

Carol E.H. Scott-Conner and Jameson L. Chassin<sup>†</sup>

## Indications

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

Undetected pneumothorax  
 Ischemia or trauma to tip of gastric tube in the neck inducing necrosis and sepsis  
 Anastomotic leak  
 Inadvertent laceration of right gastroepiploic artery

## Preoperative Preparation

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

## Operative Strategy

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

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

## Pitfalls and Danger Points

Excessive bleeding  
 Laceration of membranous trachea  
 Injury to spleen  
 Hypotension during mediastinal dissection due to compression of the heart  
 Trauma to thoracic duct, chylothorax  
 Traction injury or laceration of the recurrent laryngeal nerve  
 Bowel herniation through a too large diaphragmatic hiatus

C.E.H. Scott-Conner, MD, PhD (✉)  
 Department of Surgery,  
 Roy J. and Lucille A. Carver College of Medicine,  
 University of Iowa, 200 Hawkins Drive, 4622 JCP,  
 Iowa City, IA 52242, USA  
 e-mail: carol-scott-conner@uiowa.edu

J.L. Chassin, MD  
 Department of Surgery,  
 New York University School of Medicine, New York, NY, USA

<sup>†</sup>Deceased

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

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

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## Documentation Basics

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

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

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## Operative Technique

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

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

## Abdomen

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

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

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

## Cervical Dissection

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

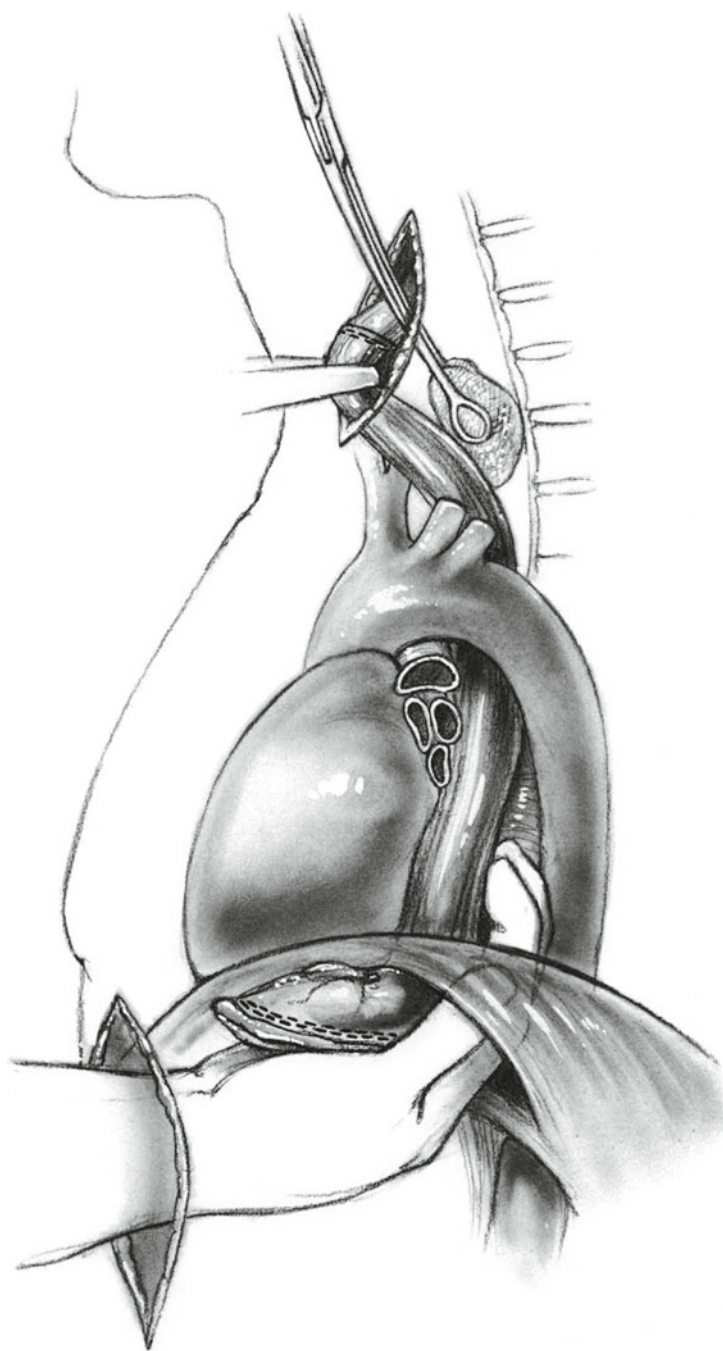
## Transhiatal Dissection

Wear a headlamp for this phase of the operation. Adjust the Thompson retractor to elevate the sternum and liver. Enlarge

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

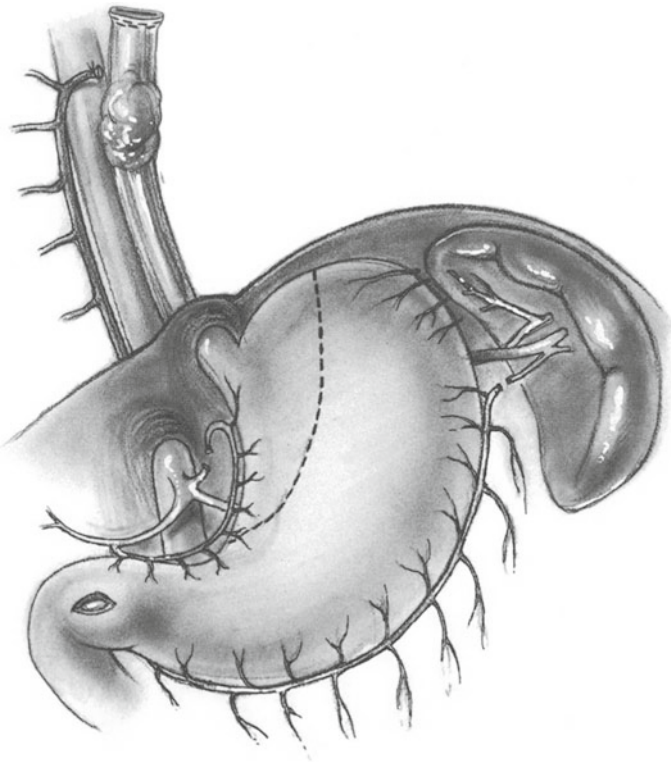
Despite the limited exposure allowed by the transhiatal approach, the transhiatal esophagectomy is neither a blind nor a crude operation. Dissection of the esophagus from the diaphragm to the arch of the aorta is performed under direct vision. Exposure can be enhanced by inserting long, narrow retractors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

After the lower esophagus has been mobilized, insert a small sponge on a long sponge holder ("sponge on a stick") along the prevertebral fascia in the neck behind the esophagus while the other hand is placed behind the esophagus in the mediastinum (Fig. 16.1). When the sponge-stick meets the hand, the posterior dissection of the esophagus has been completed. Try not to compress the heart unduly with the hand in the prevertebral space. Remind the anesthesiologist to monitor the arterial pressure carefully during this dissection. Now remove the sponge-stick from the neck. With the assistant exerting traction in a caudal direction on the Penrose drain encircling the esophagogastric junction, place the hand, palm down, on the anterior surface of the esophagus and with finger dissection free the esophagus from overlying pericardium and carina. With the other hand, insert one or two fingers, volar surface down, over the anterior face of the esophagus in the neck while cephalad traction is being applied to the Penrose drain encircling the cervical esophagus. Working with both hands simultaneously, disrupt the filmy attachments between the esophagus and the membranous



**Fig. 16.1**

trachea – left main stem bronchus. After this has been accomplished, there remain lateral attachments to be disrupted before the esophagus is freed. Again retract the upper esophagus in a cephalad direction and separate the esophagus from these attachments until the upper 8 cm of thoracic esophagus is freed circumferentially. Now insert the hand into the hiatus and slide upward along the anterior esophagus behind the trachea until the circumferentially freed upper esophagus is contacted. Trap the esophagus against the vertebral column between the index and middle fingers. Then



**Fig. 16.2**

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

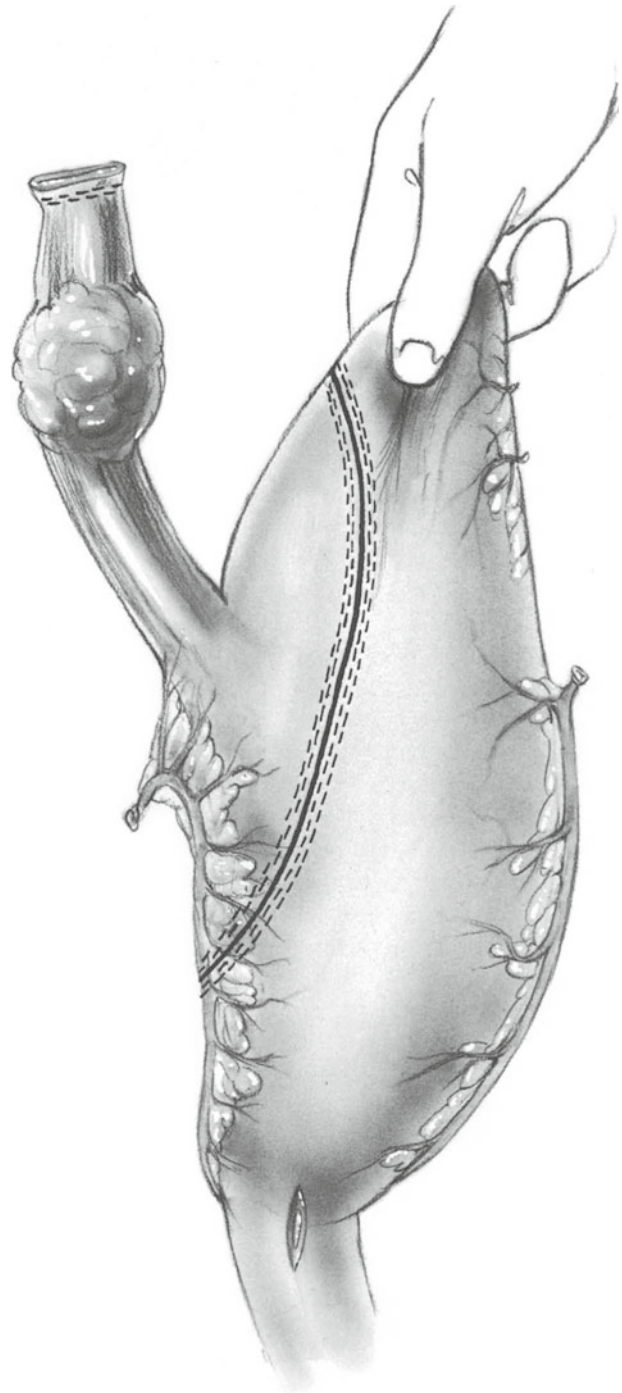
Deliver 7–8 cm of thoracic esophagus into the neck and transect the esophagus with a linear cutting surgical stapler. This maneuver provides a few centimeters of extra esophagus, allowing the option of selecting the best length when the anastomosis is performed.

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

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

Exteriorize the stomach and attached esophagus by spreading it out along the patient's anterior chest wall. Because the blood supply to the lesser curvature subsequent to ligation of the left gastric artery is poor (Akiyama), the lesser curvature is excised, converting the stomach into a tubular structure (Fig. 16.2). Manually stretch the proximal tip of the cardia in a cephalad direction. Observe the

esophagogastric junction and note where the second or third branch down of the left gastric artery enters the lesser curvature. At this point, apply the linear cutting stapler and aim it in a cephalad direction toward the cardia. While continuing to apply cephalad traction on the cardia, fire the stapler. Sequentially reapply and fire the stapler until the lesser curvature has been amputated, leaving about 6–8 cm width of cardia intact at the gastric tip (Fig. 16.3). Remember that



**Fig. 16.3**

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

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

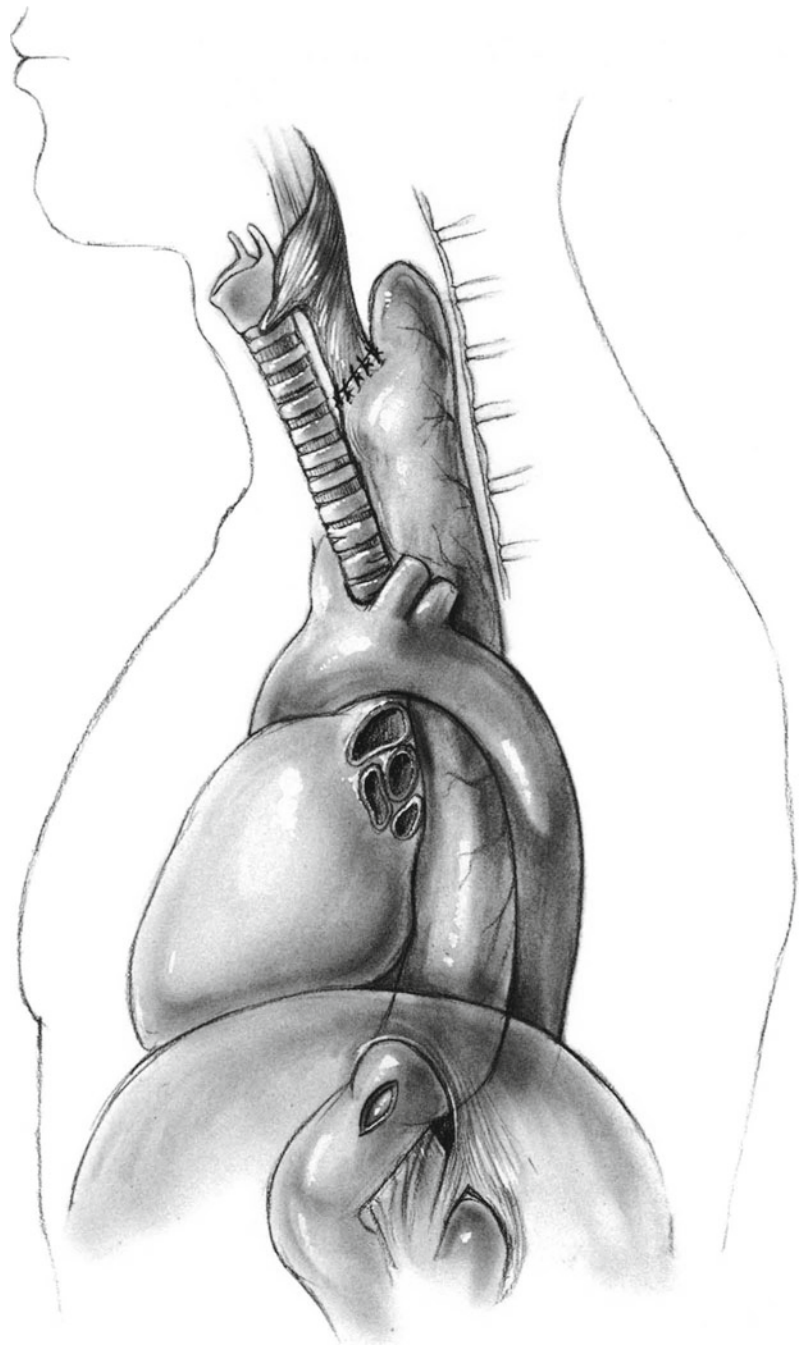
To avoid any tension whatsoever on the anastomosis, divide the cervical esophagus at a point where it can easily reach the clavicle. When dividing the esophagus, cut the anterior flap of esophagus so it is at least 1 cm longer than the posterior flap, as illustrated in Fig. 14.24. This maneuver converts the anastomotic suture line into an ellipse instead of a circle and should result in a larger stoma. Now reflect the esophagus in a cephalad position above the cervical incision. The uppermost gastric cardia has already been sutured to the neck muscles as high as is comfortable in the cervical incision. Using Babcock forceps, gently elevate the anterior wall of the stomach from behind the clavicle to a more superficial and superior location in the neck. The anastomosis between

the end of the esophagus and the anterior wall of the stomach should be located 3–5 cm down from the apex of the gastric tube and above the level of the clavicle. Bring the esophagus back into the neck so it rests on the anterior wall of the gastric tube. Make an incision in the anterior wall of the gastric tube in a vertical direction, the length being appropriate to the diameter of the elliptical esophageal orifice, which is approximately 2.5 cm.

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

## Closure

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

**Fig. 16.4**

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### Postoperative Care

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

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### Complications

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

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

## Further Reading

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