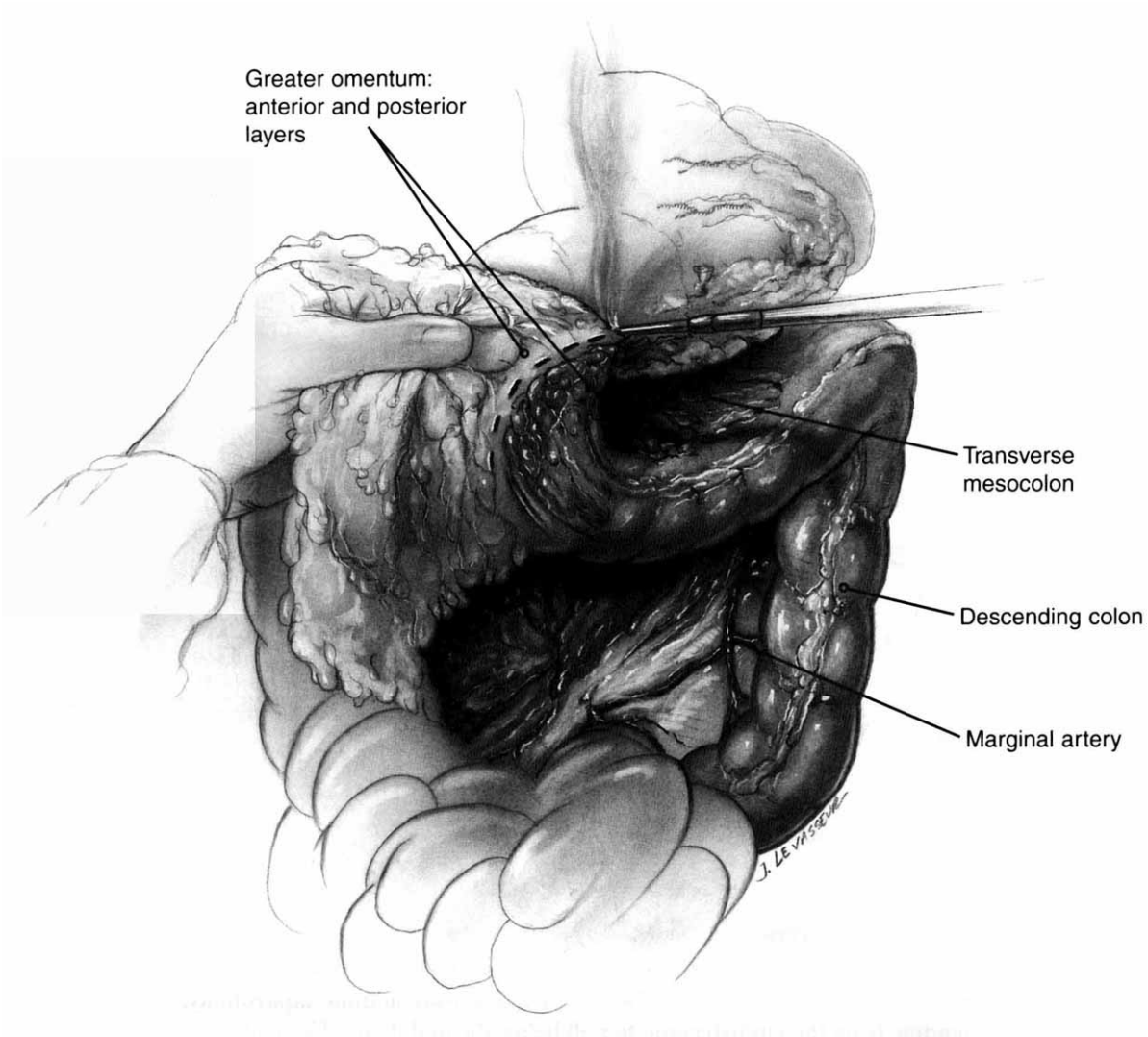
SURGICAL TECHNIQUE



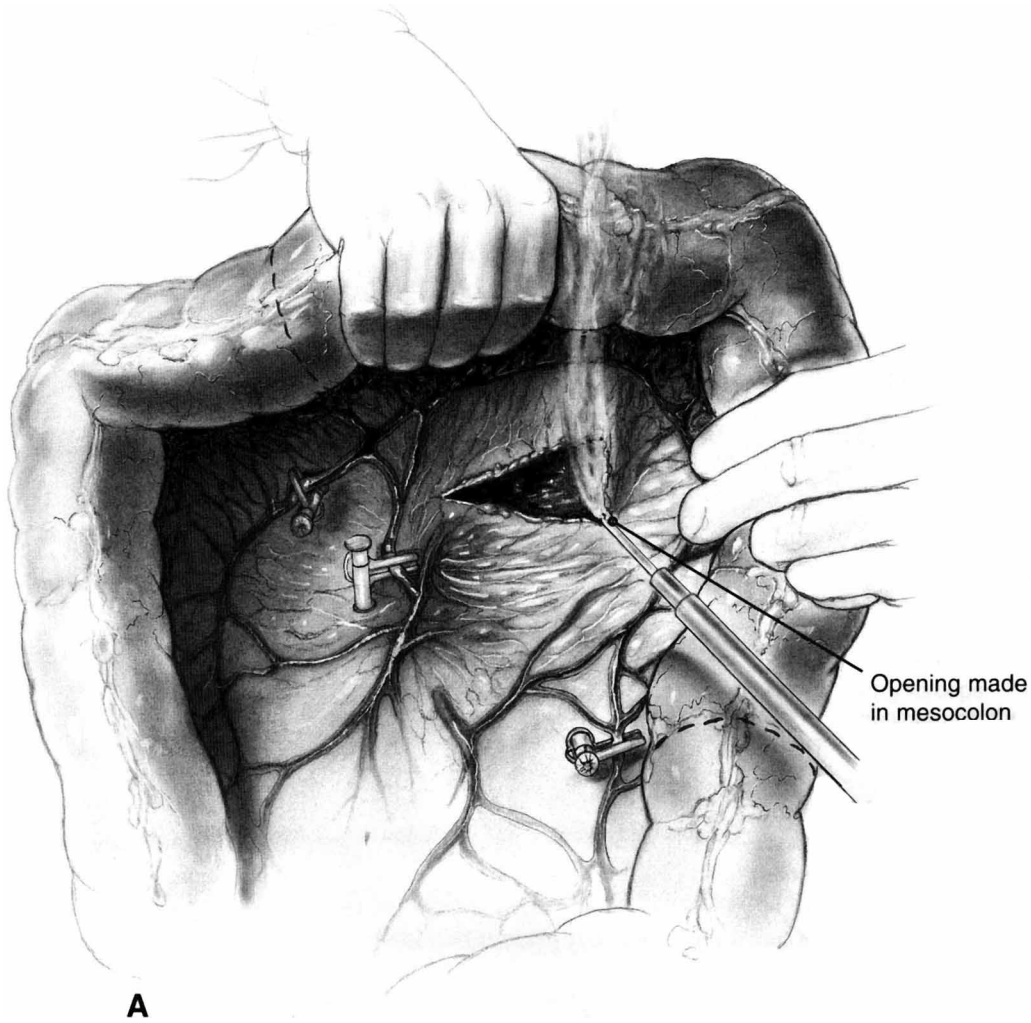
1 The long-segment left-colon graft is pedicled on the left colic artery, which is derived from the inferior mesenteric artery. The ascending and descending branches of the left colic are left intact, and the marginal artery is divided at the site of distal graft transection, near the junction with the sigmoid colon. To insure adequate proximal length of the graft, the middle colic artery is divided near its origin, preserving a generous portion of the transverse colon toward the hepatic flexure.



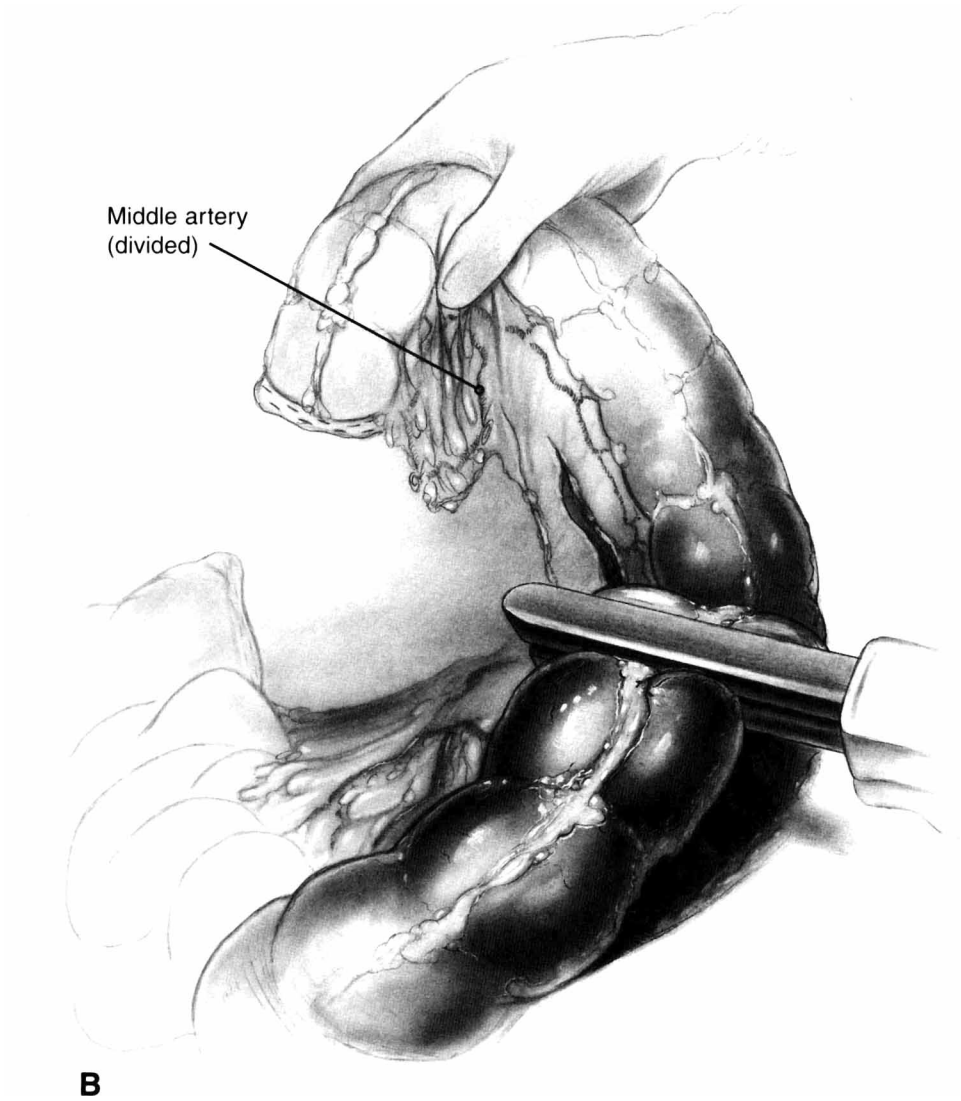
2 Esophageal replacement using a long segment of left colon is ideally performed using a left neck incision and a generous midline laparotomy, extending from the xiphisternum to well below the umbilicus. The xiphisternum is ideally excised, and a table-mounted retractor is used to exert upward traction on the costal arches bilaterally. The neck incision is carried along the anterior border of the left sternocleidomastoid muscle with a short hockey stick extension in the suprasternal notch. All of the strap muscles are divided near their sternal attachments, to maximize the exposure of the mediastinal portion of the esophagus. (The left thoracoabdominal incision, carried in the sixth or seventh intercostal space and across the left costal arch into the left upper quadrant, is another very satisfactory exposure to perform left colon replacement of the esophagus.)



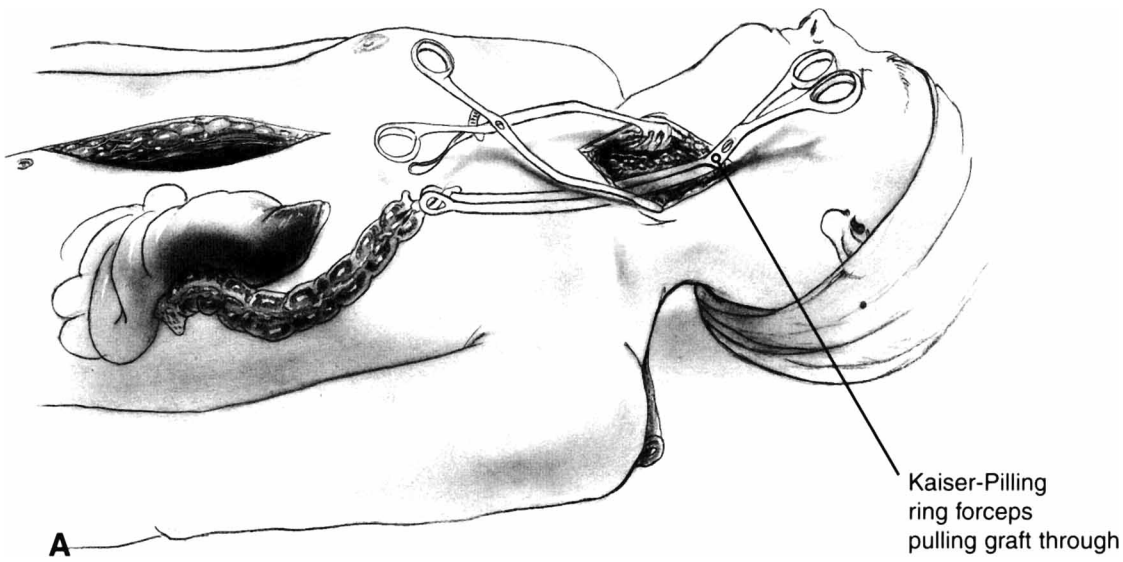
3 The colon must be mobilized extensively, including both hepatic and splenic flexures, the entire descending colon, and the upper sigmoid colon. The gastrocolic ligament is divided from the transverse colon with electrocautery or scissors. This allows the entire colon to be held upward, so that its mesocolon can be transilluminated to define the blood supply.



4 (A) The mesocolon between the left branch of the middle colic artery and the ascending branch of the left colic artery is divided with cautery, staying a generous distance away from the marginal artery itself. Atraumatic bulldog vascular clamps are then applied as shown: at the marginal artery just to the right side of the right branch of the middle colic artery, at the origin of the middle colic artery, and on the marginal artery just below the descending branch of the left colic artery. The marginal artery is then carefully inspected and palpated along its entire length to verify an adequate pulse, and the bowel is visually inspected to verify its integrity.

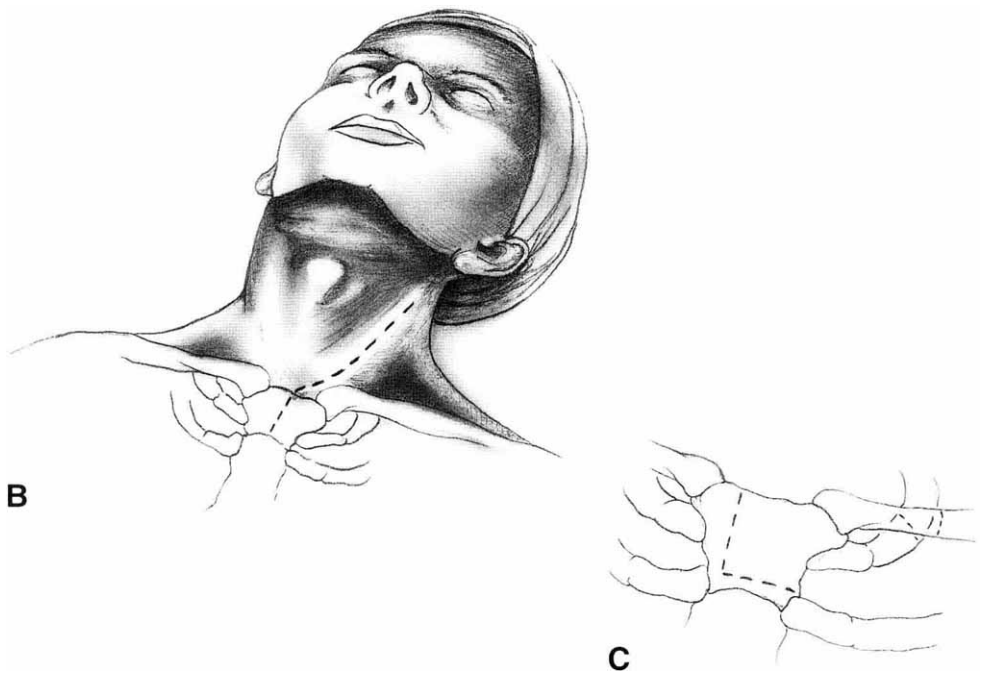


4 (continued) (B) Once this maneuver shows an excellent pulse in the marginal artery throughout the isolated segment fed by the left colic artery, the vessels are then divided between heavy (0 silk) ligatures at the sites corresponding to the bulldog vascular clamp application. The segment chosen for the colon graft is then isolated by dividing it at the proximal and distal margins using the linear stapling instrument.

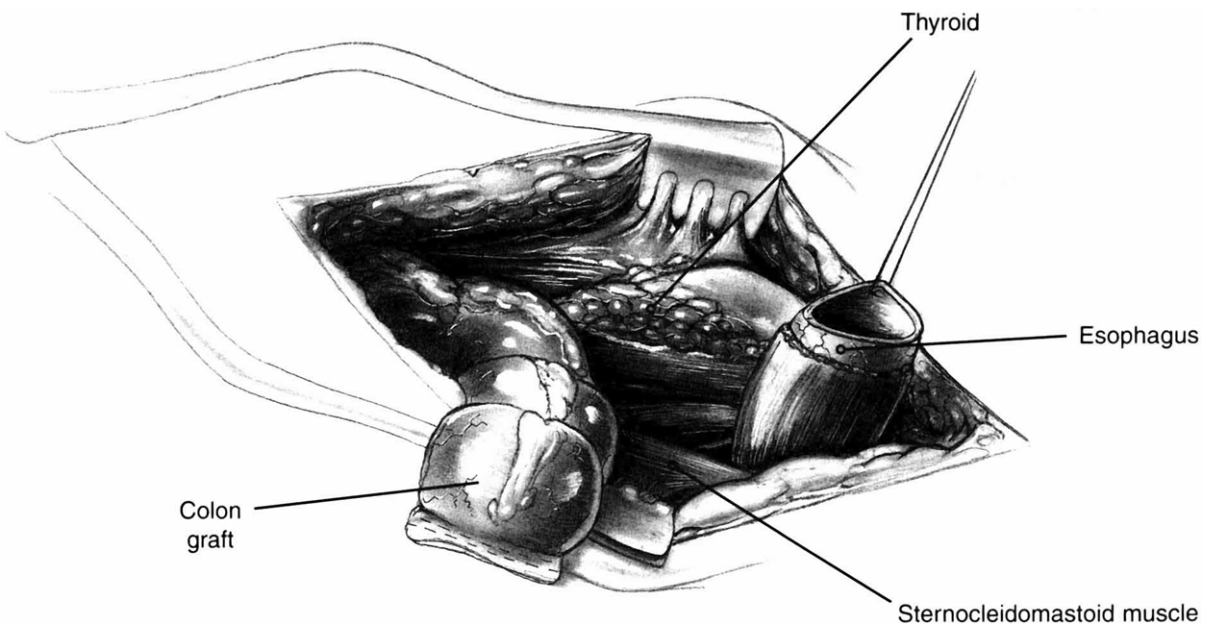


5 (A) A curved Kaiser-Pilling ring forceps (Pilling Co., Ft Washington, PA) is passed from the neck incision and along the spine (corresponding to the bed of the resected esophagus) to grasp the upper end of the colon graft. It is then gently withdrawn so that the proximal end of the colon is carefully delivered out the neck incision. This maneuver may be facilitated by suturing a short length of umbilical tape to the stapled margin of the colon graft, and then using the ring forceps to exert traction on the umbilical tape rather than the colon itself. Care is taken to ensure that the vascular pedicle does not twist, and always stays toward the right side of the colon graft.

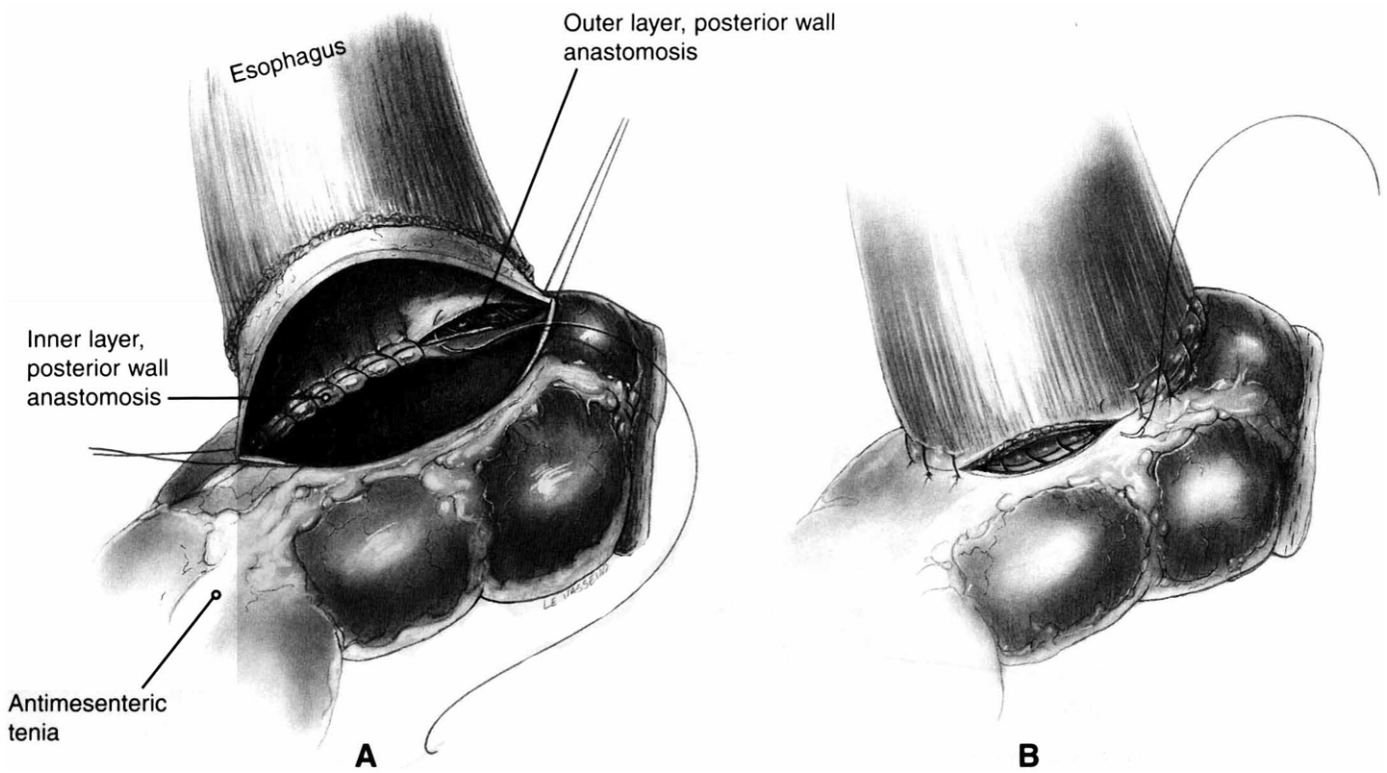
Retrosternal passage of the colon graft requires removal of the xiphisternum. The diaphragmatic fibers inserting in the posterior aspect of the distal sternum are divided with cautery, and digital dissection is then used to develop a tunnel in a cephalad direction. Similarly, digital dissection is carried out from the suprasternal notch behind the manubrium.



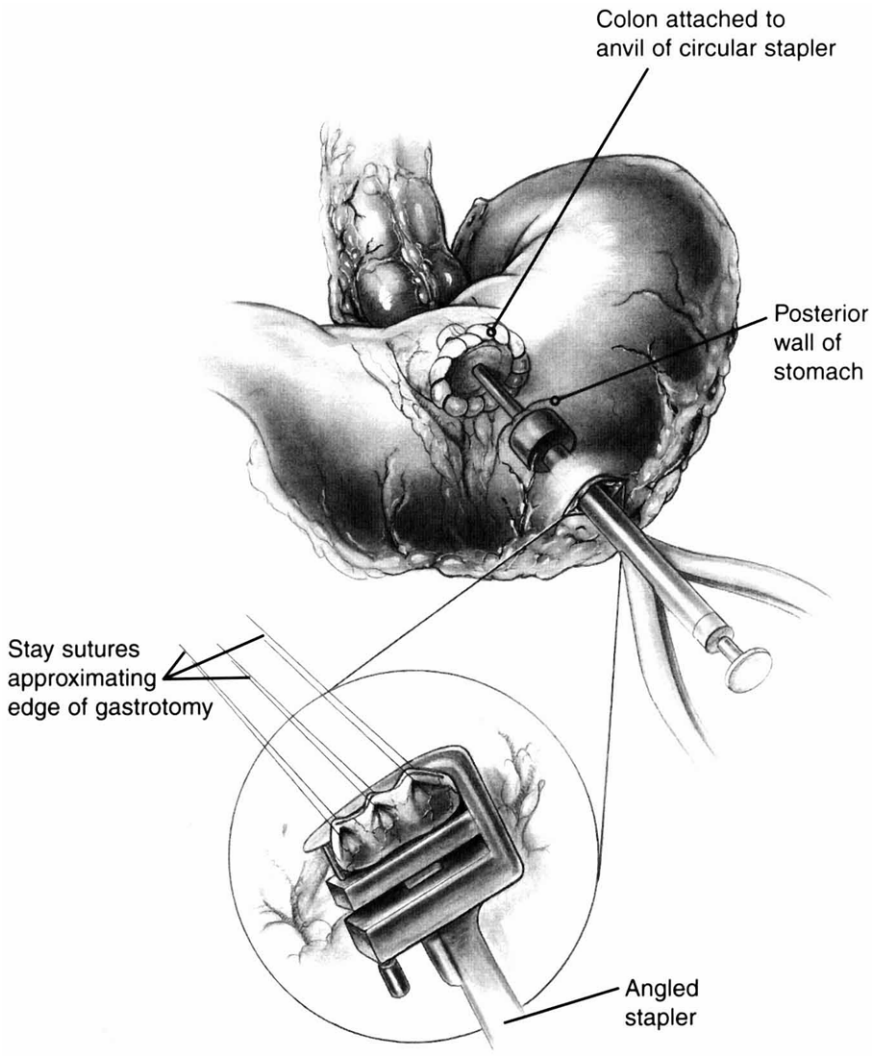
5 (continued) The lower and upper ends of this dissection are then connected by passing the long curved Kaiser-Pilling ring forceps with a small sponge to bluntly create the tunnel. Once the tunnel is established, the surgeon's hand is then passed through the entirety of the retrosternal space to insure a satisfactory caliber passage, thereby minimizing any potential compression of the colon graft or its blood supply. Retrosternal passage of the colon graft usually requires enlargement of the thoracic inlet (B and C). The skin incision is extended vertically in the midline over the sternum to the manubrial-sternal junction (B). The skin and sternocleidomastoid muscle is reflected laterally to expose the clavicular head and medial end of the first rib. The left half of the manubrium, clavicular head, and medial end of the first rib are then excised in one piece (C). This is performed extrapleurally, to avoid injury to the internal mammary vessels beneath. This maneuver is essential to obviate any compression of the upper aspect of the colon graft above the thoracic inlet.



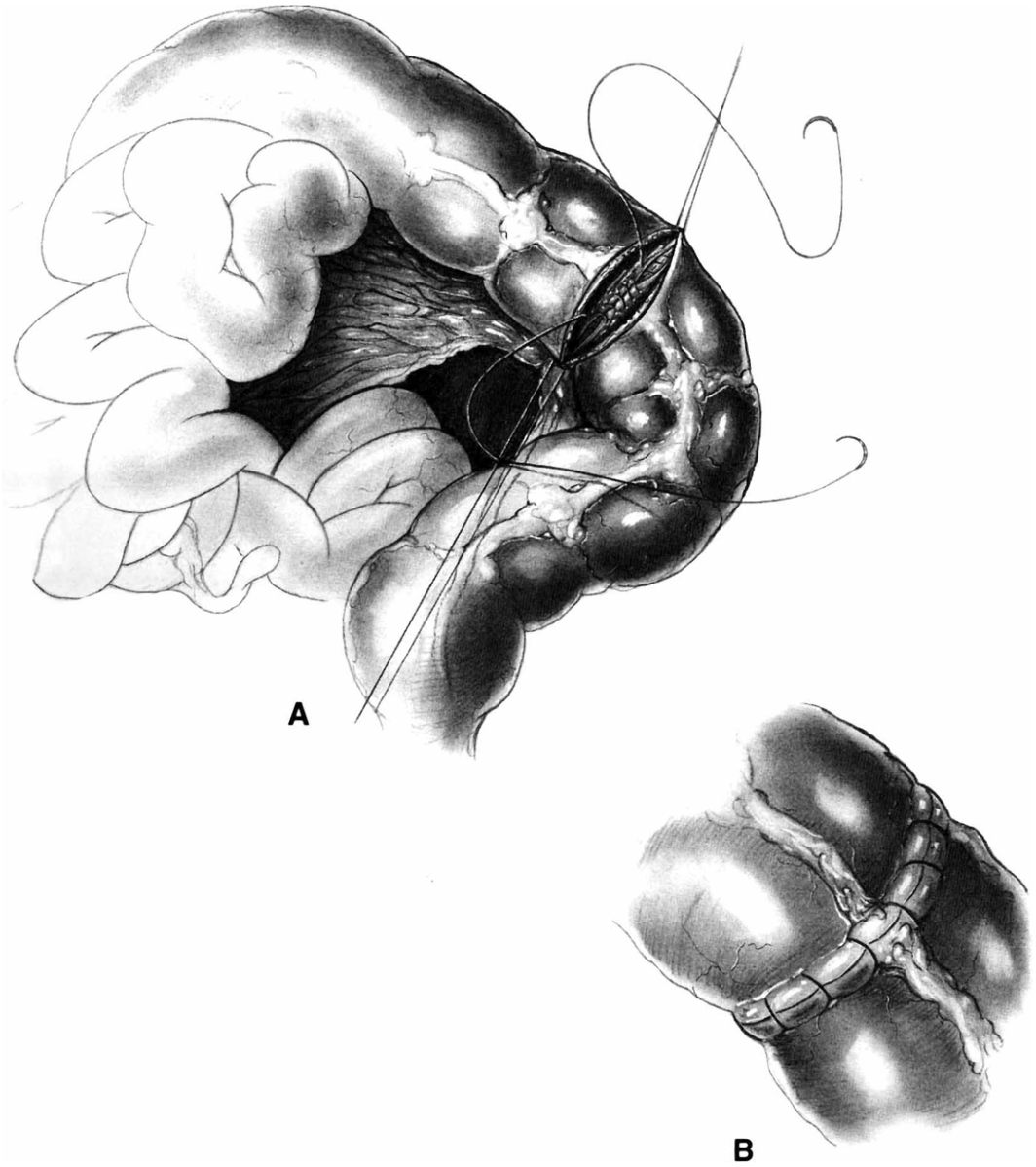
6 The esophagus is prepared for the anastomosis by performing a circular (transverse) myotomy near the site of transection. The mucosa is then divided nearly a centimeter distal to the cut edge of the muscle, thereby creating a well-defined mucosal tube protruding several millimeters beyond the cut edge of the muscle. An end-to-side anastomosis is created between the esophagus to the antimesenteric tenia of the colon just distal to the staple line on the colon.



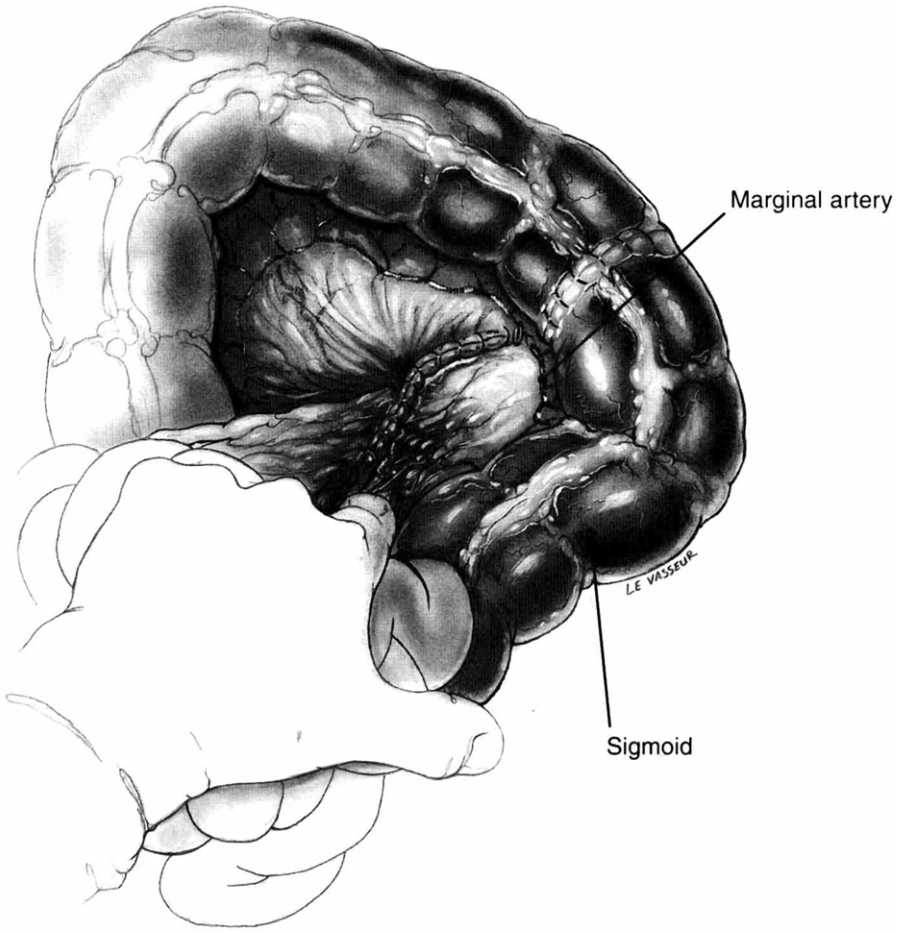
7 (A) A linear opening is made in the antimesenteric tenia of the colon, corresponding to the diameter of the opened esophagus. Stay sutures are placed at each lateral aspect of the anastomosis, approximating the seromuscular layer of the colon to the free edge of the muscle of the esophagus. The outer layer of the posterior wall of the anastomosis is then constructed using a series of interrupted 4-0 silk sutures run through mineral oil. These sutures approximate the esophageal muscle to the seromuscular layer of the colon several millimeters back from the free edge of the open bowel. The inner layer is constructed using similar suture material, and approximates the esophageal mucosa to the full thickness of the colon; all sutures are tied with knots on the inside, to maximize mucosal inversion. (B) The inner layer of the anterior aspect of the anastomosis has also been completed. The completion of the outer layer of the anterior wall is shown, consisting of interrupted 4-0 silk sutures approximating the esophageal muscle to the seromuscular layer of the bowel wall, this time with knots on the outside.



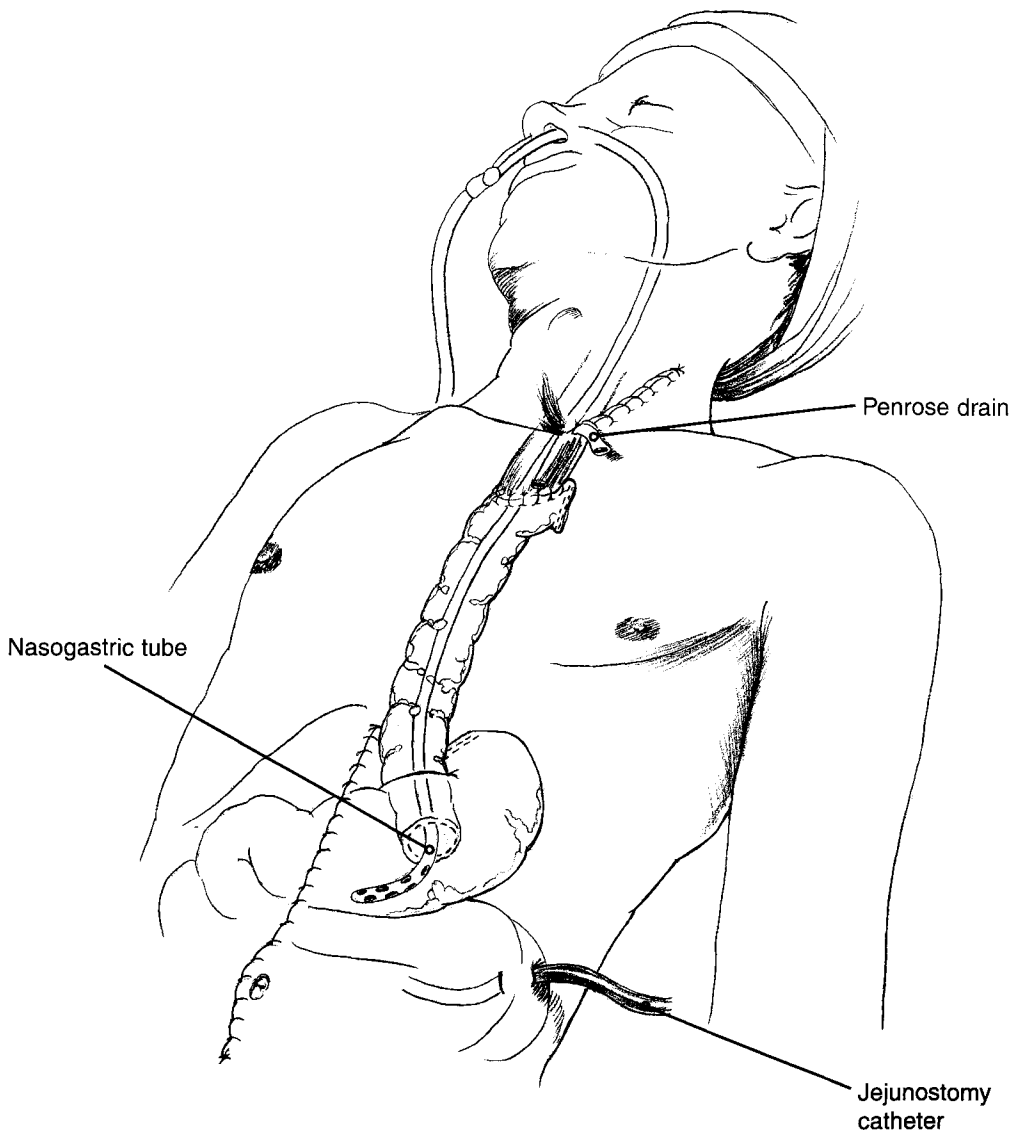
8 The distal end of the colon graft is then gently retracted back into the abdomen, to avoid any possibility of redundancy. Care is taken once again to maintain proper orientation of the vascular pedicle. The cologastric anastomosis is created using a circular stapling instrument inserted through an anterior gastrotomy. The anastomosis is constructed between the end of the colon and the posterior wall of the stomach. The insert shows the closure of the anterior gastrotomy with a single firing of the angled stapler.



9 (A) A standard hand-sewn colo-colic anastomosis is then created. Stay sutures are used to approximate the mesenteric and antimesenteric borders. The staple lines are trimmed off and the outer layer of the posterior wall is constructed using interrupted 4-0 silk suture. The inner layer consists of a continuous 4-0 Vicryl (Ethicon, Inc., Somerville, NJ) suture beginning in the posterior midline and run toward each corner. Once the corners are turned, a Connel stitch is used to approximate the anterior inner layer. (B) The colo-colic anastomosis is completed using a series of interrupted 4-0 silk sutures approximating the seromuscular layer of the bowel and inverting the inner layer.



10 Interrupted 3-0 chromic sutures are then used to approximate the mesocolon. The colon graft has been passed posteriorly, and care is taken during closure of the mesocolon not to jeopardize the integrity of the vascular pedicle of the graft.



11 A feeding jejunostomy catheter is inserted in the proximal jejunum using the Witzel technique. This is brought out through a stab incision in the left upper quadrant of the abdomen. An 18F-Davol sump nasogastric tube (Bard, Covington, GA) is then passed, usually down the esophagus and colon graft, so that its tip is in the stomach. Also, a half inch Penrose drain is brought out the inferior portion of the neck incision. Its tip is placed near the esophagocolic anastomosis. The neck incision is closed maintaining a two-finger defect from the esophagocolic anastomosis to the skin. The platysma is loosely approximated with continuous 2-0 Vicryl above this point, and the skin is loosely approximated with staples. The abdominal closure is performed using a continuous heavy monofilament nonabsorbable suture in the fascia, and staples in the skin.

Postoperative Care

The patient is admitted to the intensive care unit postoperatively. With the exception of very unusual circumstances, the patient remains intubated and mechanically ventilated overnight. Barring any significant preoperative cardiopulmonary dysfunction, the patient should be weaned from ventilatory support and extubated the following morning. Intravenous fluids are run generously in the first 24 hours. This consists of a crystalloid solution, such as normal saline, at least 150 mL per hour. After 24 hours, if the patient's progress is otherwise satisfactory, the intravenous fluid can be changed to 5% dextrose/half normal saline, and the rate can be decreased to a maintenance rate. It is imperative to avoid hypotension in the early few hours postoperatively. If a thoracic epidural catheter is used for postoperative pain control, local anesthetic agents (such as bupivicaine) should be avoided because these agents can produce a sympathectomy effect and systemic hypotension. Marginal blood pressure should be treated initially by volume infusion; alpha-adrenergic agents should be meticulously avoided in the early few hours postoperatively. In older patients, or in any patient with significant underlying cardiopulmonary disease, invasive hemodynamic monitoring is appropriate to optimize the circulation and blood pressure.

The patient is initially maintained nil by mouth, and the nasogastric tube is maintained on high continuous suction. The patient must be thoroughly evaluated clinically to make sure that the progress is satisfactory. If so, then on the third postoperative day, dextrose and water are started through the jejunostomy tube. If this is well tolerated over the ensuing 24 hours, tube feeding with a liquid feeding product is commenced on the fourth postoperative day.

Once the patient is transferred from the intensive care unit to the thoracic surgical floor, the main priorities are intensive measures to promote bronchial hygiene and thereby avoid pulmonary atelectasis and pneumonia. This consists of chest physical therapy and postural drainage when necessary. The patient should be ambulatory by the second postoperative day. Daily chest radiographs are obtained to monitor the patient's progression. Antibiotics are continued for 72 hours and then stopped. On the seventh postoperative day, the integrity of the esophagocolic and cologastric anastomoses is evaluated by means of an oral contrast study. The patient ingests hypaque. If this water-soluble contrast examination shows no evidence of anastomotic leakage, then thin barium is used. If, at this point, the patient's clinical progress is satisfactory and the contrast study shows no evidence of complications, the nasogastric tube is removed and oral intake is started. The patient initially consumes only water by mouth. This is then gradually increased on a daily basis as follows: clear liquids, full liquids, and then mechanical soft diet.

In the absence of any significant postoperative complications, the patient will be ready for discharge from the hospital within 12 to 14 days after the procedure. The patient's oral intake of calories and protein at this point may not be sufficient; in this case, arrangements can be made for the patient to receive nocturnal jejunostomy tube feedings for a short duration at home.

Comments

There have been four clinical series published within the past 5 years dealing with colon interposition for esophageal replacement.[6-9] In two of these series, approximately half of the patients undergoing esophagectomy with colon interposition had malignant disease as the indication; in the other two series, all of the colon reconstructions were performed for benign or "acquired" esophageal disease. Long segments of left colon were used in the majority, ranging from 63% to 88% of colon interpositions.

Operative mortality was less than 10%, ranging from 2% to 9%. Major factors implicated in postoperative mortality were the development of ischemic necrosis of the colon graft, and pulmonary complications, notably aspiration pneumonia and adult respiratory distress syndrome. Morbidity was not inconsequential. Nonfatal ischemic colon necrosis was observed in 3% to 10% of patients in these series and was noted more frequently with right colon grafts than long-segment left colon interpositions.[7-9] Anastomotic leaks were observed in 3% to 16% of patients and, in those series that specified the nature of the leak, approximately two thirds of these affected the esophagocolic anastomosis in the neck.[6,9] In the study by Thomas et al,[6] a multivariate analysis identified that conduit position in the posterior mediastinum was the sole independent predictor of a good functional result. In general, most authors have stated the preference that passage of the colon graft in the posterior mediastinal bed of the esophagus provides the most direct route between the neck and the abdomen. This offers the least risk of kinking or torsion of the colon vascular pedicle, thereby minimizing the incidence of ischemic graft necrosis. Ischemic necrosis of the colon conduit is the most serious complication after this operation. It is ultimately associated with fulminant mediastinitis and death; the only meaningful chance of salvaging the patient with this complication is early identification and prompt and effective management. Therefore, if the patient's clinical status postoperatively is not progressing satisfactorily, there should be a low threshold to perform a bedside fiberoptic endoscopic examination to assess the viability of the mucosa of the colon graft. Once ischemic necrosis is

identified, resection of the necrotic colon segment and exteriorization of the proximal esophagus and the distal aspect of the gastrointestinal tract must be performed to manage the complication. Definitive reconstruction must then be deferred until a considerably later date, when the patient has stabilized from the initial ischemic/septic complication.

The functional result (in terms of quality of swallowing) reported in these clinical series was very satisfactory; 90% to 93% of patients reported an excellent, good, or fair outcome from their operation. In late survivors, a poor result was seen in less than 10% of patients.

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