Laparoscopic and Thoracoscopic Ivor Lewis Esophagectomy

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Abstract

Esophagectomy is one of the most potentially morbid procedures in thoracic surgery, and patients with esophageal cancer frequently have multiple comorbidities related to obesity, smoking and/or alcohol use. Minimally invasive Ivor Lewis esophagectomy minimizes surgical morbidity to the patient, while providing oncologic benefit that is equal or superior to open approaches. This allows for better patient outcomes, especially in patients with multiple medical problems. In this chapter we provide our approach to minimally invasive Ivor Lewis esophagectomy, including surgical tips to avoid complications and intraoperative trouble shooting.

Keywords

Esophageal cancer · Esophagectomy · Minimally invasive · Laparoscopy · Thoracoscopy · Ivor Lewis

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Introduction

Minimally invasive Ivor Lewis esophagectomy (MIE) is a technically challenging procedure, requiring advanced skills in both thoracoscopy and laparoscopy. With experience, the procedure can be performed with excellent patient outcomes, both in terms of perioperative morbidity and oncologic efficacy, with only a modest increase in operative time compared to open approaches [1–7]. By avoiding open incisions, especially regarding thoracotomy, the minimally invasive approach results in less pain and blood loss and fewer pulmonary complications [4, 5, 8–13]. Accordingly, length of stay is also reduced [5, 7, 9, 14–16]. While several studies have demonstrated no difference in anastomotic leak rate [5, 6, 8–10], at least two recent studies did find a higher rate of leak with the minimally invasive approach [15, 16] and some studies have demonstrated a small but significant increased need for reintervention compared to open esophagectomy [4, 6, 15]. In several of these studies overall morbidity and length of stay were lower in the MIE group despite the higher incidence of leak. Importantly, oncologic outcomes, including completeness of resection, number of nodes removed, recurrence, and 3- and 5-year survival appear equivalent, if not improved with minimally invasive esophagectomy [7–9, 14]. Potential oncologic benefits of the minimally invasive approach include

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improved visualization for more complete lymphadenectomy, especially in obese patients, and less immune dysfunction related to surgical stress and blood transfusion. Quality of life at 1 year is also improved compared to open esophagectomy [5, 11–13, 17].

Operative Technique

The patient is intubated with a left-sided double lumen endotracheal tube, and two large bore IVs, a radial arterial line and urinary catheter are inserted. An epidural catheter is not required, an added benefit of avoiding laparotomy and thoracotomy incisions and allowing for faster removal of urinary catheters and less post-operative hypotension. If the patient has not had a recent upper endoscopy prior to surgery, this is performed prior to making incisions to determine the extent of the tumor and any associated Barrett's esophagus, to confirm the suitability of the stomach as a conduit and assess the patency of the pylorus. A pyloric drainage procedure is unnecessary in most patients and may increase long term morbidity and need for reintervention, so we do not routinely perform it [18]. If Botox pyloromyotomy is being performed (see below), there is an option to perform it endoscopically at this point, with or without pyloric dilation, but always care must be taken to minimize the amount of air insufflated into the stomach, which will hinder laparoscopy. The stomach is suctioned out with the scope and an orogastric tube is placed to completely decompress the stomach.

The patient is positioned supine on a bean bag. The feet are secured to a padded footboard with tape. The arms are comfortably abducted to allow access to the abdomen. The abdomen is widely prepped and draped. Reverse Trendelenburg position, used during laparoscopy to aid in visualization of the upper abdomen, is introduced gradually to avoid sudden hypotension.

Abdominal Port Placement

A 5 mm port is placed under direct visualization just under the left costal margin in the midclavicular line; after abdominal insufflation with CO_2 at 15 mmHg the other ports are placed as followed: a 5 mm camera port in the midline just below the falciform ligament, a 10 mm port in the right flank and a 5 mm port in the right upper quadrant such that instruments will have an easy trajectory under the liver and falciform ligament and towards the hiatus. An optional additional 5 mm port may be placed in the left upper quadrant for the assistant. A Nathanson liver retractor is placed just below the xiphoid to elevate the left lobe of the liver and expose the hiatus (Fig. 1). Most of the work is done by the primary surgeon standing on the patient's right, with an atraumatic grasper in the left hand and Harmonic scalpel (Ethicon, Somerville, NJ) in the right. The first assistant stands at the

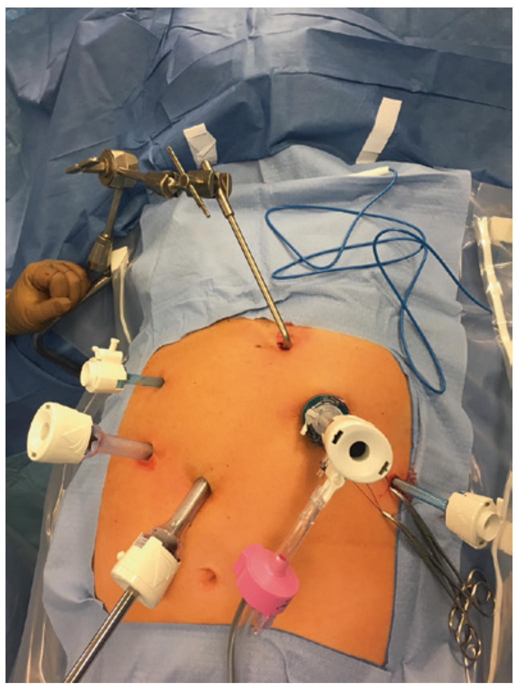

Fig. 1 Abdominal port placement

patient's left and uses a grasper in each hand to assist with retraction. The camera operator stands to the patient's right below the primary surgeon. Mobilization of the most cranial and caudal extents of greater curvature of the stomach is done by the surgeon standing on the patient's left, especially the division of the highest short gastric vessels and mobilization of the pylorus.

Abdominal Lymphadenectomy and Gastric Mobilization

The dissection begins with division of the gastrohepatic ligament, proceeding superiorly until reaching the right crus. The left gastric, splenic and common hepatic arteries are identified in order to perform a complete dissection of their associated nodes. Exposure is facilitated by the assistant lifting the stomach with a closed grasper along the lesser curve, behind the stomach and to the left of the left gatric pedicle. This puts the left gastric vessels in a vertical orientation toward the ceiling and allows optimal visualization of the lesser sac. Dissection is started at the superior aspect of the pancreas and the hepatic artery is identified. This artery is skeletonized superiorly to the takeoff of the left gastric and splenic arteries. Once the left gastric artery is identified, the lymph nodes are swept upwards into the specimen so that the artery and vein can be divided at their origin using a vascular stapler (Fig. 2). By retracting the stomach anteriorly, access is gained to the celiac artery nodes found between the left gastric artery stump and the base of the diaphragmatic crus. Using this exposure, posterior gastric attachments can start to be divided and the tip of the fundus can be partially mobilized from behind, which can facilitate the later dissection along the greater curve.

Attention then returns to the hiatus. The dissection is carried to the base of the hiatus and into the posterior mediastinum. The left crus is dissected from phrenoesophageal attachments toward the angle of His. Fibers of the crura should be preserved if possible while staying wide enough to ensure an adequate radial margin from the tumor. Muscle of the crura may be resected en bloc if there is concern for invasion by bulky disease at the gastroesophageal junction. The hiatus should be repaired in case of partial resection or when a large paraesophageal hernia is encountered. Leaving a large diaphragmatic crural opening will likely lead to paraconduit herniation of abdominal content into the mediastinum, a complication more commonly seen with minimally invasive esophagectomy, possibly due to lack of intraabdominal adhesions

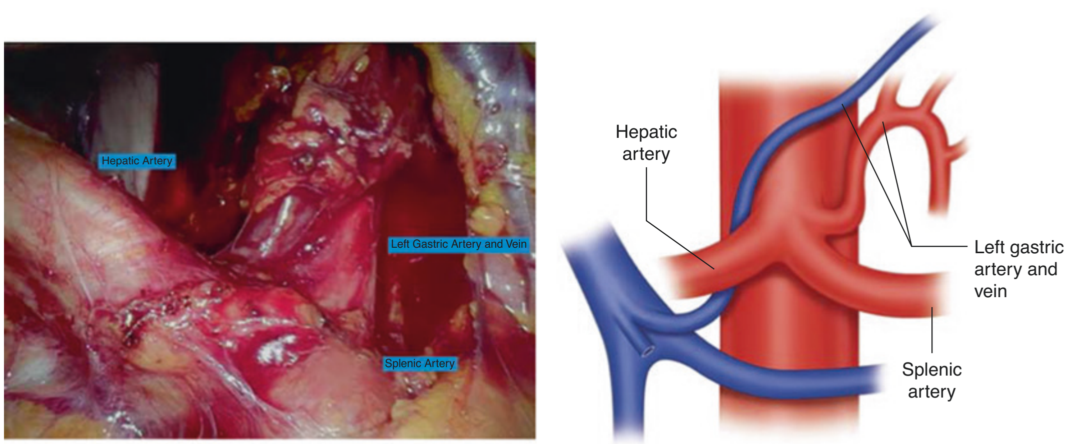

Fig. 2 The hepatic and splenic arteries are skeletonized superiorly and the left gastric vessels are completely dissected at their base before division with vascular stapler

[19]. The esophagus should not be completely encircled at this time, nor should extensive transhiatal dissection yet be performed, to avoid pneumothorax and hemodynamic instability early in the procedure.

Careful handling of the stomach throughout the procedure will help preserve the submucosal collateral vessels that are the only vascular supply of the conduit in the area of the anastomosis. Where possible the stomach should be retracted bluntly with closed instruments, avoiding grasping the stomach as much as possible in the area which will constitute the conduit. Attention is turned to dissecting the greater curvature of the stomach. The stomach is gently retracted anteriorly and to the right, exposing the gastrocolic ligament. The right gastroepiploic artery is visualized and must be preserved to perfuse the gastric conduit. Staying well away from this artery, the gastrocolic ligament is divided along the greater curve toward the fundus. While preserving this arterial pedicle it is still important not to stray to far from the greater curve, which risks injury to the transverse colon. Eventually the artery terminates, though there are sometimes horizontal collaterals with one or two short gastric arteries which should be preserved. Above this level, it is safest to stay close to the stomach. Doing so allows the short gastric arteries to be divided with a long stump on the splenic side. Care is taken not to injure the spleen as mobilization continues towards the previous dissection along the left crus. It is generally easier to divide the last attachments holding the fundus while standing at the patient's left. If posterior attachments of the stomach to the retroperitoneum are encountered these can now be divided. Posterior gastric arterial branches may also be identified and divided.

Once the fundus is completely mobilized, division of the gastrocolic ligament is continued caudally towards the pylorus. Fully dividing these attachments between the distal stomach and the colon reduces tension on the anastomosis and helps decrease the risk of colonic herniation via the hiatus. The pylorus should be freely mobile and the colon completely separated from the stomach and proximal duodenum. The pylorus will nearly reach the hiatus and a Kocher maneuver is neither required nor encouraged, as excessive duodenal mobility may result in herniation of the duodenum into the chest with kinking of the gastric conduit.

Pyloric Drainage and Feeding Jejunostomy

A pyloric drainage procedure is not necessary and we do not typicaly perform one. If a pyloric drainage procedure is being performed, 100 units of Botox in 5 cc of sterile saline are injected into the muscle of the pylorus using a transabdominal needle.

The decision to perform feeding jejunostomy should also be individualized to each patient. If a feeding tube is required, the bed is leveled for the jejunostomy placement. The colon is lifted superiorly to identify the ligament of Treitz at the base of the transverse mesocolon. A proximal loop of jejunum that reaches easily to the abdominal wall of the left mid abdomen is selected for jejunostomy placement. Four absorbable sutures are placed in a diamond pattern on the anti-mesenteric aspect of the bowel, surrounding the planned jejunostomy site. Each suture is brought through the abdominal wall with a Carter-Thompson fascial closure device and secured loosely with hemostats. A Seldinger technique is then used to perform a percutaneous jejunostomy (Fig. 3). Care is taken to ensure the tube is intraluminal and not dissecting within the wall of the bowel and is directed antegrade. Once the tube has been inserted, the four anchoring sutures are tied externally within the subcutaneous layer, securing the jejunum to the anterior abdominal wall. Next an anti-torsion stitch is placed about 2 cm distal to the jejunostomy itself. The tube is secured to the skin with non-absorbable sutures. The tube should be flushed after securing it to ensure patency. After the jejunostomy is completed, the transverse colon and the omentum are returned to their standard position.

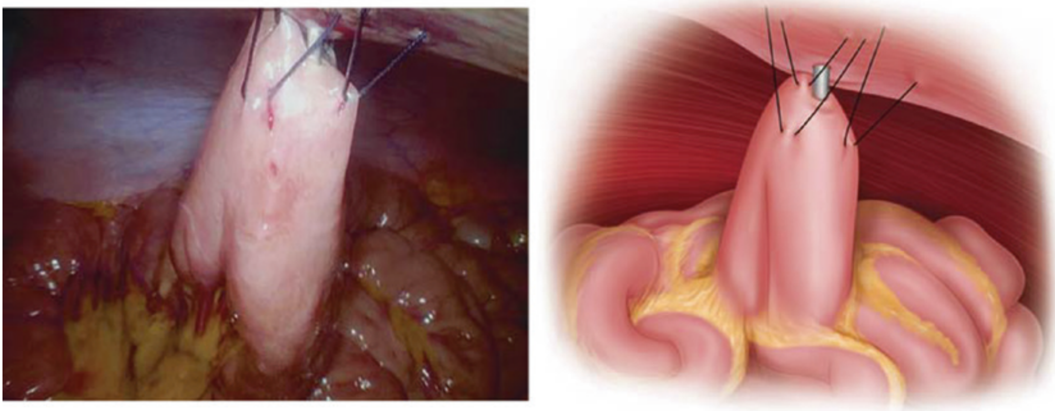

Fig. 3 A loop of jejunum is anchored to the abdominal wall with absorbable stitches placed on a diamond shape. A needle is inserted between the stitches to pass a guidewire which will allow placement of a 14F sheath and the feeding jejunostomy

Transhiatal Dissection

The bed is returned to reverse Trendelenburg position to begin the transhiatal dissection of the esophagus. A ½ inch Penrose drain is passed around the distal esophagus, and secured with a locking clip to create a mobile handle. Using the drain to aid in retraction, a transhiatal dissection is performed as high as feasible, about to the level of the inferior pulmonary vein. Periesophageal lymph nodes, including nodes anteriorly along the back of the pericardium, should be kept en bloc with the specimen. If a pneumothorax occurs at this point, make the pleural opening wide enough to avoid entrapment of air within the chest and tension physiology. If hemodynamic instability due to pneumothorax is noted several remedies can be employed. Decreasing the intra-abdominal insufflation pressure, increasing the airway pressure and taking the patient out of steep reverse Trendelenburg are useful maneuvers that resolve the problem in most cases. Placement of a chest tube is almost never required.

Creation of the Gastric Conduit

A location on the lesser curve, just cranial to the pylorus is selected to begin tubularization of the conduit. Preservation of several small draining veins along the distal lesser curve may promote better conduit perfusion. Ensure that the orogastric tube is withdrawn completely out of the stomach to avoid it being caught in the staple line. The conduit is divided from the specimen, proceeding superiorly toward the fundus. The conduit should be 4–5 cm in width. The staple line is kept as straight as possible by stretching the stomach from the tip of the fundus towards the left shoulder (Figs. 4 and 5). Stop the staple line approximately 3 cm proximal to the fundus so that the specimen and conduit can later be delivered into the chest together in the proper orientation. Finally, the Penrose drain is passed through the hiatus where it will later be retrieved via the chest. The liver retractor is removed, hemostasis is ensured and port sites are closed in the standard fashion.

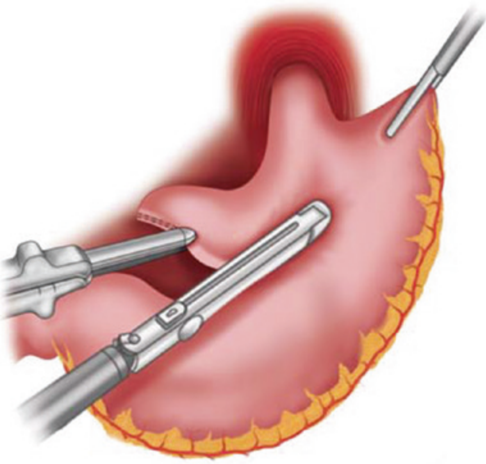

Fig. 4 The stomach is stretched at the fundus during tubularization to avoid twisting and folding. Tubularization is started just above the pylorus to allow unfolding of the lesser curvature and adequate conduit length

Positioning for the Thoracic Phase and Port Placement

The patient is positioned in the left lateral decubitus position leaning slightly forward on a bean bag, with an axillary roll and arm support and with the table flexed. At this point anesthesia should switch to single lung ventilation. The chest is entered under direct visualization with a 10 mm optical trocar in the seventh intercostal space in the posterior axillary line. Additional ports are placed as follows: A 5 mm camera port in the ninth intercostal space just posteriorly to the first port, a 10 mm port in the fourth or fifth intercostal space in the mid-axillary line, and a 5 mm port in the seventh intercostal space between the scapula and the spine (Fig. 6). Chest insufflation with CO_2 at a pressure of 8 mmHg helps exposure by flattening the diaphragm, collapsing the lungs towards the anterior mediastinum and decreasing movement of the mediastinum.

Thoracoscopic Dissection

The inferior pulmonary ligament is divided and the associated lymph nodes removed. The mediastinal pleura is incised anteriorly to the esophagus, heading superiorly to the level of the azygos vein which is divided using a vascular stapler. Next, the dissection is carried back down to the diaphragm, this time dividing the pleura posterior to the esophagus. As the dissection is carried inferiorly the transhiatal dissection performed via the abdomen is eventually encountered. Locate the Penrose drain and use this as a retraction handle. Dissect the esophagus completely out of its bed in the mediastinum, proceeding again superiorly toward the level of the

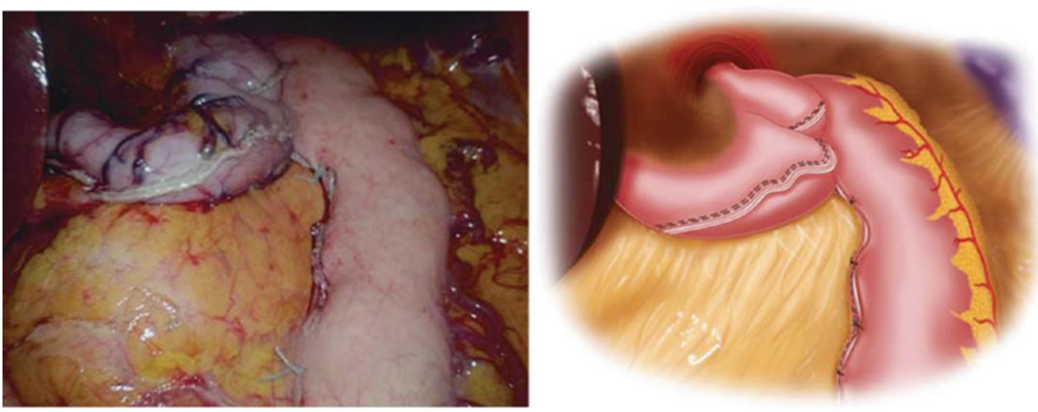

Fig. 5 The conduit is not completely divided from the specimen to facilitate transposition in the chest. A few interrupted stitches over the staple line are useful to minimize gastric injury or hematomas during retraction of the stomach

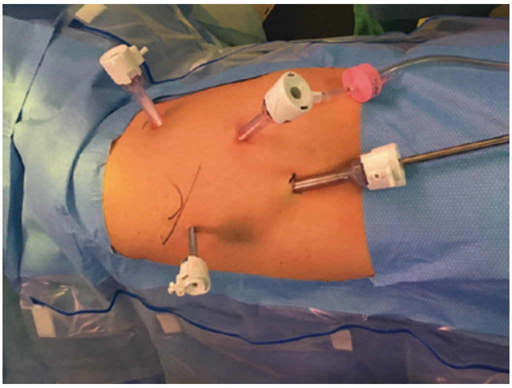

Fig. 6 Thoracic port placement

azygos vein. Before reaching the azygous, the aorta will be seen to arch towards the left chest. At this level caution must be taken to identify and avoid injury to the aorta and the left mainstem bronchus. For gastroesophageal junction tumors there is no oncologic need to obtain a wide radial margin at this proximal part of the esophagus, and staying close to the esophageal wall minimizes the risk to the airway.

The thoracic duct is also at particular risk for injury during esophageal mobilization in the chest because of its inconsistent course and the fact that it is often difficult to visualize, especially in obese patients or after neoadjuvant radiation. Again, injury occurs when dissection strays outside of the periesophageal plane of dissection. Identify and clip lymphatic branches coming from the thoracic duct and arterial branches from the aorta. Prophylactic ligation of the thoracic duct itself has not consistently been shown to reduce postoperative chylothorax, but if injury to the duct or its branches is suspected the duct should be ligated just above the hiatus. Fluorescence imaging may be useful to help delineate the anatomy of the duct to aid in its preservation or ligation, though it is not routinely necessary [20].

Complete the lymphadenectomy by dissecting the subcarinal nodes, again taking care not to injure or devascularize the airway. Avoidance of injury to the airways, including the trachea and both mainstem bronchi, is vital in preventing tracheoesophageal fistula. Exercise caution when using energy devices near the airway, particularly during the subcarinal node dissection. Even minor thermal injury, often not even visible during the operation, can progress over the course of several days to a full thickness injury and fistula formation. In addition, bronchial artery branches supplying the airway should be preserved to prevent ischemia. Always ensure that the bronchial cuff of the double lumen endotracheal tube is not overinflated, which can put the left mainstem bronchus at increased risk of injury.

Esophagogastric Anastomosis

The dissection of the esophagus is extended beneath the pleura around 2 cm superiorly past where the pleura was divided at the level of the azygos vein. The preserved pleura will act as a buttress for the eventual anastomosis. The esophagus is divided using a linear stapler at the level of—or above—the azygos vein, after confirming that the orogastric tube and esophageal temperature probe have been removed. Tension is minimized by placing the anastomosis no higher in the chest than necessary but at least at the level of the azygos vein to avoid redundant gastric conduit in the chest which can lead to reflux. Next, the anesthesiologist gently advances an oral anvil for the circular stapler (Orvil, Medtronic, Minneapolis, MN). The staple line is grasped on both sides to help guide the tube and keep the staple line horizontal. Once the tip of the tube can be seen, cautery is used to create a small opening just above the staple line on the medial aspect (towards the vena cava) of the staple line, allowing the end of the tube to be pulled through as the anesthesiologist guides the anvil over the back of the palate (Fig. 7). A pursestring stitch with reabsorbable suture is placed around the anvil to ensure a tight seal around the device.

The distal esophagus is gently pulled upwards to deliver the specimen and the conduit into the chest. Avoid excess traction and any twisting of the conduit. The staple line of

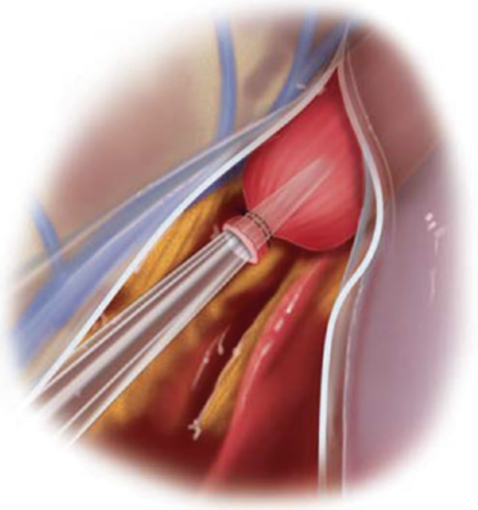

Fig. 7 The Orvil is retrieved through an opening in the esophageal stump. It is important to stay as close as possible to the esophageal stump staple line so that this is cut by the circular stapler

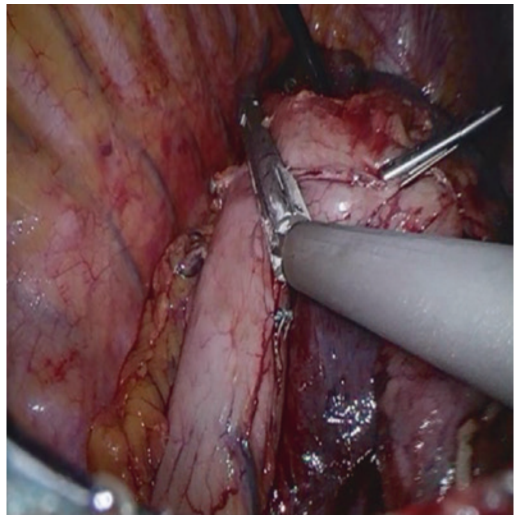

Fig. 8 The specimen is retracted towards the anterior mediastinum and the conduit is completely divided making sure the margin at the level of the hiatus is not compromised

the conduit should be oriented to the patient's right and be totally straight. At this point the conduit perfusion can be assessed using fluorescence imaging using a proprietary camera such as the Pinpoint system (Novadaq, Ontario, Canada). The speed of fluorescence appearance and any areas of demarcation can help to identify regions of poor perfusion in the conduit. If a demarcation is seen, mark the area so that the anastomosis can be created caudally where there is preserved perfusion, resecting the poorly perfused portion of the stomach after the anastomosis is performed [20].

The specimen is fully divided from the conduit using a linear stapler, taking care to maintain an adequate margin and leave enough room for insertion of the circular stapler to form an end to side esophagogastric anastomosis (Fig. 8). The specimen is removed in a retrieval bag and sent for intraoperative assessment of the proximal and distal margins. The anastomosis is performed only after the margins are confirmed to be uninvolved. The proximal tip of the conduit is grasped and opened parallel to the staple line with cautery, wide enough to allow insertion of the circular stapler. The anastomosis is performed in an area of good conduit perfusion with no tension, leaving the greater curvature vessels on the tracheal side of the anastomosis in order to protect the airways in case of leak (Fig. 9). Once the circular stapler is fired, the redundant tip of the stomach is used as a retraction handle to expose the anastomosis and place two stay sutures: One suture is placed to reinforce the area where the staple lines cross at the lateral aspect of the anastomosis. This is then further buttressed with omentum to protect the airway and aorta. The second suture is placed on the medial aspect of the anastomosis to further relieve tension. After placing these sutures, a nasogastric tube is guided into the body of the stomach under direct vision. Finally the opened proximal end of the conduit is closed with a linear stapler, making sure the anastomosis and this gastric staple line are at least 1–2 cm apart to avoid ischemia (Fig. 10). At this point the anastomosis is allowed to retract under the superior mediastinal pleura. The conduit can be tacked to the pleura with absorbable sutures. Intraoperative gastroscopy can be performed to assess the anastomosis and perform an insufflation leak test as the conduit is submerged under water. The anesthesiologist then advances a nasogastric tube under direct vision until the tip

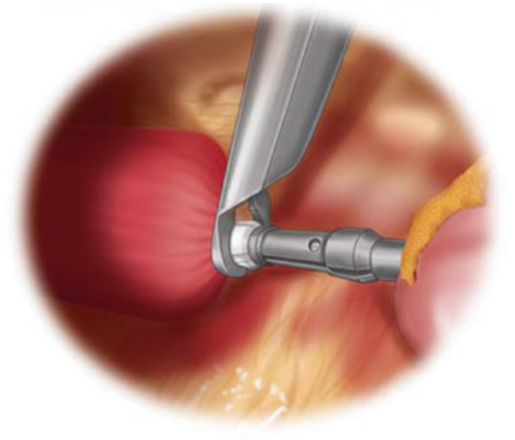

Fig. 9 The anastomosis is performed using a special grasper designed for use with the Orvil. The greater curve vessels are positioned against the airway to protect against fistula formation in the case of a leak. The preserved mediastinal pleura which will cover the eventual anastomosis is seen

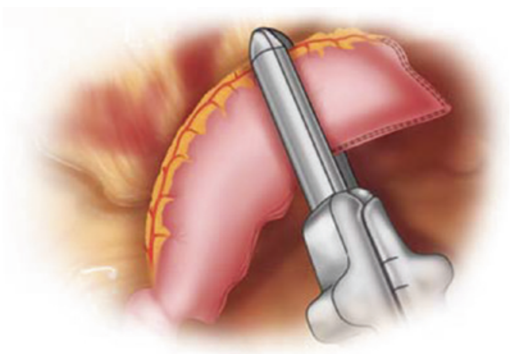

Fig. 10 Resection of opened proximal end of the conduit with linear stapler

is within the distal conduit. Lastly, the conduit can be tacked to the diaphragm at the hiatus with non-absorbable suture to help prevent against paraconduit herniation. A single straight 28 Fr chest tube is placed and the lung is re-expanded. Incisions are closed in the standard fashion.

Postoperative Care

Patients should be extubated in the operating room and monitored in the post-anesthetic care unit overnight. The nasogastric tube is kept to low intermittent suction and the patient is kept NPO. Jejunostomy feeds can be initiated on post-op day #1–2 and advanced according to protocol. The nasogastric tube is usually ready to be removed by post-op day #3 or 4, depending on the output and provided the conduit is not distended on X-ray. Contrast esophagram does not reliably identify or rule out a subclinical anastomotic leak and does not need to be routinely performed. The patient can start clear fluids on approximately post-op day #5 unless there are clinical signs of a leak such as tachycardia, atrial fibrillation, fever or rising white blood cell count. The chest tube should be removed once a chyle leak has been ruled out after initiating tube feeds, and if there are no signs of leak, typically by post-op day #3. Careful attention must be paid to the patient's fluid balance. Most patients benefit from diuresis starting on around post-op day #3, which is often continued up to discharge. Patients should ambulate 1 mile/day and use incentive spirometry at least hourly.

Any unexpected deviation from the clinical course, such as fever, cough or arrhythmia, may signal a more serious complication such as anastomotic leak or pneumonia. These should be investigated appropriately, typically with an IV and oral contrast CT scan of the chest. In the absence of complications most patients are discharged by around post-op day #7. After discharge the patient can slowly advance their diet and tube feeding can be weaned as oral calorie intake improves. The jejunostomy tube can usually be removed at the first follow-up appointment 2 weeks after discharge.

Outcomes

Several studies have compared MIE and open esophagectomy. Biere et al. randomized 115 patients at five centers to either MIE or open esophagectomy [5]. MIE was superior in terms of blood loss (200 vs 475 mL, $p<0.001$), length of stay (11 vs 14 days, $p=0.044$), recurrent laryngeal nerve injury (2 vs 14%, $p=0.012$), visual analog pain scale (2 vs 3, $p<0.001$) and several short term quality of life measures, and was inferior only in operative time (329 vs 299 min, $p=0.002$). Takeuchi, et al. performed a propensity matched comparison of MIE and open esophagectomy in 7030 patients, performed in over 700 Japanese hospitals [4]. MIE was superior in terms of blood loss (442 vs 608 mL, $p<0.001$), need for > 48 h ventilation (8.9 vs 10.9%, $p=0.006$), rate of atelectasis (3.6 vs 5.1%, $p=0.002$) and superficial infections (6.7 vs 8.7%, $p=0.022$). MIE was inferior in terms of operative time (526 vs 461 min, $p<0.001$), recurrent laryngeal nerve injury (10.3 vs 8.1%, $p=0.002$) and the need for reoperation (7 vs 5.3%, $p=0.004$) though there was no difference in anastomotic leak, pneumonia, overall morbidity, or operative and 30 day mortality. Sihag, et al. retrospectively studied the Society of Thoracic Surgeons database to compare MIE and open esophagectomy in 3740 patients [6]. MIE was superior in terms of length of stay (9 vs 10 days, $p<0.001$), postoperative transfusions (14.1 vs 18.7%, $p=0.002$) and wound infections (2.3 vs 6.3%, $p<0.001$) but was inferior in terms of operative time (443 vs 312 min, $p<0.001$), empyema (4.1 vs 1.8%, $p<0.001$), need for reoperation (9.5 vs 4.4%, $p<0.001$), and need for dilation prior to discharge (5.5 vs 1.9%, $p<0.001$). Key results of these and other studies are summarized in Table 1.

Surgical Tips

Abdominal Phase

– The addition of a 5 mm port in the left upper quadrant allows both the primary surgeon and the first assistant to work with two hands, which can facilitate exposure. This is especially useful when less experienced trainees are involved, but as expertise is gained, this port can be omitted without compromising the operation.
– Minimize grasping the greater curve of the stomach, which will become the conduit. Plan grasper placement carefully for retraction during each phase of the stomach mobilization, so that the grasper doesn't have to be continually readjusted. Bluntly lift the stomach instead of grasping it when possible.
– Avoid performing transhiatal dissection until late in the abdominal phase. This avoids a pneumothorax early in the case with resulting issues with hypotension. If a pneumothorax does occur it can usually be managed without inserting a chest tube.
– The use of the Carter-Thompson fascial closure device and the Endostitch (Covidien, Dublin, Ireland) greatly facilitates the creation of the jejunostomy, which can be one of the most frustrating parts of the operation when starting out.

Thoracic Phase

– The use of CO_2 insufflation aids exposure and stabilizes the surgical field.
– Locate the previously placed Penrose drain early on after dividing the mediastinal pleura anteriorly and posteriorly. This provides a useful handle to retract the esophagus during dissection.

Table 1 Superior operative approach for selected surgical and oncologic outcomes

Outcome	Biere [5]	Takeuchi [4]	Sihag [6]	Tapias [7]	Palazzo [9]
Length of stay	MIE	ND	MIE	MIE	MIE
ICU length of stay/ventilation	ND	MIE	ND	MIE	–
Operative time	OE	OE	OE	ND	–
Blood loss/transfusion	MIE	MIE	MIE	MIE	MIE
Anastomotic leak	ND	ND	ND	ND	ND
Recurrent nerve injury	MIE	OE	–	ND	–
Superficial/wound infection	–	MIE	MIE	–	–
Pneumonia/empyema	–	MIE	OE	ND	MIE
Pain	MIE	–	–	–	–
Need for reoperation	ND	OE	OE	–	–
Margin	ND	–	–	ND	ND
Nodes removed	ND	–	–	ND	MIE
Operative/30 day mortality	ND	ND	ND	ND	ND

MIE minimally invasive esophagectomy-blue, *OE* open esophagectomy-yellow, *ND* no difference-grey

- Preserving the mediastinal pleura above the azygos vein provides an envelope of pleura to surround the anastomosis and allows anchoring the conduit to combat the effects of gravity when the patient is upright.
- It is often easiest to perform the subcarinal node dissection separately, after the esophagus is completely mobilized.
- Assess the conduit using fluorescence, color and/or Doppler signal. This will help select the ideal location for the anastomosis.

Intraoperative Trouble Shooting

- Hypotension is a common occurrence during the abdominal phase, and is typically related to patient positioning or a pneumothorax. If hypotension occurs, start by taking the patient out of reverse Trendelenburg position. If this solves the problem, gradually reintroduce reverse Trendelenburg to allow the patient time to compensate. If a pneumothorax is suspected, ensure that the pleural opening is extended widely to prevent tension physiology. Decreasing CO_2 insufflation pressure can help in both circumstances. Communicate with the anesthesia team to avoid excess administration of IV fluids, often a reflex reaction to transient hypotension, and which can be associated with cardiac and pulmonary complications postoperatively.
- Ensure that the bronchial cuff of the double lumen tube is not overinflated. If it is, the

membranous wall of the left mainstem bronchus can be stretched and prone to injury during esophageal mobilization and subcarinal node dissection.

When performing the anastomosis, double check that the conduit is not twisted. The staple line should be straight and to the patient's right (up towards the ceiling with the patient in decubitus positioning). The greater curve vessels should lie to the left and are laid to buttress between the conduit and the airway.

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