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REVIEW ARTICLE

# Minimally Invasive Esophagectomy (MIE): Techniques and Outcomes

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**ABSTRACT**

*Background:* Esophageal cancer is one of the major public health problems worldwide. Different methods of minimally invasive esophagectomy (MIE) have been described, and they represent a safe alternative for the surgical management of esophageal cancer in selected centres with high volume and expertise in them. The procedural goal is to decrease the high overall morbidity of a traditional open esophageal resection.

*Aims:* This article reviews the most recent and largest series evaluation of MIE techniques.

*Methods:* A literature search performed using search engines Google, HighWire press, SpringerLink, and Yahoo. Selected papers are screened for other related reports.

*Results:* Though MIE requires greater expertise and a long learning curve, once technique has been mastered it greatly reduces the postoperative morbidity and mortality to a significant extent. There was not much difference in average operating time compared to open surgery but bleeding was less in MIE. Mean hospital stay was similar to open surgery. There was no significant difference in number and location of lymph nodes harvested.

*Conclusion:* The current review shows that MIE with its decreased blood loss, minimal cardiopulmonary complications and decreased morbidity and oncological adequacy, represents a safe and effective alternative for the treatment of esophageal carcinoma.

**Keywords:** Esophagectomy, Minimally invasive, Laparoscopy, Thoracoscopy, Esophageal neoplasm.

## INTRODUCTION

Esophageal cancer represents a major public health problem worldwide. It is the eighth most common cancer in the world and sixth most frequent cause of death with an estimated 462,102 new cases and 385,877 deaths per year.[1] 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.[2]

Since Czerny first successfully resected a cancer of the cervical esophagus in 1877, esophagectomy has had a long history of high morbidity and mortality followed by a relatively poor long-term survival. Published perioperative mortality rates are available since 1940s, and the initial reported rate was 72%.[8] By the 1970s, a review of all published data showed a reduction in the rate to 29%.[8] In 1980s, it was 13%, and in 1990, it declined to 9%.[8] 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 underwent chemoradiotherapy followed by surgery versus those who had surgery alone.[3,4] 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 surgery has been done and found to be possible in managing esophageal cancer, although apprehension was expressed about safety, efficacy, oncologic value or other advantages that justify longer operations. This article discusses outcomes in the management of esophageal cancer.

The use of thoracoscopy and/or laparoscopy for esophageal resection was introduced in 1992 by Cushieri et al hoping that it would further reduce pulmonary morbidity while potentially improving the oncological quality of the resection by enhancing visual control during the mediastinal dissection.[5] Laparoscopic transhiatal esophagectomy was first reported by De Paula et al[6] in 1995 and by Swanstrom and Hansen[7] in 1997. Luketich et al[9,10] described the combined thoracoscopic and laparoscopic approach for esophagectomy.

## AIMS

This article aims at discussing various techniques and outcomes of minimally invasive esophagectomy.

The following parameters were evaluated for laparoscopic and open procedure:

1. Operating technique
2. Operating time
3. Intraoperative complications
4. Risk of anesthesia
5. Rate of conversion to open surgery

6. Postoperative pain and opiate analgesic requirements
7. Postoperative morbidity and mortality
8. Hospital stay
9. Satisfying oncologlcal principle
10. Quality of life analysis.

## MATERIALS AND METHODS

A literature search was performed using search engines Google, HighWire Press, SpringerLink, and library facility available at laparoscopic hospital. Criteria for the selection of papers were upon statistical way of analysis, institute if specialized in laparoscopy, the way of management and operative techniques.

## OPERATING TECHNIQUE

Different surgical techniques are available, and the option depends on tumor location, extent of lymphadenectomy and surgeons' preference. The two most common open techniques are transhiatal and transthoracic (Ivor-Lewis) esophagectomies (THEs and TTEs respectively).[11] THE involves a laparotomy, blunt dissection of the thoracic esophagus, and cervical gastroesophageal anastomosis in the left neck.[12] 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.[13]

MIE has been explored in both transthoracic and transhiatal 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[5] in 1992, and later refined by Collard et al[14] in 1993. These first efforts involved thoracoscopic esophageal mobilization with subsequent laparotomy for gastric mobilization and cervical anastomosis. This approach avoids the morbidity of a thoracotomy, and permits complete and thorough mediastinal dissection. Several groups have reported their experience with excellent results using this technique which currently represents the most popular MIE technique. Refinements in the thoracoscopic technique have been pioneered by Luketich et al[9,10] describing a thoracolaparoscopic esophagectomy. This technique involves video-assisted thoracoscopic esophageal mobilization in complete left lateral decubitus position followed by supine laparoscopic gastric mobilization and preparation of the gastric conduit with a standard cervical anastomosis. This offers the potential benefit of avoiding the need for both thoracotomy and laparotomy, minimizing pain in the postoperative period, and allowing a more rapid recovery.

**Table 1:** Minimally invasive esophagectomy techniques

- Thoracoscopic esophagectomy with laparotomy and cervical anastomosis
- Thoracoscopic esophagectomy with laparotomy and intrathoracic anastomosis
- Thoracoscopic esophagectomy with laparoscopy and cervical anastomosis
- Thoracoscopic esophagectomy with laparoscopy and intrathoracic anastomosis
- Laparoscopic gastric mobilization with thoracotomy and intrathoracic anastomosis
- Laparoscopic THE with cervical anastomosis
- Laparoscopic hand-assisted THE with cervical anastomosis
- Laparoscopic esophagectomy with prone thoracoscopic esophageal mobilization
- Robotically-assisted laparoscopic THE with cervical anastomosis.

To facilitate the abdominal procedure, some groups use a laparoscopic-assisted hand-port system, providing more tactile control and potentially decreasing operative time.[15] Furthermore, a hand-assisted system could be used in the thoracoscopic phase of the procedure to facilitate exposure into the right thoracic cavity (hand-assisted laparoscopic and thoracoscopic surgery).[16] Other modifications to this technique include thoracoscopic mobilization of the esophagus and mediastinal lymphadenectomy in the prone position.[17] The main advantages described for prone thoracoscopic mobilization of the esophagus are shorter anesthesia time and better postoperative respiratory function than with the left lateral position.

A minimally invasive THE was initially described by DePaula et al[6] in 1995 and then Swanstrom and Hansen[7] in 1997 as the first totally laparoscopic esophagectomy. The main advantage is direct visualization of lower mediastinum without blind dissection. Using this technique, a laparotomy is avoided. Other modifications to MIE involve the use of mediastinoscopic methods to aid superior mediastinal dissection.[18]

Some limitations of the laparoscopic THE involve the instrumentation, narrow field of the mediastinum, and two-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,[20-22] which involves laparoscopic gastric mobilization, mediastinal robotic dissection, and conventional transhiatal dissection from the cervical incision. This technique allows three-dimensional visualization, improved magnification, and greater range of instrument motion and could potentially diminish intraoperative complications during esophageal dissection in the mediastinum.

## STEPS OF THREE-STAGE ESOPHAGECTOMY

### Stage 1: Thoracoscopic Esophageal Mobilization

General anesthesia with single lung ventilation is used. The patient is placed in the left lateral decubitus position. Four ports are placed in diamond formation (Fig. 1).

Pneumoinsufflation is performed under a low pressure of 7 mm Hg. A diagnostic thoracoscopy is usually performed to inspect the pleural cavity and the surface of lung for any suspicious metastatic lesion. The right lung is retracted upward and medially to expose the thoracic esophagus.

The procedure is begun by incising the visceral pleura between the esophagus and infra-azygos part of the aorta with either a bipolar forceps or a harmonic ultrasonic scalpel. The medial end of the pleura is held by the left hand lifting the esophagus. Thus, the posterior vagus is exposed. The plane of dissection is lateral to the vagus and not between the vagus and esophagus. The direct aortic branches are clipped and cut. The esophagus then is lifted from the arch of the aorta, which is seen at the level immediately below the azygos vein. The left main bronchus is exposed, and the left hilar nodes are dissected. The esophagus is completely separated posteriorly by a combination of sharp and blunt dissection. The caudal limit of posterior dissection is the hiatus.

The thoracic duct is seen crossing the descending aorta, which is clipped. The anterior pleural cut was made after the esophagus is pulled laterally and the cut is extended cranially and caudally, remaining parallel to the esophagus. The plane of dissection is between the anterior vagus and pericardium. The carinal and right hilar nodes are removed. The dissection is carried caudally between the pericardium and esophagus, stripping the pericardium of all fibro fatty tissues and nodes. The caudal end point is the hiatus and this completes the infra-azygous dissection.

The supra-azygous area is exposed by the assistant pulling down the apex of the lung. The pleura over the esophagus is lifted and cut. The cut is extended upward to the root of the neck. The vagus nerve is identified, and the vagal fibers going to the bronchus are preserved.

The dissection is started posteriorly between the esophagus and vertebrae. All the fibro fatty tissues together with the nodes are pushed with esophagus. The azygous vein is preserved or when required for better visualization or clearance, the vein can be clipped and cut. When the azygous vein is preserved, the pleura over the vein is cut, and a plane is created posterior to the vein and anterior to the esophagus. Retroazygous dissection is facilitated by retraction of the azygous vein. The esophagus is dissected all around the circumference in the supra-azygous region, and these planes are joined with those in the infra-azygous region, thus completely freeing the esophagus. This is confirmed by pulling the esophagus craniocaudally (shoeshine effect).The left recurrent nerve is identified in the tracheoesophageal groove. The nodes along this nerve are removed.

The esophageal dissection is carried cranially upto the root of the neck. An intercostal drainage tube is inserted through the working 10 mm port. The lung is inflated, and the camera port was removed under vision.

### Stage 2: Laparoscopic Gastric Mobilization

The patient is placed in a modified Lloyd-Davis 15 to 20 degrees head-up position. The surgeon stands between the legs of the patient, with the cameraman and one assistant on left, and with the second assistant and scrub nurse on the right. Five ports are used (Fig. 2).

Stomach mobilization is begun by opening the gastrocolic ligament and entering the lesser sac. The greater omentum is divided. The stomach is lifted from the pancreas by cutting the congenital bands. The fundus and entire stomach is pushed to the right side by the assistant rolling the fundus toward the right, and the gastrosplenic ligament is cut while the short gastric vessels are coagulated and cut. The hepatic flexure and transverse colon reflection are cut, and the colon

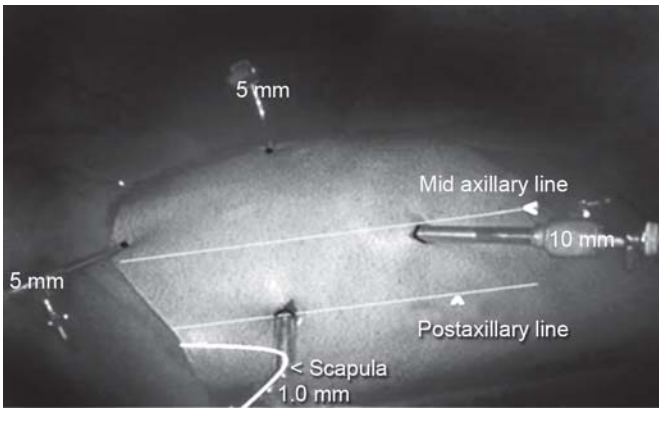


**Fig. 1:** Port position

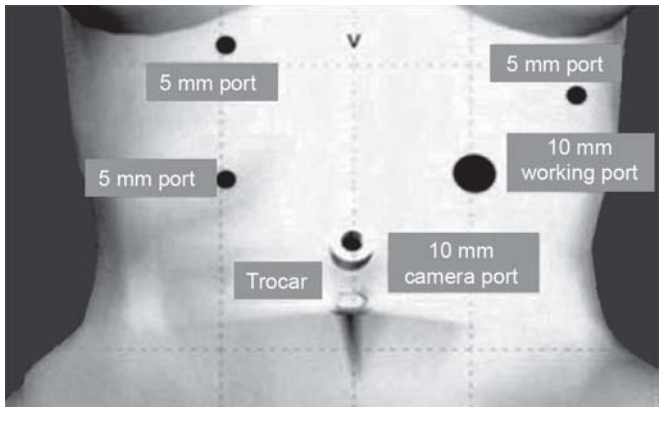


**Fig. 2:** Alternative port position

is retracted caudally. This exposes the second part of duodenum, which is kocherized.

The left lobe of liver is retracted by the left assistant, and the gastrohepatic ligament is cut. The cut is extended upward to the lower end of the hiatus. The right crus of the diaphragm is identified, and the peritoneum over it is cut. This cut is extended up to the hiatus. The dissection is continued posteriorly until the left crus is identified. The esophagus is dissected all around at the level of hiatus.

All the nodes along the celiac trunk together with the common hepatic, splenic, and left gastric artery are removed. The left gastric artery and vein are clipped and cut. The hiatal opening is then widened.

### Stage 3: Cervicotomy and Esophagogastric Anastomosis

The patient is placed in the head-up position with the neck extended and turned toward the right. A left supraclavicular transverse incision is made. The two heads of the sternocleidomastoid are separated, exposing the carotid sheath together with internal jugular vein and common carotid artery. The inferior thyroid vein is ligated, and the vessels are retracted laterally to reach the prevertebral fascia. The esophagus is lifted from its posterior bed, and the dissection is continued posteriorly until the right lateral wall is reached. The esophagus is separated from the trachea and completely encircled.

Mobilization is confirmed by pulling the esophagus into the neck. The esophagus is divided by placing two stay sutures. The distal end is tied, and a nasogastric tube is tied to the distal end. The entire esophagus together with the nasogastric tube is pulled through the hiatus laparoscopically. A small abdominal incision is made at the level of camera port. The stomach and esophagus are delivered using a skin barrier. An extracorporeal stomach tube is prepared and pulled back through the posterior mediastinum into the neck, and an esophagogastric anastomosis is done in two layers. A feeding jejunostomy is established in all cases.

*Transhiatal esophagectomy:* The esophagus is mobilized *en bloc* together with the lymph nodes of lower mediastinum through the hiatus after transection of the diaphragm vein. During the transhiatal dissection, the right and left pleura must be visible, as well as the aorta dorsally, and the vena cava and pulmonary trunk ventrally. The dissection then is continued upto the aortic arch.

*Robotically-assisted laparoscopic esophagectomy:* Robotic technology provides more accuracy, a wider range of motion through articulated robotic wrists, finer tissue manipulation capability, and three-dimensional visualization.[20-22]

## OUTCOME

- Median operative time was 230 minutes (range of medians 180-400 minutes).[9,10,14-42]
- Conversion rate to open procedures was on an average 5.6% (0-36%).[9,10,14-42]
- Median ICU stay was 1.5 days (range 0.5-6).[9,10,14-42]
- Median hospital stay was 11.4 days (5.5-31).[9,10,14-42]
- Median blood loss was 190 ml.[9,10,14-42]
- Postoperative mortality was 2%.[9,10,14-42]
- The over-all complication rate was 41%.[9,10,14-42]
- Pulmonary complication rate was 20%.[9,10,14-42]
- Anastomotic leaks were reported in 8.7% (0-25%).[9,10,14-42]
- Vocal cord paralysis occurred in 1.5%.[9,10,14-42]
- Reoperations were reported in 6%, chylothorax 2%, 0.8% tracheobronchial tears or necrosis.[9,10,14-42]
- Incidences of splenectomies 0.3% and other visceral injuries (pancreas, colon) were low.[9,10,14-42]
- Oncological outcome of MIE: Median lymph nodes retrieval of all series was 14 nodes. Lower yields were reported after transhiatal than after transthoracic MIE.[9,10,14-42]
- Among the survival rate report studies, 1-year survival rate was of a median of 75%. Reported 3-year survival was 41%.[9,10,14-42]

Operative times, blood loss, transfusion requirements, ICU and hospital stays were shorter after MIE but without any difference in fistula rates. Smithers et al reported the largest available series of MIE, comparing 309 thoracoscopic-assisted esophagectomies with 23 totally MIE (laparoscopic and thoracoscopic) and 114 open esophagectomies during the same time period.[42] Their thoracoscopic resections were found to have marginal benefits over open resections, such as reduced blood loss (400 ml *vs* 600 ml), transfusion rates (27% *vs* 37%) and one day shorter hospital stay (13 days *vs* 14 days). The morbidity profile was similar for all three approaches except for a much higher stricture rate of anastomosis after MIE (22% *vs* 6%). Using a policy of standard mediastinal LND (including periesophageal and subcarinal but not upper mediastinal nodes), Smithers et al[42] retrieved a median of 17 lymph nodes. Others have shown that even more extended lymph node dissections can be performed by MIE and lead to excellent 5-year survival rates above 50%.

Pulmonary complications are the most frequent source of complications and mortality after an esophagectomy. Their reduction seems to be one of the aims of any MIE technique. The main pulmonary complications seen were pneumonia, pleural effusion, atelectasis, pulmonary embolism and assisted ventilation. All were much less in MIE. Other than respiratory complications, the classical complications of esophagectomy, such as anastomotic leaks and vocal cord palsy is more in MIE but not significantly high. Risk of tracheobronchial injuries thus seems to be increased compared to open resections.[9,10,14-42]

In MIE, postoperative ventilation time, blood loss, transfusion rates, length of ICU and hospital stays are less. Learning curve is high in MIE. Results of various studies show that as the number of cases done are increasing, the complications are decreasing.[9,10,14-42] Regarding the survival rate, it has been shown that earlier the stage better the survival. The 5-year survival reported by various studies were for stage I—83%, stage II—42% and stage III—16%.

## CONCLUSION

MIE has been gaining attractiveness since the first report nearly two decades ago. Like open surgery, several techniques exist including totally laparoscopic transhiatal or transthoracic resections as well as combination, or hybrid techniques. Much as with open esophageal surgery, no consensus has been reached regarding the superiority of any particular MIE adaptation. By reducing perioperative morbidity and recovery time, and by maintaining the oncological principles, MIE is a safe alternative for open procedures under experienced hands. Initial outcomes of the minimally invasive approach appear to be atleast equivalent, and the promise of potential benefits a tangible possibility.

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