World Journal of Gastroenterology

Online Submissions: http://www.wjgnet.com/1007-9327office
wjg@wjgnet.com
doi:10.3748/wjg.v16.i30.3811

World J Gastroenterol 2010 August 14; 16(30): 3811-3815
ISSN 1007-9327 (print)

TOPIC HIGHLIGHT

Marco G Patti, MD, Professor, Director, *Series Editor*

Minimally invasive esophagectomy

Fernando A Herbella, Marco G Patti

Fernando A Herbella, Marco G Patti, Department of Surgery, University of Chicago Pritzker School of Medicine, Chicago, IL 60637, United States
Author contributions: Herbella FA wrote the manuscript; Patti MG revised the manuscript.
Correspondence to: Marco G Patti, MD, Professor, Director, Department of Surgery, University of Chicago Pritzker School of Medicine, 5841 S. Maryland Ave, MC 5095, Room G-201, Chicago, IL 60637, United States. mpatti@surgery.bsd.uchicago.edu
Telephone: +1-773-7024763 Fax: +1-773-7026120
Received: April 24, 2010 Revised: June 7, 2010
Accepted: June 14, 2010
Published online: August 14, 2010

Abstract

Esophageal resection is associated with a high morbidity and mortality rate. Minimally invasive esophagectomy (MIE) might theoretically decrease this rate. We reviewed the current literature on MIE, with a focus on the available techniques, outcomes and comparison with open surgery. This review shows that the available literature on MIE is still crowded with heterogeneous studies with different techniques. There are no controlled and randomized trials, and the few retrospective comparative cohort studies are limited by small numbers of patients and biased by historical controls of open surgery. Based on the available literature, there is no evidence that MIE brings clear benefits compared to conventional esophagectomy. Increasing experience and the report of larger series might change this scenario.

Key words: Esophageal resection; Transhiatal esophagectomy; Transthoracic esophagectomy; Esophageal cancer; Minimally invasive esophagectomy; Laparoscopy; Thoracoscopy

Peer reviewer: Piero Marco Fisichella, MD, Assistant Professor of Surgery, Medical Director, Swallowing Center, Loyola University Medical Center, Department of Surgery, Stritch School of Medicine, 2160 South First Avenue, Room 3226, Maywood, IL 60153, United States

Herbella FA, Patti MG. Minimally invasive esophagectomy. *World J Gastroenterol* 2010; 16(30): 3811-3815 Available from: URL: http://www.wjgnet.com/1007-9327/full/v16/i30/3811.htm DOI: http://dx.doi.org/10.3748/wjg.v16.i30.3811

INTRODUCTION

Esophageal cancer is a devastating disease. It was estimated in 2002 that 462 117 individuals developed the disease and 385 892 died worldwide[1], which corresponds to a mortality rate of 83.5%. Surgery has been considered an essential part of the treatment of patients with esophageal adenocarcinoma. However, surgery has been traditionally associated with a high morbidity and mortality rate. A lot of progress has been made since Earlam and Cunha-Melo in 1980 reviewed the literature and reported 29% mortality for esophagectomy[2]. Recent series have shown much improved rates, but they are still far from ideal. For these reasons, minimally invasive esophagectomy (MIE) brought high hopes to this field.

This final paper from a seminar on heartburn and adenocarcinoma focuses on the minimally invasive approach to esophagectomy; a treatment that is suitable for Barrett's esophagus and high-grade dysplasia and for esophageal adenocarcinoma.

TECHNIQUE

The techniques for esophagectomy can be simplistically described as those that include thoracotomy (transthoracic) and those without thoracotomy (transhiatal). The same classification can be used for MIE. According to the preferred approach, thoracotomy can be replaced by thoracoscopy and/or laparotomy can be replaced by laparoscopy. Thus, the following different combinations can be found in the literature: (1) transhiatal esophagectomy -

laparoscopy and cervicotomy[3,4]; (2) transthoracic esophagectomy (three-field) - laparoscopy, thoracoscopy and cervicotomy[5,6]; (3) transthoracic esophagectomy (three-field) - laparotomy, thoracoscopy and cervicotomy[6]; (4) transthoracic esophagectomy (three-field) - laparoscopy, thoracotomy and cervicotomy[7]; (5) transthoracic esophagectomy (Ivor Lewis) - laparoscopy and thoracoscopy[5]; (6) transthoracic esophagectomy (Ivor Lewis) - laparotomy and thoracoscopy[8]; and (7) transthoracic esophagectomy (Ivor Lewis) - laparoscopy and thoracotomy[9].

Laparoscopy

The laparoscopic approach to esophagectomy has the purpose of: (1) dissection of the abdominal esophagus and esophageal hiatus; (2) abdominal lymphadenectomy; (3) preparation of the stomach to replace the esophagus; (4) pyloroplasty or pyloromyotomy; and (5) placement of a feeding jejunostomy.

Dissection of the abdominal esophagus and esophageal hiatus follows the same principles of laparoscopic antireflux surgery. In summary, five abdominal ports are usually used. The abdominal esophagus and esophageal hiatus are dissected. The gastro-hepatic ligament is open, which preserves the right gastric artery. The greater curvature of the stomach is mobilized, which preserves the right gastroepiploic artery. The left gastric artery and coronary vein are isolated and divided with an endo-GIA stapler. A gastric conduit is constructed by dividing the stomach, starting on the lesser curvature and finishing at the angle of His. Pyloroplasty or pyloromyotomy is usually performed. The tip of the gastric conduit is sutured to the esophageal specimen that is retrieved through the neck or through the thorax if the anastomosis is performed in the chest[5,9,10]. Alternatively, the gastric conduit might be created through a mini-laparotomy[11]. The colon is rarely used for esophageal replacement during MIE.

Extended abdominal lymphadenectomy might be added to the procedure based on the philosophy adopted for the treatment of esophageal cancer by the surgeon. It is safe and feasible with a laparoscopic approach, after the lessons learned with laparoscopic treatment of gastric cancer[12].

Thoracoscopy

The thoracoscopic approach to esophagectomy has the purpose of: (1) dissection of the thoracic esophagus; (2) thoracic lymphadenectomy; and (3) esophageal anastomosis.

Dissection of the esophagus is performed using four ports in the right chest. Carbon dioxide insufflation is not considered necessary by most surgeons. The deflated lung is retracted anteriorly and the mediastinal pleura overlying the esophagus is divided. The azygos vein is then divided using an endo-GIA stapler with a vascular cartridge. A Penrose drain is placed around the esophagus to facilitate retraction. The esophagus is circumferentially mobilized from the esophageal hiatus up to the thoracic inlet. An esophageal anastomosis might be performed above the level of the azygos vein with the aid of a linear stapler. Otherwise, once the thoracoscopic dissection is completed, the operation can continue with cervicotomy, and the continuity of the digestive tract is restored with transposition of the stomach to the neck[5,9,10].

Similarly to the laparoscopic approach, extended mediastinal lymphadenectomy might be performed.

TECHNICAL VARIATIONS

Hand-assisted esophagectomy

Some surgeons perform transhiatal MIE using a laparoscopic approach to the abdomen but include a subxiphoid midline incision for manual mobilization of the mediastinal esophagus through a hand-port[5].

Prone position

Some surgeons have proposed a prone position for thoracoscopy instead of a left lateral decubitus approach[13,14]. This approach is used in order to improve ergonomics, operative time and pulmonary complications. The patient is placed in the prone position and the esophagus is approached through the right chest. The right lung is kept ventilated but it is collapsed due to the action of gravity and an 8-mmHg CO_2 pneumothorax[13,14].

Palanivelu *et al*[13] have reported an incidence of 2% for pleural and pulmonary complications in 130 patients. Fabian *et al*[15] have shown no differences in blood loss, number of lymph nodes dissected, and complications in two small cohorts of patients operated in left lateral decubitus *vs* prone position. However, operation time was significant shorter. Although good results have been reported, this technique is not widely accepted.

Robotic surgery

Robotic surgery claims to have the advantages of: (1) eliminating the counter-intuitive motion of standard laparoscopy; (2) aligning the eyes and hands over the area of interest with improved ergonomics; (3) increasing freedom of instrument movement by allowing wrist and finger movements that standard laparoscopic instruments do not have; (4) minimizing instrument tremor; and (5) 3D stereoscopic vision with dual camera technology[16]. Different types of esophageal operations have been performed with the aid of a robotic platform. Cases of robotic esophagectomy have been shown to be safe and feasible, either through thoracoscopy[17] or laparoscopy[4].

Early results have shown a conversion rate ranging from 0% to 15%[4,18]. Operating time is still high for transthoracic robotic esophagectomy, at an average of 7.5 h, which leads to a high incidence of pulmonary complications that decreases with experience[18]. Long-term outcomes are still elusive.

Vagal-sparing esophagectomy

Vagal-sparing esophagectomy is an attractive alternative to conventional procedures to avoid postoperative complications associated with vagotomy. Vagal-sparing

MIE has been described and popularized by the Portland Group[19]. The technique follows the same principles as open surgery: the vagal nerves are mobilized off the distal esophagus and stomach to the level of the pylorus; two nasogastric tubes are passed distally through the cervical esophagus and into the gastric remnant; the gastric remnant is divided and the nasogastric tubes are incorporated into the staple line; and finally, the esophagus is inverted, stripped out and removed through the cervicotomy[19].

OUTCOMES

Intraoperative complications are still frequent and they are the main cause for conversion to open surgery. During laparoscopy, bleeding is the main complication, either at the splenic hilum or parenchyma (often requiring splenectomy) or during division of gastric vessels at the time of the preparation of the gastric conduit[5]. Liver injury has also been reported[6,20]. During thoracoscopy, bleeding is reported as well[6]; however, the presence of pleural adhesions is the main cause for conversion[5,6]. Overall, the conversion rate ranges from 3% to 18%[5,6] with an average of 5%-7% depending on the technique[21,22].

Postoperative complications average 40%-50%, but can reach 80%[6,21,22]. Pleural and pulmonary complications still account for a significant proportion of morbidity; an average of 22%[22]. Nguyen *et al*[5] have reported, in a large series of 104 patients, that postoperative major morbidity occurred in 12.5%, especially anastomotic complications, staple line leaks and pulmonary complications. Minor complications occurred in an additional 15% of cases[5].

Review papers show a median length of intensive care unit stay of 2-5 d, and a median length of hospital stay of 9-18 d after MIE[21,22]. Mortality rate ranges between 0% and 4%[5,6,20-22].

COMPARISON WITH OPEN SURGERY

As far as we are aware, no randomized controlled trials have compared MIE and open esophagectomy to date. Available data suggests that MIE is similar but not superior to conventional esophagectomy.

Morbidity and mortality

MIE was expected to reduce the morbidity and mortality rate of esophageal resection when compared to conventional surgery. However, a recent meta-analysis[23] has shown similar results for major morbidity, pulmonary complications and mortality when MIE and open surgery are compared either to transhiatal or transthoracic esophagectomy. Nguyen *et al*[5] also have shown similar pulmonary complications when MIE and open cohorts were compared. Perry *et al*[24] have compared the outcomes of open and laparoscopic transhiatal esophagectomy in two sets of patients from different periods of time. They have found that lower intraoperative blood loss and overall length of hospital stay favor MIE. Complication rates were no different.

Cost

As far as we are aware, no studies have compared cost for MIE and open surgery. It is intuitive, however, that direct operative costs are higher for MIE, especially with the use of endoscopic staplers. Moreover, the clinical benefits of MIE are not yet proven to be greatly superior to open surgery in order to decrease indirect costs.

Oncological radicality

Advantages of minimally invasive techniques include a magnified view of the operative field. This advantage theoretically enhances the ability to perform more radical lymphadenectomy. In contrast, surgeons might be less confident to work close to important vascular structures without a tactile feeling and the possibility to use their hands to control bleeding. Reported experiences with different types of cancer, such as colon[25] and stomach[26], have shown a comparable number of lymph nodes retrieved when open or minimally invasive surgery are compared. MIE shows similar results. Decker *et al*[22] have shown a mean 10-27 lymph nodes were dissected in MIE, depending on the technique adopted, and these numbers are comparable to open surgery and considered adequate[27].

Survival is expectedly similar to open surgery with an average of 40% at 5 years[22].

Learning curve

It has been shown that esophagectomy outcomes are highly linked to the experience and volume of the centers performing the operation[28]. The same seems to be true for MIE[22]. To the best of our knowledge, no studies have defined the number of procedures necessary for these techniques to become safe and effective. Advanced laparoscopic skills and experience with major foregut surgery (open and laparoscopic) are clearly necessary.

CONCLUSION

Minimally invasive surgery has the advantages of better cosmetic results, reduced operative stress, postoperative immobility, and pain. These advantages are obtained by minimizing the incisions to obtain access to natural cavities, i.e. decreasing the external surgical stress. Minimally invasive surgery does not change, however, the internal part of the operation and the surgical stress determined by it. The minimally invasive approach has gained rapid acceptance and has become the gold-standard operation where external stress is higher than internal stress, such as for cholecystectomy and hiatal hernia repair[29,30]. In operations in which internal surgical stress is intensive, such as a Whipple procedure, the minimally invasive approach is questionable[31]. This is also true for MIE. This review shows that, even with a minimally invasive approach, patients are not discharged earlier and the clinical consequences of intense internal aggression, such as systemic inflammatory response syndrome[32], are still noticed after MIE. For these reasons and for the

technical skills necessary to perform a MIE, it is not a disseminated and widely used approach for esophageal resection. Boone *et al*[33] have surveyed 269 surgeons, members of the International Society for Diseases of the Esophagus, the European Society of Esophagology Group, and the World Organization for Specialized Studies on Diseases of the Esophagus. They have found that MIE was the operation of choice for only 14% of the responders, while 60% of them never used the MIE approach. Similar results have been presented by Enestvedt *et al*[34]. Not surprisingly, they also have shown that MIE is performed more frequently by high-volume surgeons compared to those from low-volume centers.

The available literature on MIE is still crowded with heterogeneous studies with different techniques. As far as we are aware, there have been no controlled comparative trials, and the few retrospective comparative cohort studies have been limited by small numbers of patients and biased by historical controls of open surgery[22]. Moreover, few studies have included > 100 patients. Based on the available literature, there is no current evidence that MIE brings clear benefits compared to conventional esophagectomy. Growing experience and studies with larger numbers of patients could change this situation.

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