Chapter 6
Minimally Invasive Ivor Lewis Esophagectomy

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6.1 Introduction

Esophageal cancer is the eighth most common cancer worldwide [1]. There will be an estimated 18,440 new cases diagnosed in the United States alone in 2020, and although 5-year survival rate falls around 19.9% [2] for all stages of disease, prognosis is much more favorable for early stage diagnosis. Operative resection, in combination with neoadjuvant chemotherapy, has been the mainstay for curative treatment of locally advanced disease. The first esophagectomy was performed in 1913, and was found to carry a high morbidity and mortality. Since then, minimally invasive approaches have been developed, including the transthoracic (Ivor Lewis) esophagectomy described in this chapter, three-field (McKeown), and transhiatal esophagectomy. These operations offer equivalent oncological outcomes [3–5] with a major reduction in the morbidity and mortality associated with open approaches [6–8]. Furthermore, studies have demonstrated that morbidity and mortality is most effectively reduced when resection is performed in high volume centers, with case volumes of more than 20 esophagectomies per year [9].

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6.2 Clinical Presentation

The classic presentation of a patient with advanced stage esophageal cancer is dysphagia to solids and eventually liquids, in combination with unintentional weight loss. Patients with early stage cancers may be asymptomatic. Some patients describe retrosternal discomfort while eating that is related to food getting “caught” as they eat, or experience regurgitation of solids and/or liquids.

6.3 Preoperative Workup

Any patients with these symptoms should undergo an endoscopic evaluation. Any abnormalities to the mucosa should be biopsied. An obvious mass is pathognomonic for esophageal cancer, but earlier stages can present with more subtle findings like ulcerations or plaques. A biopsy should be taken for tissue diagnosis. If cancer is confirmed, the patient should be fully staged:

1. An endoscopic ultrasound (EUS) will show the depth of invasion for accurate T staging. Concerning nodal disease that may be noted during EUS should undergo fine needle aspiration (FNA). Endobronchial ultrasound (EBUS) can also be used for biopsy of concerning nodes.
2. A contrast enhanced computed tomography (CT) of the neck, chest, and abdomen, along with a whole body integrated fluorodeoxyglucose positron emission tomography (FDG-PET) should be performed to evaluate for distant metastases, paying attention to common sites including the lungs, liver, adrenal glands, and bone. Lesions that are worrisome for metastatic disease should be biopsied.

If initial staging indicates that a patient should receive neoadjuvant therapy, the patient should be re-staged before undergoing surgery.

6.4 Surgical Technique and Operative Steps

6.4.1 Abdominal Phase

6.4.1.1 Position of the Patient and Trocar Placement

A double lumen endotracheal tube is used for general anesthesia. An esophagogastroduodenoscopy should be performed either on the day of surgery or few days prior to evaluate tumor position and changes related to radiation therapy. An orogastric tube is placed to decompress the stomach. The patient is placed in a supine position with feet secured against a padded foot board. Arms should be positioned out and supported so that they are secure when the patient is placed in reverse

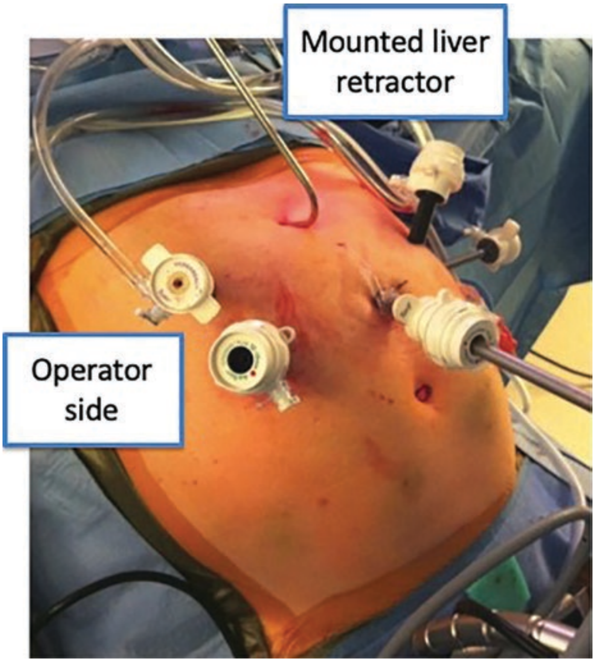

Fig. 6.1 Abdominal phase positioning: *patient is shown in supine position with surgeon on right side of the Table. A 10 mm optical trocar is placed left costal margin at the mid clavicular line, a 5 or 10 mm trocar is placed midline below the falciform ligament, two 5 mm ports are placed in the right and left upper quadrants, and a 10 mm trocar is placed in the right flank*

Trendelenburg. The abdomen and lower chest are widely prepped and draped. The primary surgeon stands on the right side of the operating table, with the camera operator on the same side towards the patient's feet. A camera holder can be very useful in case of limited available personnel. The assistant stands on the patient's left side (Fig. 6.1). The abdomen is entered with a 10 mm optical trocar underneath the left costal margin at the mid-clavicular line and pneumoperitoneum is achieved with CO_2 at 15 mmHg. All other ports are placed under direct visualization: either a 5- or 10-mm trocar in the midline just below the falciform ligament where the camera is introduced, 2 additional 5 mm ports in the right and left upper quadrants and a 10 mm trocar in the right flank. A Nathanson liver retractor is placed just below the xiphoid process.

Troubleshooting: Before prepping and draping, positioning the patient in steep reverse Trendelenburg can help identify potential issues with lines or areas of the body not sufficiently secured. Although abdominal entry with an optical trocar in the left subcostal region is fairly safe in experienced hands, a Hasson trocar might be safer for patients with extensive previous abdominal surgery.

6.4.1.2 Celiac Lymphadenectomy

Upon entry, the peritoneal cavity is examined to rule out metastatic or unresectable disease. Next, the gastrohepatic ligament is entered and divided until dissection reaches the base of the right crus, and then moves inferiorly to expose the celiac trunk. The left gastric artery is identified, along with the splenic and common hepatic arteries, and their associated lymph nodes are carefully dissected to perform a complete lymphadenectomy (Fig. 6.2). The left gastric pedicle is dissected starting along the superior edge of the pancreas and dissection continues along the hepatic artery, to the right crus and behind the left gastric artery (Fig. 6.3). The left gastric vein is usually clipped and divided with shears while the left gastric artery is stapled at its origin. Once the artery is divided, dissection is continued along the splenic artery and the lateral aspect of the left crus until the first short gastric vessels running along the left crus are identified and divided.

Troubleshooting: When a large left accessory hepatic artery or a left replaced hepatic artery is present, the left gastric artery should be preserved, and a complete lymphadenectomy should be performed by skeletonizing the artery from all surrounding fatty tissue. The branches for the stomach can be clipped or divided with energy device. While dividing the peritoneum at the superior edge of the pancreas be aware that the left gastric vein at times drains into the portal vein posteriorly to the hepatic artery rather than anteriorly.

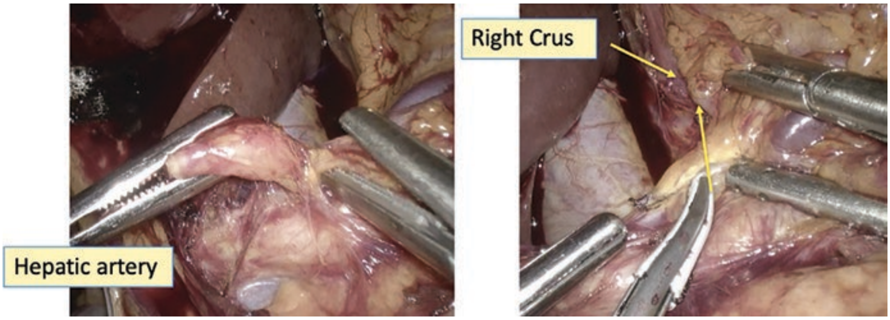

Fig. 6.2 Celiac lymphadenectomy: *A complete lymphadenectomy of the hepatic, splenic and left gastric arteries is shown*

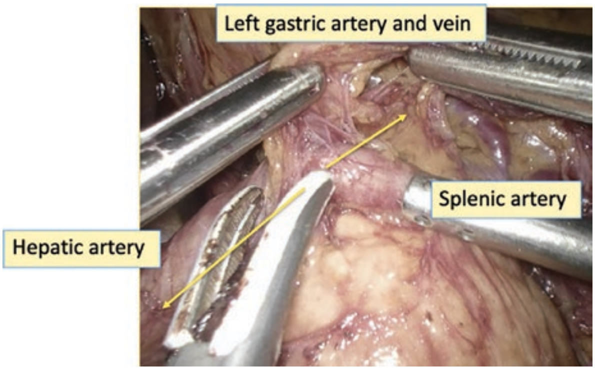

Fig. 6.3 Superior edge of the pancreas: *During celiac lymphadenopathy, the left gastric pedicle is dissected at the superior edge of the pancreas*

6.4.1.3 Mobilization of the Greater Curvature

Dissection around the right crus is continued across the hiatus down the left crus. The stomach is then retracted anteriorly and to the right to expose the gastrocolic ligament, which is divided 3–4 cm away from the right gastroepiploic artery, which will serve as the blood supply of the gastric conduit. It is important that complete mobilization of the right gastroepiploic artery to its base is performed. Dissection continues along the greater curvature of the stomach towards the fundus through the gastrosplenic ligament, preserving the greater curvature fat, until it meets the dissection of the left crus. This is performed carefully so that the short gastric vessels are taken with a long stump on the splenic side and so that the spleen itself is not injured. Posterior attachments to the stomach must also be divided for full mobilization to be complete. At this point, the pylorus should be able to reach the hiatus (Fig. 6.4).

Troubleshooting/Pearls: *A Kocher maneuver is unnecessary for this mobilization and should not be performed, as it can allow for duodenal herniation into the chest. The transverse mesocolon can be adherent to the right gastroepiploic pedicle and will hold the stomach down if not carefully dissected off the pedicle. The entire gastrocolic ligament should be divided towards the duodenum to avoid tension in the anastomosis.*

6.4.1.4 Transhiatal Dissection

The esophagus is circumferentially dissected at the level of the hiatus, allowing for passage of a penrose drain, which will serve as a handle to aid in retraction. The plane of dissection will be carried from pleura to pleura, pericardium to aorta, to the level of the inferior pulmonary vein. Periesophageal lymph nodes are kept with the specimen (Fig. 6.5).

Troubleshooting: If a pneumothorax occurs during this dissection, one must create a wide pleural opening to allow for equilibration of pressure so that a tension physiology in the chest does not develop. The patient may become hypotensive if this

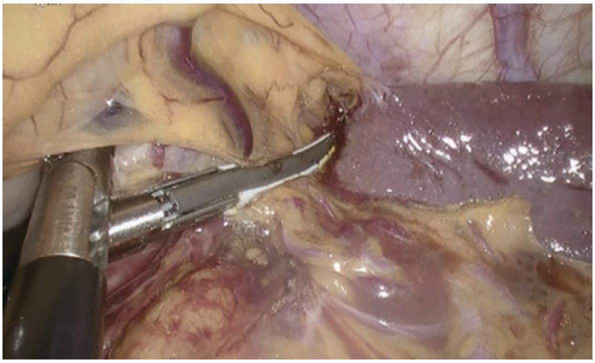

Fig. 6.4 Mobilization of the greater curvature of the stomach: *Dissection is carried towards the fundus through the gastrosplenic ligament until it meets the dissection of the left crus, and posterior attachments to the stomach are divided so that the pylorus can meet the hiatus*

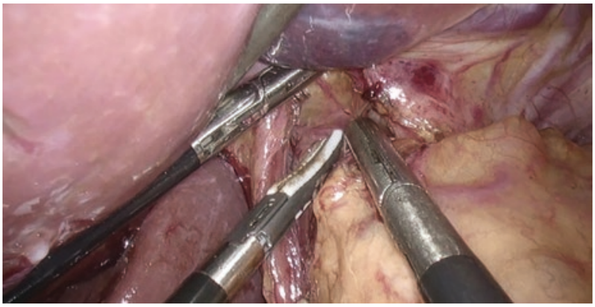

Fig. 6.5 Transhiatal dissection: *The esophagus is circumferentially dissected at the level of the hiatus*

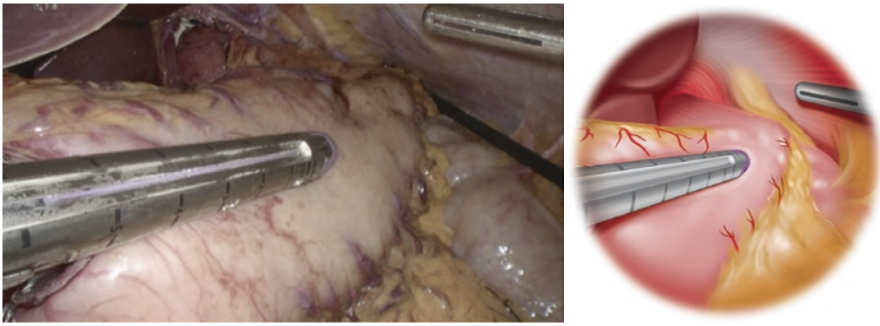

Fig. 6.6 Creation of the gastric conduit: *Serial endovascular staplers are used to make a 4–5 cm gastric conduit that begins just proximal to the pylorus on the lesser curve and continues towards the fundus*

occurs, which should prompt temporary desufflation of the pneumoperitoneum and repositioning of the patient supine to allow anesthesia to adjust ventilatory parameters and blood pressure. Placement of a chest tube is rarely required. Communication of these potential complications with anesthesia should occur before the start of the case.

6.4.1.5 Creation of the Gastric Conduit

The orogastric tube is pulled back to prevent stapling across it as tubularization of the stomach is performed. A 4–5 cm wide gastric conduit is then created using serial endovascular staplers starting just proximal to the pylorus on the lesser curvature and continuing towards the fundus. The assistant can aid the primary surgeon in the step by providing retraction of the fundus in conjunction with retraction of the lesser curve as stapling occurs. The distal margin is preserved and sent to pathology for frozen section analysis (Fig. 6.6).

Troubleshooting/Pearls: *It is important to stretch the conduit from the fundus to the pylorus in order to avoid spiraling of the gastric staple line. It is also important to ensure that the conduit is not twisted when it is eventually brought into the chest, as this would cut off the blood supply to the conduit and lead to conduit necrosis or obstruction.*

6.4.1.6 Creation of the Feeding Jejunostomy

The colon is lifted superiorly to expose the ligament of Trietz. A mobile portion of proximal jejunum is grasped and elevated to the left abdominal wall. A diamond pattern surrounding the intended jejunostomy site is created with four absorbable sutures, which are then brought through the abdominal wall utilizing a Carter-Thompson fascial closure device. A percutaneous jejunostomy is then created using a Seldinger technique, and the four anchoring sutures are tied externally within the subcutaneous layer of the abdominal wall. The tube is advanced into the bowel lumen and distal jejunum (Fig. 6.7)

Troubleshooting/Pearls: *Proximal and distal stitches adjacent to the jejunostomy can be utilized to prevent twisting.*

Fig. 6.7 Feeding jejunostomy creation: *The jejununostomy site is created with a diamond pattern of four absorbable sutures, then a percutaneous jejunostomy is created utilizing a Seldinger technique*

Fig. 6.8 Thoracic phase positioning: *The patient is placed in a modified left lateral decubitus position where they are slightly rotated towards a prone position. Four ports are placed: 10 mm posterior axillary line in seventh intercostal space, 5 mm camera port in ninth intercostal space posterior to the first port, 10 mm port along mid axillary line in third or fourth intercostal space, and 5 mm port in seventh intercostal space between the spine and scapula*

6.4.2 Thoracic Phase

6.4.2.1 Positioning and Trocar Placement

The patient is placed in a left lateral decubitus position and then slightly rotated towards a prone position, utilizing a bean bag for security on the table, along with an axillary roll and arm support. The table can be flexed at the hip so that the hip is level with the ribs, ensuring that instrumentation will not be limited by the hip's curvature. Four ports are utilized during the thoracic portion—a 10 mm port along the posterior axillary line in the seventh intercoastal space, a 5 mm camera port placed posteriorly to this in the ninth intercostal space, another 10 mm port along the mid axillary line in the third or fourth intercostal space, and a 5 mm port in the seventh intercostal space posteriorly between the spine and scapula (Fig. 6.8).

Troubleshooting/Pearls: *CO_2 can be used to insufflate the chest at 8 mmHg in order to flatten the diaphragm and collapse the lung towards the anterior mediastinum. This can help minimize movement of the mediastinum from ventilation of the contralateral chest during dissection. In cases where the spine is protruding significantly into the chest the most posterior assisting port should be moved slightly anteriorly to avoid hitting the spine while trying to retract the esophagus.*

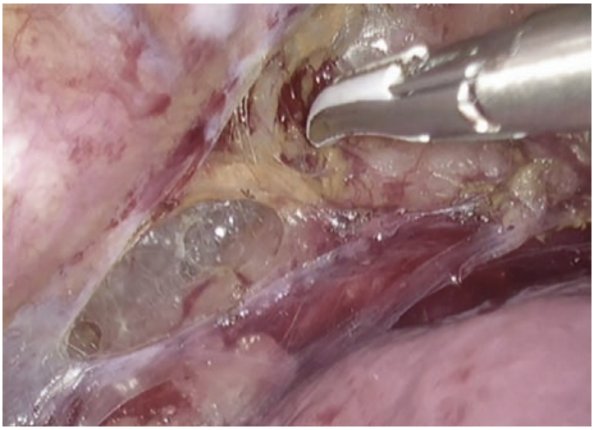

Fig. 6.9 Anterior and posterior pleural dissection of the esophagus: *Anterior dissection is carried to the level of the azygos vein. Posterior dissection is then performed back down to the transhiatal dissection performed during the abdominal phase*

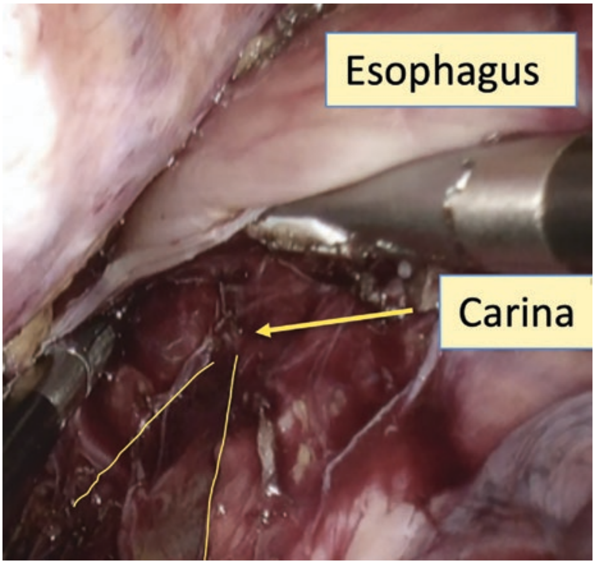

Fig. 6.10 Identification of airways, subcarinal lymphadenectomy: *Membranous portions of the mainstem bronchi and carina can be easily missed and injured during the dissection, and thus identification is crucial (shown). A subcarinal lymph node dissection is performed*

6.4.2.2 Opening of the Anterior and Posterior Pleura

The inferior pulmonary ligament is divided up to the level of the inferior pulmonary vein and its associated lymph node is resected. The mediastinal pleural is dissected anteriorly along the esophagus up to the level of the azygos vein and the vein is divided using a vascular load stapler. This dissection is then carried posteriorly and inferiorly, until it meets the transhiatal dissection performed during the abdominal phase of the operation (Fig. 6.9).

Troubleshooting/Pearls: *Precise dissection close the esophagus should be performed to avoid injury of the thoracic duct or aorta. The mediastinal pleura above the azygos vein is preserved in order to be used to cover the anastomosis.*

6.4.2.3 Circumferential Mobilization of the Esophagus, Identification of Airways, and Subcarinal Lymphadenectomy

The penrose drain that was placed during the transhiatal dissection can be used to aid in the circumferential dissection of the esophagus from the mediastinum. During this step, meticulous dissection will allow for the adequate identification, control, and clipping of lymphatic branches from the thoracic duct and arterial branches from the aorta. It is important to identify the airways during this dissection, as the membranous portions of the mainstem bronchi and carina can be easily missed and injured (Fig. 6.10). The esophagus is divided with linear staplers just above the azygos vein or higher if required by tumor margins. A subcarinal lymph node dissection is then easily performed with complete exposure of the airways and pericardium once the esophagus is pushed away from the posterior mediastinum.

Troubleshooting: It is easier to identify the airways by doing first an anterior dissection starting at the level of the vagus nerve and moving behind the esophageal wall. Unless there is a tumor invading the infracarinal nodes it is better to leave the nodes down in the pericardium while identifying the left main bronchus from behind the esophageal wall. The left inferior vein should be identified as well in order to avoid injury. Before dividing the esophagus, it is wise to ensure that the orogastric tube and/or esophageal temperature probes are removed.

6.4.2.4 Passage of the Orvil

The esophageal stump is then dissected from the pleura, the trachea and lateral mediastinal attachments for about 2 cm to allow free movement of the Orvil within the stump. The anesthesiologist then advances the oral anvil for the Orvil so that the tip of the tubing reaches the proximal staple line, which is being stabilized with graspers on both sides, and cautery is utilized to create an opening above the center of the staple line where the anvil is passed through.

Troubleshooting: *The opening for the Orvil should be just next to the staple line of the esophageal stump to avoid leaving devascularized tissue at the anastomotic site. We also prefer to pass the Orvil at the anterior corner of the staple line so that there is only 1 point of crossing between lineal and circular staple lines where a potential area of ischemia can lead to leakage. The Orvil can get stuck at the passage behind the larynx. Deflating the ET tube balloon and lifting the patient's jaw can help ease the passage into the esophagus. Pulling too hard on the NG tube will cause disassembly between the NG and the anvil.*

6.4.2.5 Gastric Conduit Pullup

The distal esophagus is then pulled up, so that the specimen and the conduit enter the chest without twisting or tension, with the staple line orientation remaining on the patient's right (Fig. 6.11). Perfusion of the conduit can be assessed using

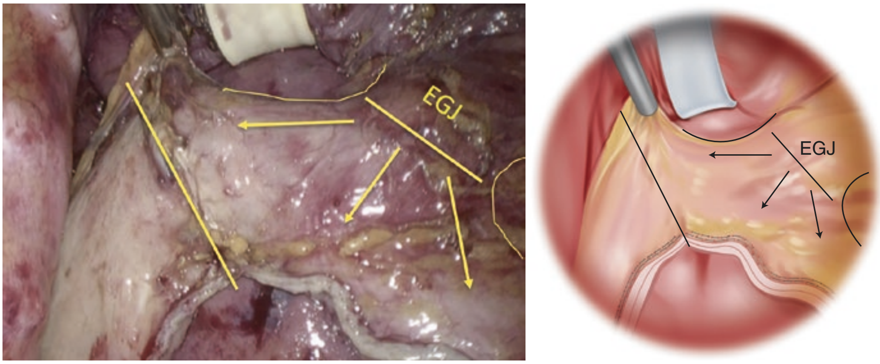

Fig. 6.11 Gastric pullup: *The gastric conduit is pulled into chest without twisting with the staple line oriented to the patient's right*

fluorescence imaging. If an area of poor perfusion is noted, efforts are made to avoid using this area for the anastomosis. The specimen is divided from the gastric conduit using a linear stapler, leaving adequate length for the insertion of the circular stapler so that an end to side esophagogastric anastomosis can be created. The specimen is then removed using a bag, and sent for pathologic assessment of margins.

Troubleshooting: The specimen can have a difficult time passing the hiatus if the tumor is large or if there is a large amount of fatty tissue along the greater curvature. It is important to pull with constant and low pressure rather than using a lot of force. Gentle pull on the greater curvature fat while protecting the gastroepiploic arcade from injury can help ease the stomach in the chest.

6.4.2.6 Anastomosis

Once the proximal and distal margins are determined by pathology to be negative for disease, the proximal conduit staple line is opened so that a circular stapler can be inserted and an anastomosis is created (Fig. 6.12). Once the circular stapler is removed, a linear stapler is inserted to transect the open end of the proximal conduit. The anastomosis can be secured in place using absorbable tacking sutures to the proximal mediastinal pleura. Anesthesia places a nasogastric tube which is advanced under direct vision, and a chest tube is placed before lung expansion (Fig. 6.13).

Troubleshooting: *The anastomosis and gastric staple line should be at least 1–2 cm apart to avoid ischemia. The vessels of the greater curvature should be on the tracheal side of the anastomosis in order to protect the airway in case of a leak. Omentum or pericardial fat can buttress the vertical staple line and protect it from the airway. The anastomosis should be tension free.*

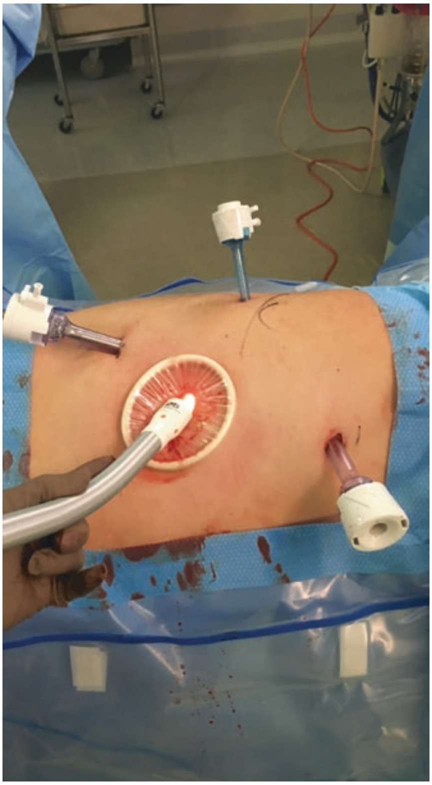

Fig. 6.12 Anastomosis: *Insertion of circular stapler*

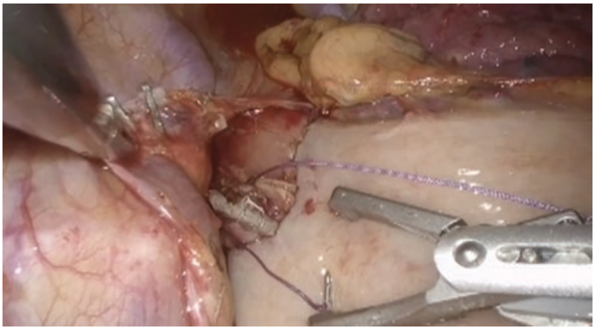

Fig. 6.13 Anastomosis: *the proximal conduit staple line is opened so that the circular stapler can be inserted and an anastomosis can be created. This is then secured in place using absorbable tacking sutures to the proximal mediastinal pleura*

6.5 Postoperative Course

Patients are managing according to a protocol used at our institution. Extubation takes place in the operating room. The nasogastric tube (NGT) is kept to suction and the patient is NPO to help prevent tension on the new anastomosis immediately after surgery. Tube feeds start on post-operative day two and slowly advanced per protocol. The NGT is removed by the third or fourth day, unless output is abnormal or there is significant conduit distension on the x-ray, along with the chest tube, unless a chyle leak is present. A clear liquid diet is started on post-operative day five. Patients are typically discharged on post-operative day seven. Diet is further advanced in the outpatient setting, along with a wean from tube feeds. The jejunostomy is typically removed at the two-week follow-up visit.

6.6 Conclusions

Minimally invasive Ivor Lewis esophagectomy is a technically demanding operation requiring meticulous dissection and purposeful post-operative care. This approach, when performed in practiced hands, can offer a reduction in the morbidity and mortality associated with esophagectomy.

Conflict of Interest The authors have no conflict of interest to declare.

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