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Mesh reinforcement of paraesophageal hernia repair: Trends and outcomes from a national database

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ABSTRACT

Background: Placement of paraesophageal type of "mesh" in paraesophageal hernia repair is controversial. This study examines the trends and outcomes of mesh placement in paraesophageal hernia repair.

Methods: The American College of Surgeons National Surgical Quality Improvement Program was queried for patients who underwent paraesophageal hernia repair with or without mesh (2010–2017). Demographics, operative approach, and outcomes were compared over time.

Results: Of 25,801, most paraesophageal hernia repair cases were elective (89.3%), without mesh (61.9%), and performed laparoscopically (91.3%).When compared with open paraesophageal hernia repair patients, the patients undergoing laparoscopic paraesophageal hernia repair had lesser rates of reoperation, readmission, mortality, overall complications and major complications (2.7% vs 4.8%, 6.2% vs 9.6%, 0.6% vs 2.9%, 7.1% vs 21.3%, 3.8% vs 11.1%, respectively; all $P < .0001$). Mesh placement was more common in laparoscopic paraesophageal hernia repair (38.9 vs 29.7, $P < .0001$) than opern paraesophageal hernia repair. During 2010–2017, mesh placement decreased from 46.2% to 35.2% of laparoscopic paraesophageal hernia repair ($P < .0001$). Operative times for laparoscopic paraesophageal hernia repair decreased over time, and laparoscpic paraesophageal hernia repair without mesh was consistently less (with mesh: 176.0 ± 71.0 to 149.9 ± 72.5 min, without mesh: 148.6 ± 71.4 to 134.6 ± 70.4). We observed no changes in comorbidities or adverse outcomes over time. Using multivariate analysis to control for potential confounding factors, chronic obstructive pulmonary disease was associated most strongly with adverse outcomes, including mortality (OR 2.53, CI 1.55–4.14), any complications (OR 1.80, CI 1.51–2.16), major complications (OR 1.80, CI 1.51–2.16), readmission (OR 1.63, CI 1.33–1.99) and reoperation (OR 1.49, CI 1.10–2.02). Mesh placement was not associated with adverse outcomes.

Conclusion: The placement of mesh during laparoscopic paraesophageal hernia repair is not associated with adverse outcomes. Use of mesh with laparoscopic paraesophageal hernia repair is decreasing with no apparent adverse impact on short-term patient outcomes. Further research is needed to investigate patient factors not captured by this national database, such as characteristics of the hernia, patient symptoms, and hernia recurrence.

Introduction

The ideal approach to paraesophageal hernia repair (PEHR) is the subject of ongoing investigation. The widespread adoption of laparoscopy in the 1990s led many surgeons to prefer a laparoscopic approach to paraesophageal hernia repair (LPEHR) to an open paraesophageal hiatus hernia repair (OPEHR).[1–3] The use of some type of prosthetic "mesh" to buttress a closed defect or to bridge an open defect has been advocated to decrease the rate of recurrence after repair. Multiple mesh types have been described, including synthetic nonabsorbable, biosynthetic and biologic matrices. In the setting of high recurrence rates, resolution of patient symptoms has been prioritized when tracking operative outcomes.[4]

The use of mesh in PEHR has been a subject of much debate. Studies in the early 2000s demonstrated lesser recurrence with the

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Table I
Categorization of outcomes as captured by NSQIP 30-day morbidity and mortality

Clavien-Dindo classification of complications	
Grade 1: Deviation from norm • Peripheral nerve injury • Progressive renal insufficiency • Acute renal failure Grade 2: Requiring pharmacologic treatment • Deep incisional surgical site infection • Organ space surgical site infection • Wound disruption • DVT requiring therapy • DVT with thrombophlebitis • Pulmonary embolism • Pneumonia • Urinary tract infection • Bleeding requiring transfusions • Superficial incisional surgical site infection • Graft, prosthesis or flap failure • Stroke or cerebrovascular accident • Sepsis	Grade 3: Requiring surgical, endoscopic or radiologic intervention • Reoperation • Return to operating room Grade 4: Life-threatening complications • On Ventilator greater than 48 h (failure to wean) • Unplanned intubation (reintubation) • Septic shock • Myocardial infarction • Cardiac arrest requiring CPR • Coma greater than 24 h • Grade 5: Death • Mortality within 30 days
Wound complication	**Other outcomes**
• Deep incisional surgical site infection • Superficial incisional surgical site infection • Wound disruption	• Unplanned readmission within 30 days • Total hospital length of stay

use of absorbable or nonabsorbable mesh, but these studies were often hindered by short follow-up with inconsistent tracking of patient symptoms. Publications describing catastrophic complications have guided many surgeons away from placement of synthetic mesh.[5,6] In a multicenter, prospective trial in 2006 by leading foregut surgeons, Oelschlager et al[7] demonstrated substantially decreased short-term recurrence rates with the use of biologic mesh to reinforce the hiatus. In contrast, the same authors published long-term follow-up in late 2011, demonstrating no differences in recurrence between the mesh and non-mesh groups, with almost 5-y follow-up.[7,8] Since the latter publication, multiple other studies have demonstrated equivalent[9–12] or lesser[13–17] recurrence rates in PEHR with mesh. Despite the high rates of recurrence, patient symptoms do not seem to be affected by mesh repair.[18]

In this setting of conflicting published information, there continues to be substantial variation in surgical practice at a national level.[19,20] The aim of this study was to investigate national trends in PEHR, specifically the utilization of mesh, the short-term complications, and the trends in operative approach to the repair of paraesophageal hiatus hernias (laparoscopic versus open).

Methods

Data source

The database of the American College of Surgeons National Surgical Quality Improvement Program was used for this study. This database records demographics, operative characteristics, and 30-day outcomes in patients, with the stated intent of improving health care outcomes using large-scale data from multiple sources. NSQIP is a nationally validated, risk-adjusted, outcomes-based program that provides a prospective database of patients undergoing major operative intervention. Data are deidentified to ensure no patient-identifiable factors are included before distribution. Data are collected by dedicated, surgical clinical nurse reviewers at each site after both inpatient and outpatient procedures. Specifics of data collection, actuary training, random sampling methods, and inclusion and exclusion criteria are described by the American College of Surgeons National Surgical Quality Improvement Program. This study was considered exempt from institutional review board approval because of the deidentified nature of the data provided by the ACS.

Patient population

In 2010, current procedural terminology (CPT) codes for laparoscopic paraesophageal hernia repair (LPEHR) were updated to describe LPEHR with or without mesh, and, before 2010, there was no distinguishing code for LPEHR. The NSQIP database was queried for patients undergoing elective paraesophageal hernia repair from 2010 to 2017. CPT codes for PEHR (laparoscopic 43281, 43282; open 39502, 43332, 43333; and transthoracic 39520, 43334, 43335, 43336, 43337) were utilized based on earlier publications.[21,22] Patients who underwent a concomitant bariatric procedure were excluded from analysis by CPT code (43644, 43645, 43772, 43774, 43775). Patients who were pregnant or under 18 y of age were excluded.

Outcomes

The NSQIP database captures 21 outcome-specific variables for evaluation of postoperative complications. These 21 variables were further categorized by the Clavien-Dindo classification of operative complications as applicable (Table I).[23,24] The primary outcome was major complications (Clavien-Dindo grade $\geq$ 3). Secondary outcomes included overall complications (Clavien-Dindo complication grades 1–5), wound complications, total hospital duration of stay, and unplanned readmission.

Statistical analysis

Data were analyzed using standard statistical methods utilizing the SAS program v 9.4 (SAS, Cary, NC, USA). Descriptive statistics, including means and standard deviations, medians and interquartile range for continuous variables without a normal distribution, or counts and percentages, were used to describe the study participants. Participants were grouped by laparoscopic and open repair, by year of procedure, and by utilization of mesh. For continuous variables, comparisons were made between groups using *t* tests and Wilcoxon-Mann-Whitney tests. For categorical

Table II
Demographics of patients undergoing LPEHR and OPEHR

	All PEHR	Operative approach		
		OPEHR	LPEHR	*P* value*
Patient distribution (%)		8.7	91.3	
Elective	89.30	69.3	91.3	< .0001
Age (y), median (IQR)	62 (48–76)	64 (50–79)	62 (47–76)	< .0001
Female (%)	71.0	68.6	71.3	.008
Caucasian (%)	93.7	93.4	93.7	.300
BMI (kg/m^2), median (IQR)	30.2 (24.0–36.4)	30.3 (24.2–36.4)	29.6 (22.9–36.3)	< .0001
Active smoker (%)	9.1	9.9	9.0	.150
Hypertension (%)	50.5	55.7	50.0	< .0001
Steroid use (%)	4.1	5.2	4.0	.004
Diabetes (%)	9.0	10.0	8.9	.100
COPD (%)	5.6	7.4	5.4	< .0001

BMI, body mass index; *COPD*, chronic obstructive pulmonary disease; *IQR*, interquartile range; *LPEHR*, laparoscopic paraesophageal hernia repair; *OPEHR*, open paraesophageal hernia repair.
* Univariate analysis comparing open and laparoscopic approach.

variables, the χ^2 and the Fisher exact tests were used to make comparisons between groups. For the primary univariate analysis, patient demographics, such as age, body mass index ([BMI] kg/m^2), diabetes, smoking, steroid use, other comorbidities, and operative outcomes were compared to identify potentially confounding variables. Variables used in multivariate logistic regression were selected based on factors identified as statistically different between groups in univariate analysis ($P < .05$), and factors known to potentially influence operative outcomes were based on prior studies of hiatus hernia repairs. Multivariate logistic regression analysis was performed controlling for potentially confounding risk factors, such as age, sex, BMI, diabetes, steroid use, smoking, chronic obstructive pulmonary disease (COPD), wound class, and placemen t of mesh. Odds ratio (OR) was used to compare outcomes of patients with and without placement of mesh. Statistical significance was set at $P < .05$ for all comparisons.

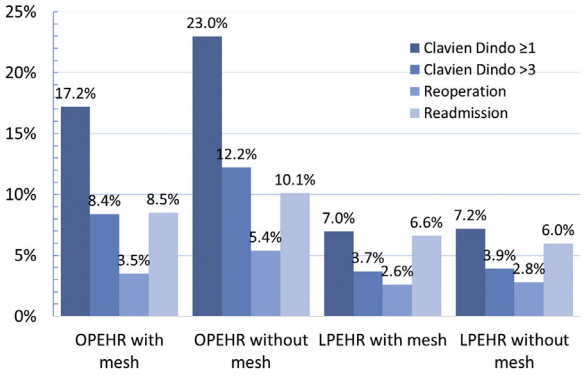

Fig 1. Postoperative complications by procedure type (all groups $P < .05$). Univariate analysis comparing complication rates between operative groups. $P < .05$ between all groups. Example: Reoperation rate between OPEHR with mesh (3.5%), OPEHR without mesh (5.4%), LPEHR with mesh (2.5%), LPEHR without mesh (2.8%), $P < .05$.

Results

A total of 46,684 PEHR were identified from 2010 to 2017. A thoracic approach was utilized in only 597 patients during this period, and these patients were excluded from the study because of low relative incidence. Concomitant bariatric procedures (sleeve gastrectomy, Roux-en-Y gastric bypass) were performed in 20,286 cases and were also excluded as described earlier in the Methods section of this report. This approach yielded 25,801 PEHR for analysis. Of these procedures, the majority were performed laparoscopically (91.3%) and without mesh (61.9%). Mean age was 62.0 ± 14 y, mean was BMI 30.2 ± 6.2kg/m^2, and 71.0% of patients were female (Table II).

When compared with LPEHR patients, patients undergoing open paraesophageal hernia repair (OPEHR) were found to be somewhat older (64.4 ± 14.2 y versus 61.7 ± 14.0 y, $P < .0001$) and had somewhat greater rates of COPD (7.4 vs 5.4%, $P = .0001$). OPEHRs took greater operative time (166.0 ± 99.3 min versus 147.7 ± 74.9 min, $P < .0001$) and were less likely to be elective (69.3% vs 91.3%) and to have mesh placed (29.7% vs 38.9%, $P < .0001$). OPEHR patients had a greater duration of stay (7.7 ± 11.8 days versus 2.8 ± 4.4 days, $P < .0001$) and greater rates of reoperation, readmission, mortality, overall complications, and major complications (4.8% vs 2.7%, 9.6% vs 6.2%, 2.9% vs 0.6%, 21.3% vs 7.1%, and 11.1% vs 3.8%, respectively; all $P < .0001$;Table II, Fig 1).

A total of 2,253 patients underwent OPEHR, 29.7% of whom had mesh placed intraoperatively. When compared with OPEHR without mesh, OPEHR with mesh was less likely to be emergent (9.4% vs 17.2%, $P < .0001$) but had greater operative times (174.4 ± 92.5 min versus 162.4 ± 101.8 min, $P < .0001$). OPEHR with mesh had a somewhat lesser duration of stay (7.0 ± 10.5 days vs 8.0 ± 12.3 days, $P < .0001$) and less reoperations, overall complications, and major complication rates (3.5% vs 5.4%, 17.2% vs 23.0%, 8.4% vs 12.2%, respectively, $p \leq .05$ all values; Table III, Fig 1).

The majority of PEHR were performed laparoscopically (23,548 LPEHR, 91.3%), and 38.9% of LPEHR had mesh placed. When compared with LPEHR without mesh, mesh was placed in somewhat older LPEHR patients (63 ± 13.5 y versus 60.9 ± 14.3 y, $P < .0001$), with similar rates of COPD (5.8% vs 5.2%), and LPEHR with mesh were somewhat less likely to be emergent (1.8% vs 2.2%, $P = .03$). LPEHR with mesh had greaterer operative times (159.0 ± 76 min versus 140.6 ± 73.3 min, $P < .0001$) but no difference in reoperation, overall complications, and major complication rates (Table III, Fig 1).

LPEHR became more common over time, with 85.7% of repairs performed laparoscopically in 2011 and 93.3% in 2017 ($P < .0001$). Placement of mesh became somewhat more frequent in OPEHR (28.3% in 2011 to 32.1% in 2017, $P = .03$) but less frequent in LPEHR (46.2% in 2010 to 35.2% in 2017, $P < .0001$; Fig 2). Despite these changes, there was no difference in complication rates over time, including reoperation, readmission, mortality, and minor and major complications (Fig 3, Table IV).

When multivariate analysis was used to control for multiple, potentially confounding factors, patients undergoing LPEHR with

Table III
Demographics of patients undergoing open and PEHR with and without mesh

	All PEHR	OPEHR			LPEHR		
		With mesh	Without mesh	*P* value*	With mesh	Without mesh	*P* value*
Patient distribution (%)		29.7	70.3		38.9	61.1	
Elective	89.30	75.1	66.8	< .0001	91.3	91.3	.9
Age (y), median (IQR)	62 (48-76)	63 (50-77)	64 (50-79)	.006	63 (49-76)	61 (57-75)	< .0001
Female (%)	71.0	67.4	69.1	.4	71.4	71.2	.7
Caucasian (%)	93.7	94.1	93.1	.57	94.4	93.3	.006
BMI (kg/m^2), median (IQR)	30.2 (24.0-36.4)	29.7 (23.4-36)	29.6 (22.7-36.5)	.2	30 (24.2-35.8)	30.5 (24.2-36.8)	<.0001
Active smoker (%)	9.1	9.1	10.2	.4	8.7	9.1	.3
Hypertension (%)	50.5	53.2	56.8	.1	52.2	48.5	<.0001
Steroid use (%)	4.1	4.3	5.6	.2	4.2	3.8	.2
Diabetes (%)	9.0	7.6	11.0	.02	8.5	9.2	.07
COPD (%)	5.6	7.6	7.3	.8	5.8	5.2	.03

BMI, body mass index; *COPD*, chronic obstructive pulmonary disease; *IQR*, interquartile range; *PVD*, peripheral vascular disease; *OPEHR*, open paraesophageal hernia repair; *LPEHR*, laparoscopic paraesophageal hernia repair.
* Univariate analysis comparing PEHR with and without mesh.

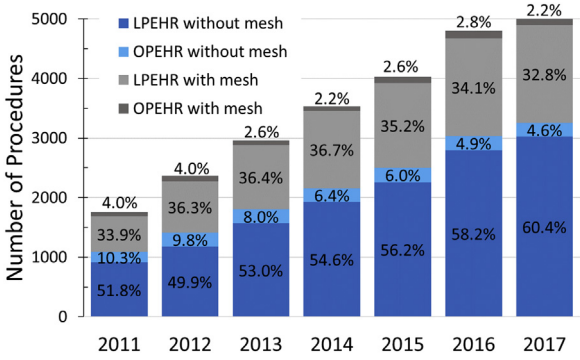

Fig 2. Mesh use over time in PEHR . Data labels (percentages) represent the proportion of operation type performed in that year.

placement of mesh had greater operative times by 17.1 min (SD 1.02, $P < .0001$). Wound complications were independently associated with increased BMI (OR 1.04 per unit, CI 1.01–1.06). COPD was independently associated with increased rates of reoperation (OR 1.49, CI 1.1–2.02), readmission (OR 1.63, CI 1.33–1.99), 30-day mortality (OR 2.53, CI 1.55–4.14), minor and major complications (OR 1.80, CI 1.51–2.16; OR 1.85, CI 1.47–2.32, respectively), and increased durations of stay (1.05 days, SD 0.12, $P < .0001$). Diabetes was independently associated with increased rates of reoperation (OR 1.37, CI 1.07–1.77), 30-day mortality (OR 1.77, CI 1.07–2.93), minor and major complications (OR 1.30, CI 1.11–1.53; OR 1.48, CI 1.20–1.82, respectively), and increased durations of stay (0.32, SD 0.10, $P < .0009$). Placement of mesh was not associated with any adverse outcomes (Table V).

Discussion

LPEHR has become the primary treatment for patients with symptoms refractory to medical management.[3,19] This retrospective review of a national database from 2010 to 2017 demonstrates an increasing proportion of laparoscopic repairs, with open repair more often performed in emergent or non-elective settings. The use of some form of "mesh" in PEHR has persisted despite conflicting evidence for its benefits, with 35% of PEHR in 2017 performed with mesh. The rate of mesh placement in PEHR, as captured by this data set, however, has decreased from 45% to 36% in this time interval.[25]

Potential benefits of placement of mesh during LPEHR have been examined closely since the 1990s. In a 2007 retrospective review, Zaninotto et al[26] described a lesser recurrence rate in patients with a median follow-up of 64 months with type III hiatal hernias repaired with mesh.[26] A short term decrease in recurrence rate with placement of mesh has been described with several types of mesh, both absorbable and synthetic.[7,13,27] Several meta-analyses have also described decreases in objective recurrence rates when mesh is placed, although this is across variable time frames of follow-up.[17,18] Studies are often hindered by retrospective review, variable different types of mesh, and short follow-up, all of which may allow for selection bias and insufficient time for objective recurrence to present.

Well-designed studies with long follo- up, however, have demonstrated no difference between recurrence and symptoms after LPEHR with and without the placement of mesh. Oelschlager et al[8] demonstrated equivalent recurrence rates at almost 5-y mean follow-up after LPEHR randomized with or without reinforcement with a biologic mesh.[8] Similarly, in a prospective, double-blind randomized controlled trial, Watson et al[28] demonstrated no difference in hernia recurrence at 6 months after the repair of large hiatal hernias when comparing suture repair (23.1%), absorbable mesh (30.8%), and nonabsorbable mesh (12.8%, $P = .16$). In another review of patients with large paraesophageal hernias, Tam et al[12] found no difference in recurrence at 27 months when mesh reinforcement was used. In a more recent paper on laparoscopic hiatal hernia repair with a median follow-up of 4.3 y, patients who had mesh reinforcement had no difference in symptomatic recurrence or reoperation when compared with patients without mesh (16.9% vs 22.4%, $P = .36$).[9] Notably, mesh reinforcement has been associated with lesser reoperation rates but equivalent recurrence rates in a recent meta-analysis of randomized controlled trials.[10] Earlier studies utilizing the ACS NSQIP database have also demonstrated that placement of mesh is not associated with more complications after PEHR but that operative times were associated with more complications, likely reflecting the operative complexity or the ability of the surgeon.[29]

Several studies have associated mesh reinforcement with worse patient symptoms,[12,30,31]but because patient symptoms were captured inconsistently, it is difficult to make any definite conclusions regarding symptoms.[9,16,18,32] Many patients report persistent symptomatic relief even in the setting of radiographic evidence of recurrence.[4,33,34] Finally, several studies have described an increased complexity of revisional operations when mesh had

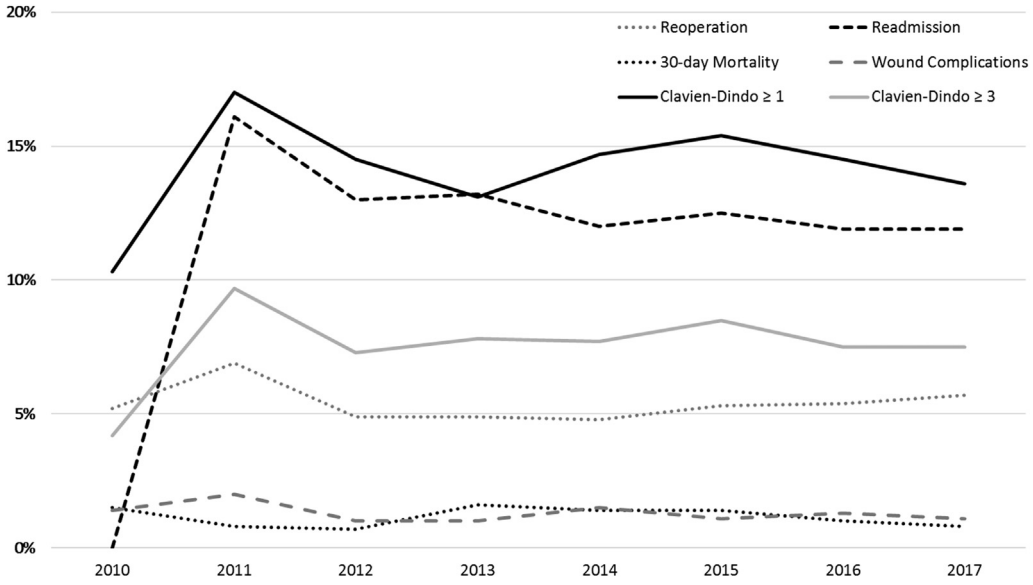

Fig 3. Complication rates of PEHR over time.

Table IV
Outcomes after elective PEHR

	All PEHR	With mesh	Without mesh	*P* value*
Reoperation (%)	2.9	2.6	3	.06
Open	4.8	3.5	5.4	.05
Laparoscopic	2.7	2.6	2.8	.3
Readmission (%)	6.5	6.7	6.4	.4
Open	9.6	8.4	10.1	.2
Laparoscopic	6.2	6.6	5.98	.08
30-day mortality (%)	0.8	0.7	0.9	.07
Open	2.9	2.1	3.2	.1
Laparoscopic	0.6	0.6	0.6	.7
Wound complications (%)	1.0	0.8	1.1	.002
Open	4.7	1	4.99	.3
Laparoscopic	0.6	0.5	0.7	.06
Clavien-Dindo grade ≥ 1	8.4	7.7	8.8	.001
Open	21.3	17.2	22.98	.002
Laparoscopic	7.1	6.96	7.2	.44
Clavien-Dindo grade ≥3	4.5	4	4.8	.006
Open	11.1	8.4	12.2	.008
Laparoscopic	3.8	3.7	3.9	.4

* Univariate analysis comparing PEHR with and without mesh.

Table V
Outcomes of LPEHR as associated with risk factors*

Outcome	Reference	Mesh		Elective		Diabetes		COPD	
		Odds ratio	(95% CI)	Odds ratio	(95% CI)	Odds ratio	(95% CI)	Odds ratio	(95% CI)
Clavien-Dindo 1-5 (overall)	1.00	0.93	0.83–1.03	0.41†	0.35–0.47	1.30†	1.11–1.53	1.80†	1.51–2.16
Clavien-Dindo ≥3 (major)	1.00	0.91	0.79–1.05	0.43†	0.36–0.52	1.48†	1.20–1.82	1.85†	1.47–2.32
30-day mortality	1.00	0.87	0.59–1.27	0.32†	0.21–0.49	1.77†	1.07–2.93	2.53†	1.55–4.14
Readmission	1.00	1.09	0.98–1.23	1.05	0.93–1.19	1.16	0.96–1.39	1.63†	1.33–1.99
Return to OR	1.00	0.91	0.77–1.08	0.64†	0.40–0.83	1.37†	1.07–1.77	1.49†	1.10–2.02
Wound complication	1.00	0.67†	0.46–0.97	0.41†	0.26–0.65	1.19	0.69–2.06	1.63	0.88–3.01

CI, confidence interval.
* Multivariate logistic regression.
† Statistically significant.

been placed previously or catastrophic outcomes after placement of nonabsorbable mesh against the esophagus.[6,35,36]

Although this study demonstrated that the use of PEHR with mesh is decreasing, the reason(s) for this trend cannot be determined from the present study. The slowly decreasing incidence of mesh repair may be tied to the growing literature, demonstrating equivalence for most outcomes with and without mesh. Nonetheless, the persistent use reflects variability in surgical practices across the country. This variability was evident in a 2010 survey, in which 25% of the surveyed members of the Society of American

Gastrointestinal and Endoscopic Surgeons (SAGES) used mesh in more than 50% of PEHR, and 23% never used mesh, and younger surgeons were much more likely to use mesh (59% vs 7%).[19] The 2013 SAGES "Guidelines for the Management of Hiatal Hernia" endorsed a lesser short-term recurrence rate with placement of mesh but discussed the limitation of inadequate data to determine any long term benefit of mesh reinforcement on recurrence rate.[37] The guidelines specifically advise against the use of synthetic, nonabsorbable mesh to bridge a hiatal defect because such mesh has the potential to erode into the esophagus. As operative technique and outcomes are strongly tied to surgical center and caseload, the use of mesh may similarly reflect surgeon factors rather than data-driven reasoning.

This study is limited by several factors. This retrospective review of surgical practices has not been reviewed in a prospective manner on a national scale. The NSQIP database is limited because it is not entirely inclusive of nationwide trends and instead is from patients and centers that participate voluntarily. Data are limited by the variables captured by the NSQIP database, and the accuracy of the personnel who enter them. Data do not include hernia-specific variables, such as defect size, type of mesh placed, volume of hernia repairs at each institution, and history of previous PEHR. The complications captured are short term (30 days) and do not include concerns specific to PEHR, such as postoperative discomfort, persistence of symptoms, and recurrence. The operative approach may have been prompted by clinical judgment not fully reflected in the comorbidities captured by the database. Finally, although many measured outcomes were found to be "statistically significant," this may be a factor of the large database and may have limited clinical relevance.

In conclusion, the placement of mesh during PEHR appears to be decreasing in frequency at a national level. It is unclear what factors influence placement of mesh at a surgeon level. Further investigation on long-term outcomes, including recurrence and symptom management, after PEHR is warranted.

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Conflict of interest/Disclosure

Vedra A. Augenstein, MD, is a speaker for Allergan, Intuitive, Acelity, and WL Gore. B. Todd Heniford, MD, is a speaker for Allergan and on the advisory committee for WL Gore. Paul D. Colavita, MD, is a speaker for Allergan. The other authors have no conflicts of interest to disclose.

References

1. Hashemi M, Peters JH, DeMeester TR, et al. Laparoscopic repair of large type III hiatal hernia: objective followup reveals high recurrence rate. *J Am Coll Surg*. 2000;190:553–560; discussion 560–561.
2. Kubasiak J, Hood KC, Daly S, et al. Improved patient outcomes in paraesophageal hernia repair using a laparoscopic approach: a study of the national surgical quality improvement program data. *Am Surg*. 2014;80:884–889.
3. Mungo B, Molena D, Stem M, Feinberg RL, Lidor AO. Thirty-day outcomes of paraesophageal hernia repair using the NSQIP database: should laparoscopy be the standard of care? *J Am Coll Surg*. 2014;219:229–236.
4. Dallemagne B, Kohnen L, Perretta S, Weerts J, Markiewicz S, Jehaes C. Laparoscopic repair of paraesophageal hernia. *Ann Surg*. 2011;253:291–296.
5. Nandipati K, Bye M, Yamamoto SR, Pallati P, Lee T, Mittal SK. Reoperative intervention in patients with mesh at the hiatus is associated with high incidence of esophageal resection—A single-center experience. *J Gastrointest Surg*. 2013;17:2039–2044.
6. Stadlhuber RJ, Sherif A El, Mittal SK, et al. Mesh complications after prosthetic reinforcement of hiatal closure: A 28-case series. *Surg Endosc*. 2009;23:1219–1226.
7. Oelschlager BK, Pellegrini CA, Hunter J, et al. Biologic prosthesis reduces recurrence after laparoscopic paraesophageal hernia repair: a multicenter, prospective, randomized trial. *Ann Surg*. 2006;244:481–490.
8. Oelschlager BK, Pellegrini CA, Hunter JG, et al. Biologic prosthesis to prevent recurrence after laparoscopic paraesophageal hernia repair: Long-term follow-up from a multicenter, prospective, randomized trial. *J Am Coll Surg*. 2011;213:461–468.
9. Abu Saleh WK, Morris LM, Tariq N, et al. Routine use of mesh during hiatal closure is safe with no increase in adverse sequelae. *Surg Endosc*. 2018;32:879–888.
10. Memon MA, Memon B, Yunus RM, Khan S. Suture cruroplasty versus prosthetic hiatal herniorrhaphy for large hiatal hernia: A meta-analysis and systematic review of randomized controlled trials. *Ann Surg*. 2016;263:258–266.
11. Ringley CD, Bochkarev V, Ahmed SI, Vitamvas ML, Oleynikov D. Laparoscopic hiatal hernia repair with human acellular dermal matrix patch: Our initial experience. *Am J Surg*. 2006;192:767–772.
12. Tam V, Luketich JD, Levy RM, et al. Mesh cruroplasty in laparoscopic repair of paraesophageal hernias is not associated with better long-term outcomes compared to primary repair. *Am J Surg*. 2017;214:651–656.
13. Asti E, Lovece A, Bonavina L, et al. Laparoscopic management of large hiatus hernia: Five-year cohort study and comparison of mesh-augmented versus standard crura repair. *Surg Endosc*. 2016;30:5404–5409.
14. Frantzides CT, Madan AK, Carlson MA, Stavropoulos GP. A prospective, randomized trial of laparoscopic polytetrafluoroethylene (PTFE) patch repair vs simple cruroplasty for large hiatal hernia. *Arch Surg*. 2002;137:649–652.
15. Granderath FA, Schweiger UM, Kamolz T, Asche KU, Pointner R. Laparoscopic Nissen fundoplication with prosthetic hiatal closure reduces postoperative intrathoracic wrap herniation: Preliminary results of a prospective randomized functional and clinical study. *Arch Surg*. 2005;140:40–48.
16. Müller-Stich BP, Holzinger F, Kapp T, Klaiber C. Laparoscopic hiatal hernia repair: Long-term outcome with the focus on the influence of mesh reinforcement. *Surg Endosc*. 2006;20:380–384.
17. Sathasivam R, Bussa G, Viswanath Y, et al. 'Mesh hiatal hernioplasty' versus 'suture cruroplasty' in laparoscopic para-oesophageal hernia surgery; a systematic review and meta-analysis. *Asian J Surg*. 2019;42:53–60.
18. Tam V, Winger DG, Nason KS. A systematic review and meta-analysis of mesh vs suture cruroplasty in laparoscopic large hiatal hernia repair. *Am J Surg*. 2016;211:226–238.
19. Pfluke JM, Parker M, Bowers SP, Asbun HJ, Daniel Smith C. Use of mesh for hiatal hernia repair: A survey of SAGES members. *Surg Endosc*. 2012;26:1843–1848.
20. Schlottmann F, Strassle PD, Allaix ME, Patti MG. Paraesophageal hernia repair in the usa: trends of utilization stratified by surgical volume and consequent impact on perioperative outcomes. *J Gastrointest Surg*. 2017;21:1199–1205.
21. Augustin T, Schneider E, Alaedeen D, et al. Emergent surgery does not independently predict 30-day mortality after paraesophageal hernia repair: Results from the ACS NSQIP database. *J Gastrointest Surg*. 2015;19:2097–2104.
22. Chimukangara M, Helm MC, Frelich MJ, et al. A 5-item frailty index based on NSQIP data correlates with outcomes following paraesophageal hernia repair. *Surg Endosc*. 2017;31:2509–2519.
23. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications. *Ann Surg*. 2009;250:187–196.
24. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications. *Ann Surg*. 2004;240:205–213.
25. Schlottmann F, Strassle PD, Patti MG. Laparoscopic paraesophageal hernia repair: Utilization rates of mesh in the USA and short-term outcome analysis. *J Gastrointest Surg*. 2017;21:1571–1576.
26. Zaninotto G, Portale G, Costantini M, et al. objective follow-up after laparoscopic repair of large type III hiatal hernia. Assessment of safety and durability. *World J Surg*. 2007;31:2177–2183.
27. Braghetto I, Korn O, Csendes A, Burdiles P, Valladares H, Brunet L. Postoperative results after laparoscopic approach for treatment of large hiatal hernias: Is mesh always needed? Is the addition of an antireflux procedure necessary? *Int Surg* 95:80–87.
28. Watson DI, Thompson SK, Devitt PG, et al. Laparoscopic repair of very large hiatus hernia with sutures versus absorbable mesh versus nonabsorbable mesh: A randomized controlled trial. *Ann Surg*. 2015;261:282–289.
29. Skancke M, Brody F, Haskins IN, Amdur R, Schoolfield C. Impact of operative times and mesh utilization on paraesophageal hernia repair: Analysis of 30-day outcomes from the American College of Surgeons National Surgical Quality Improvement Project Database. *J Laparoendosc Adv Surg Tech*. 2019;29:303–308.
30. Grubnik VV, Malynovskyy AV. Laparoscopic repair of hiatal hernias: New classification supported by long-term results. *Surg Endosc*. 2013;27:4337–4346.
31. Gouvas N, Tsiaoussis J, Athanasakis E, Zervakis N, Pechlivanides G, Xynos E. Simple suture or prosthesis hiatal closure in laparoscopic repair of paraesophageal hernia: A retrospective cohort study. *Dis Esophagus*. 2011;24:69–78.

32. Goers TA, Cassera MA, Dunst CM, Swanström LL. Paraesophageal hernia repair with biomesh does not increase postoperative dysphagia. *J Gastrointest Surg*. 2011;15:1743–1749.
33. Luketich JD, Nason KS, Christie NA, et al. Outcomes after a decade of laparoscopic giant paraesophageal hernia repair. *J Thorac Cardiovasc Surg*. 2010;139:395–404.e1.
34. Oelschlager BK, Petersen RP, Brunt LM, et al. Laparoscopic paraesophageal hernia repair: defining long-term clinical and anatomic outcomes. *J Gastrointest Surg*. 2012;16:453–459.
35. Parker M, Bowers SP, Bray JM, et al. Hiatal mesh is associated with major resection at revisional operation. *Surg Endosc*. 2010;24:3095–3101.
36. Griffith PS, Valenti V, Qurashi K, Martinez-Isla A. Rejection of goretex mesh used in prosthetic cruroplasty: A case series. *Int J Surg*. 2008;6:106–109.
37. Kohn GP, Price RR, Demeester SR, et al. Guidelines for the management of hiatal hernia—A SAGES Publication. Web site https://www.sages.org/publications/guidelines/guidelines-for-the-management-of-hiatal-hernia/. Accessed January 21, 2019.