Chapter 7
Minimally Invasive Transhiatal Esophagectomy

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7.1 Introduction

Although the transhiatal esophagectomy (THE) was popularized by Orringer and Sloan in 1978, it was first described in 1913 [1]. In contrast to the Ivor-Lewis esophagectomy that involves a right transthoracic esophageal dissection with an intrathoracic anastomosis, the THE involves a cervical anastomosis and blunt upper esophageal mobilization without any thoracic incisions. These two approaches are used primarily for adenocarcinomas of the distal esophagus and gastroesophageal junction (GEJ). The McKeown approach includes a cervical anastomosis similar to the THE, but also involves direct intrathoracic mobilization of the esophagus similar to the Ivor-Lewis esophagectomy—it is thus commonly referred to as a "three-hole" esophagectomy. The McKeown is primarily used for squamous cell carcinomas of the middle third of the esophagus, when delicate dissection between the tumor and airway is required.

Minimally invasive techniques have gradually been used in all approaches to esophagectomy in hopes of reducing the morbidity of these high-risk procedures. We have used laparoscopy to assist with THE for over two decades, with excellent results. We use laparoscopy for its benefits (visualization of the lower half of the esophagus/mediastinum, improved radial and lymph node dissection, reduction of blood loss, and decreased incision size) and employ a small laparotomy to accelerate and safely complete the operation in a timely fashion, usually 3.5–4.5 h. The open part of the procedure includes performing a Kocher maneuver, completing the upper mediastinal dissection, and safely constructing the gastric conduit.

The focus of this chapter will be the technical approach to a hybrid minimally invasive THE. We will briefly review the common indications/contraindications and

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perioperative management of the patient, but the majority of the discussion will highlight the key steps to the procedure and technical tips to consider.

7.2   Indications/Contraindications

A THE can be performed for most benign and malignant diseases of the esophagus, but there are a few contraindications that must be considered. A THE should be avoided in any situation that may cause difficulty with mobilizing the upper half of the thoracic esophagus (e.g. a T3 tumor abutting the airway). In such cases, a transthoracic approach must be used to safely address any fixation of the esophagus, usually with a three-field (McKeown) esophagectomy [2]. Another contraindication for THE is prior gastric surgery or disease that prevents adequate mobilization and/ or length of the stomach to the neck. In these situations, an intrathoracic anastomosis is preferred to the cervical anastomosis of a THE.

7.3   Preoperative Preparation

During patients' preoperative evaluation, we perform a nutritional assessment to determine whether the patient would benefit from placement of a jejunostomy feeding tube to optimize nutritional status prior to esophagectomy. In addition, patients are also referred to physical therapy as needed to maximize their preoperative physical conditioning. We have also implemented preoperative carbohydrate loading. On the day of surgery, patients receive a thoracic epidural and prophylactic heparin prior to heading to the operating room. Sequential compression devices are placed on the bilateral lower extremities to minimize the risk of deep vein thrombosis. After induction, a foley catheter is placed and the patient is then positioned.

7.4   Operative Steps

7.4.1   Patient Positioning

The patient is positioned supine on a split-leg table. Arms are tucked and legs are secured with hip straps to support severe reverse-Trendelenburg positioning. The neck is rotated 30° to the right and positioned in extension with towels beneath the shoulders. The patient is prepped widely from mandible to pubis and is draped to expose the left neck to below the umbilicus (Fig. 7.1).

Troubleshooting:

- An underbody warming blanket should be use to ensure adequate warming during the surgery. The standard lower and upper-body warmers cannot be applied to these patients due to the split-leg positioning and thoracic/neck exposure.

Fig. 7.1 Positioning
and draping
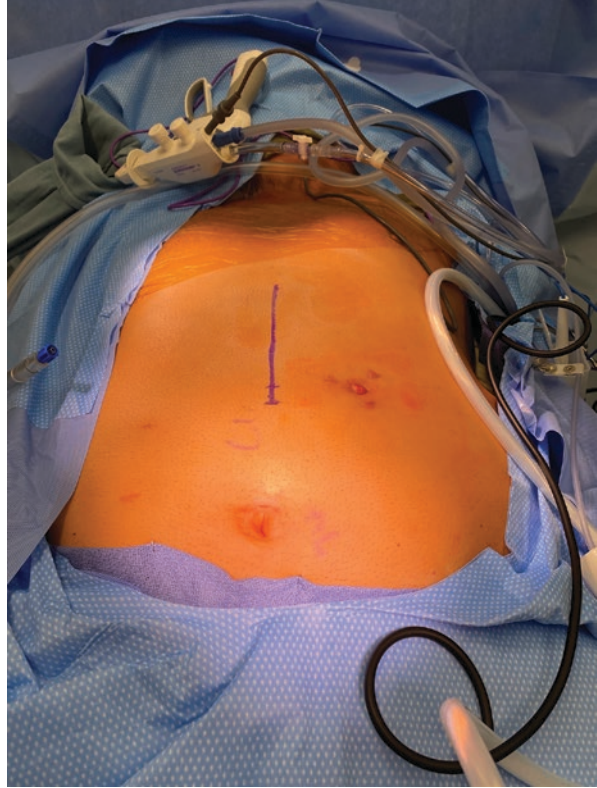
After the laparoscopic portion of the procedure, we put the legs together and add
a lower-body warmer under the drapes. We also place a fresh drape over the
lower extremities to ensure that we maintain sterility of the field.
- A gel donut placed under the occiput helps to stabilize the head and minimize
  rotational movement of the neck during the procedure. It also helps to ensure
  proper neck extension without suspending or hyperextending the neck, which
  could result in spinal cord injury.
- After tucking the arms but prior to prepping and draping, the bed rails should be
  checked to ensure there is adequate clearance for the retractors without causing
  undue compression on the patient's arm.

7.4.2 Port Placement and Diagnostic Laparoscopy

Entry to the abdomen is made using a Veress needle and 10 mm, 0-degree optical
trocar in the midline, 10 cm below xiphoid. The viscera and parietal peritoneum are
inspected for metastases and frozen biopsy is sent of any suspicious lesions. A
5 mm working port is placed in both the left and right upper quadrants, and a 5 mm

Fig. 7.2 Port placement
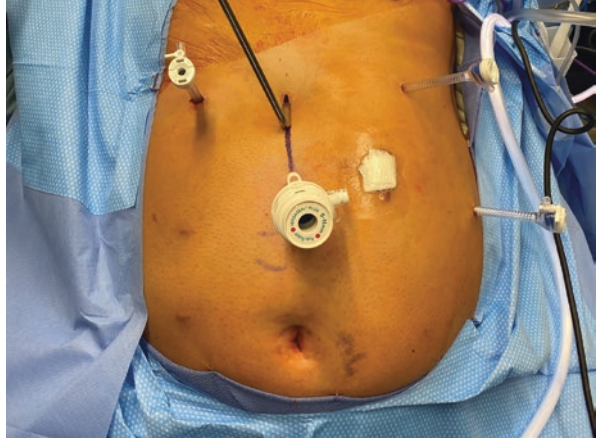
assistant port is placed in the patient's left lateral abdomen. Finally, a 5 mm incision is in placed in the midline epigastrium for the Nathanson liver retractor (Fig. 7.2).

Troubleshooting:

- The midline port incisions should be made vertically so that they can be connected later in the procedure to make an upper midline incision.
- The tip of the Nathanson retractor should be within view at all times during insertion, as it can inadvertently traumatize the diaphragm or even the pericardium.

7.4.3 Mobilization of the Greater Curve of the Proximal Stomach

This dissection starts approximately at the level of the mid-body along the greater curve. This is distal to the left gastroepiploic artery insertion, and is chosen to take advantage of the visualization of the left upper quadrant provided by laparoscopy compared to the limited visualization through a small laparotomy. The gastrocolic ligament is opened to enter the lesser sac, taking care to preserve the gastroepiploic arcade (Fig. 7.3, arrows). Ligation then proceeds cephalad along the greater curve with ligation of the left gastroepiploic artery and the short gastric arteries. The lesser sac surfaces should be inspected for any evidence of metastases.

Troubleshooting:

- The greater curve should be opened relatively distally to avoid having to mobilize around the splenic flexure through a small midline incision during the open phase of the procedure.

Fig. 7.3 Mobilization of the proximal greater curve with preservation of the gastroepiploic arcade (*arrows*)
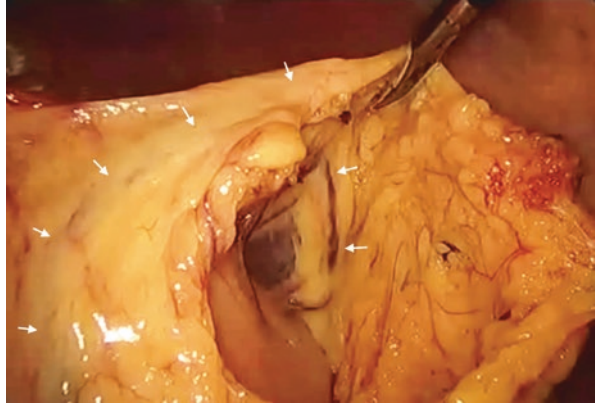
- Care should be taken to ensure preservation of the right gastroepiploic arcade at all times, and to minimize any trauma to the stomach/conduit.
- Take note of adhesions in the lesser sac that fuse the omentum to the posterior surface of the gastroepiploic arcade. These adhesions should be divided to elongate the omentum, allowing for visualization of the arcade while minimizing inclusion of omentum with the conduit.

7.4.4 Mobilization of the Gastroesophageal Junction

The left phrenoesophageal membrane is opened to enter the mediastinum and is then extended anteriorly and posteriorly to begin mobilization of the distal esophagus. Once the left lateral aspect of the hiatus has been mobilized, the gastrohepatic ligament is entered and the right phrenoesophageal membrane is entered. The dissection plane is continued anteriorly and posteriorly until the GEJ is circumferentially free of attachments. A penrose is then placed around the GEJ to assist with retraction.

   Troubleshooting:

- The GEJ fat pad can be used for retraction until the penrose can be placed.
- In the case of a large GEJ tumor, part of the crus can be divided and included with the GEJ for adequate radial margins.

7.4.5 Mobilization of the Celiac, Hepatic, and Left Gastric Lymph Nodes (for Malignancy)

Laparoscopy provides excellent, magnified visualization of the celiac, hepatic, and left gastric lymph node basins, which are the main basins for GEJ tumors. With the GEJ retracted anteriorly toward the abdominal wall and inferolaterally, the

peritoneum is divided at the superior border of the pancreas and opened along the inferior edge of the hepatic artery (Fig. 7.4a). The peritoneum overlying the lymph nodes and the surrounding fat are lifted en bloc from the hepatic artery (Fig. 7.4b). Dissection along the hepatic artery is followed proximally to the celiac trunk and the base of the left gastric artery, which can then be ligated (Fig. 7.4c).
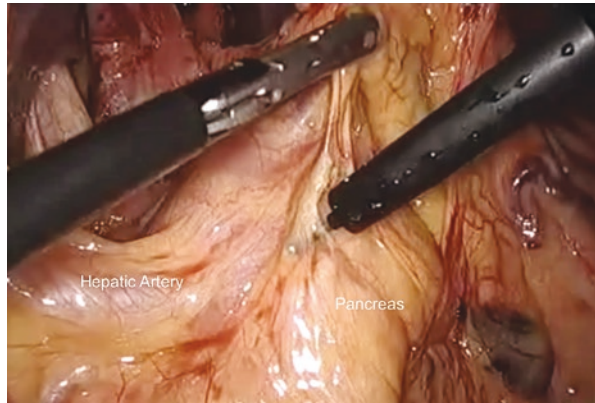
Fig. 7.4a Entering the retroperitoneum

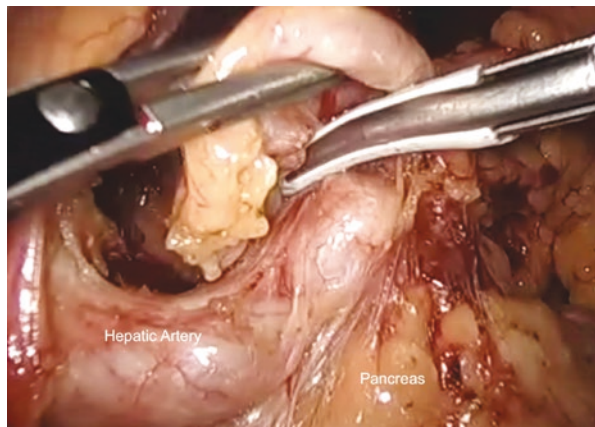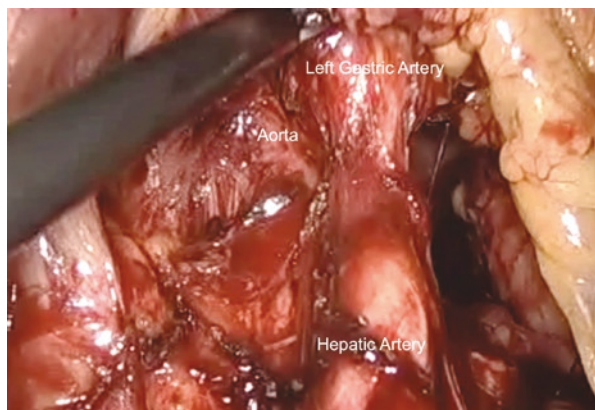**Fig. 7.4b** Hepatic lymph node dissection

Fig. 7.4c Identification of the base of the left gastric artery

Troubleshooting:

- While we typically use a bipolar vessel-sealing device to ligate the left gastric artery, other options include dividing between clips or using a vascular-load stapler.

7.4.6 Mediastinal Dissection

The esophagus is dissected circumferentially as high as possible, typically to the level of the carina. Using the laparoscopic transhiatal approach, dissection can occur right on the aorta, pericardium, and bilateral pleura to maximize radial margins. Prior to completion of the laparoscopic portion of the procedure, the liver retractor is removed and the left lateral segment of the liver is mobilized.

Troubleshooting:

- Switching to a 0-degree laparoscope can improve visibility in the proximal aspects of the mediastinum.
- If the surgery is being performed for cancer and tumor is noted to invade the pleura, pericardium, or diaphragm (T4a) during the mediastinal dissection, en-bloc resection can be performed. However, the procedure should be aborted if tumor is noted to invade the aorta, vertebral bodies, or trachea (T4b), although this should be apparent on preoperative imaging.

7.4.7 Cervical Dissection

Cervical dissection is performed prior to opening the abdomen in order to keep the patient warm and decrease insensible fluid losses. The patient's legs are repositioned to supine and covered with a lower-body warmer under the drapes, as well as a new half-sheet drape on top to ensure continued sterility of the field. Attention is then turned to the neck. A 4–5 cm oblique incision is made parallel to the left sternocleidomastoid muscle along its medial border (Fig. 7.5). The deep cervical fascia is incised medial to the carotid sheath, which is kept intact, and the middle thyroid vein is ligated. A 34F tapered bougie is inserted into the esophagus and blunt finger dissection is performed to create plane lateral to the thyroid down to the prevertebral fascia posterior to the esophagus, which should be easily palpable with the bougie in place. Once the esophagus has been identified and bluntly mobilized anteriorly, posteriorly, and to the patient's left, the bougie should be backed out so that only the thin part near the tip remains at the level of dissection. The esophagus may then be bluntly mobilized circumferentially, with dissection staying along the esophagus to remain within the avascular plane and avoid injury to the recurrent laryngeal nerve. A penrose drain is placed around the esophagus to assist with retraction. The bougie is advanced as circumferential dissection of the esophagus continues distally along

Fig. 7.5 Cervical incision
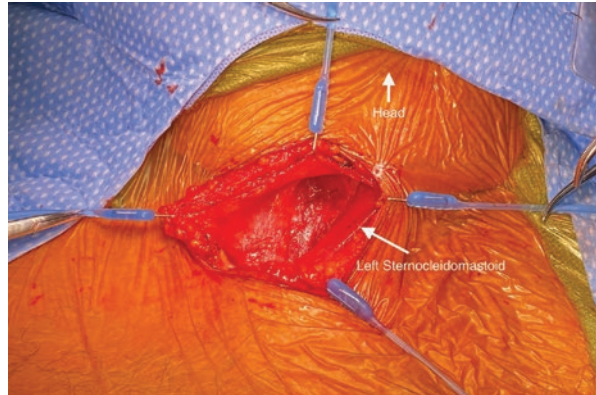
the avascular plane into the thoracic inlet as inferiorly as possible. Attention is then returned to the abdomen.

Troubleshooting:

- The omohyoid muscle may need to be divided during the cervical dissection, but often it can be preserved in a thin patient positioned with adequate neck extension.
- The recurrent laryngeal nerve should be in its own tissue plane adjacent to the trachea. If this plane is disrupted in an attempt to identify the nerve, there is an increased risk of traction injury to the nerve. Typically, contact with the recurrent laryngeal nerve can be avoided altogether by staying right on the esophagus in the avascular plane throughout the dissection.
- Whereas rigid metal retractors can be relatively bulky, the use of elastic retraction hooks attached to the drape allows for maximal retraction in the small cervical incision.

7.4.8 Kocher Maneuver and Completion of the Gastric Mobilization

A midline incision is made by connecting the epigastric and camera port sites and the abdomen is entered. The duodenum is mobilized with an extensive Kocher maneuver to allow the stomach to easily reach the neck. The distal greater curve is then mobilized taking special care to preserve the right gastroepiploic artery and vein, as well as the right gastric artery. The pulse of the right gastroepiploic artery should be verified by palpation. The key to this is dividing the ubiquitous adhesions in the lesser sac that hold the omentum to itself, especially underneath the gastroepiploic vessels (Fig. 7.6).
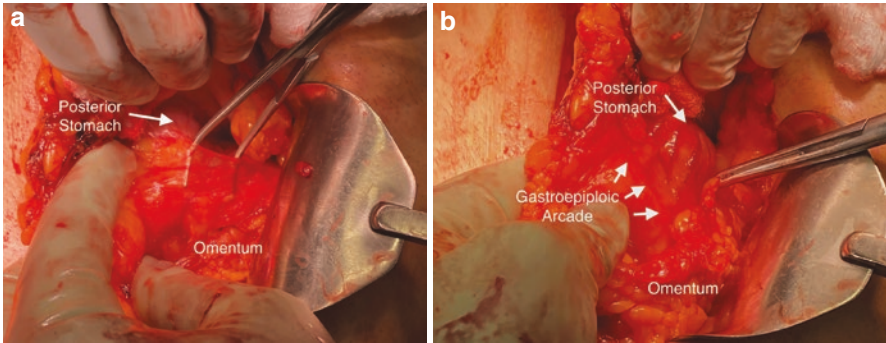
Fig. 7.6 Completion of gastric mobilization. Division of adhesions between the posterior stomach and the omentum (**a**) allow better visualization of the gastroepiploic arcade (**b**), which can then be preserved while minimizing inclusion of excess omental fat on the gastric conduit

Troubleshooting:

- The lesser sac adhesions mentioned above tend to fold the omentum to itself, closing the gastroepiploic vessels like a book. By identifying these adhesions and dividing them, the "book" is opened, and the vessels are more easily identified and preserved without including excess omental fat. These adhesions are rarely mentioned in anatomy books, chapters, or papers, but I am convinced they are key. This subtle recognition protects gastric conduit perfusion, and as a result, we have had no cases of conduit ischemia in 500+ cases.

7.4.9 Completion of the Esophageal Mobilization

The esophagus receives axial tension from an assistant pulling cephalad on the cervical esophageal penrose drain while the surgeon uses their non-dominant hand to pull distally on the esophagus. With the bougie advanced to the distal esophagus, the surgeon places a hand through the hiatus and bluntly dissects along the avascular plane posterior and anterior to the esophagus up until the dissection meets the assistant's fingers placed through the cervical incision above. The danger is lateral, so this is saved for last and gentle finger dissection is performed right along the esophageal wall by trapping the esophagus between the index and middle fingers while "raking" inferiorly to perform the lateral blunt dissection. These adhesions should divide easily, and any resistance should halt the dissection. The bougie is then removed and an 18F nasogastric tube is placed.

Troubleshooting:

- For GEJ cancers, err on the side of staying as close to the esophagus as possible, even if this means causing some esophageal muscle tearing.

7.4.10 Pyloromyotomy

A pyloromyotomy is created by making a longitudinal incision across the anterior pylorus, extending from 2 cm on the anterior stomach to 1 cm on the proximal duodenum. Stay sutures placed superior and inferior to the myotomy site allow for improved countertension during the myotomy and can later be clipped for future radiographic localization (Fig. 7.7).

   Troubleshooting:

- If the mucosa is injured during the pyloromyotomy, a pyloroplasty can be performed by closing the pylorus transversely with a series of interrupted, absorbable, full-thickness sutures, followed by 3–0 silk Lembert sutures.

7.4.11 Construction of the Gastric Conduit

An endoscopic stapler with 4–5 mm staples is used to begin construction of the conduit starting at the incisura of the lesser curve. The staplers are fired sequentially and proximally along the lesser curve, always staying at least 5 cm away from the GEJ. This should result in a 5 cm conduit with gradual narrowing more proximally
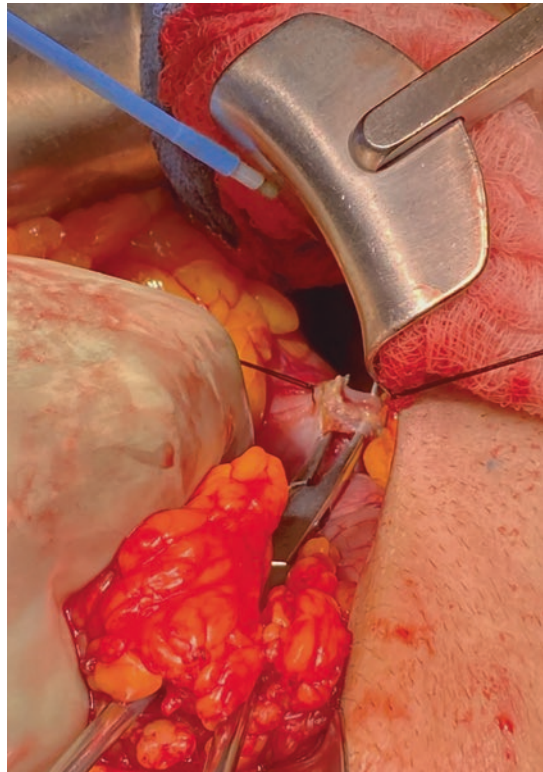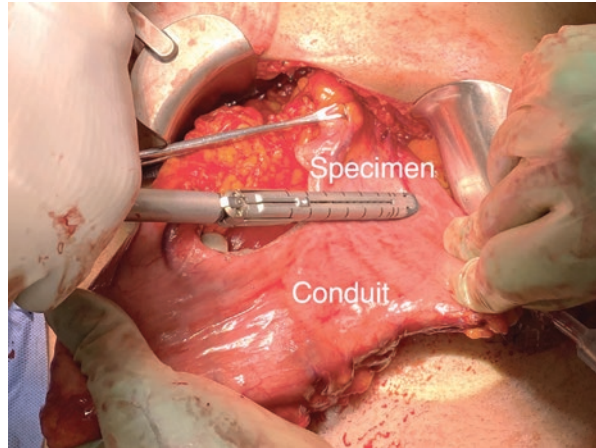
Fig. 7.7 Pyloromyotomy

Fig. 7.8 Construction of
the gastric conduit

toward the fundus (Fig. 7.8). A stapler load with 3–4 mm staples is used to complete the conduit across the gastric fundus, which is thinner than the antrum and body. The staple line is then oversewn with a series of 3–0 silk Lembert sutures. A full-length penrose drain is stitched between the distal aspect of the specimen and the proximal conduit. The bougie is removed and the esophagus is then pulled out through the cervical incision until the penrose is identified. The conduit is then pushed up through the posterior mediastinum while removing slack out through the neck incision.

Troubleshooting:

- The posterior stomach naturally has greater surface area than the anterior stomach. Any redundant posterior gastric tissue should be excluded by the stapler during conduit construction such that the anterior and posterior surfaces of the conduit remain equal. This is accomplished by pulling on the greater curve while stapling. This technique will also help minimize spiraling of the conduit.
- Adequate length of the conduit is confirmed by bringing it out of the abdomen and laying it across the chest past the cervical incision. Ideally the tip of the conduit will be redundant and can be transected prior to creation of an esophago-gastrostomy. If there is insufficient length, check for adequate gastric and duodenal mobilization.
- The conduit should be pushed into the thorax, not pulled. Throughout the maneuver, the orientation of the conduit must be checked and rechecked to avoid any twisting that could compromise the vascular supply to or from the conduit. If there is ever any uncertainty as to the orientation of the conduit, it should be returned to the abdomen and the maneuver should be reattempted from the beginning.
- The left lobe of the liver is typically retracted cephalad for most of the procedure, but the position of the retractor can interfere with passage of the conduit into the thorax. To move the liver and the retractor out of the way, the left lobe can be gently folded under itself (if the triangular ligament is divided) and then retracted toward the right upper quadrant to open up space around the hiatus.

7.4.12 Construction of the Esophagogastrostomy

Once the conduit has been properly positioned and oriented in the thorax, the penrose drain is removed from the tip of the conduit. The conduit tip itself is resected with a stapler (3–4 mm staple height) to ensure there is healthy, well-perfused tissue at the anastomosis. The nasogastric tube is pulled back and the distal esophageal margin is sharply transected. A 3–0 silk traction stitch is placed at the anterior edge of the esophagus to maintain orientation. The esophagus lays anteriorly over the stomach, so that a linear anastomosis can be created with the posterior wall of the esophagus and anterior wall of the conduit. Two stay sutures are placed on each side between the esophagus and gastric conduit, one set at the lateral corners of the open esophagus, and another set near the proximal tip of the conduit (Fig. 7.9a). A 1 cm gastrotomy is made between the two stiches next to the mouth of the esophagus. A 30 mm stapler (3–4 mm staple height) is positioned with the anvil in the conduit and the staple load in the esophagus. The stapler is then left in place while a series of additional 3–0 silk Lembert reinforcing stitches are placed along the entire length of the interface between the esophagus and conduit medially and laterally (Fig. 7.9b). The stapler is then fired to create a side-to-side, functional end-to-end posterior anastomosis between the posterior esophagus and the anterior conduit. The tip of the nasogastric tube is carefully directed through the anastomosis and is advanced distally along the conduit. The open edge of the esophagogastrostomy is closed in layers with a full-thickness, running 3–0 absorbable monofilament suture and an outer layer of 3–0 silk interrupted Lembert sutures. A drain is left near the anastomosis and into the thoracic inlet.

Troubleshooting:

- Any ischemic tissue at the tip of the gastric conduit should be resected and the tip re-inspected for viability before creation of the anastomosis. We routinely resect the tip of the conduit as we always have excess conduit length due to extensive gastric and duodenal mobilization.
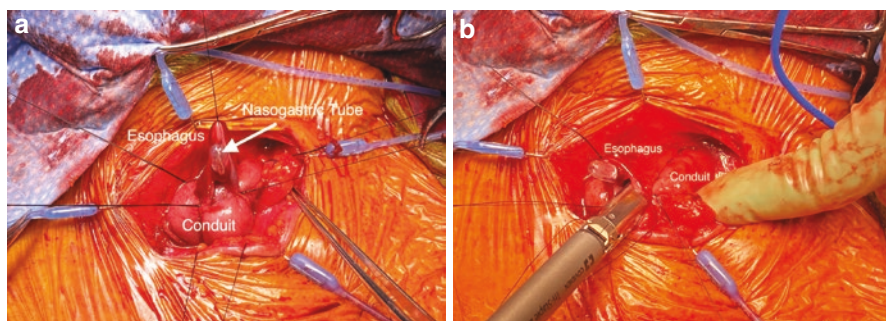

Fig. 7.9 Construction of the esophagogastrostomy. Multiple stay stitches are used to maintain the orientation of the anastomosis, with the gastric conduit positioned posterior to the esophagus (**a**). The staple line is reinforced bilaterally with interrupted Lembert stitches (**b**)

- To minimize anastomotic ischemia, the anastomotic staple line should be positioned several centimeters away from the lesser curve staple line of the gastric conduit, directly between the staple line and the greater curve.
- The reinforcing Lembert stitches across the anastomosis should be placed obliquely on the esophagus so as to not tear through the longitudinal fibers.

7.4.13   Closure of the Hiatus

Excess slack in the conduit is reduced into the abdomen and the gastric conduit is secured bilaterally to each crus, as well as anteriorly to both crura to prevent a postoperative hiatal hernia.

Troubleshooting:

- Caution should be taken to avoid creating undue tension on the anastomosis when reducing the redundancy of the gastric conduit.

7.4.14   Placement of Feeding Jejunostomy Tube

A 3–0 silk pursestring suture is placed followed by an enterotomy on the antimesenteric aspect of the jejunum, 25–30 cm distal to the ligament of Treitz. A 12F silastic feeding tube is introduced through the left abdominal wall and advanced through the enterotomy. Several silk Witzel sutures are placed over the tube, which is then secured to the abdominal wall in four quadrants around the tube entry site. An additional antivolvulus stitch is placed several centimeters distally between the jejunum and the abdominal wall.

Troubleshooting:

- The jejunostomy tube entry site should be at least 20 cm from the ligament of Treitz and the loop of bowel should be able to reach the abdominal wall without tension or bowel angulation.
- We prefer to trim the jejunostomy tube such that there is no more than 30 cm of intraluminal length, as additional length merely serves to increase resistance of anything administered through the tube.
- We use a tube with an intraluminal balloon, but we only place 1 cc of fluid and do not pull it back against the jejunum and abdominal wall. This is to prevent obstruction or bowel wall ischemia.
- Care should be taken to avoid any technical errors that could narrow the lumen, such as placing Witzel sutures too wide or placing tacking sutures too far from the jejunostomy.

7.5 Postoperative Management

The patient is admitted to the floor postoperatively with a thoracic epidural and intravenous acetaminophen for pain control. The nasogastric tube is kept to low intermittent suction and the patient remains strictly nil per os. On postoperative day (POD) 3, we start limited ice chips and jejunal tube feeds. When output from the nasogastric tube is low (usually POD 2–3), the nasogastric tube is removed and patient is started on clear liquids and crushed medications. We do not perform a routine esophagram, but rather selectively order it if there are signs or concerns for an anastomotic leak. All patients get a routine nutrition consultation and are typically discharged by POD 5–6 with a slowly progressive soft diet and 28 days of enoxaparin for prophylaxis against postoperative venous thromboembolism. Patients follow up in clinic within 2 weeks postoperatively.

7.6 Complications

Complications of THE include bleeding, infection, anastomotic leak, conduit necrosis, thoracic duct injury or chyle leak, recurrent laryngeal nerve injury, pleural effusion or pneumothorax, pulmonary embolism, aspiration pneumonitis, and cardiac dysrhythmias.

7.7 Conclusions

A hybrid approach to a THE allows the avoidance of any thoracic incisions while allowing for maximal radial dissection of the lower-to-middle mediastinum and superior visualization during the proximal gastric mobilization and the lymph node dissection. Patients overall do well postoperatively and are typically home within a week of surgery.

References

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2. Orringer MB. Transhiatal esophagectomy without thoracotomy. Operative techniques in thoracic and cardiovascular surgery. Philadelphia: Elsevier, Inc; 2005. p. 2004–24.