Minimally Invasive Surgery for Esophageal Cancer

Alfredo A. Santillan, MD, MPH, Jeffrey M. Farma, MD, Kenneth L. Meredith, MD, Nilay R. Shah, MD, and Scott T. Kelley, MD, Tampa and Lakeland, Florida

Key Words
Esophagectomy, laparoscopy, thoracoscopy, esophageal neoplasms

Abstract
Esophageal cancer represents a major public health problem worldwide. Several minimally invasive esophagectomy (MIE) techniques have been described and represent a safe alternative for the surgical management of esophageal cancer in selected centers with high volume and expertise in them. This article reviews the most recent and largest series evaluating MIE techniques. Recent large series have shown MIE to be equivalent in postoperative morbidity and mortality rates to conventional surgery. MIE has been associated with less blood loss, less postoperative pain, and decreased intensive care unit and hospital length of stay compared with conventional surgery. Despite limited data, conventional surgery and MIE have shown no significant difference in survival, stage for stage. The myriad of MIE techniques complicates the debate of defining the optimal surgical approach for treating esophageal cancer. Randomized controlled trials comparing MIE with conventional open esophagectomy are needed to clarify the ideal procedure with the lowest postoperative morbidity, best quality of life after surgery, and long-term survival. (JNCCN 2008;6:879-884)

Esophageal cancer represents a major public health problem worldwide. It is the eighth most common cancer in the world, with an estimated 462,102 new cases and 385,877 deaths per year. Survival is poor, with a high mortality-to-incidence ratio of 0.83. According to SEER (Surveillance Epidemiology and End Results) data, 5-year survival has improved modestly over the past 30 years, from 6% in 1975 to 1977, to 17% in 1996 to 2002.

Surgery is the gold standard for treating localized esophageal cancer. Poor long-term outcome and predominance of distant failure prompted the evaluation of the role of chemoradiotherapy. No major difference was seen in survival between patients who undergo chemoradiotherapy followed by surgery versus those who had surgery alone. Furthermore, the mortality rate after esophagectomy ranges from 5% to 23%, depending on hospital volume and surgeon experience. Advances in surgical technology, staging, and perioperative care could further reduce surgical morbidity and mortality. Of these advances, minimally invasive esophagectomy (MIE) has the greatest potential to improve on conventional esophageal surgery.

Minimally invasive procedures involving laparoscopic or thoracoscopic surgery are the mainstay surgical approach for various benign esophageal disorders and are associated with functional results equal to open procedures. These techniques offer the potential advantages of enhanced recovery, reduction in pain, and quicker return to normal function, although larger studies are needed to provide definitive evidence of these benefits. Minimally invasive surgery has been explored and found to be feasible in managing esophageal cancer, although concern was expressed about safety, efficacy, oncologic value, or other advantages that justify longer operations. This article discusses MIE indications, techniques, and outcomes in the management of esophageal cancer.

Indications for Minimally Invasive Surgery in Esophageal Cancer

Staging
Patient selection represents the most important factor in MIE. At the authors’ institution, all patients with...
esophageal carcinoma undergo staging with endoscopic ultrasound (EUS), CT of the thorax and abdomen, and whole-body PET/CT. Thoracoscopic or laparoscopic staging is performed in selected patients who are found to have advanced locoregional disease on imaging studies. The efficacy of laparoscopy in staging is more relevant for adenocarcinomas of the lower esophagus than more proximal tumors. Laparoscopy has been reported to be more sensitive and accurate in detecting lymph node, peritoneal, and liver metastases. It is safe, with low morbidity and no mortality, and avoids unnecessary operative procedures. However, some studies have reported small yield. Therefore, minimally invasive techniques for staging purposes are used mainly at planned MIE.

**Techniques**

Several surgical techniques are available, and the choice depends on tumor location, extent of lymphadenectomy, and surgeon preference. The 2 most frequent open techniques are transthoracic and transthoracic (Ivor-Lewis) esophagectomies (THEs and TTEs, respectively). THE involves a laparotomy, blunt dissection of the thoracic esophagus, and cervical gastroesophageal anastomosis in the left neck. Limitations include inability to perform a full thoracic lymphadenectomy and lack of visualization of the mid-thoracic esophageal dissection. In contrast, TTE combines a laparotomy with right thoracotomy and intrathoracic anastomosis. This approach allows for wide mediastinal lymphadenectomy with direct visualization. Other modifications of the transthoracic approach include a left thoracoabdominal incision, extended 3-field esophagectomy, and cervical anastomosis.

Which esophagectomy technique results in less morbidity and increased survival is controversial. A recent randomized trial involving 220 patients assigned to THE or TTE with extended en-bloc lymphadenectomy concluded that perioperative morbidity was higher after TTE but found no significant difference in in-hospital mortality. THE was associated with a shorter operative time, decreased blood loss, fewer pulmonary complications, shorter duration of mechanical ventilation, and shorter stay in the ICU and hospital. However, after a median follow-up of almost 5 years, no significant difference was seen in survival between the THE versus TTE groups (29% vs. 39%). Furthermore, a recent cohort study showed no difference in outcome after THE and TTE, although higher-volume centers had lower mortality and morbidity. Because no clear consensus has established the ideal esophagectomy, MIE has been explored in both transthoracic and transthoracic approaches with the goal of overcoming intrinsic limitations. Multiple minimally invasive approaches have been described that combine thoracoscopic or laparoscopic procedures with various operative positions of the patient and anastomotic techniques (Table 1).

MIEs for the management of esophageal cancer were first described by Cuschieri et al. in 1992, and later refined by Collard et al. in 1993. These first efforts involved thoracoscopic esophageal mobilization with subsequent laparotomy for gastric mobilization and a cervical anastomosis. This approach avoids the morbidity of a thoracotomy and permits complete and
Minimally Invasive Surgery for Esophageal Cancer

Table 1  Minimally Invasive Esophagectomy Techniques

<table>
<thead>
<tr>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracoscopic esophagectomy with laparotomy and cervical anastomosis</td>
</tr>
<tr>
<td>Thoracoscopic esophagectomy with laparotomy and intrathoracic anastomosis</td>
</tr>
<tr>
<td>Thoracoscopic esophagectomy with laparoscopy and cervical anastomosis</td>
</tr>
<tr>
<td>Thoracoscopic esophagectomy with laparoscopy and intrathoracic anastomosis</td>
</tr>
<tr>
<td>Laparoscopic gastric mobilization with thoracotomy and intrathoracic anastomosis</td>
</tr>
<tr>
<td>Laparoscopic THE with cervical anastomosis</td>
</tr>
<tr>
<td>Laparoscopic hand-assisted THE with cervical anastomosis</td>
</tr>
<tr>
<td>Laparoscopic esophagectomy with prone thoracoscopic esophageal mobilization</td>
</tr>
<tr>
<td>Robotic-assisted laparoscopic THE with cervical anastomosis</td>
</tr>
</tbody>
</table>

Abbreviation: THE, transhiatal esophagectomy.

A minimally invasive THE was initially described by DePaula et al. in 1995 and then Swanstrom and Hansen in 1997 as the first totally laparoscopic esophagectomy. This procedure has been used by other groups and has undergone several modifications. The main advantage is direct visualization of the lower mediastinum without blind dissection. Using this technique, a laparotomy is avoided.

A laparoscopic-assisted hand-port system is the most common technique performed at the authors' institution for tumors of distal esophagus (Kelley technique). Diagnostic laparoscopy is used to stage patients, and a 5-cm subcostal incision is made in the right upper quadrant for the hand-port system. Gastric mobilization is performed laparoscopically and mediastinal dissection is extended to the tracheal bifurcation through the diaphragmatic hiatus. A cervical incision is performed, and the cervical esophagus is mobilized. Once the esophagus and stomach are mobilized, the cervical esophagus is divided and thoracic esophagus and stomach are exteriorized through the hand-port incision. The specimen is transected and the gastric conduit created. The gastric conduit is pulled through the posterior mediastinum to the neck and a stapled gastroesophageal anastomosis is performed.

Other modifications to MIE involve the use of mediastinoscopic methods to aid superior mediastinal dissection. This has been explored in both conventional transhiatal and laparoscopic esophagectomy. A mediastinoscope is used to dissect the upper mediastinum. The efficacy of this approach is limited by the extent of lymph node dissection possible. Other techniques to aid mediastinal dissection involve placement of laparoscopic trocars into the neck to facilitate esophageal mobilization of the upper mediastinum.

Some limitations of the laparoscopic THE involve the instrumentation, narrow field of the mediastinum, and 2-dimensional view of conventional laparoscopic equipment. Robotic systems allow the possibility of overcoming some of these limitations. Some groups have reported their early experience with robotically assisted THE, which involves laparoscopic gastric mobilization, mediastinal robotic dissection, and conventional transhiatal dissection from the cervical incision. This technique allows 3-dimensional visualization, improved magnification, and greater range of instrument motion, and could potentially diminish intraoperative complications during esophageal dissection in the mediastinum.
Outcomes
Major intraoperative complications, including bleeding, tracheobronchial injury, and recurrent laryngeal nerve injury, have been reported with MIE. Conversion to open surgery is required in approximately 10% of patients. As surgical techniques improve, incidence of intraoperative complications could potentially decrease. MIE is a technically advanced surgical procedure with a prolonged learning curve. Technical complications are known to be operator-, technique-, and instrument-dependent. Reports have shown that a minimum of 17 cases were necessary to acquire MIE skills, and more than 35 cases to see outcomes difference. Most major complications in MIE were described in initial experience series; therefore, the full potential may not have been realized. Finally, with the multitude of MIE techniques, the ability to compare results with those of conventional esophagectomy is difficult (Table 2).

In theory, obviating the need of a thoracotomy or laparotomy could reduce postoperative pain, wound infections, ventilator dependence, cardiopulmonary complications, ICU and hospital stays, and mortality rates. However, a clear advantage with MIE over conventional esophagectomy has not been shown. Reasons for a lack in difference in postoperative outcomes could result from inadequate power to detect differences in small series and historic control comparisons. Lack of well-designed trials, publication bias of satisfactory outcomes, and the myriad of MIE techniques complicate this debate.

Smithers et al. reported outcomes after esophagectomy, comparing 114 patients who underwent open procedures with 309 treated with a thoracoscopic-assisted approach and 23 with a total thoracoscopic/laparoscopic approach. Operative time was not significantly different for open and thoracoscopic-assisted groups, but the total laparoscopic approach took significantly longer than the other 2 procedures. Total laparoscopic and thoracoscopic-assisted procedures were associated with a significant decrease in blood loss and transfusions. Total laparoscopic and thoracoscopic-assisted procedures were associated with shorter ICU and hospital stays. Nonetheless, overall complication rates were not different. Incidence of respiratory infections was not different nor was the need to return to the ICU. The mortality rate was 2.6% for the open group, 2.2% for the thoracoscopic-assisted group, and 0% in the total laparoscopic group.

The authors recently reported their MIE experience with the use of a hand-assist port, finding no difference in the median operative time between the MIE group and the open group (234 vs. 300 minutes; P = .059). However, a trend was seen toward longer operative times in the MIE cohort. Additionally, they found no differences in blood loss (202 vs. 285 mL; P = .45) or length of hospitalization (10.5 vs. 10 days; P = .67) between the MIE and open groups, respectively. This

<table>
<thead>
<tr>
<th>Study</th>
<th>Surgical Technique</th>
<th>Patients (N)</th>
<th>Median Blood Loss (mL)</th>
<th>Mean Operative Time (min)</th>
<th>Mean Hospitalization (d)</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
<th>5-year Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smithers et al.</td>
<td>Open</td>
<td>114</td>
<td>600</td>
<td>300</td>
<td>14</td>
<td>67</td>
<td>2.6</td>
<td>30*</td>
</tr>
<tr>
<td></td>
<td>Thoracoscopic</td>
<td>309</td>
<td>400</td>
<td>285</td>
<td>13</td>
<td>62</td>
<td>2.2</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>MIE</td>
<td>23</td>
<td>300</td>
<td>330</td>
<td>11</td>
<td>61</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Yamamoto et al.</td>
<td>Thoracoscopic</td>
<td>112</td>
<td>134</td>
<td>112</td>
<td>19</td>
<td>26</td>
<td>—</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>MIE</td>
<td>222</td>
<td>—</td>
<td>—</td>
<td>7</td>
<td>32</td>
<td>1.4</td>
<td>36</td>
</tr>
<tr>
<td>Luketich et al.</td>
<td>MIE</td>
<td>46</td>
<td>279</td>
<td>350</td>
<td>8</td>
<td>17</td>
<td>4.3</td>
<td>57*</td>
</tr>
<tr>
<td>Nguyen et al.</td>
<td>MIE</td>
<td>28</td>
<td>274</td>
<td>220</td>
<td>—</td>
<td>35</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Osugi et al.</td>
<td>Thoracoscopic</td>
<td>80</td>
<td>202</td>
<td>300</td>
<td>10</td>
<td>35</td>
<td>2.7</td>
<td>—</td>
</tr>
<tr>
<td>Meredith et al.</td>
<td>Hand-assisted THE</td>
<td>130</td>
<td>220</td>
<td></td>
<td>20.76</td>
<td>1.54</td>
<td>47*</td>
<td></td>
</tr>
<tr>
<td>Palanivelu et al.</td>
<td>Thoracolaparoscopic prone position</td>
<td>130</td>
<td>220</td>
<td></td>
<td>20.76</td>
<td>1.54</td>
<td>47*</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: MIE, combined thoracoscopic and laparoscopic esophagectomy; THE, transhiatal esophagectomy.
*3-year overall survival.
study supports the concept that MIE is safe and comparable to open surgery, and provides evidence that the main source of morbidity is the surgical trauma of the mediastinal dissection, which is independent of the incision size and type.13

One of the most controversial issues is whether disease-free and overall survival are comparable in MIE and conventional surgery. MIE in esophageal cancer has been questioned because the extent of lymphadenectomy could be compromised. Nevertheless, the largest randomized trial comparing approaches showed no significant difference in survival between TME and TTE with extended en-bloc lymphadenectomy.5

With multiple MIE techniques, the quality of lymph node dissection is difficult to evaluate, and many series fail to report on lymph node dissection. The only prospective study that compared this outcome between open and MIE showed no significant difference in number and location of lymph nodes harvested.14 The authors found no differences in number of nodes in patients undergoing MIE and those treated with the open technique.

Other concerns include the adequacy of R0 resection, inadequate staging, local recurrence caused by inadequate margins, port-site recurrence, and tumor dissemination during MIE. Despite these concerns, comparable long-term survival has been reported in most series when results are compared with historic controls or open surgery.15,16 Smithers et al.17 recently reported no difference in 3-year survival when open, thoracoscopic-assisted, and total thoracoscopic/laparoscopic approaches were compared stage-for-stage. Clearly, with refinements of MIE and the increasing experience of surgeons, surgical oncologic principles such as adequate free margin resections and lymphadenectomy are feasible. In addition, at a mean follow-up of 19 months, patients who underwent MIE have been shown to have quality-of-life scores comparable to preoperative values.18

Conclusions

Several MIE techniques have been described and represent a safe alternative for the surgical management of esophageal cancer in centers with high volume and expertise in these procedures. In larger series, MIE has been shown to be equivalent to conventional surgery in postoperative morbidity and mortality rates. MIE has been associated with reduced blood loss, postoperative pain, and ICU and hospital stays compared with conventional surgery. Despite limited data, no significant difference in survival has been observed between conventional surgery and MIE. The myriad of MIE techniques complicates the debate of defining the optimal approach to treatment of esophageal cancer. Randomized controlled trials comparing MIE with open esophagectomy are needed to clarify the ideal procedure with the lowest postoperative morbidity, best quality of life, and greatest long-term survival.

References


© Journal of the National Comprehensive Cancer Network | Volume 6 Number 9 | October 2008


