J Gastrointest Surg (2012) 16:1775–1781
DOI 10.1007/s11605-012-1895-5

HOW I DO IT

Minimally Invasive Esophagectomy with Cervical Esophagogastric Anastomosis

Steven N. Hochwald · Kfir Ben-David

Received: 15 February 2012 / Accepted: 17 April 2012 / Published online: 2 May 2012

Abstract
Objective Thoracoscopic dissection of the esophagus and laparoscopic dissection of the stomach with cervical esophagogastric anastomosis is a safe method for resection of esophageal and gastroesophageal junction malignancy.
Setting The setting was at University Tertiary Care Center.
Patients Subjects are patients with esophageal or gastroesophageal junction malignancy undergoing minimally invasive esophagectomy with cervical esophagogastric anastomosis.
Main Outcome Measures Technique of a 6-cm side-to-side stapled cervical esophagogastric anastomosis is described.
Results The technique of minimally invasive esophagectomy with side-to-side stapled cervical esophagogastric anastomosis is described.
Conclusions Thoracoscopic dissection of the esophagus, laparoscopic dissection of the stomach, and a side-to-side stapled cervical esophagogastric anastomosis is safe, oncologically appropriate, and provides excellent functional results.

Keywords Minimally invasive esophagectomy · Cervical anastomosis

Introduction

Although minimally invasive esophagectomy was first described more than 15 years ago,[1,2] adoption of this technique has been slow due to its technical difficulty, long associated operative times, and lack of a standardized approach. We describe our preferred approach for minimally invasive esophagectomy utilizing thoracoscopic dissection of the esophagus, laparoscopic mobilization of the stomach, and cervical esophagogastric anastomosis.

S. N. Hochwald · K. Ben-David (✉)
Department of Surgery, University of Florida College of Medicine,
1600 SW Archer Road, P.O. Box 100109, Gainesville,
FL 32610, USA
e-mail: kfir.bendavid@surgery.ufl.edu

Methods

Standard work-up for staging of esophageal cancer and cancer of the gastroesophageal junction is utilized including EUS, CT, and PET scans.[3] Neoadjuvant therapy is performed for T2–T4 and/or node positive, M0 malignancy. Following the completion of neoadjuvant therapy, patients are re-staged with radiographic CT/PET imaging and surgery is offered to medically fit patients who do not have metastatic disease. Thoracoscopic mobilization of the esophagus, laparoscopic mobilization of the stomach with gastric conduit formation, and a cervical anastomosis is our standard surgical approach.[4]

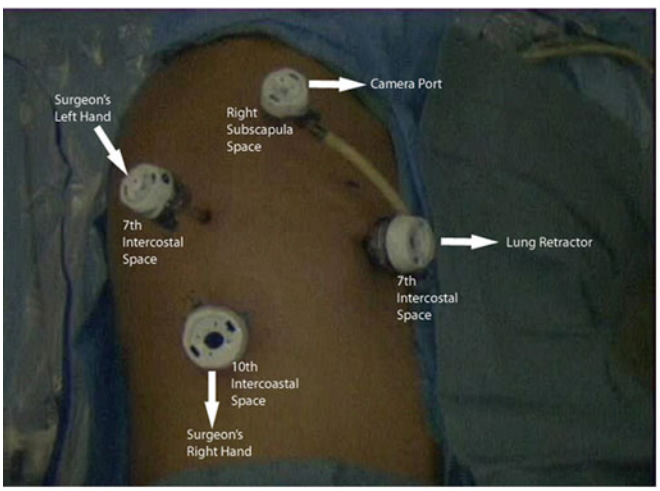
Operative Description

Thoracic Dissection

The patient is intubated with a double lumen endotracheal tube with plans for deflation of the right lung and isolated left lung ventilation. An 18-gauge nasogastric tube is placed. Subsequently, the patient is placed in the left lateral

decubitus position. The right lung is deflated and a 5-mm optiview trocar is placed under direct vision using a 5-mm 0° scope just inferior to the tip of the scapula. This serves as the camera port for the duration of the case and the scope is switched to a 5 mm 30° scope. The right chest cavity is insufflated with 8 mm Hg of carbon dioxide ($C0_2$) pressure. A 5-mm port is placed in the posterior axillary line, in a straight line inferior to the first port, in the seventh intercostal space. A 5-mm port is placed in a straight line inferior to this in the tenth intercostal space, just above the diaphragmatic insertion. These two ports serve as the surgeon's working ports. A 12-mm port is placed anteriorly in the seventh intercostal space. This port is utilized for the fan retractor on the lung (Fig. 1).

The lung is retracted anteriorly. The inferior pulmonary ligament is divided. The lower esophagus is widely dissected with an ENSEAL® tissue sealing device (Ethicon Endo-Surgery, Inc. Cincinnati, OH) and encircled with a Realize™ (Ethicon EndoSurgery, Inc. Cincinnati, OH) blunt-tip dissector and subsequently a penrose drain (Fig. 2). Care is taken not to enter into the left pleural space during this portion of the dissection. The penrose drain is secured around the esophagus with an endo-loop tie. The penrose is left slightly loose so that it can slide up and down the esophagus to facilitate the dissection. The esophagus is mobilized from its distal end to the proximal portion, starting at a point just above the GE junction. Care is taken not to enter into the abdominal cavity during the thoracic dissection. The penrose is advanced up the esophagus and used to put traction on the esophagus. Periesophageal and subcarinal lymph nodes are included with the specimen. If the thoracic duct is identified, it is ligated. The azygous vein is divided with a 45- or 60-mm vascular Powered ECHELON FLEX™ ENDOPATH® vascular load stapler (Ethicon EndoSurgery, Inc. Cincinnati, OH) (Fig. 3). The esophagus is dissected from underneath the azygous vein. Since the vast majority of patients are undergoing resection for adenocarcinoma of the distal esophagus or GE junction, the dissection is typically performed close to the esophagus at the point above the azygous vein. This ensures no injury to the recurrent laryngeal nerves. The dissection continues with mobilization of the proximal esophagus away from the trachea. It is important to continue the esophageal mobilization proximal to the thoracic inlet. This can be safely



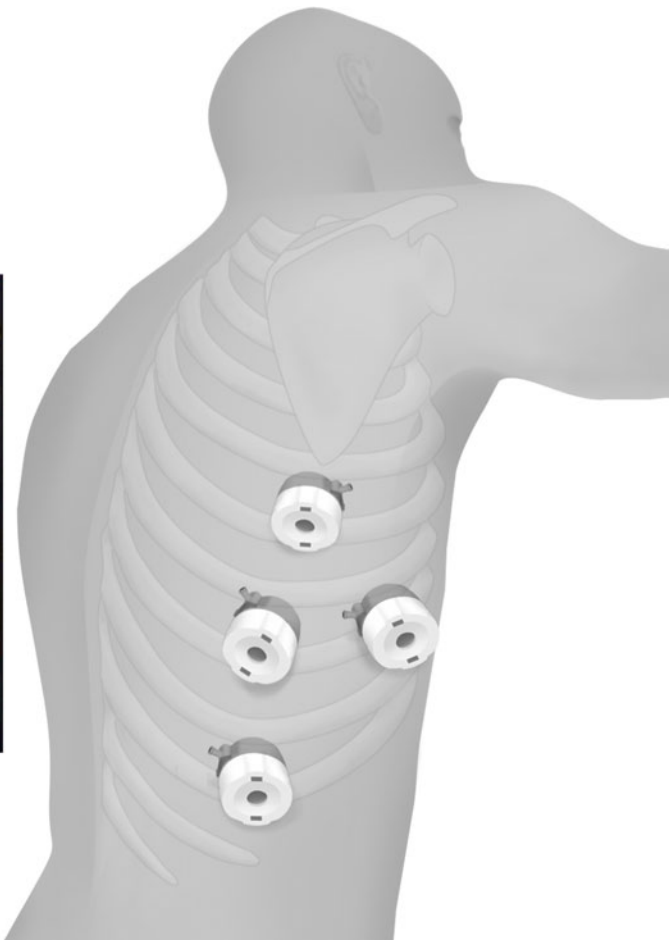


Fig. 1 Thoracic port placement

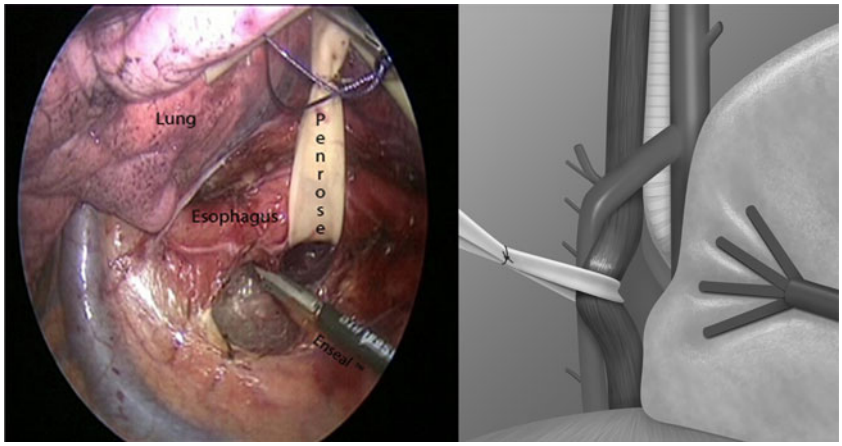


Fig. 2 Thoracoscopic mobilization of the esophagus

done and limits injury to the recurrent laryngeal nerve during the cervical phase of the dissection. In fact, we make it a point to perform the entire cervical esophageal mobilization through the thoracoscopic ports. This can be easily and routinely accomplished with long instruments and the camera positioned just inferior to the tip of the scapula. Following complete mobilization of the intrathoracic and cervical esophagus, the penrose drain is pushed into the apex of the dissection and kept in continuity around the cervical esophagus. A 24 French Blake drain is placed through the inferior 12 mm port and positioned along the posterior mediastinum. The ports are removed and the single 12 mm anterior port is closed with a 2–0 vicryl for the muscle and with a 4–0 vicryl subcuticular stitch.

Cervical Dissection

The patient is repositioned with the left arm tucked at the side, the head turned to the right, and the left neck exposed. The neck, chest, and abdomen are prepped under sterile conditions. A 6-cm incision is made along the anterior border of the sternocleidomastoid muscle (SCM). The SCM is mobilized laterally and the omohyoid muscle is divided. Anterior crossing veins from the jugular vein are divided and ligated with ties. The jugular vein and carotid artery are retracted laterally. The prevertebral fascia plane is entered. The penrose drain from our previous thoracic dissection is identified and secured with a Kelly clamp through our neck exposure (Fig. 4). Once the penrose drain is grasped, the cervical dissection is done with minimal effort, and mobilization of the cervical esophagus since the majority of the cervical dissection has been performed under direct vision through the thoracoscopic ports. As a result, this portion of the operation should take 5–10 min.

Abdominal Dissection

Our most frequent approach includes placement of a 5-mm optiview trocar under direct vision into the lateral aspect of the left subcostal region. Additional ports include a 5-mm camera port, 2 cm to the left and above the umbilicus. These two ports will be controlled by the assistant. A 12-mm port is placed at the same level as the previous port but just lateral to the rectus muscle on the right side. An additional 12 mm port is placed 6 cm superior and lateral to this port on the right side. These are the surgeon's working ports. The abdomen is evaluated for evidence of metastatic disease. If there is evidence of metastatic disease, the options are to

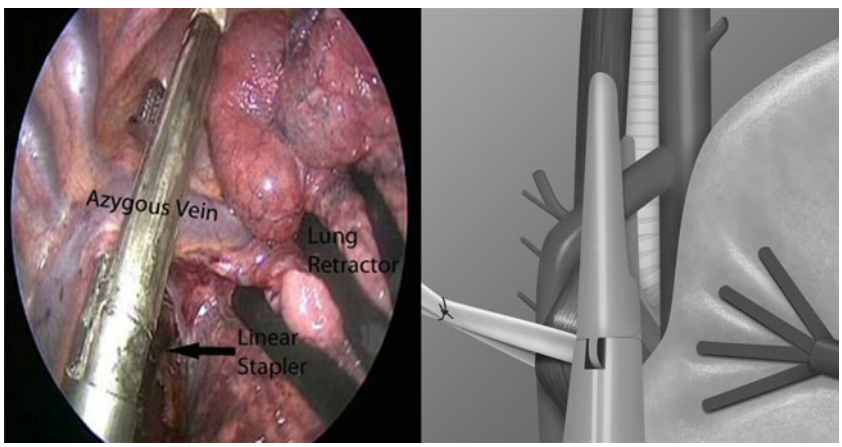


Fig. 3 Thoracoscopic division of the azygous vein

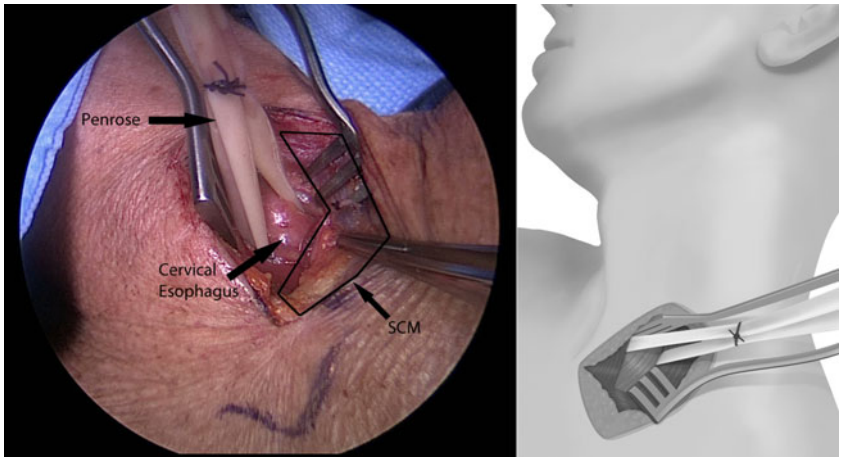


Fig. 4 Left cervical esophageal mobilization

abort the esophageal resection or to continue with palliative resection. In our experience of over 180 minimally invasive esophagectomies, we have encountered this scenario in two patients. Due to their significant comorbidities, we elected to abort the procedure in these two patients resulting in minimal sequela and overall outcome.

The patient is placed in steep reverse Trendelenburg position. A 5-mm trocar is introduced inferior and to the left of the xiphoid process. The tissues are spread open with a hemostat. A Nathanson liver retractor is placed and secured to a fixed arm on the right side of the table.

The abdominal dissection can be divided into nine simple steps:

(1) Penrose drain placement around the gastroesophageal junction. A retrogastric tunnel is created by incising the tissue along the right crus of the diaphragm. Care is taken to visualize the left crus and place a blunt grasper behind the GE junction from the right to left. The assistant grasps the fundus of the stomach and retracts in downwards and to the right. The grasper is visualized as it exits the loose connective alveolar tissue to the left and superior to the gastric cardia and inferior to the left crus of the diaphragm. The penrose is secured around the GE junction with an endo-loop.

(2) Mobilization of the upper half of the greater curvature of the stomach. The anterior aspect of the stomach is grasped by the operating surgeon and the lesser sac is entered at a point about halfway up the greater curvature of the stomach. A tissue sealing device is utilized to divide the gastrocolic omentum and short gastric vessels. Care is taken to preserve the right gastroepiploic vessels. The stomach is mobilized all the way until the left crus and penrose drain are visualized.

(3) Mobilization of the lower half of the greater curvature of the stomach. The assistant standing on the left side of the table continues the mobilization of the lower half of the stomach. The plane between the right transverse colon and the right gastroepiploic vessels is entered. The gastropancreatic folds are divided. The stomach is mobilized away from the pancreas until the gastroduodenal artery is visualized.

(4) Mobilization of the proximal duodenum. The surgeon on the right side of the table mobilizes the first and second portions of the duodenum. Dissection is performed along the superior aspect of the duodenum until the bile duct is reached. Adhesions between the first portion of the duodenum to the liver, gallbladder, or porta hepatis are divided. Although formal Kocher maneuver is often times not necessary, in patients with gastroesophageal junction tumor who require greater mobilization of the duodenum, a Kocher maneuver is performed.

(5) Division of the right gastric artery. A point is selected 4 cm proximal to the pylorus. The tissue along the superior aspect of the lesser curvature of the stomach is divided with the sealing device.

(6) Division of the left gastric artery and vein. The assistant elevates the lesser curvature of the stomach. The surgeon dissects the left gastric artery to its base, skeletonizing the celiac trunk while performing an extensive lymphadenectomy along the vessels (Fig. 5). Subsequently, the left gastric artery and vein are stapled and divided with a vascular load (1.5–2.0 mm staples). Dissection continues superior to this to make sure that the lesser curvature of the stomach is completely free up to the GE junction.

(7) Creation of gastric conduit. The gastric conduit is created by a series of 5–6 firings of the 6-cm stapler (2.5–3.0 mm staples) along the lesser curvature of the stomach. The nasogastric tube is pulled back to above the GE junction. The first firing is done using the right upper abdominal 12 mm port. The stapler is introduced onto the stomach 4 cm proximal to the pylorus, and the first firing is used to create the appropriate width of the gastric tube. The next several firings continue along the body and fundus of the stomach. The last firing of

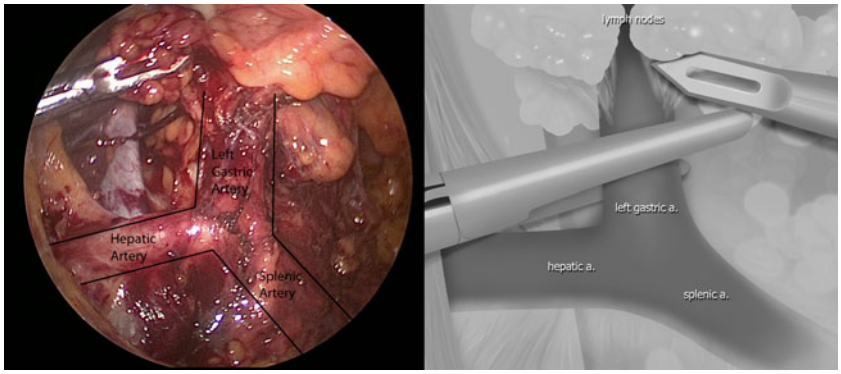


Fig. 5 Skeletonization of the celiac trunk and division of the left gastric artery

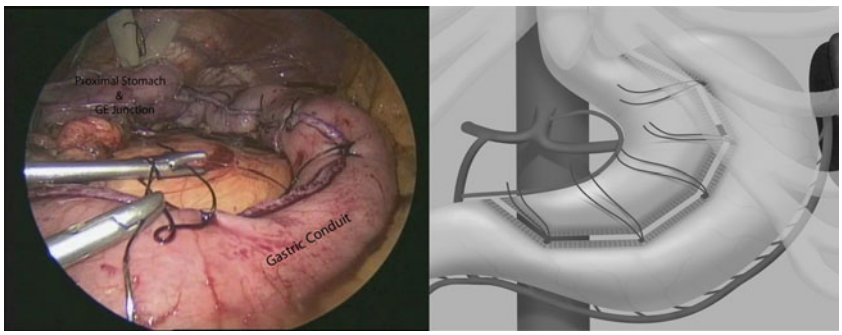


Fig. 6 Creation of gastric conduit

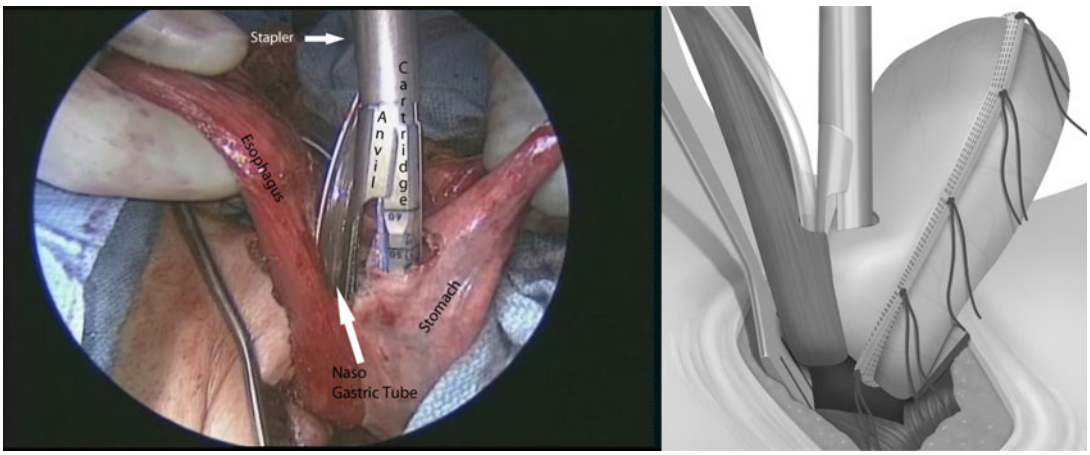


Fig. 7 Cervical linear-stapled esophagogastrostomy

the stomach is not done until after each staple line is reinforced with a single interrupted inverting suture of 2–0 silk. These sutures are placed at the junction of the staple lines and left long (about 3 cm) to use as handles for subsequent transfer of the stomach to the posterior mediastinum (Fig. 6).

(8) Final dissection to mobilize GE junction and lower esophagus. Following the final application of the stapler and division of the gastric tube from the upper stomach and GE junction, the GE junction is mobilized utilizing the penrose drain. The penrose drain is pulled laterally and medially and the phrenoesophageal ligament is widely divided. The lower esophagus is widely dissected until the thoracic and abdominal dissections are in continuity. Subsequently, the gastric tube is sutured to the lesser curvature side of the upper divided stomach utilizing two interrupted 2–0 silk sutures.

(9) Transfer of stomach to posterior mediastinum and neck. The assistant grasps the penrose enveloping the cervical esophagus and pulls the esophagus, GE junction, and attached gastric tube through the posterior mediastinum and out the cervical incision. The surgeon keeps the orientation of the gastric tube so that it does not twist. This is done by pulling on the sutures placed along the lesser curvature of the stomach and straightening the gastric tube as it is pulled through the mediastinum. Care is taken to ensure that the gastric staple line is properly oriented (along the medial aspect of the tube) as it exists in the cervical incision.

Cervical Esophagogastrostomy

The esophagus and gastric tube are pulled outwards from the cervical incision at a 60–90 angle from the patient. The posterior aspect of the gastric tube is placed alongside the medial aspect of the cervical esophagus. Cautery is utilized to make an opening in the medial aspect of the esophagus and the posterior gastric tube. The tip of the nasogastric tube is pulled out from the opening in the esophagus. The anvil of a 6-cm staple load (2.5 mm staples) is introduced alongside the nasogastric tube in the esophagus, and the staple cartridge is placed in the stomach. The stapler is closed. Care is taken to make sure the nasogastric tube is not caught in the staple line. The stapler is fired and removed (Fig. 7). The nasogastric tube is then placed through the anastomosis and the tip left in the lower aspect of the gastric conduit. The common openings in the stomach and esophagus are grasped with clamps and placed together for closure. A right angle (TA) stapler with 2.5 mm staples is utilized to close the common channel and to excise the tip of the gastric tube. The TA staple line is over sewn with a running 3–0 PDS suture. The crotch of the gastroesophageal anastomosis is reinforced with two 3–0 silk sutures. The completed gastroesophageal anastomosis is reduced back into the posterior–superior mediastinum. A 7-mm French drain is placed alongside the gastroesophageal anastomosis and is brought to exit the skin posterior to the SCM.

The gastric conduit is sutured to the diaphragm with two sutures of 2–0 silk in an effort to decrease the chance of herniation of bowel. A 16 French feeding tube is inserted in the proximal jejunum. The 12-mm port sites are sutured closed.

Discussion

The ideal technique for minimally invasive esophagectomy is under debate. Various methods have been described with variations in the location of the esophagogastric anastomosis.[5–16] Minimally invasive esophagectomy utilizing thoracoscopic and laparoscopic techniques with cervical esophagogastric anastomosis has several advantages. All components of the operation are done under direct vision. There is no blunt dissection. Appropriate lymphadenectomy can be easily accomplished. The anastomosis is performed extracorporally utilizing a 6-cm stapler, without a concern regarding the lumen size. Potential advantages of a long side-to-side stapled anastomosis results includes lower leak rates and long-term stenosis.[4] We have successfully utilized this technique in over 100 patients and our results have been previously reported.[4] More specifically, our mortality rate, pneumonia, anastomotic leak, and median length of stay was 1 %, 9 %, 4 % and 7.5 days, respectively.[4]

In addition, although not common, anastomotic leaks can be managed with minimal intervention to the patient. In our experience, the management has consisted of cervical wound opening. The leak is frequently self limited with prompt closure in 2–3 weeks. The main disadvantage of a cervical esophagogastric anastomosis includes potential morbidity to the recurrent laryngeal nerve resulting in postoperative hoarseness and swallowing dysfunction. Our refined technique of extended thoracoscopic dissection with intra-thoracic mobilization of the cervical esophagus allows for dissection of the esophagus away from the trachea under direct vision. This results in fewer traumas to the recurrent laryngeal nerve and less long-term dysfunction.

In summary, we describe a refined technique for construction of a cervical esophagogastrostomy using a 6-cm side-to-side linear stapled anastomosis. This method is applicable to the majority of patients undergoing resection for esophageal or GE junction cancer. This has become our standard approach to minimally invasive resection of the esophagus for carcinoma and overcomes many of the limitations associated with esophagectomy. Performing this procedure requires a learning curve; however, as with any new technique, having the prerequisite technical skills will ensure safe results as described in this article.

References

1. DePaula AL, Hashiba K, Ferreira EA, de Paula RA, Grecco E. Laparoscopic transhiatal esophagectomy with esophagogastroplasty. Surg Laparosc Endosc 1995;5:1–5.
2. Luketich JD, Nguyen NT, Weigel T, Ferson P, Keenan R, Schauer P. Minimally invasive approach to esophagectomy. JSLS 1998;2:243–247.
3. Ben-David K, Rossidis G, Zlotecki RA, Grobmyer SR, Cendan JC, Sarosi GA, Hochwald SN. Minimally invasive esophagectomy is safe and effective following neoadjuvant chemoradiation therapy. Ann Surg Oncol. 2011;18:3324–9.
4. Ben-David K, Rossidis G, Sarosi G, Hochwald SN. Decreasing morbidity and mortality in one hundred consecutive minimally invasive esophagectomies. Surg Endosc. 2012;26:162–7.
5. Nguyen NT. Minimally invasive esophagectomy, lessons learned from 104 operations. Ann Surg 2008;248:1081–91.
6. Benzoni E, Bresadola V, Terrosu G, Uzzau A, Cedolini C, Intini S, Noce L, Bresadola F. Minimally invasive esophagectomy: a comparative study of transhiatal laparoscopic approach versus laparoscopic right transthoracic esophagectomy. Surg Laparosc Endosc Percutan Tech 2008;18:178–187.
7. Bernabe KQ, Bolton JS, Richardson WS. Laparoscopic hand-assisted versus open transhiatal esophagectomy: a case–control study. Surg Endosc 2005;19:334–337.
8. Bintintan VV, Mehrabi A, Fonouni H, Esmaeilzadeh M, Muller-Stich BP, Funariu G, Ciuce C, Gutt CN. Feasibility of a high intrathoracic esophagogastric anastomosis without thoracic access after laparoscopic-assisted transhiatal esophagectomy: a pilot experimental study. Surg Innov 2009;16:228–236.
9. Braghetto I, Csendes A, Cardemil G, Burdiles P, Korn O, Valladares H. Open transthoracic or transhiatal esophagectomy versus minimally invasive esophagectomy in terms of morbidity, mortality and survival. Surg Endosc 2006;20:1681–1686.
10. Dapri G, Himpens J, Cadiere GB. Robot-assisted thoracoscopic esophagectomy with the patient in the prone position. J Laparoendosc Adv Surg Tech A 2006;16:278–285.
11. Fabian T, McKelvey AA, Kent MS, Federico JA. Prone thoracoscopic esophageal mobilization for minimally invasive esophagectomy. Surg Endosc 2007;21:1667–1670.
12. Gerhart CD. Hand-assisted laparoscopic transhiatal esophagectomy using the dexterity pneumo sleeve. JSLS 1998;2:295–298.
13. Verhage RJ, Hazebroek EJ, Boone J, Van Hillegersberg R. Minimally invasive surgery compared to open procedures in esophagectomy for cancer: a systematic review of the literature. Minerva Chir 2009;64:135–146.
14. Horgan S, Berger RA, Elli EF, Espat NJ. Robotic-assisted minimally invasive transhiatal esophagectomy. Am Surg 2003;69:624–626.
15. Zhou J, Chen H, Lu JJ, Xiang J, Zhang Y, Hu H, Zhou X, Luo X, Yang F, Tam J. Application of a modified McKeown procedure (thoracoscopic esophageal mobilization three-incision esophagectomy) in esophageal cancer surgery: initial experience with 30 cases. Dis Esophagus 2009;22:687–693.
16. Ben-David K, Sarosi GA, Cendan J Hochwald SN. Technique of minimally invasive IVOR-LEWIS esophagogastrectomy with intrathoracic stapled side to side anastomosis. Journal of Gastroint Surg 2010:14;1613–8.