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# Impact of hiatal hernia repair technique on patient-reported gastroesophageal reflux symptoms following laparoscopic sleeve gastrectomy

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## Abstract

**Introduction** Repairing a hiatal hernia at the time of laparoscopic sleeve gastrectomy (SG) can reduce or even prevent gastroesophageal reflux disease (GERD) symptoms in the post-operative period. Several different hiatal hernia repair techniques have been described but their impact on GERD symptoms after SG is unclear.

**Methods** Surgeons ( $n = 74$ ) participating in a statewide quality collaborative were surveyed on their typical technique for repair of hiatal hernias during SG. Options included posterior repair with mesh (PRM), posterior repair (PR), and anterior repair (AR). Patients who underwent SG with concurrent hiatal hernia repair ( $n = 7883$ ) were compared according to their surgeon's reported technique. Patient characteristics, baseline and 1-year GERD health-related quality of life surveys, weight loss and 30-day risk-adjusted complications were analyzed.

**Results** The most common technique reported by surgeons for hiatal hernia repair was PR ( $n = 64$ , 85.3%), followed by PRM ( $n = 7$ , 9.3%) and AR ( $n = 4$ , 5.3%). Patients who underwent SG by surgeons who perform AR had lower rates of baseline GERD diagnosis (AR 55.3%, PR 59.5%, PRM 64.8%,  $p < 0.01$ ), but were more likely to experience worsening GERD symptoms at 1 year (AR 29.8%, PR 28.7%, PRM 28.2%,  $p < 0.0001$ ), despite similar weight loss (AR 29.8%, PR 28.7%, PRM 28.2%,  $p = 0.08$ ). Satisfaction with GERD symptoms at 1 year was high (AR 73.2%, PR 76.3%, PRM 75.7%,  $p = 0.43$ ), and risk-adjusted 30-day outcomes were similar among all groups.

**Conclusions** Patients undergoing SG with concurrent hiatal hernia repair by surgeons who typically perform an AR were more likely to report worsening GERD at 1 year despite excellent weight loss. Surgeons who typically performed an AR had nearly one-half of their patients report increased GERD severity after surgery despite similar weight loss. While GERD symptom control may be multifactorial, technical approach to hiatal hernia repair at the time of SG may play a role and a posterior repair is recommended.

**Keywords** Bariatric surgery · Sleeve gastrectomy · Hiatal hernia repair · Gastroesophageal reflux disease · Surgical technique · Patient-reported outcomes

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Sleeve gastrectomy (SG) is the most common bariatric surgery performed worldwide, with more than 150,000 patients undergoing this procedure annually in the United States

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(US) [1]. Despite its growing popularity, there continues to be significant concerns about new or worsening gastroesophageal reflux disease (GERD) following the procedure. Studies suggest that up to 18–48% [2–5] of patients develop new or worsening reflux following SG, and GERD is the number one predictor of patient satisfaction in this population [6]. As a result, there is ongoing interest in understanding how to minimize adverse GERD outcomes for patients.

While patient selection certainly plays a role, technical considerations in the operating room may influence GERD outcomes post-operatively. Anatomic changes related to the size and shape of the gastric conduit as well as approach to the hiatal dissection have been suggested as important contributors, and there is evidence to suggest that surgeon technique may play an important role in new or worsening GERD following SG [7]. While hiatal hernia repair at the time of SG is thought to reduce the impact of post-operative GERD symptoms, less attention has been paid to understanding the most effective hiatal hernia repair technique in this population. This is of interest given the fact that several techniques for repairing hiatal hernias have been described in the literature (i.e., anterior, posterior, use of mesh, etc.) [8–11] and that approximately one-third of patients undergo concurrent hiatal hernia repair at the time of SG [5]. Given that worsening GERD symptoms can have an effect on patient satisfaction, development of Barrett's esophagus, and may warrant revisional surgery, understanding the technical aspects of repairing a hiatal hernia in a patient with severe obesity who is undergoing SG can be valuable.

Within this context, the goal of this study was to identify variation in how surgeons typically repair hiatal hernias when performing SG and also to compare patient-reported GERD outcomes among their patients. To do this, we analyzed data from a statewide quality improvement collaborative and included patients with baseline and 1-year follow-up. In addition, we evaluated pre-operative patient characteristics, 30-day complication rates, and 1-year weight loss after SG.

## Materials and methods

### Study setting and data sources

This study used data from the Michigan Bariatric Surgery Collaborative (MBSC), a payer-supported statewide quality improvement consortium. The MBSC includes 38 bariatric surgery programs with 75 surgeons. Each program submits bariatric surgery data to a statewide clinical registry [12, 13]. The registry collects information about patient demographics, disease characteristics, peri-operative management, and post-operative outcomes. Trained, audited abstractors collect MBSC data directly from the medical record

using standardized definitions. Data integrity is ensured through annual audits at participating hospitals. Patients who undergo surgery within MBSC hospitals receive surveys at baseline (before surgery) and follow-up to assess patient-reported outcomes. The study was approved by the institutional review board of the University of Michigan for the MBSC and patients signed consent prior to participation.

### Data collected

Surgeons participating in the MBSC voluntarily completed a survey in 2020 that assessed different aspects of their surgical technique. The survey contains questions regarding items such as landmarks or measurements used to determine staple placement; use of sealants or other staple line reinforcement; and judgment regarding the best bariatric surgery procedure for a patient with a moderate sized hiatal hernia and reflux symptoms. Included in the 2020 questionnaire was surgeon reported technique that they typically used for hiatal hernia repair performed at the time of SG. The options for concurrent management of hiatal hernia repair included “anterior suture repair,” “posterior suture repair without mesh,” “posterior suture repair with biologic mesh,” “posterior suture repair with synthetic mesh,” “any of the above with additional fundoplication,” and “no repair.” A copy of the surgeon survey is included in the Supplementary Material.

Patients undergoing SG with concurrent hiatal hernia repair from 2008–2019 at bariatric surgery programs participating in the MBSC were included in the analysis. Information about age, sex, race, weight, body mass index (BMI), and comorbid conditions including pre-operative diagnosis of GERD and antacid medication use were collected from the medical record. Patients were assigned a pre-operative diagnosis of GERD if any of the following diagnoses were present: “chronic heartburn,” “acid regurgitation,” “acid reflux disease,” “acid dyspepsia,” “esophageal reflux,” “esophagitis,” “reflux laryngitis,” “Barrett's esophagus,” or “reflux-induced cough or asthma.”

To assess patient-reported GERD severity, we used the GERD Health Related Quality of Life (GERD-HRQL) instrument. Patients completed this at baseline and at the time of the one-year follow-up survey. The GERD-HRQL instrument provides a quantitative assessment of GERD symptoms to assess response to various treatments, [14] and has been used in a number of studies assessing GERD outcomes. [5–7]. The instrument contains 10 questions, each of which is rated on a scale of 0–5 with 0 “no symptoms,” 1 “symptoms noticeable, but not bothersome,” 2 “symptoms noticeable and bothersome, but not every day,” 3 “symptoms bothersome every day,” 4 “symptoms affect daily activities,” and 5 “symptoms are incapacitating, unable to do daily activities.” Higher scores indicate worse symptoms,

and the maximum total score is 50 [14]. In this analysis, we designated overall heartburn severity based on the patient's response to the first question in the GERD-HRQL instrument: "How bad is your heartburn?" Total patient scores were reported as 0–5. Included in the survey was whether patients were taking any acid suppressive therapy (recorded as yes/no), as well as what a question that asked "How satisfied are you with the present condition of your reflux?" (recorded as satisfied, neutral, or dissatisfied).

Clinical outcomes collected from the registry included 30-day risk-adjusted complications of myocardial infarction, acute renal failure, venous thromboembolism, cardiac complications (myocardial infarction or cardiac arrest), hospital acquired infections (urinary tract or *Clostridium difficile*), respiratory complications (pneumonia, reintubation, or tracheostomy), shock, and death. Surgical complications included hemorrhage (requiring transfusion or re-intervention); abdominal abscess; leak (either requiring intervention or conservatively managed); small bowel obstruction requiring reoperation; and wound infection or dehiscence. We also report rates of stricture or endoscopic dilation performed post-operatively. Weight loss is reported in percent of total body weight loss at one year.

## Statistical analysis

Patient characteristics were summarized using frequency distributions for binary/categorical variables and means for continuous variables. Significance testing was performed using Chi-square tests for categorical variables and one way ANOVA was used to compare the three cohorts on continuous variables. To determine the association between hiatal hernia repair technique and GERD outcomes, patients were stratified into three cohorts using the techniques reported by their surgeon: anterior repair alone (AR), posterior repair without mesh (PR), and posterior repair with wither biological or synthetic mesh (PRM). We compared risk and reliability adjusted outcomes using multiple logistic and

linear regression analyses; adjusting for baseline patient characteristics, comorbidities, and surgical program where the operation took place.

## Results

Among 74 surgeons, the most commonly reported technique was PR ( $n=64$ , 85.3%), followed by PRM ( $n=7$ , 9.3%), and AR ( $n=4$ , 5.3%). Surgeon characteristics are reported in Table 1. Among 7883 patients who underwent concurrent hiatal hernia repair and SG, the vast majority ( $n=6131$ , 78%) underwent SG by a surgeon who used PR technique to repair hiatal hernias at the time of surgery. Of the remaining patients, 886 (11%) had surgery performed by a surgeon who reported a PRM technique while 866 (11%) had surgery performed by a surgeon who reported an AR technique only. Patients who underwent PRM were slightly older (PRM 49.3 vs PR 48.9 vs AR 46.1,  $p<0.0001$ ) and less often had private insurance (PRM 71.2% vs PR 74.3% vs AR 81.1%,  $p<0.0001$ ). Patients who underwent PR were more often white (PR 78.3% vs 76.5% vs 68.8%,  $p<0.0001$ ) while patients who underwent AR had the highest rates of current smoking (AR 10.2% vs PRM 9.8% vs PR 7.7%,  $p=0.0069$ ). There were significant differences in nearly all baseline comorbidities between the three cohorts as demonstrated in Table 2.

Mean baseline heartburn severity as measured by the GERD-HRQL was highest among patients in the PRM cohort (PRM 1.40 vs PR 1.20 vs AR 0.99,  $p<0.0001$ ) but patients in the PR cohort had the lowest mean heartburn severity score at one-year post-operatively (PR 0.81 vs PRM 0.84 vs AR 0.96,  $p=0.0032$ ). Patients in the AR cohort were less likely to have a baseline diagnoses of GERD (AR 55.3%, PR 59.5%, PRM 64.8%,  $p<0.01$ ), and were more likely to experience worsening GERD symptoms at one year (AR 29.8%, PR 28.7%, PRM 28.2%,  $p<0.0001$ ). Despite these differences, most patients reported overall satisfaction with GERD symptoms at one year (PRM 75.7% vs PR

**Table 1** Participating surgeon demographics

	Anterior repair $N=4$	Posterior repair without mesh $N=63$	Posterior repair with mesh $N=7$	$p$ value
Female sex (%)	1 (25)	9 (14.3)	2 (28.6)	0.55
Age (SD)	48.5 (4.2)	51.8 (8.4)	45.8 (8.2)	0.2149
Mean years practicing bariatrics (SD)	16.3 (3.5)	16.1 (5.0)	11.0 (7.5)	0.1216
Mean annual number of cases (SD)	135.8 (99.8)	95.7 (87.6)	106.1 (58.4)	0.6501
Mean annual number of sleeve gastrectomies (SD)	77.8 (48.8)	51.1 (48.4)	75.6 (39.3)	0.2737
<i>Hospital type</i>				
Teaching (%)	2 (50)	48 (76.2)	3 (42.9)	0.11
Non-teaching (%)	2 (50)	15 (23.8)	4 (58.1)	

**Table 2** Baseline characteristics of patients stratified by hiatal hernia repair technique

	Anterior repair N=866 (11%)	Posterior repair Without mesh N=6131 (78%)	Posterior repair With mesh N=886 (11%)	p value
Mean age, years	46.1 (11.7)	48.9 (11.5)	49.3 (12.3)	<0.0001
Mean BMI	45.6 (7.4)	45.6 (7.2)	45.7 (7.4)	0.7610
Female, n (%)	742 (85.7)	5216 (85.1)	761 (85.9)	0.7543
White, n (%)	582 (68.8)	4705 (78.3)	664 (76.5)	<0.0001
Private insurance, n (%)	702 (81.1)	4556 (74.3)	631 (71.2)	<0.0001
Current Smoker, n (%)	88 (10.2)	469 (7.7)	87 (9.8)	0.0069
<i>Comorbidities, n (%)</i>				
Musculoskeletal disorder	696 (80.4)	4423 (72.1)	594 (67.0)	<0.0001
Cardiovascular disease	404 (46.7)	3320 (54.2)	471 (53.2)	0.0002
Psychological disease	443 (51.2)	3616 (59.0)	485 (54.7)	<0.0001
Hypertension	381 (44.0)	3172 (51.7)	462 (52.1)	<0.0001
Sleep apnea	367 (42.4)	2849 (46.5)	365 (41.2)	0.0021
GERD	479 (55.3)	3646 (59.5)	574 (64.8)	0.0003
Hyperlipidemia	412 (47.6)	3016 (49.2)	408 (46.1)	0.1720
Diabetes	183 (21.1)	1869 (30.5)	241 (27.2)	<0.0001
Cholelithiasis	246 (28.4)	1845 (30.1)	274 (30.9)	0.4883
Lung disease	279 (32.2)	1522 (24.8)	176 (24.8)	<0.0001
Liver disease	133 (15.4)	444 (7.2)	33 (3.7)	<0.0001
Urinary incontinence	200 (23.1)	1270 (20.7)	195 (22.0)	0.2173
Peptic ulcer disease	9 (1.0)	212 (3.5)	16 (1.8)	<0.0001
Use of mobility device	33 (3.8)	275 (4.5)	53 (6.0)	0.0712
History of venous thromboembolism	41 (4.7)	296 (4.8)	47 (5.3)	0.8109

76.3% vs AR 73.2%,  $p=0.43$ ). Complete results of GERD outcomes are included in Table 3.

There was no significant difference in the adjusted rates of 30-day hemorrhage, leak, and surgical complications between the three cohorts; however patients undergoing PR had higher adjusted rates of undergoing any complication (PR 5.5% vs PRM 5.1% vs AR 2.4%,  $p<0.0001$ ). Adjusted percent total body weight loss was similar across the groups (PRM 28.2% vs PR 28.7% vs AR 29.8%,  $p=0.08$ ). Complete results of adjusted clinical outcomes are included in Table 4.

## Discussion

By using a statewide bariatric specific data registry we were able to compare GERD outcomes of over 7,000 patients who underwent concurrent SG and hiatal hernia repair based on their surgeon's preference for hiatal hernia technique. Although overall satisfaction with GERD symptoms was high after surgery, regardless of technique, we found that surgeons who commonly performed an anterior repair had patients who reported higher rates of worsening GERD symptoms at 1 year after surgery. Interestingly, pre-operative BMI and post-operative weight loss were similar among groups, indicating that technical factors involving hiatal

hernia repair do appear to influence GERD symptoms after SG.

As sleeve gastrectomy has become increasingly common, new or worsening GERD has emerged as a significant concern for both patients and surgeons. It is well-established that worsening GERD not only leads to worse patient satisfaction, but also may predispose to more sinister outcomes such as the development of Barrett's esophagus or the need for revisional bariatric surgery [15–17]. While this risk may not be acceptable for some patients or surgeons the risk of new or worsening GERD is often tempered by other concerns such as the need for additional interventions or procedures later on, which is higher for patients undergoing gastric bypass [18] and for many patients SG is the preferred operation. Particularly for patients who may have GERD symptoms prior to their SG, understanding the most effective operative techniques to reduce these symptoms is critical. Repair of hiatal hernia at the time of SG is routinely recommended, but to our knowledge ours is the first study to evaluate variation in hiatal hernia repair technique and how this may impact GERD outcomes. While patients who underwent repair by surgeons who routinely perform an anterior repair had worse GERD outcomes, we also found that there were different rates of baseline GERD among the three cohorts that possibly influenced their surgeon's

**Table 3** Comparison of patient-reported GERD outcomes stratified by hiatal hernia repair technique

	Anterior repair N=866 (11%)	Posterior repair Without mesh N=6131 (78%)	Posterior repair With mesh N=886 (11%)	p value
Mean heartburn severity at baseline (0–5; higher = more severe)	0.99 (1.16)	1.20 (1.29)	1.40 (1.28)	<0.0001
Mean heartburn severity at 1 year (0–5; higher = more severe)	0.96 (1.28)	0.81 (1.17)	0.84 (1.17)	0.0032
<i>Heartburn severity at 1 year (%)</i>				
0	411 (53.0)	2809 (58.8)	377 (56.0)	0.0244
1	148 (19.1)	811 (17.0)	126 (18.7)	
2	110 (14.2)	674 (14.1)	100 (14.9)	
3	69 (8.9)	302 (6.3)	44 (6.5)	
4	20 (2.6)	118 (2.5)	20 (3.0)	
5	18 (2.3)	62 (1.3)	6 (0.9)	
New onset GERD	110 (15.9)	547 (12.9)	74 (12.3)	0.0755
<i>Existing GERD severity</i>				
Increased	406 (46.9)	2327 (38.0)	313 (35.3)	<0.0001
Decreased	276 (31.9)	1865 (30.4)	300 (33.9)	
No change	184 (21.3)	1939 (31.6)	273 (30.8)	
Antacid use at baseline (%)	149 (17.2)	1381 (22.5)	208 (23.5)	0.0011
Discontinuation of antacid use at 1 year (%)	117 (13.5)	818 (13.3)	121 (13.7)	0.9622
<i>BL Satisfaction w/present reflux condition</i>				
Satisfied	457 (62.7)	3117 (60.9)	430 (58.9)	0.3345
Neutral	188 (25.8)	1389 (27.1)	195 (26.7)	
Dissatisfied	84 (11.5)	615 (12.0)	105 (14.4)	
<i>1-year satisfaction w/present reflux condition</i>				
Satisfied	560 (73.2)	3570 (76.3)	504 (75.7)	0.4299
Neutral	165 (21.6)	872 (18.6)	128 (19.2)	
Dissatisfied	40 (5.2)	239 (5.1)	34 (5.1)	
<i>Change in satisfaction</i>				
Increased	407 (62.0)	2585 (62.1)	357 (60.5)	0.2502
No change	81 (12.4)	425 (10.2)	56 (9.5)	
Decreased	168 (25.6)	1154 (27.7)	177 (30.0)	

**Table 4** Adjusted clinical outcomes stratified by hiatal hernia repair technique

	Anterior repair N=866 (11%)	Posterior repair Without mesh N=6131 (78%)	Posterior repair With mesh N=886 (11%)	p value
30-day hemorrhage rate (%)	1.2	1.2	0.7	0.3660
30-day leak rate (%)	0.1	0.3	0.0	0.8017
% Total body weight loss, Mean (SD)	29.8 (8.8)	28.7 (9.1)	28.2 (9.4)	0.0771
Post-operative stricture (%)	0.1	0.2	0.5	0.1611
Endoscopic dilation (%)	2.1	2.3	2.3	0.4649
<i>Complications (%)</i>				
Any	2.4	5.5	5.1	<0.0001
Surgical	1.7	2.5	2.4	0.0581

technique. For example, patients in the AR cohort had the lowest rates of baseline GERD (55.3%) compared to patients in the PRM cohort (64.8%). This may indicate that surgeons

who have patients with more severe GERD perform more intensive interventions in response (e.g., routinely using mesh) or have tailored their interventions over time.

Hiatal hernia is common both at the time of SG as well as in the post-operative follow-up period. Approximately one-third of patients undergo concurrent hiatal hernia repair at the time of SG (compared to only 20% of gastric bypass patients) [5, 19] and development of a new hiatal hernia after SG is also common (up to 45–72% of patients) [17, 20]. While there is limited data on the effect of concurrent hiatal hernia repair on objective evidence of GERD (e.g., abnormal pH study) or patient-reported outcomes such as GERD severity, small studies show that concurrent hiatal hernia repair can reduce patient-reported GERD symptoms severity scores overall [21]. In addition, the procedure is generally very safe. One analysis of 32,581 patients undergoing SG in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database found that risks of mortality, reoperation, and major complications were not different [22]. However, other studies show that patients undergoing concurrent hiatal hernia repair may have a higher risk of readmission following surgery or re-intervention including additional interventions or procedures [23, 24]. We found this to be true, as well, with overall low risk of adverse outcomes. Interestingly, we did find that patients in the PR cohort (the most common technique) had slightly higher risks of any complications, and had a small but not statistically significant higher risk of surgical complications.

Because of the limiting data comparing different crural closure techniques, a “gold standard” does not exist for patients undergoing concurrent hiatal hernia repair with SG. While some studies advocate for posterior repair as the most effective intervention, other have found no difference based on technique and it is thus up to the discretion of the operating surgeon [25]. In the one prospective trial comparing anterior vs posterior crural repair, early results showed that at 6 months post-operatively there was no significant difference in terms of GERD symptoms or satisfaction, but that patients who underwent posterior repair had a higher incidence of undergoing additional interventions to address dysphagia [26]. At the 10-year follow-up, patients undergoing anterior repair had lower rates of dysphagia to certain foods but there was otherwise no difference in medication use, GERD symptoms, or satisfaction [27]. However, it should be noted that these findings were based on only 102 patients and have not been replicated. Moreover, the patients in this study were also undergoing concomitant Nissen fundoplication which further reduces GERD symptoms and thus the results may not be applicable to patients undergoing sleeve gastrectomy. Our findings suggest that while all methods of closure are likely safe, there may be an advantage in terms of GERD symptoms control to undergoing a posterior repair without mesh. As prevention of GERD symptoms is a paramount concern for surgeons, this should be considered when performing concurrent hiatal hernia repair with SG

and strong consideration should be given to performing a posterior repair.

This study has several limitations. First, we only included patients who completed both a baseline and follow-up survey, which represents approximately 40% of the entire MBSC patient population and thus may have introduced a selection bias toward patients with significantly better or worse reflux control. However, our study did include over 7000 patients and captured 100% of the surgeons participating in the MBSC, which provides largest and most inclusive data set on this topic. Another limitation is that data was limited to 1 year and we lacked the opportunity to evaluate long-term GERD symptoms or rates of hiatal hernia recurrence. Although hiatal hernia repair technique may influence long-term outcomes, it is also likely that additional patient-factors such as weight regain or other changes in health (e.g., pregnancy), may bias these analyses. In addition, we relied exclusively on patient-reported symptoms when analyzing GERD outcomes, rather than obtaining objective data such as pH studies or endoscopy. Since our intent was to assess symptom severity, we felt that patient-reported outcomes were superior to procedural-based assessments, which are also resource intensive and not performed routinely. Finally, we recognize that we compared patient outcomes based on surgeon’s preference for hiatal repair technique and not the actual technique performed at the time of the procedure, since this is not a data-element that is captured by the MBSC. If a surgeon deviated from their typical approach on a given case, then some patients may have been misclassified. Nevertheless, this is likely to be a rare event which is unlikely to have an impact on the overall analysis.

Overall, patients undergoing sleeve gastrectomy with concurrent hiatal hernia repair had a high rate of satisfaction with GERD symptoms at 1 year after surgery. However, surgeons who typically performed an anterior repair had nearly one-half of their patients reporting an increase GERD severity after surgery, despite no differences in weight loss, when compared to posterior repair either with or without mesh. Although GERD symptom control after sleeve gastrectomy is likely multifactorial, the technical approach to hiatal hernia repair at the time of surgery may play a role and a posterior repair is recommended over an anterior repair.

## Declarations

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