2 Minimally Invasive Ivor Lewis Esophagectomy

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General Approach

We perform minimally invasive Ivor Lewis esophagectomy through a combined laparoscopic/robotic approach. The abdominal portion of the operation is typically performed laparoscopically without the robot, and the thoracic portion is performed robotically. We have observed limited advantage to using the robot for the gastric mobilization; and additional ports are required for robotic mobilization. In the abdomen, there is also the disadvantage of having to undock the robot for any adjustment in table positioning, unless an integrated operating room table is used. In the chest, there is less need to adjust table or patient positions during the course of the procedure. The robotic wristed instrumentation enables the circumferential esophageal mobilization to be performed with greater ease [1]. Likewise, suturing the esophageal purse string for the esophagogastric anastomosis is also facilitated by the robot.

Electronic supplementary material The online version of this chapter (https://doi.org/10.1007/978-3-030-18740-8_2) contains supplementary material, which is available to authorized users.

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Laparoscopic Mobilization of Gastric Conduit

Positioning and Preoperative Esophagoscopy

The patient is positioned on the operating room table with the right arm tucked and a foot board well-secured on the bottom of the feet. Before preparing the patient, the table should be placed in steep reverse Trendelenburg to test bed positioning. Esophagogastroduodenoscopy (EGD) should be performed intraoperatively prior to prepping the patient. It is important to assess the length of the tumor and Barrett's disease and to inspect the stomach for ulcerations or other lesions. Excessive insufflation should be avoided. During endoscopy, we inject botulinum toxin (200 units) into the pylorus and balloon dilate the pylorus. We do not perform pyloroplasty or pyloromyotomy and instead favor endoscopic botulinum toxin injection and pyloric dilatation. Alternatively, botulinum toxin can be injected into the pylorus during the laparoscopic procedure using a 25-gauge needle. A nasogastric tube (NGT) is then placed following endoscopy.

Surgical Technique

Port Placement

The surgeon stands on the patient's right side with the assistant standing on the patient's left side

J. Kim, J. Garcia-Aguilar (eds.), *Minimally Invasive Surgical Techniques for Cancers of the Gastrointestinal Tract*, https://doi.org/10.1007/978-3-030-18740-8_2

(Fig. 2.1). A 12-mm port is placed two-thirds of the distance between the xiphoid process and umbilicus to the right of the midline. Later, the linear stapler will be inserted through this port to create the gastric conduit. We use a 5-mm 30° laparoscope to allow the camera to be used in multiple ports. The peritoneum and omentum are inspected for carcinomatosis and the liver is inspected for metastases. A 5-mm port is placed to the left of the midline in the same line to mirror the other port. The patient is then placed in reverse Trendelenburg position. A 5-mm port is placed along the costal margin in the right mid-clavicular line and another 5-mm port is placed in the left mid-clavicular line (Fig. 2.2). A 5-mm port is placed laterally on the right and close to the costal margin. A 5-mm liver retractor is then inserted, and the left lobe of the liver is retracted to expose the esophageal hiatus.

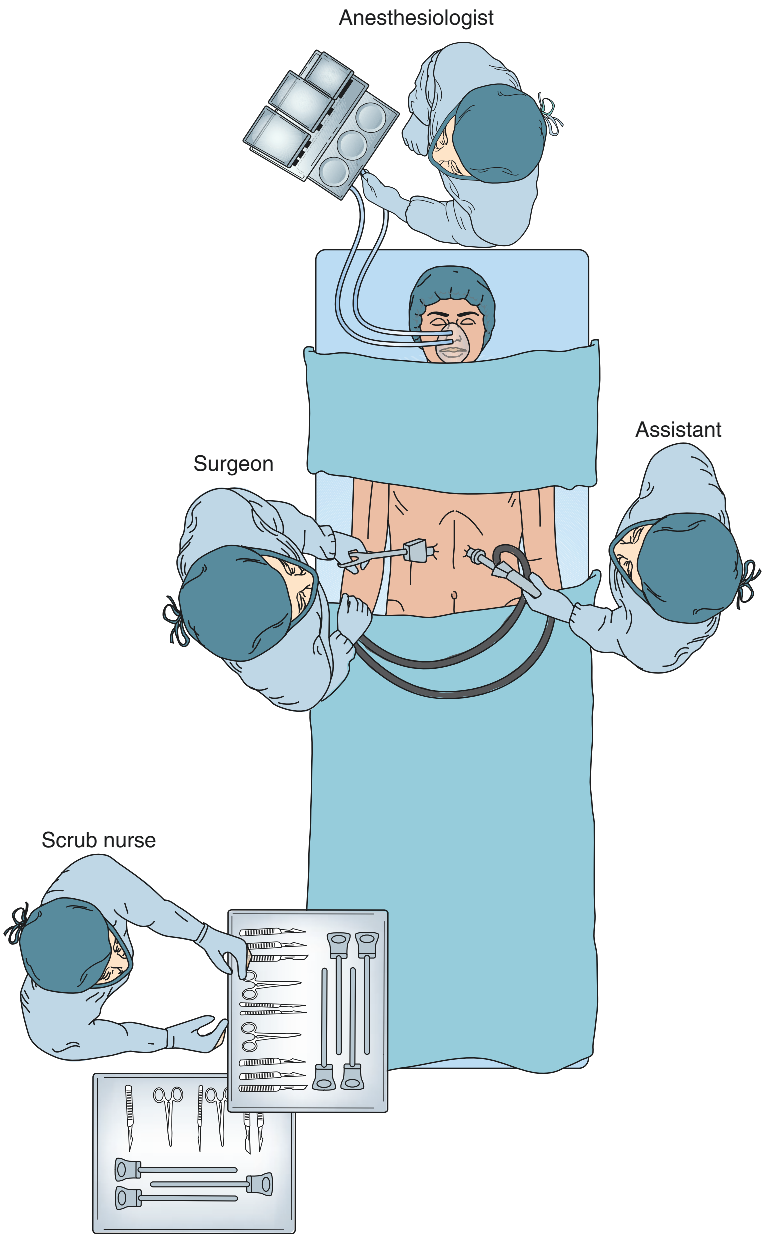


Fig. 2.1 Operating room setup for laparoscopic steps

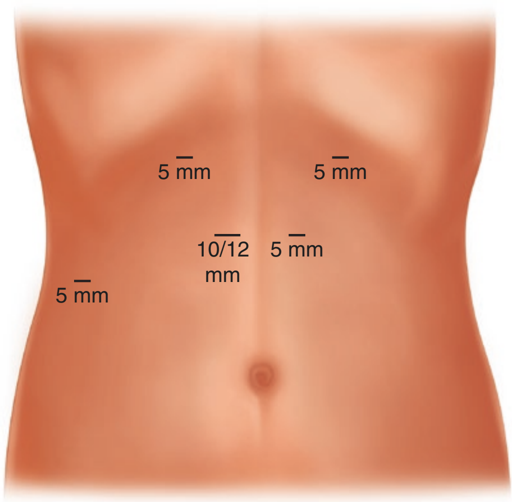


Fig. 2.2 Port placement for laparoscopic steps

Gastric Mobilization

The dissection is started at the hiatus. The right crus is exposed using an energy device and blunt dissection. The LigaSure (Covidien) and Harmonic Scalpel (Ethicon) are both adequate instruments for this step. We typically remove the peritoneal lining around the crus, but do not routinely excise muscle fibers unless the tumor is directly adherent. The dissection from the right crus is followed anteriorly and over to the left crus. If there is a hiatal hernia, it is helpful to reduce the sac and completely separate the sac from the crura. For patients who do not have a hiatal hernia or only a small hernia, we divide some of the right crural fibers to enlarge the hiatus so that it will easily accommodate the size of the gastric conduit. It is important not to divide the fibers of the left crus to avoid development of a paraesophageal hernia.

Next, the right gastroepiploic artery is visually identified. The stomach is separated from the omentum and mesocolon by retracting the omentum caudally near the point of transection and dividing the omentum using an energy device away from the gastroepiploic artery (Video 2.1 Robotic Ivor Lewis Esophagectomy). We avoid trauma to the gastric conduit by minimizing grasping of the stomach itself. We usually harvest an omental flap by leaving a pedicled portion of the omentum attached to the conduit perfused by two to three branches of the gastroepiploic vessels—any more vessels would be too bulky. This “tongue” of omentum is dissected directly off the colon. Then, the dissection continues parallel to the gastroepiploic artery until the short gastric vessels are identified. All short gastric arteries are then serially transected using a vessel-sealing device, and the stomach is completely mobilized free from the spleen and left crus. Additional attachments to the mesocolon are then divided. To prevent paraesophageal hernia and to allow maximum mobility of the gastric conduit, the gastrocolic ligament as well as adhesions between the posterior stomach and mesocolon are completely divided. Extreme caution must be taken in the vicinity of the takeoff of the right gastroepiploic artery from the gastroduodenal artery to avoid accidental injury of either artery. The lesser sac is then dissected, freeing the stomach from the pancreas. While the assistant retracts the gastric conduit anteriorly, the left gastric artery pedicle is dissected from the celiac axis. Nodal tissue is carefully dissected and swept towards the stomach (Fig. 2.3). Once this step is completed, the left gastric artery pedicle is transected using a vascular stapler cartridge or between clips.

Before the gastric conduit is created, we check to ensure that the stomach is circumferentially free, and that the pylorus easily reaches the hiatus. A Kocher maneuver is not necessary for an Ivor Lewis esophagectomy, but can be easily performed laparoscopically. The posterior gastroesophageal junction is then dissected, and the mediastinal esophagus is circumferentially dissected as cephalad as safely possible. It is easy to enter one or both pleural cavities during the mediastinal dissection, so it is best to wait until the latter part of the laparoscopic procedure to perform this dissection. A pleural defect can be a nuisance during laparoscopy and impair the surgeon’s ability to insufflate the abdomen adequately.

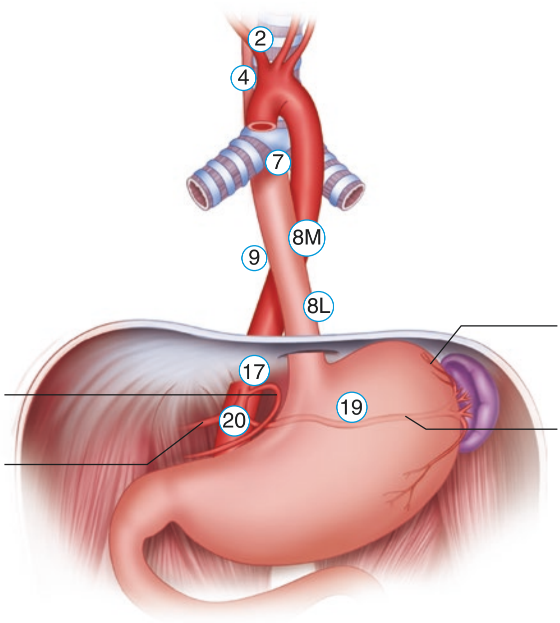


Fig. 2.3 Key lymph node stations for Ivor Lewis esophagogastrectomy

Creating the Gastric Conduit

The NGT is then pulled back into the pharynx. A point on the lesser curvature of the stomach between the right and left gastric arteries is identified just proximal to the incisura. Collateral vessels overlying this point are divided. Medium/thick tissue staple cartridges are then used to create the conduit, firing multiple stapler loads up until a point on the gastric fundus. We do not oversew the staple line. Ideally, the gastric conduit is no smaller than 4 cm in width. The gastric conduit is then sewn back to the specimen with a single mattress stitch. Alternatively, the last 2 cm of the stomach can be left undivided while creating the gastric conduit and can be later divided within the chest. We leave a quarter inch Penrose drain around the GE junction, secured by a suture, to facilitate retrieval of the gastric conduit and dissection within the chest.

Feeding Jejunostomy

Finally, the feeding jejunostomy is placed. A loop of jejunum approximately 30 cm distal to the ligament of Treitz is identified and the proximal bowel is tacked to the anterior abdominal wall near the site of the proposed jejunostomy using 2-0 silk suture. We insert a jejunostomy catheter using a modified Seldinger technique and a peel away catheter kit. An additional stitch is placed on the opposite side of the first stitch to secure the jejunum to the abdominal wall in a Stamm fashion. One additional stitch is placed 2–3 cm distally, tacking the jejunum to the anterior abdominal wall to prevent twisting of the jejunum around the jejunostomy insertion site.

Closure

The fascia of the 12-mm port is closed with a figure-of-eight 0-vicryl suture. All the skin incisions are then closed, and sterile dressings are applied. If the left pleural cavity is entered during the mediastinal dissection, a 19-Fr round Blake drain may be placed through one of the abdominal ports in the left pleural space to prevent accumulation of an effusion postoperatively.

Thoracic Procedure

The following narrative describes the robotic esophagectomy technique with the Xi version of the intuitive robot platform. The Si version is nearly identical with the exception of using a 12-mm camera port and a 5-mm posterior retraction port rather than the 8-mm ports of the Xi system. Also, the Si robot is docked over the patient's right shoulder rather than from an anterior approach as described below for the Xi robot.

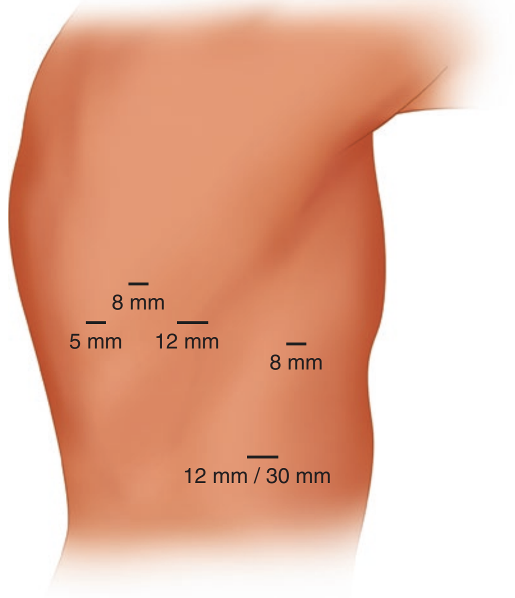


Fig. 2.4 Trocar placement for robotic and thoracoscopic dissection and anastomosis

Esophageal Mobilization

After the abdominal incisions are closed, the patient is placed in the left lateral decubitus position. After single lung ventilation has been established, an 8-mm port is initially introduced in the anterior axillary line, at approximately the seventh intercostal space. The chest is insufflated to 8-mm Hg pressure with a low flow rate to prevent hypotension. An 8-mm port is placed approximately 1 cm posterior to the posterior axillary line at the level of the major fissure to be used for the robotic camera. This is typically in the same interspace as the first port. Another 8-mm robotic port is placed one-hand breadth posterior to the camera port in the same intercostal space. Another 8-mm robotic port is placed one intercostal space caudally, just lateral to the transverse process. A 12-mm assistant port is placed in the tenth intercostal space, just above the insertion of the diaphragm (Fig. 2.4). The robot may be docked from the patient's anterior side, roughly perpendicular with the table (Fig. 2.5).

We begin with a 30° down-viewing scope. With the aid of insufflation, additional retraction on the diaphragm is rarely necessary. The inferior pulmonary ligament is divided and any lymph nodes at that station should be removed. A thoracic grasper placed through the most posterior port is used to retract the lung anteriorly, exposing the esophagus. We divide the azygous vein with a vascular staple cartridge. The mediastinal pleura overlying the esophagus is then opened anteriorly and posteriorly, allowing a layer of mediastinal pleura to stay attached to the esophagus. The esophagus is mobilized circumferentially using the robotic harmonic scalpel or vessel sealer to ligate small perforating vessels from the aorta. This is typically performed using the energy device in robotic arm 4 and a Cadiere forceps in robotic arm 2. The borders of the dissection are the pericardium anteriorly, the aorta and spine posteriorly, and the edges of the mediastinal pleura laterally. All tissues within these borders should be mobilized and removed en bloc with the esophagus. The network of lymphatics overlying the aorta should be removed en bloc as well. Using the Cadiere forceps to grasp the Penrose drain and providing traction on the esophagus greatly facilitate this part of the dissection (Fig. 2.6a, b). For our standard Ivor Lewis operation, the esophagus is mobilized from just above the azygous vein to the diaphragmatic hiatus. Above the level of the aortic arch, use of electrocautery should be minimized, as the left recurrent laryngeal nerve is at risk for injury.

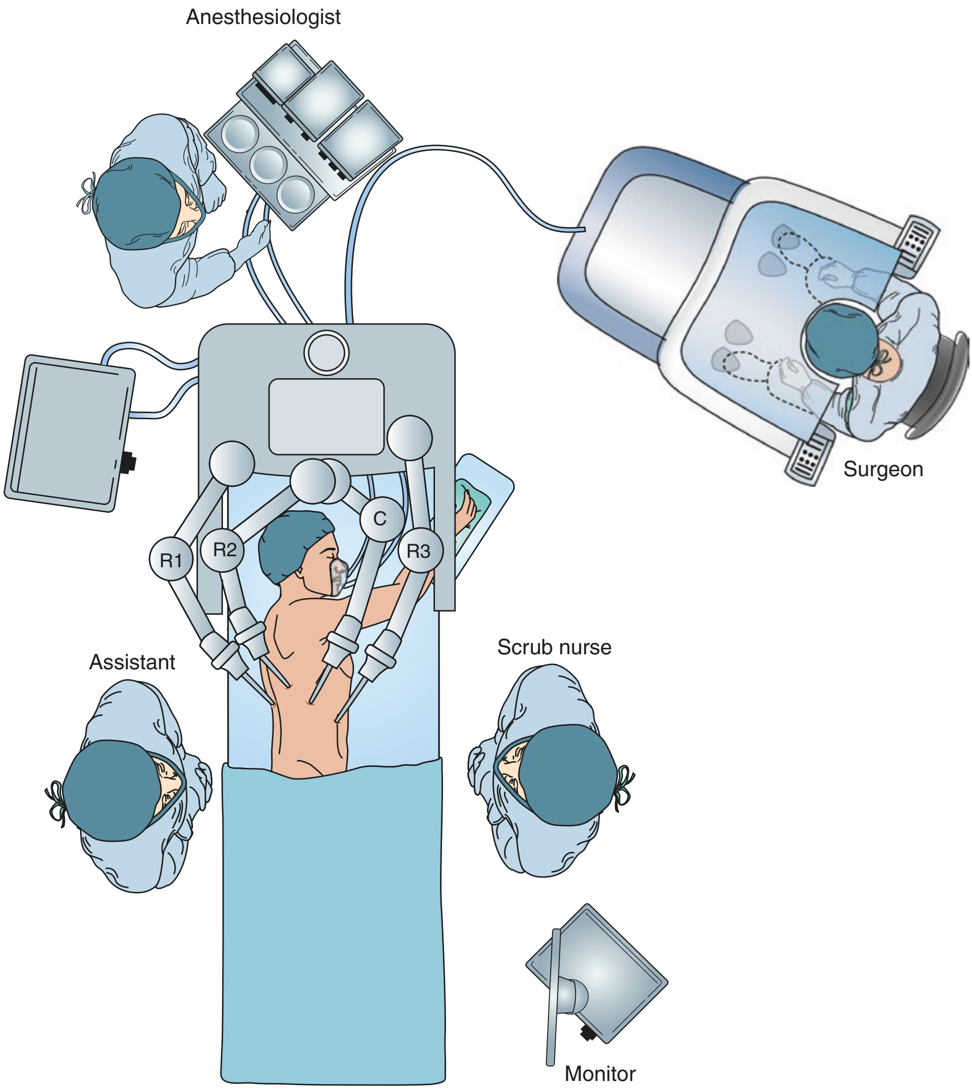


Fig. 2.5 Operative positioning for robotic dissection and esophagogastric anastomosis

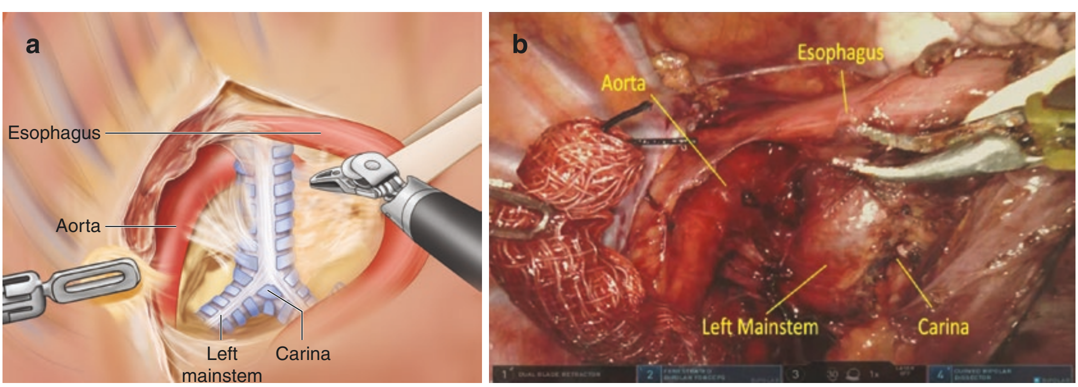


Fig. 2.6 (**a**) Illustration showing lateral retraction of a Penrose drain encircling the esophagus. (**b**) Intraoperative image showing retraction of the esophagus

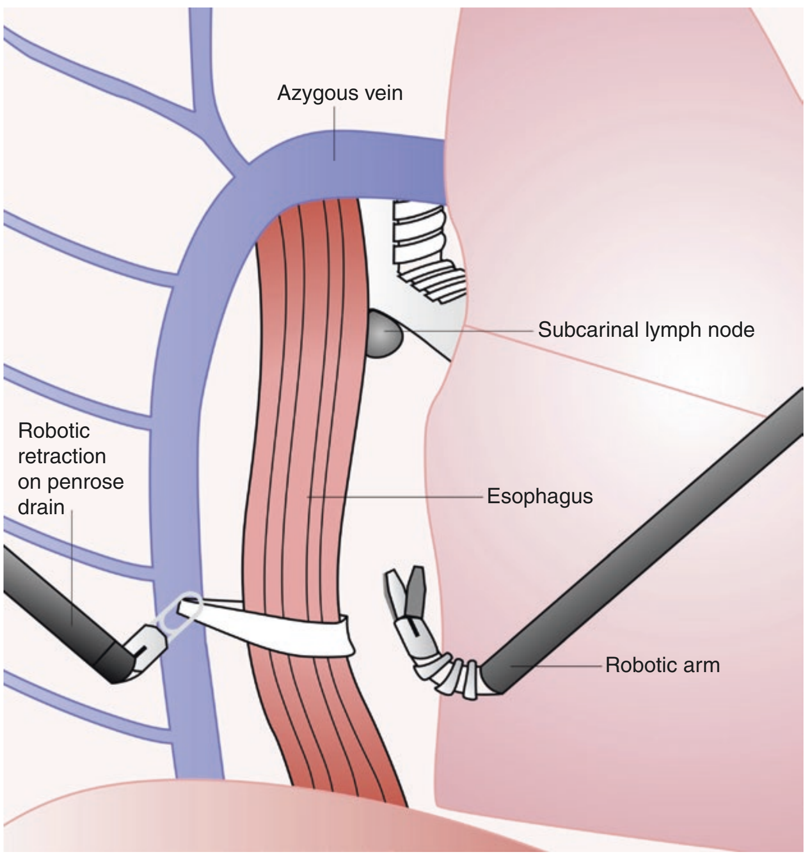
The subcarinal lymph node station should be completely excised. To facilitate exposure, we typically divide the bronchial branches of the vagus nerve and the main bronchial artery to the level of the right mainstem bronchus. The thoracic duct is easily ligated using the robot to ligate all the tissue between the azygous vein and the aorta at the level of the diaphragmatic hiatus (i.e., mass ligation) using a 0-silk tie.

Anastomosis

After the mobilization is complete, the gastric conduit is gently pulled into the chest along with the omental flap. The esophagus is divided sharply at the level of the azygous vein. If the conduit has not yet been divided completely from the specimen, it is done so at this point using a linear stapler. Otherwise, the suture attaching the conduit to the proximal stomach and specimen is cut. The assistant port is enlarged to accommodate the specimen and an extra-small wound protector is placed. Frozen section is obtained on the proximal and distal margins. The proximal esophagus is sized using a Foley catheter balloon to gauge the appropriate-sized stapler. The anvil of an EEA stapler is placed through the assistant port and then placed into the proximal esophagus. Using a robotic needle driver in robotic arm 4, a double purse string suture using 2-0 absorbable suture is placed around the anvil. A zero-degree camera usually provides a better image for this step of the operation. After confirming the absence of cancer at the margins, the robot is undocked.

The remainder of the operation is performed using a 5-mm 30° camera placed through the anterior port. A gastrotomy is made in the proximal conduit by opening up the lesser curve staple line. The stapler is placed through the gastrotomy and the spike is brought out in a well-perfused portion of the greater curve (Fig. 2.7). The anastomosis

Fig. 2.7 Illustration showing a circular stapler inserted through the staple line into the gastric conduit. The spike is attached to the anvil in the distal end of the esophagus



should be made at the lowest point possible on the greater curve that will not create tension. Creating the anastomosis too high (i.e., too proximal) on the conduit can result in a redundant conduit within the chest, allowing the conduit to take on a sigmoid shape above the diaphragm and impeding conduit emptying. Also, the lower on the conduit (i.e., more distal), the better the blood supply. After firing the stapler, the donuts are inspected for completeness. The NGT is advanced beyond the anastomosis. The linear stapler is then used to close the gastrotomy and remove the excess portion of conduit that lies proximal to the anastomosis. We routinely perform a repeat endoscopy at this point to inspect the anastomosis and test for leak by insufflating endoscopically while submerging the anastomosis under irrigation. This is a very safe maneuver and poses virtually no risk to the anastomosis if performed by an experienced endoscopist. The omental flap is placed between the anastomosis and the posterior wall of the trachea and secured to the pleura with sutures.

Closure

A 24-Fr chest tube and 19-Fr Blake drain are placed in the posterior mediastinum. Local anesthetic is infiltrated into the intercostal spaces. The lung is reinflated and the remaining port sites are closed with absorbable sutures.

Reference

1. Sarkaria IS, Rizk NP. Robotic-assisted minimally invasive esophagectomy: the Ivor Lewis approach. Thorac Surg Clin. 2014;24(2):211–22. https://doi.org/10.1016/j.thor-surg.2014.02.010. vii