Three-field minimally invasive esophagectomy: Current results and technique

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The adoption of minimally invasive esophagectomy has increased worldwide since its first description more than 15 years ago. The technique has evolved from a transhiatal to a 3-hole McKeown approach and, more recently, to a minimally invasive Ivor Lewis approach. We reviewed the technique and results of 3-hole minimally invasive esophagectomy. We favor thoroscopic esophageal mobilization with the patient in a lateral decubitus position, although other groups have reported this with a prone or robotic approach. Several series have demonstrated low perioperative mortality with minimally invasive esophagectomy. A major advantage compared with esophagectomy with thoracotomy is a lower incidence of respiratory complications, which have been shown to be a significant predictor of mortality in other studies. (*J Thorac Cardiovasc Surg* 2012;144:S63-6)

The overall results for the treatment of esophageal cancer have been poor, with more than 95% of patients eventually succumbing to their disease.¹ Surgical removal of the esophagus continues to play a major role in the treatment of esophageal cancer. However, esophagectomy is a complex procedure that can be associated with significant morbidity and mortality, requiring dissection within the chest and abdominal cavities, as well as the neck in many cases.

The concept of 3-field esophagectomy was introduced by McKeown,² who described transthoracic esophagectomy with cervical anastomosis, in which the thoracic esophagus and adjacent lymph nodes were removed en bloc using thoracotomy combined with laparotomy and cervical incision. In an effort to decrease the morbidity, allow a quicker recovery, and return to normal activities, several centers have introduced minimally invasive approaches to esophagectomy.^{3,4}

DePaula and colleagues³ and Swanson and Hansen⁴ were the first to report a total minimally invasive approach to esophagectomy (MIE). Their procedure included laparoscopic transhiatal esophagectomy similar to the open transhiatal technique described by Orringer and Sloan.⁵ Around the same time, Law and colleagues⁶ reported a series of esophagectomies in which thoroscopic mobilization was performed. Subsequently, Luketich and colleagues⁷ reported a minimally invasive approach that included thoroscopic esophageal mobilization and laparoscopic creation

of a gastric pull-up with a cervical anastomosis, in effect a minimally invasive McKeown or 3-hole approach. In the present report, we have briefly reviewed the technique and indications and describe the results for 3-hole MIE.

TECHNIQUE

The steps of 3-hole MIE have been previously described.⁸ After intubation with a double-lumen tube, right-sided video-assisted thoracic surgery (VATS) is undertaken with the patient in the left lateral decubitus position. Typically, 4 port incisions are used. The esophagus is mobilized from the diaphragm to the thoracic inlet. To facilitate exposure of the distal esophagus, a single retracting suture is placed in the dome of the diaphragm and brought out anteriorly and inferiorly through a small stab incision. Placing the patient in a slightly reverse Trendelenburg position with some rotation anteriorly will also help rotate the lung anteriorly away from the esophagus. We also place a Penrose drain around the esophagus for traction during the thoracic dissection. Generally, we use a harmonic scalpel (Ethicon, Cincinnati, Ohio) or ultrasonic shears (Covidien, Norwalk, Conn) to perform the dissection. After dissecting the esophagus for a short distance into the neck from the mediastinum, the Penrose drain is left in the neck to help with identification of the esophagus when the cervical portion of the procedure is performed. It is also important to not extend the lower part of the dissection beyond the crura inferiorly, because this will lead to difficulties with insufflation during the laparoscopic portion of the procedure. We do not use epidural analgesia and favor the use of an extrapleural catheter for postoperative analgesia⁹ combined with patient-controlled analgesia.

After completion of the thoracic portion, the patient is turned to the supine position with a footboard at the end of the table. The patient is placed in a steep reverse Trendelenburg position for laparoscopic gastric mobilization.

The gastrohepatic ligament is initially divided, exposing the right crus of the diaphragm. The stomach is then mobilized with division of the short gastric vessels superiorly.

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Abbreviations and Acronyms

MIE = minimally invasive esophagectomy
VATS = video-assisted thoracic surgery

The dissection then continues inferiorly along the greater curve, taking care to preserve the right gastroepiploic arcade. One of the more difficult parts of the dissection is the most distal part of the greater curve. It is important to have sufficient mobilization without compromising the origin of the gastroepiploic artery. One method of testing the adequacy of gastric mobilization is to determine whether the pylorus will retract, close to the hiatus. This will be easier to determine after division of the left gastric artery, which is undertaken with an endoscopic GIA stapler. After this has been performed, any remaining adhesions close to the distal stomach and pylorus will be easier to visualize and divide.

The gastric tube is then created by stapling the lesser curve in parallel to the greater curvature, using a moderate to thick tissue endoscopic GIA stapler. No additional sutures are placed over the gastric staple line, keeping this to a diameter of approximately 5 cm. After creation of the gastric tube, the top of the tube is tacked to the proximal stomach using a 0-0 Surgideck endostitch (Covidien, Norwalk, Conn). We no longer perform pyloroplasty and favor the use of Botox, which is injected into the pyloric muscle.¹⁰ At this point, we routinely place a jejunostomy tube. To assist in the identification of the ligament of Treitz, the patient is placed in the Trendelenburg position and the transverse colon retracted superiorly. After placement of the jejunostomy tube, the patient is placed back in the reverse Trendelenburg position. The final part of the abdominal dissection is to divide the phrenoesophageal membrane and complete any remaining dissection of the distal esophagus into the mediastinum. This is left as the last step, again to minimize loss of the pneumoperitoneum during the laparoscopic mobilization. The right and left crura are also partially divided to facilitate passage of the gastric tube into the mediastinum. At this point, a cervical incision is made and the esophagus identified using the previously placed Penrose drain. As upward traction is applied to the esophagus in the neck, the assistant guides the specimen in its proper alignment into the mediastinum from the abdomen. Care is taken to maintain orientation of the gastric tube. The esophagus and the top of the gastric tube is delivered through the mediastinum and into the neck. The vagus nerve is usually divided in the chest during the dissection. Care is taken to ensure that the nerve is divided below the thoracic inlet to minimize the risk of injury to the right recurrent laryngeal nerve.

For the patients who are undergoing a neck anastomosis, the following steps are undertaken to minimize injury to the recurrent nerve:

1. During the VATS portion of the procedure, the esophagus is mobilized for a short distance under direct vision into the neck. A Penrose drain is placed around the cervical esophagus and left in place.
2. When neck dissection is performed, we adhere to the following principals:
 - A. Avoid the use of self-retaining retractors deeper than the sternomastoid muscle.
 - B. Minimize the use of cautery during the deep part of the dissection, particularly around the esophagus.
 - C. Use the Penrose drain previously placed during the intrathoracic portion, because this significantly aids in identifying and dissecting the esophagus.

After removal of the specimen, an anastomosis between the gastric tube and cervical esophagus is created. This can be hand sewn or stapled; our preference is to use an EEA stapler, usually a 25-mm stapler. The cervical esophagus is dilated using a Foley catheter with a 30-mL balloon. The anvil is placed into the cervical esophagus and a purse-string placed to secure it, the stapler is inserted via a gastrotomy at the gastric tip for an end-to-side esophagogastric anastomosis (at the lesser curvature side). It is being performed while the gastrotomy site is closed with endo-GIA stapler or hand sewn.

Before closing the abdomen, we also place some tacking sutures between the crura and gastric tube to minimize the chance of herniation of abdominal contents alongside the pull-up occurring later.

DISCUSSION

The first report involving the use of 3-hole MIE was by Luketich and colleagues.¹¹ That initial series of 8 patients included 1 patient who underwent a completely minimally invasive 3-hole approach and 3 patients in whom a minithoracotomy was performed. Subsequently, the same group reported successive series involving progressively greater numbers of patients using primarily the 3-hole MIE technique.^{7,8} The latter series, involving 222 patients, documented a perioperative mortality of only 1.8% and a pneumonia rate of 7.7%, lower than reported by many open series of esophagectomy around that time. More recently, the Pittsburgh group has favored a minimally invasive Ivor Lewis approach with an intrathoracic anastomosis.¹² Their most recent experience was presented at the American Surgical Association in 2011 and involved 973 patients.¹³ Neck anastomosis was undertaken in 478 patients and intrathoracic anastomosis in 494. No difference was found in the hospital or intensive care unit lengths of stay or in the lymph node counts; however, a greater

incidence of recurrent nerve paresis was seen in the cervical anastomosis group. In our own experience, we believe that the minimally invasive Ivor Lewis procedure offers the following advantages: (1) it is a shorter procedure because the chest mobilization is easier after starting mediastinal dissection from the abdomen, and no neck incision is required; (2) the risk of anastomotic leak/vocal cord injury is decreased; and (3) less aggressive dissection of the stomach is required distally. However, the intrathoracic anastomosis is technically a more challenging procedure, and, if a leak occurs, this will likely prolong the patient's length of stay compared with a cervical leak, which can be more simply drained.

Although we favor the use of an intrathoracic anastomosis in many cases, we have continued to use the 3-hole approach for those patients with midesophageal cancer, patients with long-segment Barrett's esophagus extending to the midthoracic esophagus, and patients with long-segment benign disorders such as end-stage achalasia or complex benign strictures.

Other approaches to 3-hole MIE have been described. These include a prone approach to the chest mobilization.¹⁴ The series by Palanivelu and colleagues¹⁴ represents the largest experience with this technique and involved 130 patients. However, only 1 patient (0.77%) in that series received neoadjuvant therapy. The perioperative mortality was 1.54%, and the hospital stay was 8 days. The main advantage of the prone technique is that it allows better visualization of the esophagus as the lung falls away from the mediastinum, and, unlike with the decubitus position, blood does not tend to pool over the surgical field. However, we do not favor this approach because of the potential difficulty should emergency conversion to thoracotomy be required.

Another approach involves the use of robotics.¹⁵ This has been described elsewhere in this Supplement. Although there are certainly proponents of this approach, we do not favor it because of the longer setup times needed and our current comfort with nonrobotic minimally invasive esophagectomy. Additionally, for a multistep procedure requiring dissection in different body cavities, as well as different areas of those body cavities, we do not believe that the robot in its current form can facilitate all the steps of the operation. The robot is most helpful for procedures focused in a limited anatomic site, such as the mediastinum.^{16,17}

A significant advantage of minimally invasive esophagectomy and, in particular, a VATS approach compared with thoracotomy could be the lower incidence of pulmonary morbidity. A center from Europe recently reported a case-controlled series comparing open esophagectomy and MIE.¹⁸ The morbidity was significantly less in the MIE group at 25% versus 74% ($P = .014$). Specifically, the incidence of respiratory complications was lower in those patients who had undergone VATS rather than thoracotomy (9.7% vs 38.7%; $P = .008$). A group from

Australia also compared their experience with MIE and open esophagectomy.¹⁹ As with the European study, the use of MIE led to a lower incidence of respiratory complications, which has been shown in other studies to be a factor predictive of mortality.²⁰

A phase II multicenter study of MIE was also previously presented.²¹ The final end-point data from that study has not yet been reported. However, the pneumonia rates were low in that series at around 4%. This compares well to the pneumonia rate of 8.1% reported after esophagectomy from the Society of Thoracic Surgeons database.²²

CONCLUSIONS

Minimally invasive 3-hole esophagectomy can be undertaken by a number of approaches and has been adopted by several centers. The preliminary results are encouraging. Although a trend has been seen toward favoring an Ivor Lewis approach among surgeons using minimally invasive techniques, the 3-hole approach should continue to be a part of the surgeon's armamentarium.

References

1. Lee PC, Mirza FM, Port JL, Stiles BM, Paul S, Christos P, et al. Predictors of recurrence and disease-free survival in patients with completely resected esophageal carcinoma. *J Thorac Cardiovasc Surg.* 2011;141:1196-206.
2. McKeown KC. Total three-stage oesophagectomy for cancer of the oesophagus. *Br J Surg.* 1976;63:259-62.
3. DePaula AL, Hashiba K, Ferreira EAB, de Paula RA, Grecco E. Laparoscopic transhiatal esophagectomy with esophagogastroplasty. *Surg Laparosc Endosc.* 1995;5:1-5.
4. Swanson L, Hansen P. Laparoscopic total esophagectomy. *Arch Surg.* 1997;132:943-7.
5. Orringer MB, Sloan H. Esophagectomy without thoracotomy. *J Thorac Cardiovasc Surg.* 1978;76:643-54.
6. Law S, Fok M, Chu KM, Wong J. Thoracoscopic esophagectomy for esophageal cancer. *Surgery.* 1997;122:8-14.
7. Luketich JD, Schauer PR, Christie NA, Weigel TL, Raja S, Fernando HC. Minimally invasive esophagectomy. *Ann Thorac Surg.* 2000;70:906-11.
8. Luketich JD, Alvelo-Rivera M, Buenaventura PO, Christie NA, McCaughan JS, Little VR, et al. Minimally invasive esophagectomy outcomes in 222 patients. *Ann Surg.* 2003;238:486-95.
9. Luketich JD, Land SR, Sullivan EA, Alvelo-Rivera M, Ward J, Buenaventura PO, et al. Thoracic epidural versus intercostal nerve catheter plus patient-controlled analgesia: a randomized study. *Ann Thorac Surg.* 2005;79:1845-50.
10. Martin JT, Federico JA, McKelvey AA, Kent MS, Fabian T. Prevention of delayed gastric emptying after esophagectomy: a single center's experience with botulinum toxin. *Ann Thorac Surg.* 2009;87:1708-14.
11. Luketich JD, Nguyen NT, Weigel T, Ferson P, Keenan R, Schauer P. Minimally invasive approach to esophagectomy. *JSLS.* 1998;2:243-7.
12. Levy RM, Wizorek J, Shende M, Luketich JD. Laparoscopic and thoracoscopic esophagectomy. *Adv Surg.* 2010;44:101-16.
13. Awais O, Shende M, Christie NA, Weksler B, Landreneau RJ, Jobe BA, et al. Outcomes after minimally invasive esophagectomy from the University of Pittsburgh, Pittsburgh, PA. Presented at: American Surgical Association 131st Annual Meeting; April 14-16, 2011; Boca Raton, FL.
14. Palanivelu C, Rangarajan M, Senthikumar R, Velusamy M. Combined thoracoscopic and endoscopic management of mid-esophageal benign lesions: use of the prone patient position: thoracoscopic surgery for mid-esophageal benign tumors and diverticula. *Surg Endosc.* 2008;22:250-4.
15. Kernstine KH. The first series of completely robotic esophagectomies with three-field lymphadenectomy: initial experience. *Surg Endosc.* 2008;22:2102.
16. Ruckert JC, Swierzy M, Ismail M. Comparison of robotic and non-robotic thymectomy: a cohort study. *J Thorac Cardiovasc Surg.* 2011;141:673-7.

17. Fernando HC, Erdem CC, Daly B, Shemin RJ. Robotic assisted thoracic surgery for resection of an esophageal cyst. *Dis Esophagus*. 2006;19:509-11.
18. Schoppmann SF, Prager G, Langer FB, Riegler FM, Kabon B, Fleischmann E, et al. Open versus minimally invasive esophagectomy: a single-center case controlled study. *Surg Endosc*. 2010;24:3044-53.
19. Zingg U, McQuinn A, DiValentino D, Esterman AJ, Bessell JR, Thompson SK, et al. Minimally invasive versus open esophagectomy for patients with esophageal cancer. *Ann Thorac Surg*. 2009;87:911-9.
20. Zingg U, McQuinn A, DiValentino D, Esterman AJ, Bessell JR, Thompson SK, et al. Analysis of respiratory complications after minimally invasive esophagectomy: preliminary observation of persistent aspiration risk. *Dysphagia*. 2007;22:49-54.
21. Luketich JD, Pennathur A, Catalano P, et al. Minimally invasive esophagectomy: results of a multicenter Eastern Cooperative Group Study (ECOG E2202). Presented at the American Society of Clinical Oncology 131st Annual Meeting, April 2009. *J Clin Oncol*. 2009;27:15s.
22. Wright CD, Kucharczuk JC, O'Brien SM, Grab JD, Allen MS. Predictors of major morbidity and mortality after esophagectomy for esophageal cancer: A Society of Thoracic Surgeons general thoracic surgery database risk adjustment model. *J Thorac Cardiovasc Surg*. 2009;137:587-96.