Minimally Invasive Versus Open Esophagectomy for Esophageal Cancer: A Comparison of Early Surgical Outcomes From The Society of Thoracic Surgeons National Database

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Background. **Open esophagectomy results in significant morbidity and mortality. Minimally invasive esophagectomy (MIE) has become increasingly popular at specialized centers with the aim of improving perioperative outcomes. Numerous single-institution studies suggest MIE may offer lower short-term morbidity. The two approaches are compared using a large, multi-institutional database.**

Methods. **The Society of Thoracic Surgeons (STS) National Database (v2.081) was queried for all resections performed for esophageal cancer between 2008 and 2011 (n = 3,780). Minimally invasive approaches included both transhiatal (n = 214) and Ivor Lewis (n = 600), and these were compared directly with open transhiatal (n = 1,065) and Ivor Lewis (n = 1,291) procedures, respectively. Thirty-day outcomes were examined using nonparametric statistical testing.**

Results. **Both open and MIE groups were similar in terms of preoperative risk factors. Morbidity and all-cause mortality were equivalent at 62.2% and 3.8%. MIE was associated with longer median procedure times (443.0 versus 312.0 minutes; $p < 0.001$), but a shorter median length of hospital stay (9.0 versus 10.0 days; $p < 0.001$). Patients who underwent MIE had higher rates of reoperation (9.9% versus 4.4%; $p < 0.001$) and empyema (4.1% versus 1.8%; $p < 0.001$). Open technique led to an increased rate of wound infections (6.3% versus 2.3%; $p < 0.001$), postoperative transfusion (18.7% versus 14.1%; $p = 0.002$), and ileus (4.5% versus 2.2%; $p = 0.002$). Propensity score-matched analysis confirmed these findings. High- and low-volume centers had similar outcomes.**

Conclusions. **Early results from the STS National Database indicate that MIE is safe, with comparable rates of morbidity and mortality as open technique. Longer procedure times and a higher rate of reoperation following MIE may reflect a learning curve.**

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Esophageal cancer is the sixth leading cause of cancer death worldwide, and the incidence continues to rise, with an estimated 18,170 new cases in 2014 in the United States alone [1]. Esophageal resection remains the mainstay of multimodality treatment for esophageal cancer, in combination with chemoradiotherapy [2]. However, open esophagectomy (OE) is associated with a mortality rate of 1% to 6% and morbidity rate of 19% to 60%, even at experienced centers, although outcomes tend to be better with increased hospital volume [3, 4]. During the past 15 years, minimally invasive esophagectomy (MIE) has gained increasing popularity and is now performed at most academic centers with the aim of decreasing overall morbidity and mortality related to esophagectomy. Minimally invasive esophagectomy consists presently of three main techniques: (1) combined thoracoscopic and laparoscopic approach (Ivor Lewis); (2) thoracoscopic, laparoscopic, and cervical approach (three-hole); or (3) laparoscopic and cervical approach only (transhiatal).

Several case series and retrospective analyses have been published to date comparing outcomes between open and minimally invasive techniques for esophagectomy. Most report a shorter length of hospital stay, lower rate of pulmonary complications, and fewer wound infections associated with MIE [5–10]. A number

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of meta-analyses in the literature, including close to 1,000 patients, further support the safety of MIE in the absence of important differences in 30-day mortality between open and minimally invasive approaches. Indeed, MIE is favored with respect to length of hospital stay, immediate postoperative recovery, and overall morbidity [11–13]. Only one prospective, randomized controlled trial from the Netherlands has been reported that enrolled 115 patients from five different centers, and validates a lower rate of pulmonary infection after MIE [14].

Thus, our hypothesis is that MIE provides potential benefit to patients in terms of short-term morbidity and length of hospital stay in comparison with OE technique, as would be expected given trends in data pertaining to other minimally invasive procedures, such as laparoscopic colectomy and thoracoscopic lobectomy [10, 15, 16]. In this paper, we present the results of a multiinstitutional, large database comparison in the United States between OE and MIE based on query of The Society of Thoracic Surgeons (STS) National Database.

Material and Methods

The STS General Thoracic Database (v. 2.081) was queried for all patients who underwent OE and MIE from 2008 to 2011 for esophageal cancer. These corresponded to International Classification of Disease (ICD) 9/10 diagnostic codes 150.4, 150.5, and 151.0 and procedure codes 43107, 43117, 43112, 43117, 43122, and 43XXX on the STS General Thoracic Database Data Collection Form. The comparison included the total case groups of MIE and OE, and a subgroup analysis of Ivor Lewis and transhiatal cohorts. Patients who underwent esophagectomy using a thoracoabdominal or three-hole approach were excluded from subgroup analysis, as there was no procedure code available for three-hole MIE in this version of the database. Each participating center exempted this investigation from formal institutional review board approval as it represents an analysis of data collected for quality review and secondary research purposes with the absence of Health Insurance Portability and Accountability Act patient identifiers.

Demographics, including age, sex, and race, and relevant preoperative risk factors including major comorbidities, use of induction chemotherapy and radiation, forced expiratory volume in 1 second (FEV_1), diffusion capacity of carbon monoxide (DLCO), histology, and clinical staging were harvested and analyzed for all groups of patients. Perioperative events, procedure duration, number of transfusions, and length of hospital stay, as well as all 30-day postoperative events as defined by the STS General Thoracic Database (http://www.sts.org/national-database) were examined for all four case groups. As a result of institutional bias, postoperative "atelectasis requiring bronchoscopy" was eliminated from our analysis of pulmonary complications. Surgical outcomes of low- and high-volume centers in our dataset were also compared. High-volume centers were defined as performing at least 20 MIEs per year [17].

Continuous variables were summarized with mean and standard deviation or median and interquartile range as appropriate, and compared across groups using a two-sample nonparametric Wilcoxon rank-sum test. Categorical data were summarized with frequencies and percentages, and compared across groups with a Fisher's exact test. To account for differences in patient populations in OE and MIE groups, propensity-matched analysis was performed. Estimated probability of receiving MIE (propensity score) was calculated using a logistic regression model with preoperative risk factors as covariates. Matched pairs of OE and MIE patients were then generated based on these propensity scores. The majority of pairs had differences in propensity score less than 0.0001, and matched pairs were not formed if the propensity score difference exceeded 0.1. Subsequently, outcomes were compared between propensity-matched OE and MIE groups. A significance threshold of a probability value less than 0.05 was used. All statistical analyses were performed with SAS Statistical Package (SAS Institute, Cary, NC).

Results

Query of the STS General Thoracic Database resulted in a total of 3,780 esophagectomies that were performed for cancer of the middle and lower esophagus between 2008 and 2011, of which 2,966 were OE and 814 were MIE. Total populations of MIE and OE, as well as subgroups, were analyzed. Excluding alternative approaches, subgroup analysis was performed such that minimally invasive approaches included both transhiatal ($n = 214$) and Ivor Lewis ($n = 600$), and these were compared directly with open transhiatal ($n = 1,065$) and Ivor Lewis ($n = 1,291$) procedures, respectively (Supplemental Table 1).

Our study period spanned the introduction of MIE procedures into the STS national database with version 2.081. There were 135 database participants, 63 of which submitted data on patients undergoing MIE procedures. Only 2 of these centers, however, performed at least 20 minimally invasive resections per year, while the vast majority of institutions performed between 1 and 10 per year between 2009 and 2011.

Patient demographics, including age and sex, were similar in all groups (Table 1). The percentage of white versus minority patients who underwent MIE was similar across all groups, which suggests there was no true discrimination in access to or eligibility for MIE. In addition, clinical staging of esophageal tumors resected between the MIE and OE groups was not significantly different (Supplemental Table 2).

Relevant comorbidities, including a history of cardiopulmonary disease, diabetes, and prior thoracic surgery, were also similar among OE and MIE populations (Table 1). Patients who underwent MIE had better pulmonary function, with a higher preoperative mean percent predicted FEV_1 and DLCO. These differences