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Minimally Invasive Ivor Lewis Esophagectomy Improves Pulmonary Complications Compared to Open Ivor Lewis Esophagectomy

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Abstract

Background: The morbidity and mortality remain relatively high for transthoracic esophagectomy with open thoracotomy. I compared a total laparoscopic and thoracoscopic Ivor Lewis esophagectomy (MIE) cohort with a well matched cohort of open Ivor Lewis esophagectomy (OIE) cases.

Methods: This is a retrospective review 50 patients diagnosed with esophageal carcinoma or high grade dysplasia who underwent minimally invasive or open Ivor Lewis esophagectomy from August 2009 to June 2013. A total of 25 patients underwent MIE and 25 patients underwent OIE. The postoperative morbidity and 60-day mortality were reported for the two groups.

Results: The MIE and OIE groups were well matched for age, gender, FEV-1 % predicted, ejection fraction, coronary artery disease, COPD, and neoadjuvant chemoradiation. The 60 day mortality rate was 0% in the MIE group compared 4% in the OIE group (p=0.98). The mean hospital length of stay was 11 days + 4.3 for the MIE group compared to 13.4 days + 6.9 for the OIE group [p=0.149]. The rate of all pulmonary complications were significantly higher in the OIE group compared to the MIE group (44% compared to 4% [p=0.002].

Conclusion: Total thoracoscopic and laparoscopic Ivor Lewis (MIE) esophagectomy produced clinical outcomes that are similar to the outcomes for OIE at our institution. The advantage for MIE appears to be fewer pulmonary complications which may be a function of the deleterious effects of thoracotomy.

Keywords: Esophagectomy; Minimally invasive surgery; Esophageal surgery

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Introduction

The traditional Ivor Lewis esophagectomy combines right thoracotomy and laparotomy with an intrathoracic anastomosis. The two stage esophagectomy technique was described by Ivor Lewis at the Hunterian Lecture at the Royal College of Surgeons in 1946 [1]. This operative technique has been associated with an increase in respiratory complications, such as pneumonia and respiratory failure requiring prolonged ventilation, in a randomized study comparing transthoracic esophagectomy to the transhiatal approach [2]. Rizk et al. [3] have demonstrated that procedure related complications after esophagectomy have adverse effects on overall survival. In recent years, minimally invasive techniques for esophagectomy have been developed with the hope of minimizing postoperative morbidity and mortality associated with the procedure. Luketich et al. [4] reported a large series of over 1000 minimally invasive esophagectomies, which demonstrated a very low mortality rate and a relatively low rate of pulmonary complications. In theory, minimally invasive esophagectomy should minimize the pulmonary morbidity associated with open thoracotomy because MIE does not involve rib-spreading.

There are numerous different techniques of laparoscopic and laparoscopic-thoracoscopic esophagectomies reported in the literature [5]. Some of these techniques incorporate mini-thoracotomy and hand ports in order to conduct the operation. There are a limited number of reports that describe the total thoracoscopic and laparoscopic Ivor lewis esophagectomy [4,6,7-10]. In this report, I describe the outcomes of a small series of patients with esophageal carcinoma who underwent total thoracoscopic and laparoscopic Ivor Lewis esophagectomy at a single institution. The outcomes of the MIE cohort were compared to a well matched cohort of open Ivor Lewis esophagectomies that were performed by the same surgeon during the same study period.

Materials and Methods

Study design

This study is a retrospective review of 50 patients who underwent Ivor Lewis esophagectomy for esophageal carcinoma on the General Thoracic Surgery Service at the Stanford Hospitals and Clinics between August 2009 and June 2013. A total of 25 patients underwent total thoracoscopic and laparoscopic Ivor Lewis esophagectomy and 25 patients underwent open Ivor Lewis Esophagectomy with right thoracotomy. The charts and electronic medical records of all patients identified were reviewed and data was collected in de-identified fashion. The study was approved by the Stanford Institutional Review Board and the requirement for informed consent was waived. All of the patients were clinically staged before the initiation of treatment with endoscopy, Computed Tomography (CT) scans, and clinical history and exam. Endoscopic Ultrasound (EUS) and Positron Emission Tomography (PET) scans were performed in all 50 patients prior to esophagectomy. Patients who underwent transhiatal, a modified McKeown (3-hole), or thoracoabdominal esophagectomy techniques were excluded. Patients were eligible for either OIE or MIE based on preoperative assessment of comorbidities and the clinical stage of esophageal cancer. The inclusion and exclusion criteria were the same for the MEI and OIE groups. Patients with FEV-1 values less than 40% predicted, ejection fraction less than 30%, home oxygen use, or stage IV esophageal cancer were excluded from consideration for esophagectomy. The decision to perform MIE or OIE was random, although patients with a previous history previous laparotomy were more likely to undergo OIE due to concern for adhesions. The esophagectomy cases in this report were performed by the author and represent a fraction of the total number of esophagectomy cases performed at our institution by other thoracic surgeons. The MIE cases reported in this report represent the early experience of the author who is an experienced esophageal surgeon who routinely performed laparoscopic foregut procedures and open esophagectomy procedures.

Cardiac comorbidity was defined by a history of acute myocardial infarction or a previous coronary artery bypass grafting or percutaneous coronary stenting procedure. Chronic obstructive pulmonary disease (COPD) was defined by a prior diagnosis of asthma, emphysema, or chronic bronchitis. The patients' ages and genders were recorded. The preoperative ejection fractions were obtained from echocardiogram reports. The FEV-1 percent predicted values were recorded from the preoperative pulmonary function test reports. A prior history of mid-line laparotomy incision for an abdominal operation was also recorded. The decision to perform a MIE or OIE was at the surgeon's discretion, but all of the patients with a previous laparotomy for an abdominal operation underwent on open Ivor Lewis. The concern for abdominal adhesions and potential inadvertent injury to the right gastroepiploic artery was the primary reasons for the choice of performing an OIE. A total of 20 of the OIE cases were performed with general surgery colleagues who performed the abdominal portion of the Ivor Lewis esophagectomy. All 50 of the intrathoracic anastomoses were performed by a single surgeon (the author) during the same period.

Surgical technique for total thoracoscopic and laparoscopic Ivor Lewis esophagectomy

The patient is positioned on the operating room table in the supine position. A double lumen tube, central line, arterial line, and epidural are placed by the anesthesiologist. An esophagogastroduodenoscopy (EGD) is performed initially to confirm the location of the esophageal tumor. A total of five laparoscopic ports are placed for laparoscopic mobilization of the gastric conduit. A 12 mm port is placed to the left of the mid-line approximately 4 cm above the umbilicus using the Hasson cut-down technique. A 12 mm port is placed to the right of the mid-line. A 5mm port is placed at the left costal margin, the right costal margin, and the right flank area. A 5mm laparoscopic liver retractor is used to retract the left lateral segment of the liver cephalad. The greater curvature of the stomach is mobilized by dividing the gastrocolic ligament using the LigaSure device (Covidien, Mansfield, MA) while avoiding injury to the right gastroepiploic artery. The short gastric vessels are then divided along the greater curvature of the stomach with the LigaSure device. The lesser omentum is then incised with the Harmonic Scalpel (Ethicon Endosurgery, Cincinnati, OH) and the esophagus is encircled with penrose drain the hiatus. In addition, a pyloric drainage procedure is not performed routinely. A 5 cm gastric conduit is then formed with multiple applications of the Endo GIA endoscopic stapler (Covidien, Mansfield, MA) along the lesser curvature. A 10-French jejunostomy tube is placed over a seldenger wire into the proximal jejunum and secured with a 2-0 silk purse string using the Endo Stich device (Covidien, Mansfield, MA). The jejunostomy insertion site is secured to the abdominal wall with two interrupted 2-0 silk sutures taking great care to avoid torsion of the small bowel.

The thoracoscopic portion of the procedure is performed with the patient in the left lateral decubitus position with three thoracoscopic ports and a small access incision without rib-spreading. A 12 mm port is placed in the 8th intercostal space posterior axillary line for the 12 mm thoracoscope. A 12 mm port is placed in the 5th intercostal space anterior-line for retraction of the lung. A 3-4 cm access incision is made in the 9th intercostal space for removal of the specimen and placement of the EEA circular stapler. A 5mm port is placed below the tip of the scapula. The azygous vein is dissected and divided with Endo GIA endoscopic stapler. The esophagus and the lymphatic tissue are dissected circumferentially from the hiatus to about 2-3 cms above the azygous vein. The conduit and specimen are then pulled gently into the chest, taking great care not to twist the gastric conduit. A 25 mm anvil (OrVil, Covidien, Mansfield, MA) is passed trans-orally, which his connected to a 90 cm polyvinyl chloride delivery tube, through a small opening in the esophageal stump staple line. The anastomosis is completed by joining the anvil with the 25 mm end-to-end anastomosis (EEA) stapler (Covidien, Mansfield, MA) inserted through a gastrotomy at the tip of the gastric conduit. A nasogastric tube is then passed under direct vision into the gastric conduit. The gastrotomy is then resected with 2-3 applications of the Endo GIA stapler. The anastomosis is either covered with redundant omentum or mediastinal pleura. A barium swallow study was obtained on postoperative day number 6 to evaluate the esophagogastric anastomosis.

Surgical technique for open Ivor Lewis esophagectomy

The open Ivor Lewis esophagectomy was performed with a mid-line laparotomy incision and a posterior-lateral right thoracotomy incision. The conduct of the operation is the same as described above for the MIE technique. The key differences for the OIE technique include the frequency of drainage procedure and the technique for anastomosis. In the MIE technique, a 25 mm end-to-end anastomosis (EEA) stapler (Covidien, Mansfield, MA) was used to create an esophago-gastric anastomosis in all of the 25 patients. In the OIE group, a total of 7 patients underwent two-layer hand-

Table 1: Patient Demographics.

Variable	MIE Ivor Lewis	Open Ivor Lewis	P-value
N	25	25	
Age (mean ± SD), years	68.4 ± 8.9	65.9 ± 10.1	0.371
Sex, M: F, n (%)	16:9(64:36)	20:5(80:20)	0.345
Ejection Fraction (%)	62.5 ± 5.8	61.5 ± 5.3	0.546
FEV-1% predicted, mean ± SD	90.1 ± 9.8	89.3 ± 13.2	0.810
Coronary Artery Disease, n (%)	7(28)	4(16)	0.496
COPD, n (%)	5(20)	3(12)	0.701
Neoadjuvant Chemoradiation, n (%)	13 (52)	17(68)	0.386
Prior Abdominal Surgery, n (%)	0	10 (40%)	0.001

*COPD= Chronic Obstructive Pulmonary Disease

Table 2: Histologic Diagnosis.

Histology	MIE Ivor Lewis	Open Ivor Lewis	P-value
High Grade Dysplasia, n (%)	0	1 (4)	0.868
Adenocarcinoma, n (%)	20 (80%)	24 (96)	0.189
Squamous Cell Carcinoma, n (%)	5 (20)	0	0.363

sewn anastomoses and 18 patients had 25 mm end-to-end stapled anastomosis (EEA) anastomoses. A total of 20 patients in the OIE group underwent a pyloroplasty and none of the patients in the MIE group underwent a drainage procedure. None of the MIE patients developed a post-operative gastric outlet obstruction requiring pyloric dilation.

Postoperative complications were classified as anastomotic leak, pneumonia, respiratory failure, prolonged ventilation (>48 hours), thoracic duct leak, pulmonary embolus, myocardial infarction, atrial fibrillation, and symptomatic pleural effusion requiring drainage. Anastomotic leaks were diagnosed by observing extravasation of oral contrast at the esophagogastric anastomosis on a contrast esophagram and/or by direct clinical observation. Respiratory failure was defined as the need for re-intubation for isolated respiratory dysfunction during the postoperative period. Pneumonia was diagnosed if patients developed an infiltrate on chest imaging studies with associated fever and received antibiotic therapy. A postoperative mortality was defined as a death occurring during hospitalization or within 60 days of esophagectomy. Deaths were verified with the Social Security Death Index.

Statistical analysis

Categorical variables were analyzed with the Fisher exact test and continuous variables were analyzed with an unpaired student t test. The arithmetic means were reported with the standard deviation. Univariate analyses were performed to determine the potential preoperative risk factors for overall pulmonary complications. The independent variables with a $p < 0.2$ on univariate analysis were entered into a forward stepwise multiple logistic regression analysis. The statistical analyses were performed using the MedCalc statistical software (MedCalc Software, Mariakerke, Belgium). Differences were considered significant when the probability was less than 0.05.

Results

A total of 25 patients underwent total thoracoscopic and laparoscopic Ivor Lewis esophagectomy (MIE) and 25 patients underwent an open Ivor Lewis esophagectomy (OIE). A total of 13/25 (52%) of the MIE patients and 17/25 (68%) of the OIE patients underwent preoperative chemoradiation. The radiation doses in all the cases ranged from 45 Gray to 50.4 Gray.

Table 3: Clinical Stages.

Clinical Stage	MIE Ivor Lewis	Open Ivor Lewis	P-value
Stage 0, n (%)	0	1(4)	0.868
Stage I, n (%)	4 (16)	2 (8)	0.667
Stage II, n (%)	14 (56)	12 (48)	0.778
Stage III, n (%)	7 (28)	10 (40)	0.551
Stage IV, n (%)	0	0	--

Table 4: Operative Outcomes.

Variable, mean (median)	MIS Ivor Lewis	Open Ivor Lewis	P-value
Operative time (minutes)	479 ± 65 (480)	460 ± 76 (468)	0.343
Estimated blood loss (mL)	167 ± 75.9 (150)	206 ± 96 (200)	0.118
Intraoperative IV fluids (L)	3613 ±1203 (3500)	4042 ± 1560 (3500)	0.282
ICU length of stay (days)	1.5 ±1.8 (1.0)	4.3 ± 6.8 (2.0)	0.05
Days on ventilator (days)	0.08 ± 0.2 (0.0)	1.7 ± 6.1 (0)	0.190
Length of hospital stay (days)	11 ± 4.3 (10)	13.4 + 6.9 (11)	0.149
Number of lymph nodes (n)	14.2 ± 7.5 (13)	16.3 ± 5.3 (17)	0.25

Two patients in the MIE group were converted to an open Ivor Lewis esophagectomy and were included in the OIE group. The patient demographics are listed on Table 1. The patients in the two groups were well matched for age, gender, preoperative ejection fraction, FEV-1 percent predicted, coronary artery disease, COPD, and neoadjuvant chemoradation. The 10/25 (40%) of the patients in the OIE group had a prior laparotomy incision for a cholecystectomy, bariatric surgery, trauma, or small bowel obstruction. Adenocarcinoma was the most common histologic diagnosis in the MIE group (20/25 [80%]) and the OIE group (24/25 [96%]) (Table 2). The clinical staging base in endoscopic ultrasound and PET CT scan is listed in Table 3. Nodal involvement was based on abnormal radiotracer uptake on PET CT scans and endoscopic ultrasound findings of suspicious peri-esophageal lymphadenopathy. Fine needle aspiration was not attempted in most cases because the needle would have to be passed through large bulky tumors to reach the lymph nodes.

The mean total operative time for the MIE group was 479 minutes ± 65 minutes and the median total operative time was 480 minutes compared to a mean operative time of 460 minutes ± 76 and median time of 468 minutes (p=0.343) for the OIE group. The mean estimated blood loss was and intraoperative intravenous volume was the similar between the two groups (Table 4). The mean number of lymph nodes dissected in the MIE group was 14.2 nodes ± 7.5 compared to 16.3 nodes ± 5.3 nodes in the OIE group. All of the patients in the MIE and OIE groups had a R0 resection with negative proximal, distal, and radial margins on final pathology.

The mean ICU length of stay was significantly higher in the OIE group (4.3 days ± 6.8 compared to 1.5 days ± 1.8 [p=0.05]) for the MIE group). The mean ventilator days and length of hospital stay was similar between the groups (Table 4). The overall operative 60–day mortality rate was 0% in the MIE group compared to 1/25 (4%) in the MIE group (p=0.988). The single postoperative death in the OIE group was related to Acute Respiratory Distress Syndrome (ARDS). A summary of the complications are summarized in Table 5. The total pulmonary complication rate was 11/25 (44%) in the OIE group compared to 1/25 (4%) in the MIE group (p=0.002). The anastomotic leak rate was 1/25 (4%) in both groups.

Table 5: Postoperative Complications.

Variable, n (%)	MIE Ivor Lewis	Open Ivor Lewis	P-value
Pneumonia	0	4 (16)	0.110
Respiratory Failure	0	2 (8)	0.470
Prolonged Ventilation (>48hrs)	0	2 (8)	0.470
Pulmonary Embolus	0	2 (8)	0.470
Pleural Effusion	1 (4)	1 (4)	0.471
Myocardial Infraction	0	0	--
All Pulmonary Complications	1 (4)	11 (44)	0.002
Anastomotic leak	1 (4)	1 (4)	0.471
Thoracic duct leak	1 (4)	0	0.868
Atrial Fibrillation	3 (12)	5 (20)	0.698
60 – day mortality	0	1 (4)	0.868

A forward stepwise multiple logistic regression analysis was performed to determine the independent risk factors for postoperative pulmonary complications. Only open Ivor Lewis esophagectomy was significantly associated with the occurrence of a postoperative pulmonary complication (p=0.015 [odds ratio = 9.33]). Neoadjuvant chemoradiation, age, preoperative COPD, and preoperative coronary artery disease were not significant risk factors for the development of postoperative respiratory complications.

Comment

Since the first description of the two stage Ivor Lewis esophagectomy in 1946 [1], the procedure has become the procedure of choice at most centers for the resection of esophageal carcinoma involving the distal third of the esophagus. The main disadvantage of the open Ivor Lewis esophagectomy is the deleterious effects of the right thoracotomy. In a randomized clinical trial comparing transthoracic and transhiatal esophagectomy, Hulscher et al. [2] demonstrated that patients undergoing esophagectomy with open thoracotomy had a significantly higher rate of pulmonary complications which resulted in more ventilator days, ICU days, and hospital days. In an attempt to minimize the perioperative morbidity associated with esophagectomy, some centers have developed Minimally Invasive Esophagectomy (MIE) techniques for surgical resection of esophageal carcinoma. Luketich et al. [4] reported their extensive experience with the total laparoscopic and thoracoscopic Ivor Lewis esophagectomy. In this series, 530 patients with high grade dysplasia or esophageal carcinoma underwent minimally invasive Ivor Lewis esophagectomy with relatively low operative mortality (0.9%). The median ICU days were 2 days and the median hospital length of stay was 7 days. These results for operative mortality rate and length of stay were superior to two large contemporary series involving open transthoracic and transhiatal esophagectomy [11,12].

This report describes a series of total thoracoscopic and laparoscopic Ivor Lewis esophagectomy compared to a contemporary cohort of open Ivor Lewis esophagectomies performed by the same surgeon. The author wanted to determine if the minimally invasive Ivor Lewis esophagectomy technique was at least equivalent in terms of operative outcomes, such as postoperative morbidity and mortality. The expectant outcome would be a decrease in postoperative pulmonary complications in the patients who underwent minimally invasive Ivor Lewis esophagectomy. Shirag et al. [13] reported the operative results of 38 minimally invasive Ivor Lewis esophagectomies compared to 73 open Ivor Lewis esophagectomies. Overall pulmonary complications were significantly higher in the open Ivor Lewis group compared to the minimally invasive group [43.4% versus 2.6%] p <0.001).

In this report, the operative times, estimated blood loss, an intraoperative fluid was similar between the two groups. The ICU length of stay was significantly less in the minimally invasive Ivor Lewis group. The total ventilator days and hospital length of stay were lower in the minimally invasive Ivor Lewis group, but the differences were not statistically significant. This finding is likely related to the small sample size of the study. The overall 60 day mortality rate was 4% in the open Ivor Lewis group. A single patient died on postoperative day number 32 from Adult Respiratory Distress Syndrome. There were no 60 day mortalities in the minimally invasive Ivor Lewis cohort. The anastomotic leak rates (4%) were the same in each group. One patient in the MIE group and one patient in the OIE group developed an anastomotic leak requiring reoperation and primary repair of the anastomosis using a right thoracotomy. The overall pulmonary complication rate was significantly higher in the OIE group compared to the MIE group. On multiple logistic regression analysis, the open Ivor Lewis esophagectomy technique was predictive of postoperative pulmonary complications (odd ratio = 9.3 [p=0.015]). This result is likely related to the negative impact of open thoracotomy on postoperative pulmonary toilet. Transthoracic esophagectomy resulted in significantly higher rates of pulmonary complications compared to transhiatal esophagectomy in a randomized study [2]. In addition, Avendano et al. [14] demonstrated 20% rate of prolonged ventilation after open transthoracic esophagectomy. The deleterious effects of thoracotomy are likely caused by a decrease in the functional reserve capacity in the postoperative period. This negative impact is probably mitigated by the less invasive thoracoscopic approach.

The oncologic results of the MIE approach were comparable to the OIE technique in this report. The mean and median numbers of lymph nodes that were dissected in the MIE group were similar to the OIE group. All of the patients in both cohorts underwent a complete R0 resection with negative margins on final pathology. The long term overall survival data was not reported given the small sample size of this retrospective review and the relatively short follow up time. A randomized phase III clinical trial would be the most appropriate way to determine the long term survival impact of MIE compared to OIE.

The results of this report comparing minimally invasive Ivor Lewis esophagectomy to open Ivor Lewis esophagectomy determined that our MIE technique is equivalent to our OIE. The primary advantage of the MIE technique appears to be a mitigation of the adverse effects of open thoracotomy. In this report, the patients in the MIE group experienced minimal pulmonary complications and spent less time in the ICU. The overall mean hospital length of stay was two days less in the MIE group. This retrospective study is unique because a single surgeon serves as a control, which limits the variability of individual technique and postoperative management. The operative technique of the Ivor Lewis is virtually the same with a few exceptions, regardless of the degree of invasiveness. In addition, the postoperative management was uniform between the two techniques. Regardless, the results of this report are limited by selection bias that is inherent to retrospective studies and a small sample size. The author believes that the MIE Ivor Lewis technique is a suitable alternative to the open Ivor Lewis technique. The MIE technique appears to minimize postoperative pulmonary complications; therefore, MIE may particularly advantageous in elderly patients and patients with compromised respiratory function.

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