Original Investigation

Esophagectomies With Thoracic Incisions Carry Increased Pulmonary Morbidity

Neil H. Bhayani, MD, MHS; Aditya Gupta, MD; Christy M. Dunst, MD; Ashwin A. Kurian, MD; Kevin M. Reavis, MD; Lee L. Swanström, MD

IMPORTANCE Thoracic incisions are not required for all esophagectomies and may increase pulmonary morbidity.

OBJECTIVE To compare the pulmonary and overall morbidity of esophagectomies with and without thoracic incisions.

DESIGN Observational study.

SETTING Hospitals participating in the National Surgical Quality Improvement Project.

PARTICIPANTS Patients without metastatic cancer undergoing nonemergency total esophagectomies with reconstruction from 2005 through 2010. Patients who underwent transhiatal esophagectomy (THE) were compared with a THORACIC group (Ivor Lewis and McKeown techniques).

MAIN OUTCOMES AND MEASURES Pulmonary and overall morbidity, infection, and thromboembolic complications.

RESULTS Of 1568 patients, 717 (45.7%) underwent THE, and 851 (54.3%) were in the THORACIC group (Ivor Lewis technique in 487 [31.1%] and McKeown technique in 364 [23.2%]). The population was 80.5% male, with a mean age of 62.9 years. Patients undergoing THE were older (*P* = .02). Diabetes mellitus was less common in the THORACIC group (11.2% vs 15.9% for THE; *P* = .02), and cancer was more common (91.0% vs 87.0%; *P* = .01). Morbidity was 49.2% and mortality was 3.3%, without differences between groups. The mean length of stay was 1.6 days shorter (*P* = .009) in the THE group. Multivariable analysis showed that thoracic incisions increased rates of pneumonia (odds ratio [OR], 1.47; *P* = .007), ventilator dependence (OR, 1.35; *P* = .04), and septic shock (OR, 1.86; *P* = .001) but not mortality. Compared with the Ivor Lewis technique, the McKeown technique worsened the odds of superficial wound infections (OR, 1.71; *P* = .02) but not septic shock (OR, 0.84; *P* = .47).

CONCLUSIONS AND RELEVANCE Esophagectomies have an acceptable mortality rate but a significant morbidity rate. We demonstrated that rates of pneumonia, ventilator dependence, and septic shock are increased with the use of thoracic incision. Avoiding thoracic incisions may therefore decrease the risk of pulmonary morbidity and septic shock.

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Invited Commentary page 739

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Author Affiliations: Providence Cancer Center, Portland, Oregon (Bhayani, Kurian); Legacy Weight Management Institute, Portland, Oregon (Gupta, Reavis); The Oregon Clinic, Portland (Dunst, Swanström).

Corresponding Author: Neil H. Bhayani, MD, MHS, Providence Cancer Center, 4805 Glisan NE, Ste 6N50, Portland, OR 97213 (neil03@gmail.com).

Esophageal cancer is the eighth most common cancer worldwide. Better use of multimodality therapy and advances in chemotherapy and radiotherapy have enhanced survival.[1] Surgical resection remains the preferred treatment for curable esophageal adenocarcinoma, although it is accompanied by significant morbidity.[2] Morbidity rates may be influenced by institutional volume, comorbid conditions, and surgical technique.[3] Pulmonary morbidity, which frequently complicates the postoperative course, may be averted by avoiding thoracic incisions.

Transhiatal esophagectomy (THE) is an alternative to the conventional Ivor Lewis or McKeown esophagectomy techniques that is posited to reduce pulmonary morbidity rates. Meta-analyses, randomized clinical trials, and comparative series have found reductions in operative times, blood loss, and pulmonary complication with the transhiatal approach.[4-6] Other studies have challenged the pulmonary and morbidity benefits of omitting thoracic incisions.[7-9] All the while, similar oncologic efficacy has been suggested by results of large databases, randomized clinical trials, and case series.[10-12]

We hypothesized that avoiding the use of thoracic incisions would reduce the pulmonary and overall morbidity associated with THE compared with the Ivor Lewis or McKeown technique. We tested this hypothesis in a large nationwide database designed for surgical outcomes research.

Methods

Data Source and Population

We analyzed the American College of Surgeons National Surgical Quality Improvement Project (ACS NSQIP) data from 2005 through 2010. Briefly, the ACS NSQIP database is a nationwide quality improvement and surgical outcomes research effort on behalf of the ACS. In 2005 only 121 sites submitted cases, but by 2010 participation had increased to 258 institutions. For randomly selected surgical patients, the database collects 135 clinical data points, including preoperative comorbid conditions, intraoperative variables, and 30-day postoperative morbidity and mortality outcomes. Information is limited to the index admission. Specially trained nurses record the data, which are audited semiannually. The database is deidentified by stripping any information that might permit identification of patients or center, so this study was exempt from the institutional review board process. The ACS NSQIP and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

All patients who underwent esophagectomy as their primary procedure were identified by the *Current Procedural Terminology* codes (eTable in the Supplement). To obtain a population of patients undergoing elective surgery for primary disease, we excluded patients in the following categories: (1) emergency surgery, (2) resection without reconstruction, (3) disseminated cancer, and (4) resection for secondary esophageal disease (eg, hypopharyngeal cancer and laryngeal stenosis) (eTable in the Supplement). Patients who underwent THE without a thoracic incision, as identified by procedure codes, were designated as the control group. Patients who underwent esophagectomy performed with the Ivor Lewis (right thoracic and abdominal incisions) or McKeown (right thoracic, abdominal, and cervical incisions) techniques were designated as the THORACIC group. If the *Current Procedural Terminology* code was ambiguous regarding thoracic incision or a thoracic incision was optional, the case was excluded.

Data and Outcomes

Standard demographic data were examined. We also examined the following comorbid conditions for significant associations and potential confounding: (1) age, (2) diabetes mellitus, (3) hypertension, (4) coronary artery disease (defined as any of the following: angina, myocardial infarction, or previous cardiac angioplasty or bypass surgery), (5) active pulmonary disease (pneumonia or severe chronic obstructive pulmonary disease), (6) smoking or alcohol abuse, (7) indication for surgery and presence of cancer, and (8) history of chemotherapy or radiotherapy. Thoracic-specific outcomes, such as pneumothorax, hemothorax, or chylothorax, are not collected for the ACS NSQIP database. The perioperative transfusion of at least 2 U of packed red blood cells was assessed as a potential confounder.

The primary outcome was pulmonary morbidity (ie, pneumonia, ventilator required for >48 hours, or reintubation). The secondary outcomes were mortality, overall morbidity, surgical site infections, cardiac events (ie, cardiac arrest and myocardial infarction), thromboembolism (deep vein thrombosis or pulmonary embolus), and septic shock. Outcomes were chosen based on likely association with the variable of interest: the use of thoracic incisions.

Statistical Analysis

Mean and median values were used to describe continuous data, with discrete variables displayed as frequencies. For bivariable analyses, Mann-Whitney tests were used to compare continuous data, and Fisher exact or χ^2 tests were used for categorical variables. Multivariable regression analysis was used to control for differences between groups in bivariable analysis ($P < .20$) and known confounders of postoperative morbidity: age, active smoking, American Society of Anesthesiologists (ASA) classification of at least 3, diabetes, hypertension, and preoperative weight loss of 10% or more. To determine whether complex reconstructions may have influenced any results, a sensitivity analysis was performed after removing patients whose operations involved nongastric (colonic or small-bowel) conduits. We decided a priori on a secondary analysis comparing Ivor Lewis with McKeown esophagectomies to parse out any possible effects of the anastomotic location (neck vs thorax). All statistical analyses were performed with Stata SE software (version 12; StataCorp).

Results

Population Characteristics

There were 2092 esophagectomies in the ACS NSQIP database from 2005 through 2010. Excluded from analysis were pa-

Table 1. Description of Study Sample

Characteristic	Patients, No. (%)[a] THE Group	Patients, No. (%)[a] THORACIC Group	*P* Value
Age, mean (SE), y	64 (11)	62 (11)	<.001[b]
Male sex	579 (80.8)	684 (80.4)	.90
Body mass index ≤18.5[c]	28 (3.9)	39 (4.6)	.51
Smoking	175 (24.4)	225 (26.4)	.36
Alcohol abuse	29 (4.0)	53 (6.2)	.053
Cancer	624 (87.0)	774 (91.0)	.01[b]
Esophageal	424 (59.1)	491 (57.7)	.57
Gastric	196 (27.3)	275 (32.3)	.03[b]
Comorbid condition			
Radiotherapy	207 (28.9)	251 (29.5)	.79
Chemotherapy	58 (8.1)	61 (7.2)	.49
Exertional dyspnea	78 (10.9)	87 (10.2)	.16
COPD	45 (6.3)	56 (6.6)	.81
Previous coronary stent	65 (9.1)	70 (8.2)	.56
Previous cardiac bypass	57 (7.9)	52 (6.1)	.15
Hypertension	387 (54.0)	419 (49.2)	.06
Diabetes mellitus	114 (15.9)	95 (11.2)	.02[b]
Weight loss >10%	132 (18.4)	193 (22.7)	.04[b]
ASA class ≥3	542 (75.6)	661 (77.7)	.33
Operative time, mean, min	303	399	<.001[b]
Procedure			
Ivor Lewis	...	487 (57.2)	.77
McKeown	...	364 (42.8)	
Nongastric conduit	38 (5.3)	48 (5.6)	
≥2 U RBCs transfused	254 (35.4)	375 (44.1)	.001[b]

Abbreviations: ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease; RBCs, red blood cells; THE, transhiatal esophagectomy; THORACIC, Ivor Lewis and McKeown esophagectomies.

[a] Unless otherwise indicated, data represent number (percentage) of patients. The THE group (no thoracic incision) included 717 patients (46%) and the THORACIC group (thoracic incision), 851 patients (54%).

[b] Significant difference between groups ($P < .05$).

[c] Calculated as weight in kilograms divided by height in meters squared.

tients in whom reconstruction was not performed (380 patients [18.2%]), whose procedure was designated as "emergency" by surgeon or anesthesiologist (55 patients [2.6%]), or who had metastatic cancer (61 patients [2.9%]) or a diagnosis other than primary gastroesophageal disease (28 patients [1.3%]). The final study population included 1568 patients, 717 (45.7%) in the THE and 851 (54.3%) in the THORACIC group; the latter group comprised 487 (57.2%) who underwent Ivor Lewis and 364 (42.8%) who underwent McKeown procedures.

The study population overall was predominantly male (80.5%) and white (81.6%), with a median age of 62.9 years. The most common comorbid conditions were hypertension and diabetes, present in 51.4% and 13.3%, respectively. Radiotherapy and chemotherapy had been given previously in 29.2% and 7.6% of patients, respectively. Cancer was the diagnosis in most patients (89.2%); two-thirds of tumors were esophageal and one-third gastric. In this population, 61.3% of patients had at least 1 comorbid condition and 76.7% had an ASA score of at least 3. The mean operative time was 355 minutes (5.9 hours). Complex reconstruction with a nongastric conduit was required in 86 patients (5.5%) and 629 patients (40.1%) required transfusion of at least 2 U of packed red blood cells.

Compared with the THE group, the THORACIC group was younger (mean age, 62 vs 64 years; $P < .001$). Cancer was marginally more common in the THORACIC group (91.0% vs 87.0%; $P = .01$), mainly owing to a higher proportion of gastric cancer (32.3% vs 27.3%; $P = .03$); rates of esophageal cancer were similar in both groups. The proportions of patients who received preoperative radiotherapy and neoadjuvant chemotherapy were similar in both groups, as were the rates of exertional dyspnea, chronic lung disease, and coronary artery disease, but fewer patients in the THORACIC group were diabetics (11.2% vs 15.9%; $P = .02$). Preoperative weight loss was more common in the THORACIC group (22.7% vs 18.4%; $P = .04$) (**Table 1**). Overall, the distribution of ASA score and the proportions of patients with an ASA score of at least 3 were similar between groups. Operations in the THORACIC group were substantially longer than in the THE group (399 vs 303 minutes; $P < .001$). Complex reconstruction cannot account for this difference because the use of a nongastric conduit did not differ between groups. However, more patients in the THORACIC group required transfusion of at least 2 U of packed red blood cells (44.1% vs 35.4%; $P = .001$).

Outcomes

The overall mortality was 3.3% and the overall morbidity rate was 49.2%, with no significant difference between groups (**Table 2**). This was confirmed at multivariable analysis (**Table 3**). The most common complications were pulmonary, specifically pneumonia (17.1%), prolonged mechanical ventilation (18.3%), and reintubation (16.2%). Although the rates of prolonged mechanical ventilation and reintubation were similar in both groups, more patients in the THORACIC group had post-

Table 2. Outcomes After Esophagectomy

Outcome	Patients, %[a] THE Group	THORACIC Group	*P* Value
Death	21 (2.9)	31 (3.6)	.43
Any morbidity	354 (49.4)	417 (49.0)	.88
Pneumonia	107 (14.9)	162 (19.0)	.03[b]
Reintubation	111 (15.5)	143 (16.8)	.48
Ventilator dependence	106 (14.8)	154 (18.1)	.08
Superficial site infection	94 (13.1)	86 (10.1)	.06
Organ-space infection	42 (5.9)	55 (6.5)	.62
Cardiac	20 (2.8)	29 (3.4)	.48
Thromboembolism	46 (6.4)	58 (6.8)	.75
Septic shock	48 (6.7)	96 (11.3)	.002[b]
Length of stay, mean, d	15.6	17.2	.009[b]

Abbreviations: THE, transhiatal esophagectomy; THORACIC, Ivor Lewis and McKeown esophagectomies.

[a] Data represent percentages unless otherwise indicated. The THE group (no thoracic incision) included 717 patients (46%), and the THORACIC group (thoracic incision), 851 patients (54%).

[b] Significant difference between groups ($P < .05$).

operative pneumonia (19.0% vs 14.9%; *P* = .03) (Table 2). At multivariable analysis, they had increased odds of both pneumonia (odds ratio [OR], 1.47; *P* = .007) and prolonged mechanical ventilation (OR, 1.35; *P* = .04) (Table 3).

Cardiac events were uncommon (3.1%) with similar rates in both groups. Venous thromboembolism was more common but also with similar rates; 6.6% of all patients experienced either deep vein thrombosis or pulmonary embolus. The rates of deep and organ-space surgical site infections were also similar between groups. The THORACIC group had a slightly lower rate of superficial wound infections (10.1% vs 13.1%), but this difference was not statistically significant (*P* = .06) (Table 2). At multivariable analysis, the THORACIC group did not have increased odds of cardiac, thromboembolic, or wound complications (Table 3).

Septic shock, marked by hemodynamic instability, occurred more frequently in the THORACIC group (11.3% vs 6.7%; *P* = .002) despite equal rates of sepsis (Table 2). Even after multivariable adjustment, the THORACIC group had increased odds of septic shock (OR, 1.86; *P* = .001) (Table 3) and a significantly longer mean hospital stay (17.2 vs 15.6 days; *P* = .009) (Table 2).

Sensitivity and Subgroup Analyses

We conducted a sensitivity analysis after eliminating the 80 patients whose procedures were potentially the most complicated, including esophagectomies and reconstructions with colon or small bowel. The results were similar to those in the entire population. In this analysis, the morbidity and mortality rates in the THE and THORACIC groups were similar to each other and to those in the complete study sample. The odds of pneumonia were still increased in the THORACIC group (OR, 1.46; *P* = .01), the odds of prolonged mechanical ventilation were attenuated (OR, 1.28; *P* = .10), and the odds of septic shock were diminished but still considerable (OR, 1.77; *P* = .01).

Furthermore, the 487 patients who underwent Ivor Lewis esophagectomy were compared with the 364 who underwent McKeown esophagectomy in a secondary analysis. Age, demographic characteristics, and comorbid conditions were similar in both groups, with few exceptions. Cancer diagnoses were equally common, but the Ivor Lewis group had more gastric cancers (35.7% vs 27.7%; *P* = .004) and fewer esophageal cancers (53.6% vs 63.2%; *P* = .02) than the McKeown group. Hypertension was also more common (54.0% vs 42.9%; *P* = .001) in the Ivor Lewis group. As to postoperative morbidity, patients in the McKeown group had more superficial surgical site infections (8.0% vs 12.9%; *P* = .02) with a higher adjusted odds for this complication (OR, 1.71 [95% CI, 1.1-2.7]; *P* = .02). Despite higher rates of superficial surgical site infections, the McKeown group did not have higher odds of septic shock (OR, 84; *P* = .47). Pulmonary, cardiac, thromboembolic, and septic complication rates did not differ between groups.

Discussion

Improvements in perioperative care and surgical techniques, combined with concentration of care in high-volume centers, have improved outcomes and increased the numbers of esophagectomies performed.[13] Despite these advances, esophagectomy remains a complex procedure; mean operative times exceeded 6 hours. This complexity is manifested by a 49.2% clinical morbidity rate but low mortality (3.3%). Our data are consistent with those of other large data sets and single-institution studies, lending external validity to our study and data set.[14,15] Our definition of morbidity includes both major complications (sepsis) and minor complications (superficial surgical site infections); others have reported major complications in 24% of esophagectomies.[16] Perioperative interventions and technical modifications to ameliorate outcomes present fruitful grounds for research.

Pulmonary complications are the most common complications after esophagectomy.[17] This study and others have shown rates of pneumonia, prolonged mechanical ventilation, and reintubation above 15%.[2,18,19] The effect of pulmonary complications on outcomes after esophagectomy cannot be overemphasized; they account for up to 64% of hospital deaths.[15,20-22] To reduce morbidity rates for esophagectomy, THE was developed as an alternative to the Ivor Lewis and McKeown techniques. Our study provides a description of esophagectomies performed in the United States. Of the 1568

Table 3. Adjusted Odds of Morbidity Due to Thoracic Incisions

Characteristic	Adjusted Odds Ratio (95% CI)[a]	P Value
Death	1.6 (0.9-2.8)	.14
Any morbidity	1.1 (0.9-1.3)	.45
Pneumonia	1.47 (1.1-1.9)	.007[b]
Reintubation	1.1 (0.9-1.5)	.36
Ventilator dependence	1.35 (1.02-1.8)	.04[b]
Surgical site infection	0.9 (0.7-1.1)	.36
Cardiac arrest	1.5 (0.7-3.1)	.28
Myocardial infarction	1.8 (0.7-5.1)	.24
Septic shock	1.86 (1.3-2.7)	.001[b]

[a] Odds ratios represent increased odds in the THORACIC (Ivor Lewis and McKeown esophagectomies) surgical group (ie, for thoracic incisions) and were adjusted for age, smoking status, history of chronic obstructive pulmonary disease, hypertension, diabetes mellitus, American Society of Anesthesiologists class ≥3, diagnosis of cancer, and preoperative weight loss.

[b] Significant at $P < .05$.

procedures analyzed, nearly half (45.7%) were THE, and the balance were split almost equally between Ivor Lewis (57.2%) and McKeown (42.8%) techniques. There is no apparent consensus on the optimal approach, and our data demonstrate the variations in current practice. We used the NSQIP database to contribute to the ongoing discussion of the purported perioperative benefits of THE compared with THORACIC esophagectomies.

In our study we found 35% increased odds of ventilator dependence for more than 48 hours and 47% increased odds of pneumonia in the THORACIC group, which also had 86% higher odds of septic shock despite no other differences in surgical infections. The cause of septic shock cannot be ascertained, but the increased rates of pneumonia in these patients would provide a plausible explanation. Rentz et al[23] studied 945 patients undergoing esophagectomy in the Veterans Affairs system and found that pneumonia was significantly more common in those undergoing transthoracic esophagectomy (26% vs 18% for THE; $P < .007$). This benefit has been further championed by Hulscher et al[4,5] using data from esophagectomies in Europe.

In addition to using multivariable analysis to control for possible confounders, we performed a sensitivity analysis after removing the most complex procedures, those involving nongastric conduit reconstruction. The THE and THORACIC groups had similar rates of complex reconstruction, and removing these patients from the analysis did not change results significantly. Patients in the THORACIC group remained at elevated risk for pneumonia and septic shock.

There is some suggestion that anastomotic leak is more common after cervical anastomoses performed during THE.[9] McKeown procedures use the same thoracic approach as Ivor Lewis procedures but instead site the anastomosis in the neck. We therefore compared outcomes of these procedures in a secondary analysis to identify any effects on surgical infections, sepsis, or septic shock related to the anastomosis site, keeping the use of thoracic incision constant. Rates of organ-space infections and septic complications were similar in these groups, suggesting that rates of anastomotic leakage were also similar.

Avoiding pulmonary morbidity should only be one consideration in choosing a surgical approach to esophagectomy. The approach may be dictated by the disease treated, its biologic mechanism, or surgeon preference. In our data set, however, the surgical diagnosis did not seem to influence the choice of operative technique. Esophageal cancer was equally frequent in both groups. Although it was statistically significant, the small difference in the use of THE (27.3%) vs thoracic incision (32.3%) for gastric cancers is unlikely to represent a strong clinical bias favoring THE for this diagnosis. Despite controversy regarding the oncologic equivalence of THE and THORACIC approaches, studies have demonstrated similar 5-year survival rates for both.[10,24] In evaluating these data, it is clear that many surgeons do not shy away from using THE in patients with cancer. The extent of disease and the presence of nodal disease may affect the chosen technique, but this could not be ascertained from our data. Although these and other patient factors may help determine the choice of procedure, the apparent variations in current practice suggest that surgeon preference may also play a prominent role. We propose that the pulmonary benefits of THE exhibited in our data are significant and should influence the selection of surgical technique.

Some of the limitations of this study arise from the nature of the database and the potential for selection bias. In this data set, center-level information was not released, obviating hierarchical modeling. This surgical data set inherently obscures the preoperative decision-making and risk-stratification process, leading to the potential for selection bias. Certainly medically unfit patients and those simply deemed "too high risk" for surgery have not entered into this population. However, 61.3% of this population did have at least 1 comorbid condition, and 76.7% had an ASA class of at least 3, suggesting that selection did not lead to inclusion of only the healthiest patients. Because most patients underwent surgery for cancer, the absence of staging data might be a limitation. The study sample shows very different rates for radiotherapy vs chemotherapy, which might not seem consistent with the usual pattern of neoadjuvant chemoradiotherapy for esophageal cancer. This is explained by the way this information is collected. Only chemotherapy received within 30 days is considered, when radiotherapy within 90 days is recorded. The patients who received radiotherapy may also have received chemotherapy, but this would not be captured if interval surgery allowed adequate delay to maximize radiation effect and allow for washout of chemotherapy. However, we attempted to limit the impact of differences in stage by excluding patients with disseminated cancer. Similarly, exclusion of patients who underwent surgery without reconstruction or emergency surgery helped establish groups that were stable for comparison.

In our data set, we were unable to distinguish between minimally invasive esophagectomy and conventional approaches. Theoretically, the use of thoracoscopic surgery could reduce the pulmonary morbidity rate for transthoracic techniques. Bakhos et al[25] showed that pleural effusions (P = .02) and pneumonia (P = .01) were significantly reduced with the minimally invasive approach. However, data from an experienced center shows a 26.7% rate of pneumonia after minimally invasive Ivor-Lewis, similar and slightly higher than what we see in our potentially mixed, minimally invasive, and conventional open THORACIC esophagectomies.[6,26,27] Currently, however, the proportion of minimally invasive esophagectomies is probably small—16% by one estimate[27]—thereby decreasing the effect of this potential confounder on our data.

In conclusion, THE presents an oncologically sound alternative to transthoracic techniques for esophagectomy. Current practice patterns exhibit no bias toward a specific approach. Regardless of age or comorbid conditions, patients who underwent THE were less likely to suffer pneumonia, prolonged mechanical ventilation, or septic shock. The substantial pulmonary morbidity associated with esophagectomies might be averted by avoiding thoracic incisions.

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Acquisition of data: Bhayani.
Analysis and interpretation of data: Bhayani, Gupta, and Reavis.
Drafting of the manuscript: Bhayani, Gupta, Dunst, Kurian, and Swanström.
Critical revision of the manuscript for important intellectual content: Gupta, Dunst, Kurian, Reavis, and Swanström.
Statistical analysis: Bhayani, Gupta, and Kurian.
Administrative, technical, and material support: Bhayani.
Study supervision: Bhayani, Gupta, Dunst, Reavis, and Swanström.

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Invited Commentary

Incisions and Esophagectomy
Is Surgical Approach All That Matters?

Andrew C. Chang, MD

A variety of issues relating to the performance of esophagectomy have been fodder for lively discussion among thoracic surgical oncologists. These debates have focused largely on the effect on surgical outcomes of differences in operative technique (method of anastomosis or conduit choice for esophageal reconstruction) or approach (resection with or without thoracotomy, minimally invasive, or open).

Bhayani and colleagues,[1] reporting in this issue, abstracted data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) to address whether perioperative outcomes differ between patients undergoing transthoracic or transhiatal esophagectomy. In this study of 1568 patients for whom the surgical approach could be determined, transthoracic approaches were associated with increased rates of pulmonary complications and sepsis, but overall 30-day mortality and complication rates were similar in both cohorts. Within the transthoracic esophagectomy cohort, the authors also concluded that anastomotic leak rates did not differ between cervical and thoracic esophagogastric anastomoses. Because such procedure-specific complications were not monitored within the ACS NSQIP database, sepsis and organ-space infection were used as markers for this complication.

Related article page 733

The ACS NSQIP database is upheld justly as a paragon for assessing risk-adjusted short-term surgical outcomes and is representative of both academic and private sector health systems,[2] but this database captures only a fraction of major operations performed annually in the United States.[3] Missing values within this prospective clinical database can lead to inaccurate estimation of risk-adjusted outcomes,[4] particularly in smaller data sets with sample sizes ranging from 3000 or fewer to 15 000.[5] Although patients undergoing high-risk operations such as esophagectomy are less likely to have missing data,[4] the present study indicates a disparity between the rates of radiotherapy (29%) and chemotherapy (8%), which suggests that other unidentified but important patient-level variables may have been recorded incompletely.

As in findings from other studies using broadly collected databases, administrative or clinical, the association between thoracotomy and increased perioperative complication rates probably indicates the presence of unidentified factors for which the surgical approach is at best a surrogate. This study underscores the need for further collaborative efforts to collect, share, and analyze patient-specific and systems-related data and identify the salient adverse risk factors associated with worse outcomes after esophagectomy.

ARTICLE INFORMATION

Author Affiliation: Section of Thoracic Surgery, Department of Surgery, University of Michigan Health System, Ann Arbor.

Corresponding Author: Andrew C. Chang, MD, Section of Thoracic Surgery, Department of Surgery, University of Michigan Health System, TC2120, Mail Stop 5344, 1500 E Medical Center Dr, Ann Arbor, MI 48109-5344 (andrwchg@umich.edu).

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