Esophagogastric Anastomotic Techniques for Minimally Invasive and Robotic Ivor Lewis Operations

Raul Caso, MDMSCI, and Jon O. Wee, MD

Minimally invasive esophagectomy is an accepted approach to treating esophageal malignancy and is associated with excellent postoperative outcomes. Creation of the intrathoracic anastomosis with a minimally invasive approach remains one of the most critical and challenging steps of the operation. There is currently no consensus regarding the optimal technique for the esophagogastric anastomosis. Here we aimed to review the most commonly used esophagogastric anastomotic techniques for minimally invasive Ivor Lewis operations.

Operative Techniques in Thoracic and Cardiovascular Surgery 25:105 – 123 © 2020 Elsevier Inc. All rights reserved.

KEYWORDS Esophagogastric anastomosis, minimally invasive esophagectomy, robotic-assisted thoracic surgery, robotic esophagectomy, Ivor Lewis esophagectomy

Introduction

Minimally invasive esophagectomy (MIE) is an accepted approach in the management of esophageal malignancy. Multiple variations have been introduced, including laparoscopic, total thoracoscopic, robotic, and hybrid approaches. Two randomized trials have compared minimally invasive to open esophagectomy.1,2 In addition to both randomized trials, multiple other studies have also documented excellent outcomes, including shorter hospital stay and a lower frequency of respiratory complications with comparable oncologic outcomes, in patients undergoing a MIE and thus support the routine use of minimally invasive approaches for esophageal and gastroesophageal junction tumors.1-6

The 3 commonly used approaches for MIE are McKeown or 3-field, Ivor Lewis, and transhiatal.7 The Ivor Lewis esophagectomy is the most commonly performed procedure in the United States for esophageal malignancies, accounting for 48% of all oncologic cases.8 The minimally invasive Ivor Lewis esophagectomy, consisting of a laparoscopic and thoracoscopic approach, is preferred for most distal esophageal cancers, gastroesophageal junction tumors with gastric cardia extension, and short- to moderate-length Barrett esophagus with high-grade dysplasia.9 Additionally, when there is concern for the length of the gastric conduit, an intrathoracic anastomosis is preferable. Although the procedure itself, and in particular the intrathoracic anastomosis, can be technically demanding and associated with a significant learning curve, it remains an excellent approach for esophageal resection. The challenge with the intrathoracic anastomosis is partly due to the limited space in the thoracic cavity and impaired mobility of instruments.

Complications associated with the esophagogastric anastomosis, however, remain a significant cause of morbidity and mortality in the postoperative period.10 Many factors have been well described to impact anastomotic healing such as the anastomotic technique. Multiple techniques have been described for the creation of the intrathoracic anastomosis utilizing video-assisted thoracoscopic surgery (VATS) and robotic-assisted surgery. Here we aimed to review the most commonly used esophagogastric anastomotic techniques for minimally invasive Ivor Lewis operations: VATS end-to-end anastomosis (EEA) transthoracic, VATS EEA trans-oral anvil, VATS side-to-side linear-stapled, VATS hand-sewn, robotic-assisted minimally invasive esophagectomy (RAMIE) hand-sewn, and RAMIE purse-string Figures 1-6.
Figure 1  The EEA technique can be less time consuming than the hand-sewn technique and can be performed with a shorter gastric conduit compared to the linear-stapling technique. The transthoracic technique involves transecting the esophagus sharply, either with scissors, cautery, or an energy device. The transected ends of the proximal esophagus are grasped with instruments and the anvil of the EEA stapler (Medtronic, Dublin, Ireland) is guided into the open end (Fig. 1A). This can be difficult as the anvil is prone to “popping” out of the open esophagus if proper pressure is not applied. One should choose the largest anvil size that the esophagus can accommodate, which in most cases is 28 mm. If there is a very dilated esophagus, a 33 mm size is used. We do not routinely dilate the esophagus. If there is difficulty encountered with inserting the anvil, it can help to perform a dilation, but in our experience, this is not usually required. With the graspers in place, a suture is placed in a baseball stitch fashion, making sure to incorporate the mucosa and esophageal wall, around the open edge (Fig. 1A). This is tied down to secure the anvil in place, but it may not be completely tight. Hence, a second purse-string is placed outside of the baseball stitch layer and synched down to make it tight around the base of the anvil (Fig. 1B). The outer edge should be flat with no puckering (Fig. 1C). The EEA handle is generally placed through the posterior inferior port incision which is increased in size by 2-3 cm. The most distal end of the conduit staple line is divided open and the handle of the EEA placed within. The spike is brought out through the gastric wall along the greater curvature (Fig. 1D). This forms a “candy cane” like structure. The spike is brought up to the anvil to decrease any redundancy of the conduit in the chest. Once docked, the anvil is closed down to the handle and fired (Fig. 1E). Once the handle is removed and the anastomosis verified, the open end of the gastric conduit is resected with a linear stapler (Fig. 1F). Care is taken to line up the staple line with the body of the conduit as well as leaving at least a centimeter of space between the anastomosis and the cut end of the linear staple line. If an omental flap was harvested, it is wrapped around the anastomosis (Fig. 1G).
Figure 1 Continued

EEA stapler placed in gastric conduit through proximal gastrotomy
Figure 1 Continued
Figure 1 Continued
Anastomosis wrapped with omentum
Figure 2  The trans-oral anvil can be more efficient and less time consuming than the purse-string technique. The trans-oral anvil, however, only comes in 25 mm which can limit its use. The OrVil™ (Covidien, Dublin, Ireland), by design, comes preconnected to a long nasogastric tube-like attachment (Fig. 2, insert). Because of its similarity to a nasogastric tube, it may be inadvertently placed through the patient’s nostril if someone unfamiliar with this process is assisting with the trans-oral placement. Education and closed-loop communication are critical during placement to avoid this pitfall. Because of its size, the anvil portion of the prosthesis can get hung up along the way from the patient’s mouth to the transected esophagus, in particular in petite women. There are specific maneuvers to prevent and resolve these occurrences. First, the smooth portion of the disk, should be positioned so that it is facing posteriorly, along the hard palate. Second, if hung up at the piriform sinus, lifting and shaking the patient’s jaw can encourage the anvil to slide into the esophagus. Next, it can get hung up at the level of the aortic arch. Typically, a gentle tugging back and forth between the surgeon at the chest and the assistant at the head of the bed will allow re-orienting of the disk so that it slides past the aortic arch. Lastly, it can get hung up at the endotracheal balloon. Here, a transient deflation of the cuff will allow the anvil to pass. If the surgeon pulls with too much force, the anvil may become dissociated from the orogastric tube. If this occurs, the blue retrieval suture can be used to retrieve the separated end of the anvil. Also, some surgeons may use the XL EEA. This can only mate with the XL OrVil™, and the standard EEA can only mate with the standard OrVil™. To bring the orogastric tube out and guide the OrVil™ to the end of the esophagus, an incision is made in the middle of the esophageal staple line (Fig. 2). The blue sutures are then transected to separate the orogastric tube as well as allow the anvil head to rotate perpendicular so that it may be available for docking. When the blue suture is cut, the head is supposed to flip 90° so that it is perpendicular to the post. However, this rotation may not happen easily. If it does not, it takes some effort to make sure the anvil rotates so that it can dock with the EEA handle. The placement of the EEA handle and creation of the anastomosis is the same technique as described above.
Figure 3  The linear-stapled anastomosis results in a wider anastomosis, potentially resulting in a lower rate of postoperative strictures. However, a longer gastric conduit is required to successfully complete the esophagogastric anastomosis. An esophagotomy is created on the posterior esophagus near the distal end of the transected esophagus and a gastrotomy is created on the greater curvature (Fig. 3A). A side-to-side intrathoracic linear stapled esophagogastrostomy is performed by placing the anvil portion of the stapler through the esophagotomy and the cartridge through the gastrotomy (Fig. 3B). The common opening of the gastrotomy and esophagotomy are sutured with an absorbable braided inner layer followed by a nonabsorbable outer layer suture (Fig. 3C).
Gastroesophageal anastomosis joined & opened with stapler

Esophagus

Gastric conduit

Figure 3 Continued
First row of sutures placed for closing joined gastrotomy & esophagotomy
Creation of the esophagogastric anastomosis via a thoracoscopic hand-sewn technique requires advanced laparoscopic and thoracoscopic suturing ability. The posterior wall of the proximal esophagus is tagged to the gastric conduit with interrupted seromuscular sutures. A gastrotomy is made on the greater curvature and an end-to-side esophagogastric anastomosis is performed with interrupted PDS sutures (Ethicon, Somerville, NJ) or running sutures (V-loc [Medtronic, Dublin, Ireland], Stratafix [Ethicon, Somerville, NJ]), starting in the center and working toward both ends (Fig. 4A). If using the self-locking V-loc or Stratafix, make sure proper technique is utilized for these sutures. One can use a single armed suture which has a loop at one end or a double armed suture. Sutures must be pulled tight to get rid of any slack, and to finish the suture, you must have enough length to suture back along your suture line or use an end suture device. Once the posterior ends are complete, Connell stitches are inserted at both ends to ensure inversion and accurate mucosal apposition when connecting the anterior layer (Fig. 4B). A nasogastric tube is passed through the anastomosis and the anterior layer is completed with running sutures (Fig. 4C).
Connell suture pattern in lateral aspects of anastomosis for inversion of edges
Continuous suture placed in anterior row to complete handsewn anastomosis

Figure 4 Continued
RAMIE takes advantage of the 4 degrees of freedom, superior visualization, and improved ergonomics associated with the robotic platform. A 2-layered hand-sewn technique decreases conduit ischemia by allowing a more precise and controlled gastrostomy and avoids staple lines that may harbor areas of low blood supply along the stomach. Disadvantages of this technique include the time required to create the anastomosis, learning curve, and costs associated with the robot. A location on the tubularized gastric conduit, at least 3- to 4-cm below the most superior aspect of the gastric staple line and as far away as possible from the lesser curve staple line, is selected for the gastrostomy for the anastomosis. The back layer of the posterior aspect of the anastomosis is constructed first using interrupted 3-0 silk sutures (Ethicon, Somerville, NJ) to sew the postmuscular layer of the esophagus to the serosal layer of the stomach (Fig. 5A). The inner layer of the anastomosis is constructed next by using a running layer of 3-0 PDS sutures starting on the medial part of the anastomosis at the 3 o'clock location (Fig. 5B). Once the posterior inner layer of the anastomosis is completed, a second PDS suture is run from the 9 o'clock location back anteriorly. The second layer of the anterior part of the anastomosis is completed with several interrupted 3-0 silk sutures (Fig. 5C). Some surgeons have utilized a single layer autolocking suture such as the V-loc or Stratafix suture.

**Figure 5** RAMIE takes advantage of the 4 degrees of freedom, superior visualization, and improved ergonomics associated with the robotic platform. A 2-layered hand-sewn technique decreases conduit ischemia by allowing a more precise and controlled gastrostomy and avoids staple lines that may harbor areas of low blood supply along the stomach. Disadvantages of this technique include the time required to create the anastomosis, learning curve, and costs associated with the robot. A location on the tubularized gastric conduit, at least 3- to 4-cm below the most superior aspect of the gastric staple line and as far away as possible from the lesser curve staple line, is selected for the gastrostomy for the anastomosis. The back layer of the posterior aspect of the anastomosis is constructed first using interrupted 3-0 silk sutures (Ethicon, Somerville, NJ) to sew the postmuscular layer of the esophagus to the serosal layer of the stomach (Fig. 5A). The inner layer of the anastomosis is constructed next by using a running layer of 3-0 PDS sutures starting on the medial part of the anastomosis at the 3 o'clock location (Fig. 5B). Once the posterior inner layer of the anastomosis is completed, a second PDS suture is run from the 9 o'clock location back anteriorly. The second layer of the anterior part of the anastomosis is completed with several interrupted 3-0 silk sutures (Fig. 5C). Some surgeons have utilized a single layer autolocking suture such as the V-loc or Stratafix suture.
Figure 5 Continued
Figure 5 Continued

- **Interrupted sutures placed in 2nd anterior row**
- **Continuous sutures in 1st anterior row oversewn with 2nd row**
The robotic EEA purse-string technique is quite similar to the VATS EEA purse-string technique in concept. The esophagus is transected sharply with robotic scissors. Stay sutures are placed medially and laterally in the proximal esophagus to allow correct alignment of the transected esophagus and the gastric conduit. A full-thickness baseball stitch is hand-sewn on the proximal esophagus starting at the 12 o’clock position and continued clockwise (Fig. 6A). It takes about 6-9 throws to get around the esophagus, making sure the wall and mucosa are together. The anvil head is then inserted into the esophagus and the baseball stitch is tied. There may be small gaps and outpouchings, but the anvil should remain in place. A purse-string is then placed just outside the first suture around the anvil to synch and secure the esophagus around the base of the anvil (Fig. 6B-C). The staple line on the gastric conduit is opened a few centimeters proximal to the end. The EEA stapler handle is placed in line into the conduit. The spike is brought out through the greater curve of the conduit and docked with the anvil (Fig. 6D). The residual gastrotomy and gastric margin are resected using a linear stapler. It is important to line up the staple line from the conduit up to the area of the anastomosis. It may take multiple staple fires, with the first fire getting only the first 1 to 2 cm of the opening until the corner is set. You should also leave a distance of about a centimeter or more from the linear staple line to the anastomosis. The anastomosis and staple line can be reinforced with an omental patch attached to the pleural reflection.
Figure 6 Continued

- Anvil secured in esophagus
- EEA stapler in gastric conduit prepared for mating with anvil & firing
Conclusions

MIE or RAMIE are complex and technically challenging operations with steep learning curves but currently represent the surgical treatment of choice for esophageal and gastroesophageal junction tumors. It is well established that a minimally invasive approach is associated with reduced morbidity, shorter hospital stays, and earlier return to function, among others. Since the technique for the minimally invasive Ivor Lewis esophagectomy was first described, many centers began to adapt their favored method for creating the intrathoracic esophagogastric anastomosis. Creation of the intrathoracic anastomosis with a minimally invasive approach remains one of the most critical and challenging steps of the operation, not only because of the learning curve necessary to successfully complete the anastomosis but because of the well-described anastomotic complications and patient morbidity. There is yet no consensus as to which technique for creating the anastomosis is both technically feasible for most esophageal surgeons and associated with better outcomes for the patient. Larger studies are needed to determine the optimal esophagogastric anastomotic technique.

References