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# Surgeon specialty does not influence outcomes of hiatal hernia repair

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ABSTRACT

*Background:* Hiatal hernia repair is commonly performed by both general and thoracic surgeons. The present study examined differences in approach, setting, and outcomes by specialty for hiatal hernia repair.

*Methods:* Adults undergoing hiatal hernia repair were identified in the 2012–2019 American College of Surgeons National Surgical Quality Improvement Program. Patients were grouped by specialty of the operating surgeon (thoracic surgery vs general surgery). Generalized linear models were used to evaluate the effect of specialty on mortality, major morbidity, and 30-day readmission.

*Results:* Among 46,739 patients, 5.0% were operated on by thoracic surgery. General surgery operated on younger patients (44.7 years vs 47.0, $P < .001$) with lesser systemic illness (American Society of Anesthesiologists class $\geq 3$ 50.4% vs 54.8%, $P < .001$) compared to thoracic surgery. General surgery more commonly used laparoscopy (95.0% vs 82.6%) and less commonly used thoracic approaches than thoracic surgery (0.6% vs 8.5%, $P < .001$). From 2012 to 2019, the proportion of cases performed as an outpatient by general surgery increased (28.1% to 46.4%, $P < .001$), but it remained stable for thoracic surgery (0.1% to 0.7%, $P = .10$). After risk adjustment, thoracic surgery specialty was not associated with mortality (odds ratio 0.9, 95% confidence interval 0.5–1.5), major morbidity (0.9, 95% confidence interval 0.7–1.1), or readmission (0.9, 95% confidence interval 0.8–1.1). Rather, factors including surgical approach (laparotomy 1.6, 95% confidence interval 1.4–1.9; thoracoscopy/thoracotomy 2.0, 95% confidence interval 1.5–2.7), inpatient case status (2.4, 95% confidence interval 2.2–2.7), increasing ASA class, and functional status more strongly influenced major morbidity.

*Conclusion:* Operative factors, surgical approach, and patient comorbidities more strongly influence outcomes of hiatal hernia repair than does surgeon specialty, suggesting continued safety of hiatal hernia repair by both thoracic and general surgeons.



## Introduction

Hiatal hernia is a complex disease process for which surgery remains the mainstay of therapy. The surgical approach to hiatal hernia repair (HHR) has developed over time to include a vast array of techniques. The goals of such procedures have evolved from simple mechanical reduction and hiatal closure to true restoration of gastroesophageal physiology.[1] Commonly employed procedures for HHR use either a transabdominal or transthoracic approach. At the same time, residency training in general surgery has transitioned to include a greater emphasis on minimally invasive techniques for common procedures.[2] Complex foregut surgery, however, may still require further subspecialty training in dedicated minimally invasive or thoracic surgical fellowships.[3,4]

A body of existing literature has described the impact of surgeon subspecialty training on postoperative outcomes.[5,6] Hannan et al showed a reduction in adverse outcomes after carotid endarterectomy if performed by a vascular rather than general or neurological surgeons.[7] Similarly, Tu et al demonstrated a dramatic reduction in the mortality associated with repair of abdominal aortic aneurysms if performed by vascular or cardiac surgeons compared to general surgeons.[8] Yet financial factors and concerns for limited health care access across the United States have hampered efforts in streamlining surgical referrals exclusively to expert centers and specialty trained surgeons.[9]

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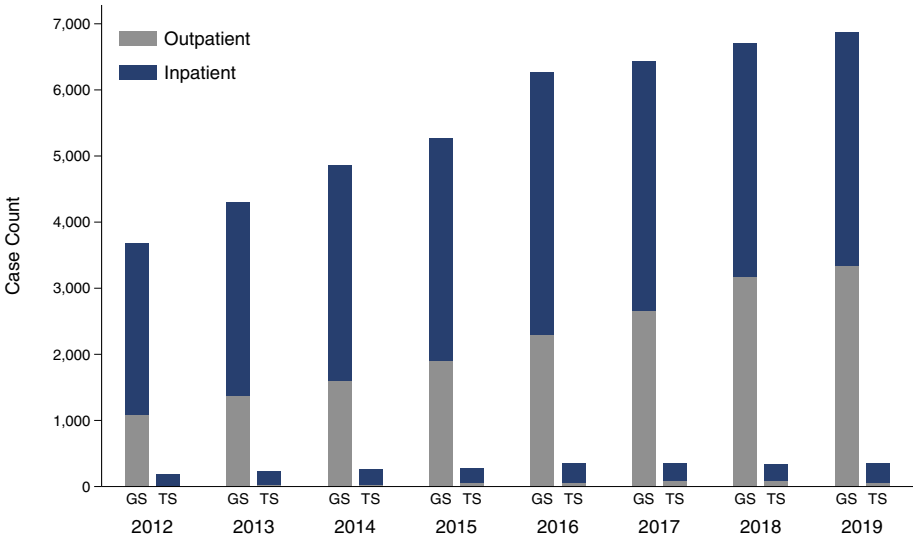


**Figure 1.** Trends in hiatal hernia repair by operative setting. A small proportion of cases by TS were performed as outpatient, while a significant proportion of GS cases were performed as outpatient relative to inpatient.

Given the nuances in selection and operative management of hiatal hernias, the present national study characterized trends in HHR based on type of approach as well as specialty of the operating surgeon. We hypothesized that outcomes were driven primarily by patient and operative characteristics, rather than the specialty of the operating surgeon.

## Methods

### *Data source and study population*

The present study was a retrospective cohort study using the 2012 to 2019 National Surgical Quality Improvement Program (NSQIP) essential participant use files.[10] A national effort led by the American College of Surgeons (ACS), NSQIP collects data from more than 700 participating hospitals in order to assess and improve the quality of surgical care. 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. As NSQIP data are distributed in a deidentified format, this study was deemed exempt from full review by the Institutional Review Board at the University of California, Los Angeles.

All adults who undergoing surgical repair of hiatal hernia were identified using relevant Current Procedural Terminology (CPT) codes (Supplementary Table S1). Records missing data regarding survival, age, sex, and urgency or setting of the operation were excluded from further analysis (880, 1.7% of initial cohort). Patients were then divided into 2 groups based on whether the operation was performed by thoracic surgeon (TS) or general surgeon (GS) using the NSQIP surgeon specialty identifier.

### *Variable definitions and outcome measures*

Variables were defined according to the NSQIP Data Dictionary and included age, sex, race, functional status, hospital setting (outpatient or inpatient), and case urgency.[10] Clinical status was assessed using the American Society of Anesthesiologists (ASA) physical status score. Medical comorbidities and risk factors included congestive heart failure, hypertension, chronic obstructive pulmonary disease, diabetes, renal disease, and bleeding disorders as reported by the NSQIP. Surgical approach was classified into laparoscopy, laparotomy, and thoracoscopy/thoracotomy based on CPT codes. Indications for hiatal hernia repair were classified into gastroesophageal reflux disease (GERD) or Barrett's esophagus, uncomplicated hiatal hernia, complicated hiatal hernia (presence of obstruction or gangrene), or other using the postoperative diagnosis field reported by the NSQIP.

The ACS NSQIP includes postoperative outcomes up to 30 days after surgery. We defined major complications in accordance with the ACS NSQIP risk calculator.[11] Briefly, major complications included cardiac arrest, myocardial infarction, pneumonia, progressive renal insufficiency, acute renal failure, pulmonary embolism, deep vein thrombosis, reoperation, deep incisional surgical site infection, organ space surgical site infection, sepsis, unplanned intubation, urinary tract infection, or wound disruption.

The primary outcomes of the study were 30-day mortality or major morbidity. We secondarily examined differences in operative time as well as hospital length of stay by surgical specialty.

### *Statistical analysis*

Descriptive data were reported as frequency and percentage for categorical variables, while continuous variables reported as mean and standard deviation or median and interquartile range if non-normally distributed. Trends in hiatal hernia repair by specialty and operative setting over the study period were assessed using a nonparametric test for trend.[12] Differences in patient characteristics and unadjusted outcomes were examined using the $\chi^2$ test for categorical variables, and unpaired *t* test or rank sum test for continuous variables.

We used generalized linear models to test for independent association of surgical specialty with outcomes of interest after adjusting for patient and operative factors. Covariate selection was guided by the least absolute shrinkage and selection operator (LASSO), a regression technique that minimizes collinearity and overfitting.[13] Given the right-skewed distribution of length of stay and operative time, these models were fit using a gamma error distribution with log-link. Regression estimates are reported as odds ratio or transformed beta-coefficient with 95% confidence interval (CI). Statistical analysis was using Stata version 16.0 (StataCorp LLC, College Station, TX).

**Table I**
Characteristics of patients undergoing hiatal hernia repair stratified by operating surgeon specialty

| | GS (n = 44,392) | TS (n = 2,347) | P value |
|---|---|---|---|
| Age, years (mean, SD) | 44.7 (12.6) | 47.0 (11.7) | <.001 |
| Female | 31,632 (71.3) | 1,580 (67.3) | <.001 |
| Race | | | |
| White | 38,578 (86.9) | 1,866 (79.5) | <.001 |
| Black | 2,385 (5.4) | 66 (2.8) | |
| Asian or Pacific Islander | 372 (0.8) | 14 (0.6) | |
| Other* | 3,057 (6.9) | 401 (17.1) | |
| Site | | | <.001 |
| Outpatient | 17,442 (39.3) | 411 (17.5) | |
| Inpatient | 26,950 (60.7) | 1,936 (82.5) | |
| Elective case | 40,919 (92.2) | 2,151 (91.7) | .35 |
| Emergency case | 965 (2.2) | 46 (2.0) | .49 |
| Approach | | | <.001 |
| Laparoscopic | 42,175 (95.0) | 1,939 (82.6) | |
| Laparotomy | 1,967 (4.4) | 209 (8.9) | |
| Thoracoscopy or thoracotomy | 250 (0.6) | 199 (8.5) | |
| Mesh use | 11,493 (25.9) | 384 (16.4) | <.001 |
| Diagnosis | | | <.001 |
| GERD or Barrett's esophagus | 11,137 (25.1) | 443 (18.9) | |
| Complicated hernia | 3,592 (8.1) | 239 (10.2) | |
| Uncomplicated hernia | 25,683 (57.9) | 1,428 (60.8) | |
| Other or unspecified | 3,980 (9.0) | 237 (10.1) | |
| ASA class | | | <.001 |
| 1 | 568 (1.3) | 21 (0.9) | |
| 2 | 21,446 (48.3) | 1,041 (44.4) | |
| 3 | 21,256 (47.9) | 1,203 (51.3) | |
| 4 | 1,112 (2.5) | 80 (3.4) | |
| 5 | 10 (0.02) | 2 (0.09) | |
| Functional status | | | .42 |
| Independent | 43,737 (98.5) | 2,305 (98.2) | |
| Partial dependence | 561 (1.3) | 37 (1.6) | |
| Totally dependence | 94 (0.2) | 5 (0.2) | |
| BMI, kg/m$^2$ | | | <.001 |
| <25 | 7,218 (16.0) | 437 (18.6) | |
| 25–29.9 | 15,438 (34.8) | 880 (37.5) | |
| 30–34.9 | 12,852 (29.0) | 670 (28.6) | |
| ≥35 | 8,884 (20.0) | 360 (15.3) | |
| Comorbidities | | | |
| Bleeding disorder | 875 (2.0) | 44 (1.9) | .74 |
| CHF | 190 (0.4) | 14 (0.6) | .23 |
| COPD | 2,481 (5.6) | 177 (7.5) | <.001 |
| Diabetes | | | .001 |
| Nondiabetic | 39,983 (90.1) | 2,137 (91.1) | |
| Diabetes, not requiring insulin | 3,339 (7.5) | 136 (5.8) | |
| Diabetes, requiring insulin | 1,070 (2.4) | 74 (3.2) | |
| Dyspnea | 5,116 (11.5) | 385 (16.4) | |
| Hypertension | 21,892 (49.3) | 1,159 (49.4) | .95 |
| Renal disease | 68 (0.2) | 7 (0.3) | .09 |
| Steroid use | 2,004 (4.5) | 136 (5.8) | .004 |

Variables are reported as count and percentage, except age (mean and standard deviation).
*Other race includes American Indian, Alaska native, unknown, or not reported.
*ASA*, American Society of Anesthesiologists; *BMI*, body mass index; *CHF*, congestive heart failure; *COPD*, chronic obstructive pulmonary disease; *GERD*, gastroesophageal reflux disease.

## Results

### *Trends in hiatal hernia repair by surgical specialty and setting*

Among the 46,739 patients meeting study criteria, 2,347 (5.0%) were operated on by TS. The overall proportion of cases performed by TS did not significantly change from 2012 to 2019 (4.9% to 4.8%). During the study period, the proportion of cases performed as an outpatient by GS increased (28.1% to 46.4%, $P < .001$), but it remained stable for TS (0.1% to 0.7%, $P = .10$, Figure 1). Despite an increase in utilization of laparoscopy for both, TS exhibited persistently lower rates (69.6% in 2012 to 86.1% in 2019, $P < .001$) for the use of this technique compared to GS (92.8% to 96.3%, $P < .001$).

### *Cohort characteristics*

Compared to TS, patients treated by GS were younger (44.7 years vs 47.0, $P < .001$) and had a lower severity of systemic illness (ASA class ≥3 50.4% vs 54.8%, $P < .001$). Operations performed by GS were more commonly for GERD or Barrett's esophagus (25.1% vs 18.9%) and less commonly for complicated hernias (8.1% vs 10.2%, $P < .001$) compared to TS. In addition, TS operated on a greater proportion of patients with chronic obstructive pulmonary disease (7.5% vs 5.6%, $P < .001$), insulin-dependent diabetes (3.2% vs 2.4%, $P < .001$), and corticosteroid use (5.8% vs 4.5%, $P = .004$). Relative to TS, GS performed more outpatient cases (39.3% vs 17.5%, $P < .001$) but a similar proportion of emergency operations (Table I). Operations were more commonly performed using laparoscopy by GS

**Table II**
Unadjusted outcomes following hiatal hernia repair stratified by operating surgeon specialty

| | GS (n = 48,233) | TS (n = 2,517) | P value |
|---|---|---|---|
| Mortality | 263 (0.6) | 19 (0.8) | .19 |
| Any major complication | 2,648 (6.0) | 171 (7.3) | <.001 |
| Specific complications | | | |
| Cardiac arrest or MI | 222 (0.5) | 17 (0.7) | .17 |
| DVT or PE | 353 (0.8) | 29 (1.2) | .02 |
| Unplanned reintubation | 395 (0.9) | 34 (1.5) | .006 |
| Pneumonia | 645 (1.5) | 37 (1.6) | .63 |
| Deep SSI | 27 (0.1) | 3 (0.1) | .21 |
| Organ space SSI | 298 (0.7) | 22 (0.9) | .13 |
| Wound dehiscence | 43 (0.1) | 3 (0.1) | .64 |
| Sepsis | 231 (0.5) | 20 (0.9) | .03 |
| Urinary tract infection | 426 (1.0) | 19 (0.8) | .47 |
| Renal complication | 138 (0.3) | 8 (0.3) | .80 |
| Reoperation | 1,136 (2.6) | 79 (3.4) | .02 |
| 30-day readmission | 2,534 (5.7) | 139 (5.9) | .68 |

*DVT*, deep vein thrombosis; *MI*, myocardial infarction; *PE*, pulmonary embolism; *SSI*, surgical site infection.

(95.0% vs 82.6%), while TS more commonly used thoracic approaches (8.5% vs 0.6%, $P < .001$). Mesh was more frequently used for repair by GS compared to TS (25.9% vs 16.4%, $P < .001$).

### *Unadjusted outcomes*

Unadjusted outcomes by specialty are presented in Table II. There were no significant differences in 30-day mortality for TS compared to GS (0.8% vs 0.6%, $P = .19$). Major complications were more common among patients undergoing operations performed by TS than by GS (7.3% vs 6.0%, $P < .001$). These were driven primarily by differences in unplanned reintubation, sepsis, and reoperations, which were more frequent in the TS group (Table II). While deep vein thrombosis or pulmonary embolism was more common among TS (1.2% vs 0.8%, $P = .02$), other systemic complications such as renal failure (0.3% vs 0.3%) and cardiovascular complications (0.7% vs 0.5%) were similar in both groups. Compared to GS, TS had greater unadjusted operative times (162 ± 83 minutes vs 135 ± 71.2 minutes, $P < .001$) and postoperative length of stay (1 day, IQR 1–2 vs 2 days, IQR 1–4, $P < .001$). Readmission rates at 30 days were similar in both groups (5.9% vs 5.7%, $P = .68$).

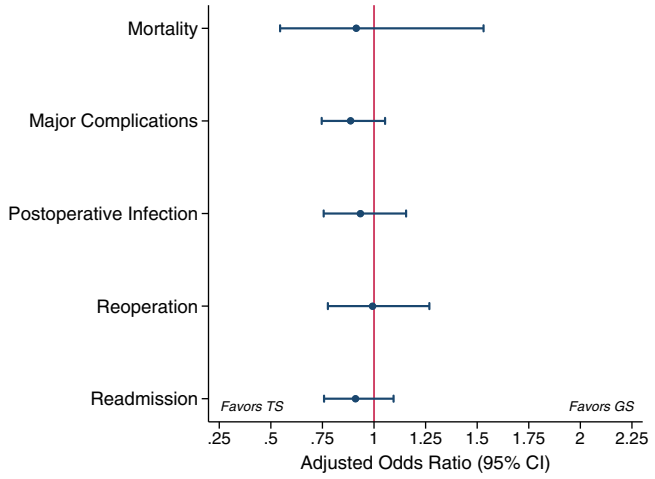


**Figure 2.** Impact of surgeon specialty on risk-adjusted outcomes following hiatal hernia repair. Adjusted odds ratio with 95% confidence interval (CI) reported for thoracic surgery relative to general surgery.

### *Impact of surgeon specialty on outcomes following hiatal hernia repair*

After adjustment for patient and operative factors, surgical specialty was not associated with mortality (adjusted odds ratio for TS 0.9, 95% CI 0.5–1.5) or major complications (Figure 2). Multivariable models demonstrated adequate discrimination (C-statistic for mortality and major complications 0.87 and 0.70, Figure 3A-B) and were appropriately calibrated (Figure 3, *C–D*). While risk-adjusted operative times were greater for TS by 18 minutes (95% CI 15–21 minutes), length of stay was similar ($\beta = 0.1$ days, 95% CI -0.1–0.3) relative to GS. Similarly, surgical specialty was also not associated with readmission (Figure 2).

### *Factors associated with mortality and major morbidity*

While surgical specialty was not associated differences in risk-adjusted outcomes following hiatal hernia repair, several key patient and operative factors influenced the risk of mortality or major complications. Notably, laparotomy was associated greater odds of mortality (1.8, 95% CI 1.3–2.5), while thoracoscopy or thoracotomy did not alter these odds (1.6, 95% CI 0.8–3.4) relative to laparoscopy. Similarly, both thoracic approaches and laparotomy were associated with major morbidity relative to laparoscopy (Figure 4). In addition, operations performed for complicated hernias were associated with greater morbidity compared to those performed for GERD or Barrett's esophagus, while indication did not influence odds of mortality. Several chronic medical conditions remained associated with increased odds of mortality and included congestive heart failure (2.7, 95% CI 1.5–4.9) and COPD (1.4, 95% CI 1.1–2.0). These conditions were also associated with increased odds of major morbidity (Figure 4). The severity of medical illness as well as functional status both strongly influenced adjusted odds of mortality and morbidity (Figure 4). Operative factors strongly impacted odds of mortality among patients undergoing hiatal hernia repair, including elective status (0.6, 95% CI 0.4–0.8) and inpatient cases (2.1, 95% CI 1.4–3.3), and similarly influenced odds of major morbidity (Figure 4). Additional procedures had no significant influence on mortality (0.9, 95% CI 0.7–1.2) or major morbidity (1.0, 95% CI 0.9–1.1) but were associated with greater readmission (1.1, 95% CI 1.0–1.2).

### *Sensitivity analysis examining outcomes by specialty for laparoscopic repairs*

As GS had a greater than 10-fold lower use of thoracic approaches, a sensitivity analysis examining outcomes by specialty for laparoscopic cases was performed. After risk adjustment, TS was not associated with mortality (1.3, 95% 0.7–2.2), major morbidity (0.9, 95% CI 0.8–1.1), reoperation (1.0, 95% CI 0.8–1.3), or readmission (0.9, 95% CI 0.8–1.1) relative to GS. Similar to the initial analysis, risk-adjusted operative times were 21 minutes (95% CI 18–24 minutes) longer for TS compared to GS, while LOS was not significantly different (0.1 days, 95% CI -0.1–0.3).

## Discussion

Hiatal hernia repair is a common yet complex procedure that is performed by both general and thoracic surgeons. Given the wide range of indications and operative techniques routinely employed in HHR, the present study of the ACS NSQIP sought to characterize the association of surgeon specialty with outcomes of hiatal hernia repair. We found that general surgeons have adopted outpatient HHR to a greater degree compared to thoracic surgeons over time and more frequently use laparoscopic approaches. In

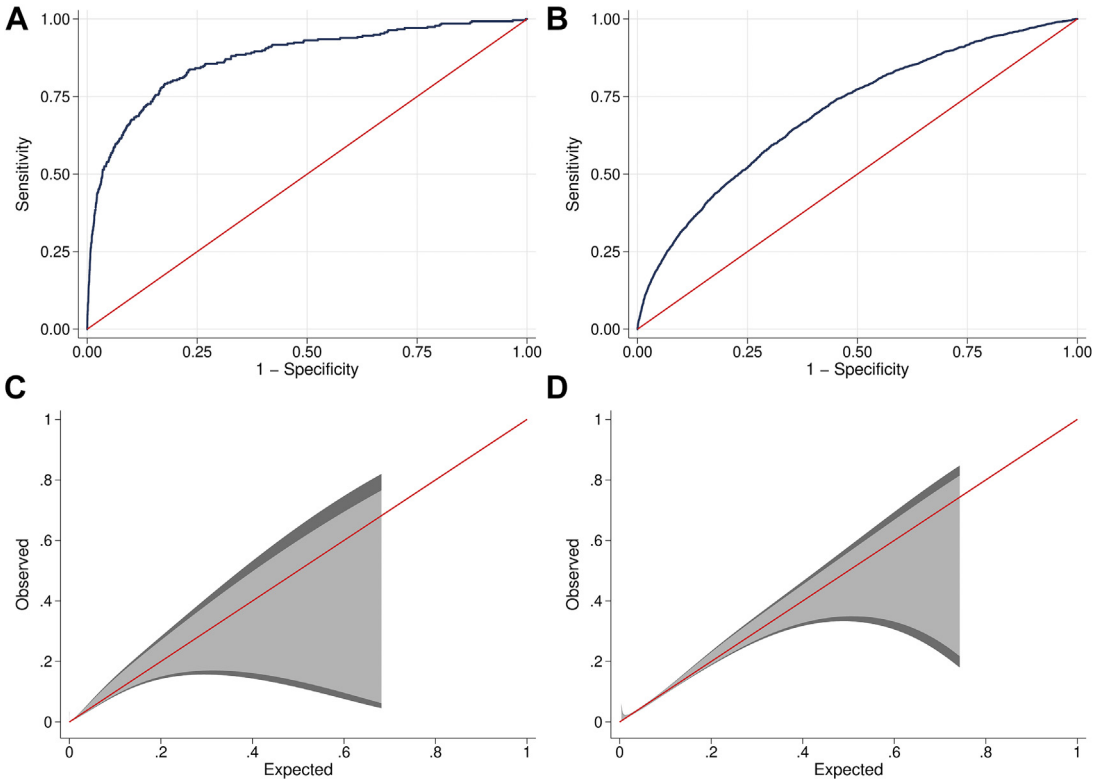


**Figure 3.** Evaluation of mortality and major complication model characteristics. Both mortality (A) and major complication (B) models demonstrated excellent discrimination. Assessment of goodness of fit or calibration of mortality (A) and major complication (B) models was evaluated by comparing outcome rates with estimated probabilities, with no significant deviation evident. Light gray and dark gray depict 80% and 95% confidence intervals, respectively.

addition, surgeon specialty was not associated with risk of mortality, complications, or readmissions after hiatal hernia repair. Importantly, outcomes were more strongly dictated by operative factors, such as indication, surgical approach, and patient comorbidities.

Over the past several decades, the surgical management of refractory gastroesophageal reflux disease has evolved significantly, with an increasing emphasis on early reduction and repair of hiatal hernias, as well as minimally invasive surgery.[14,15] Fenton et al compared the transthoracic approach (Belsey Mark IV) to a variety of transabdominal approaches over 16 years and found that, in general, both approaches are equally safe and effective.[16] However, general surgery training programs may not offer robust exposure to the transthoracic technique, leaving this approach more commonly used by surgeons with advanced training in thoracic surgery.[17] In our study, thoracic surgeons were noted to use a thoracic approach over 10 times more commonly than general surgeons. Yet the majority of hernia repairs performed among both groups were done via a laparoscopic, transabdominal approach. Nonetheless, there are clinical circumstances in which a transthoracic approach may be favorable, especially in patients with coexistent motility disorders, extreme obesity, previous intra-abdominal surgery, massive hernia, or in which other intrathoracic disease can be simultaneously treated.[18–20] As such, proficiency in both techniques continues to be warranted. NSQIP does not contain anatomic data to define the rationale for a specific surgical approach, including prior surgery. It is possible that patients operated on by one specialty may have been managed differently if treated by the alternate specialty. Nonetheless, our sensitivity analysis demonstrates similar outcomes for TS and GS when solely examining laparoscopic repairs.

Interestingly, only 5% of cases in our cohort were performed by thoracic surgeons. This may be due to a general lack of patient referrals to thoracic surgery for HHR, given the otherwise wide scope of practice of thoracic surgery. Additionally, a robust number of general surgeons specialize in minimally invasive abdominal surgery, many of whom focus on the surgical management of gastroesophageal reflux, which was the most common indication for HHR performed by general surgeons in our study.[2,21] Moreover, we found that thoracic surgeons appear to operate on older patients who have a higher degree of systemic illness as defined by ASA class. This same subset of patients was additionally noted to have a higher degree of systemic comorbidities such as COPD or insulin-dependent diabetes and a higher overall rate of routine corticosteroid use. These findings suggest that higher-risk patients are referred to thoracic surgeons at greater rates compared to their counterparts in general surgery. Not surprisingly, thoracic surgeons more commonly performed HHR on an inpatient basis or using an open approach via laparotomy or thoracic approach, while general surgeons more routinely deployed a minimally invasive laparoscopic approach. Notably, emergency operations were found to be performed equally by both specialties, suggesting that both specialties similarly contributed to the on-call care of these patients.

Regardless of surgeon specialty, we found no difference in the rates of major operative mortality or morbidity following HHR. In particular, operations by thoracic and general surgeons were associated with similar rates of perioperative renal failure, cardiovascular complications, and hospital readmissions. These findings suggest appropriate case selection by each specialty, leading to comparable outcomes following risk adjustment for patient and case mix. Schipper et al found that lung resections performed by thoracic and cardiac surgeons were associated with reduced

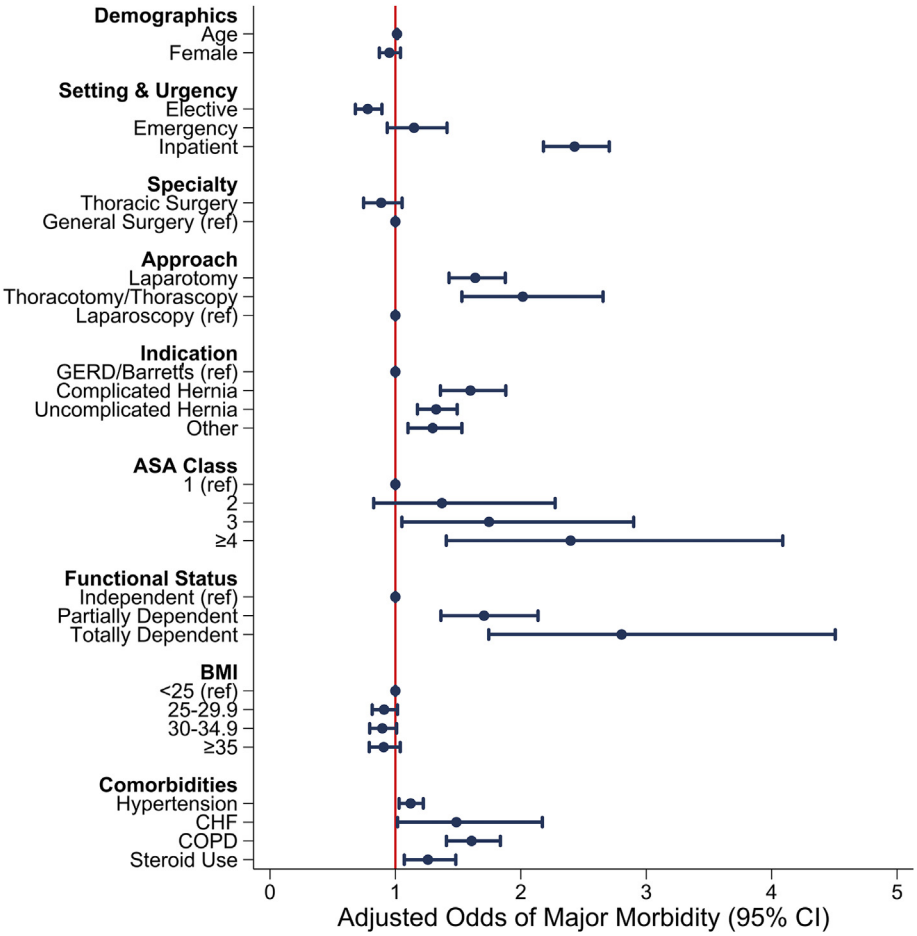


**Figure 4.** Factors associated with major morbidity following hiatal hernia repair. *ASA*, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure.

mortality and morbidity, but that these differences were more strongly related to operator volume.[22] Importantly, several patient and operative factors were noted to be significantly associated with rates of complications and mortality, consistent with prior studies.[23,24] In the present study, we found patient functional status and severity of the underlying medical illness to be strongly associated with the overall odds of mortality and morbidity. Open approaches had an approximately 2-fold increase in risk of morbidity in HHR patients, which may reflect anatomic complexity owing to patients' burden of disease. In addition, case urgency and performance in an inpatient setting portended worse outcomes, again reflective of a more severe underlying disease process. Altogether, these findings suggest that while surgeon specialty is not the most critical factor in improving outcomes of HHR, continued risk stratification and patient optimization efforts are warranted.

This study has several important limitations including those inherent to its retrospective design. NSQIP-participating hospitals are known to be higher-volume, teaching institutions and do not necessarily represent all hospital types in the United States.[25] As such, differences in outcomes by specialty may be more pronounced in less experienced, lower-volume centers. Moreover, subspecialty training in minimally invasive surgery is not documented in NSQIP, and, as such, we could not study the effect of further specialization. Specific details regarding the type of repair performed are limited due to the use of CPT codes, including distinguishing thoracoscopy from thoracotomy. Outcomes in NSQIP are only recorded for 30 days postoperatively, limiting our analysis to short-term outcomes, and making study of intermediate or late hernia recurrence not possible. Further studies may seek to evaluate longer-term outcomes after hiatal hernia repair whether performed by general or thoracic surgeons. Nonetheless, our study captured a large sample of hiatal hernia repairs and used robust statistical methodology to mitigate the impact of these limitations.

In conclusion, hiatal hernia repair can be safely and effectively performed by both general and thoracic surgeons. General surgeons more commonly use laparoscopy and perform outpatient cases, while thoracic surgeons more frequently used thoracic approaches and operate on patients with greater systemic illness. Among NSQIP-participating hospitals, surgical indication, operative approach, and associated underlying comorbidities appear to affect patient outcomes following HHR more so than does the specialty of the operative surgeon. Continued performance of this operation by experienced surgeons in both specialties will maximize access to hiatal hernia repair.

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## Conflict of interest/Disclosure

None declared.

## Supplementary materials

Supplementary materials associated with this article can be found in the online version https://doi.org/10.1016/j.surg.2022.03.044.

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