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Factors influencing the choice between laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass

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Abstract

Background While laparoscopic sleeve gastrectomy (LSG) continues to be the most commonly performed bariatric operation, several variables influence surgeons' practice patterns and patients' decision-making in the type of bariatric procedure to perform. The aim of this study was to evaluate patient factors that influence the decision between laparoscopic Roux-en-Y gastric bypass (LRYGB) versus LSG.

Methods The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database was queried for patients undergoing LSG and LRYGB between 2015 and 2017. Univariate analysis and multivariate logistic regression were used to evaluate factors associated with performing LRYGB compared to LSG.

Results A total of 252,117 (72.3%) LSG and 96,677 (27.7%) LRYGB cases were identified. Patients undergoing LSG were younger (44.3 ± 12.0 vs 45.2 ± 11.8 years; $p < 0.01$) and had a lower body mass index (BMI; 45.1 ± 7.8 vs 46.2 ± 8.1 kg/m^2; $p < 0.01$). Most of the patients were females (79.4%), white (73.0%), with an American Society of Anesthesiology (ASA) class ≤ 3 (96.4%). The factors associated with undergoing LRYGB compared to LSG were diabetes mellitus, gastroesophageal reflux disease, BMI ≥ 50 kg/m^2, ASA class > 3, obstructive sleep apnea, hypertension, and hyperlipidemia. However, patients with kidney disease, black race, chronic steroid use, age ≥ 60 years, recent smoking history, chronic obstructive pulmonary disease, and coronary artery disease were more likely to undergo LSG.

Conclusions The decision to perform LRYGB is primarily driven by obesity-associated comorbidities and higher BMI, whereas LSG is more likely to be performed in higher risk patients.

Keyword Bariatric surgery · Roux-en-Y gastric bypass · Sleeve gastrectomy · Procedure choice · Comorbidities · Body mass index

In 2013, laparoscopic sleeve gastrectomy (LSG) surpassed laparoscopic Roux-en-Y gastric bypass (LRYGB) as the most commonly performed bariatric procedure [1]. The proportion of LSGs performed continued to increase and constituted 61.4% of all primary metabolic and bariatric procedures performed in 2018 in the United States [1]. The continued increase in LSG may be primarily related to its superior safety profile compared to LRYGB [2, 3], as well as comparable long-term weight loss and comorbidity remission [4–6].

Despite the adoption of LSG by most surgeons and centers, there continues to be significant variability in the practice patterns of individual surgeons and a lack of standardized guidelines for procedure selection [7]. Kallies et al. emphasized the importance of providing risks and benefits of each procedure and the role of patient preference in the decision-making [8]. Moreover, Opozda et al. surveyed 236 patients and demonstrated that patients had a clear procedure preference based on their research, knowledge, and experience [9]. On the other hand, in their statewide analysis evaluating 142 surgeons, Udelsman et al. described that surgeon practice patterns had the strongest correlation with procedure selection compared to patient or hospital-related factors [7]. This may be due to the surgeon's crucial role in presenting and interpreting data for patients [7, 9].

Although the decision in procedure choice may be multifactorial, there continues to be a paucity of data on metabolic factors and comorbidities that play a role in procedure choice. As a result, though one procedure may be better suited for

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certain comorbidities and patient characteristics, this does not always reflect the procedure which is ultimately selected. The objective of this study was to evaluate patients' factors that influence the decision to perform LRYGB versus LSG using the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database.

Materials and methods

This retrospective study identified patients in the MBSAQIP database who underwent elective nonrevisional LSG and LRYGB from January 1, 2015 to December 31, 2017 to evaluate the factors influencing the choice between these two procedures. The Institutional Review Board at our institution deemed this study exempt from review. Written consent was not obtained due to the de-identified nature of the data and lack of patient interaction.

Data source

Data were obtained from the MBSAQIP Participant Use File, the largest bariatric-specific database with 832 participating centers in the United States and Canada, and over 200,000 cases captured each year [10]. Specific preoperative demographic variables, preoperative comorbidities, procedure information, and 30-day outcomes are collected by certified clinical reviewers with specific training in metabolic bariatric surgery. Data accuracy and integrity are ensured through regular audits.

Study population

We identified adult patients (≥ 18 years) using Current Procedural Terminology codes 43,775 for LSG and 43,644 and 43,645 for LRYGB. Only cases completed with the conventional laparoscopic approach were included, and cases completed with the open or robotic-assisted approach were excluded. Cases labeled as emergent or conversion/revision were excluded.

Variables analyzed

Demographic variables including age, sex, race, body mass index (BMI), and American Society of Anesthesiologists (ASA) class were collected. Age was reported as a categorical variable. ASA class was represented as a binary variable (≤ 3 and > 3). BMI was also represented as a binary variable (< 50 kg/m^2 and ≥ 50 kg/m^2). Preoperative comorbidities and laboratory values included diabetes mellitus, hypertension, hyperlipidemia, coronary artery disease, gastroesophageal reflux diseases (GERD), chronic kidney disease or end-stage renal disease, deep vein thrombosis or pulmonary embolism, anticoagulation, chronic steroid use, smoking within 1 year, chronic obstructive pulmonary disease, obstructive sleep apnea (OSA), previous foregut surgery, and hematocrit. Coronary artery disease was defined as the occurrence of at least one of the following variables: previous percutaneous coronary intervention, history of myocardial infarction, or previous cardiac surgery. Hematocrit was reported as a binary variable ($< 30\%$ and $\geq 30\%$). The year the procedure was performed was also reported as a separate variable.

Statistical analysis

Descriptive statistics were used to report baseline demographics, comorbidities, and laboratory values. Univariate analysis used Pearson X^2 for categorical variables and Student's t-test for continuous variables. To determine the association between procedure performed and baseline characteristics, multivariate logistic regression modeling was used. Variables were selected using a stepwise forward selection with $p < 0.05$ used as an entry criterion. The adjusted odds ratio (AOR) with 95% confidence intervals (95% CI) was reported for each variable. Statistical significance was set to $p < 0.05$. All analyses were conducted using IBM SPSS version 25 (IBM Corp, Armonk, NY, USA).

Results

A total of 348,794 cases were included in the analysis: 252,117 (72.3%) LSG and 96,677 (27.7%) LRYGB. Baseline demographics, preoperative comorbidities, and laboratory values are shown in Table 1. Patients undergoing LSG were younger (44.3 ± 12.0 vs 45.2 ± 11.8 years; $p < 0.01$) with a lower proportion of patients ≥ 60 years old (11.2% vs 12.1%; $p < 0.01$). Most of the patients were white (73.0%), females (79.4%), with an ASA class of ≤ 3 (96.4%). The LSG group had a lower BMI (45.1 ± 7.8 vs 46.2 ± 8.1 kg/m^2; $p < 0.01$) with a lower proportion of patients having a BMI ≥ 50 kg/m^2 (21.5% vs 26.8%; $p < 0.01$). The most common comorbidities recorded were hypertension (48.7%), OSA (38.2%), GERD (30.6%), diabetes mellitus (26.4%), and hyperlipidemia (24.1%). Hypertension, hyperlipidemia, coronary artery disease, GERD, deep vein thrombosis or pulmonary embolism, preoperative anticoagulation, chronic obstructive pulmonary disease, OSA, and previous foregut surgery were higher with LRYGB. On the other hand, chronic steroid use, smoking within the last year, and hematocrit $\leq 30\%$ were higher in the LSG group. There was an incremental increase in the percentage of LSG performed through the years reported (69.7% in 2015; 72.7% in 2016; 74.0% in 2017).

Table 2 and Fig. 1 represent the results of the multivariate logistic regression analysis. The AOR represents

Table 1 Baseline patient characteristics for laparoscopic sleeve gastrectomy and laparoscopic Roux-en-Y gastric bypass

	LSG ($n=252,117$)	LRYGB ($n=96,677$)	p-value
Age, years			**< 0.01**
18–29	30,566 (12.1%)	10,145 (10.5%)	
30–39	65,446 (26.0%)	23,548 (24.4%)	
40–49	73,097 (29.0%)	28,231 (29.2%)	
50–59	54,663 (21.7%)	23,048 (23.8%)	
≥ 60	28,345 (11.2%)	11,705 (12.1%)	
Sex			**< 0.01**
Female	199,443 (79.1%)	77,510 (80.2%)	
Male	52,674 (20.9%)	19,167 (19.8%)	
Race			
White	182,318 (72.3%)	72,387 (74.9%)	**< 0.01**
Black	47,720 (19.0%)	13,718 (14.2%)	
Other/Not reported	22,079 (8.8%)	10,572 (10.9%)	
American Society of Anesthesiologists class			
≤ 3	244,090 (96.8%)	92,150 (95.3%)	**< 0.01**
> 3	8027 (3.2%)	4527 (4.7%)	
Body mass index ≥ 50 kg/m^2	54,067 (21.5%)	25,930 (26.8%)	**< 0.01**
Diabetes mellitus			
Insulin dependent	16,524 (6.6%)	13,310 (13.8%)	**< 0.01**
Noninsulin dependent	41,555 (16.5%)	20,572 (21.3%)	
Hypertension	118,550 (47.0%)	51,152 (52.9%)	**< 0.01**
Hyperlipidemia	56,193 (22.3%)	27,880 (28.8%)	**< 0.01**
Coronary artery disease	7679 (3.1%)	3498 (3.6%)	**< 0.01**
Gastroesophageal reflux disease	70,293 (27.9%)	36,434 (37.7%)	**< 0.01**
Chronic kidney disease or end-stage renal disease	2014 (0.8%)	733 (0.8%)	0.22
Deep vein thrombosis or pulmonary embolism	5512 (2.2%)	2612 (2.7%)	**< 0.01**
Anticoagulation	6400 (2.5%)	2592 (2.7%)	**0.02**
Chronic steroid use	4540 (1.8%)	1485 (1.5%)	**< 0.01**
Smoker within 1 year	22,523 (8.9%)	8201 (8.5%)	**< 0.01**
Chronic obstructive pulmonary disease	4134 (1.6%)	1915 (2.0%)	**< 0.01**
Obstructive sleep apnea	91,330 (36.2%)	41,874 (43.3%)	**< 0.01**
Previous foregut surgery	4009 (1.6%)	1632 (1.7%)	**< 0.01**
Hematocrit ≤ 30%	1186 (0.5%)	405 (0.4%)	**0.04**
Year of operation			
2015	73,985 (29.4%)	32,116 (33.2%)	**< 0.01**
2016	84,495 (33.5%)	31,705 (32.8%)	
2017	93,637 (37.1%)	32,856 (34.0%)	

Bold values indicate statistical significant ($p < 0.05$)

the odds of undergoing LRYGB for each variable using LSG as a reference. A positive association with performing LSG compared to LRYGB was noted with older age (≥ 60 years: AOR 0.83; 95% CI 0.80–0.86; $p < 0.01$), male sex (AOR 0.79; 95% CI 0.77–0.80; $p < 0.01$), and black race (AOR 0.71; 95% CI 0.69–0.72; $p < 0.01$). Variables associated with performing LRYGB were diabetes mellitus, particularly insulin-requiring diabetes mellitus (AOR 2.41; 95% CI 2.35–2.48; $p < 0.01$), GERD (AOR 1.47; 95% CI 1.45–4.50; $p < 0.01$), and BMI ≥ 50 kg/m^2 (AOR 1.35; 95% CI 1.32–1.37; $p < 0.01$). Other obesity-related comorbidities associated with performing LRYGB included OSA, hypertension, and hyperlipidemia. An ASA class > 3 was associated with performing LRYGB compared to LSG (AOR 1.22; 95% CI 1.17–1.27; $p < 0.01$). On the other hand, comorbidities more likely to be associated with performing LSG included kidney disease (AOR 0.67; 95% CI 0.61–0.73; $p < 0.01$), chronic steroid use (AOR 0.77; 95% CI 0.72–0.81; $p < 0.01$), preoperative anticoagulation (AOR 0.85; 95%

Table 2 Multivariate logistic regression model showing adjusted odds ratio for significant variables associated with undergoing laparoscopic Roux-en-Y gastric bypass compared to laparoscopic sleeve gastrectomy

	AOR (95% CI)†	*p*-value reference
Age, years		
18–29	1.00	
30–39	1.00 (0.98 – 1.03)	0.88
40–49	0.98 (0.95 – 1.00)	0.08
50–59	0.95 (0.92 – 0.97)	**< 0.01**
≥ 60	0.83 (0.80 – 0.86)	**< 0.01**
Sex		
Female	1.00	Reference
Male	0.79 (0.77 – 0.80)	**< 0.01**
Race		
White	1.00	Reference
Black	0.71 (0.69 – 0.72)	**< 0.01**
Other/Not reported	1.27 (1.24 – 1.30)	**< 0.01**
American Society of Anesthesiologists class		
≤ 3	1.00	Reference
> 3	1.22 (1.17 – 1.27)	**< 0.01**
Body mass index ≥ 50 kg/m^2	1.35 (1.32 – 1.37)	**< 0.01**
Diabetes mellitus		
Insulin dependent	2.41 (2.35 – 2.48)	**< 0.01**
Noninsulin dependent	1.46 (1.43 – 1.49)	**< 0.01**
Hypertension	1.04 (1.02 – 1.06)	**< 0.01**
Hyperlipidemia	1.09 (1.07 – 1.11)	**< 0.01**
Coronary artery disease	0.94 (0.90 – 0.98)	**< 0.01**
Gastroesophageal reflux disease	1.47 (1.45 – 1.50)	**< 0.01**
Chronic kidney disease or end-stage renal disease	0.67 (0.61 – 0.73)	**< 0.01**
Deep vein thrombosis or pulmonary embolism	1.15 (1.09 – 1.21)	**< 0.01**
Anticoagulation	0.85 (0.80 – 0.89)	**< 0.01**
Chronic steroid use	0.77 (0.72 – 0.81)	**< 0.01**
Smoker within 1 year	0.92 (0.90 – 0.95)	**< 0.01**
Chronic obstructive pulmonary disease	0.93 (0.88 – 0.98)	**0.01**
Obstructive sleep apnea	1.22 (1.20 – 1.24)	**< 0.01**
Hematocrit ≤ 30%	0.87 (0.78 – 0.98)	**0.02**
Year of operation		
2015	1.00	Reference
2016	0.87 (0.85 – 0.88)	**< 0.01**
2017	0.81 (0.80 – 0.83)	**< 0.01**

Bold values indicate statistical significant ($p < 0.05$)

AOR adjusted odds ratio, *CI* confidence interval

†AOR for laparoscopic Roux-en-Y gastric bypass compared to laparoscopic sleeve gastrectomy as reference

CI 0.80–0.89; $p < 0.01$), hematocrit ≤ 30% (AOR 0.87; 95% CI 0.78–0.98; $p = 0.02$), smoking within 1 year (AOR 0.92; 95% CI 0.90–0.95; $p < 0.01$), chronic obstructive pulmonary disease (AOR 0.93; 95% CI 0.88–0.98; $p = 0.01$), and coronary artery disease (AOR 0.94; 95% CI 0.90–0.98; $p < 0.01$). With the progression of the year of operation, there was an incremental decrease in the AOR of performing LRYGB compared to LSG.

Discussion

Our analysis of this multi-institutional database suggests that patient characteristics and comorbidities influence the type of bariatric procedure performed. After multivariable adjustment, obesity-related comorbidities such as diabetes mellitus, GERD, OSA, and hyperlipidemia increase the odds of undergoing LRYGB. The greatest association was noted

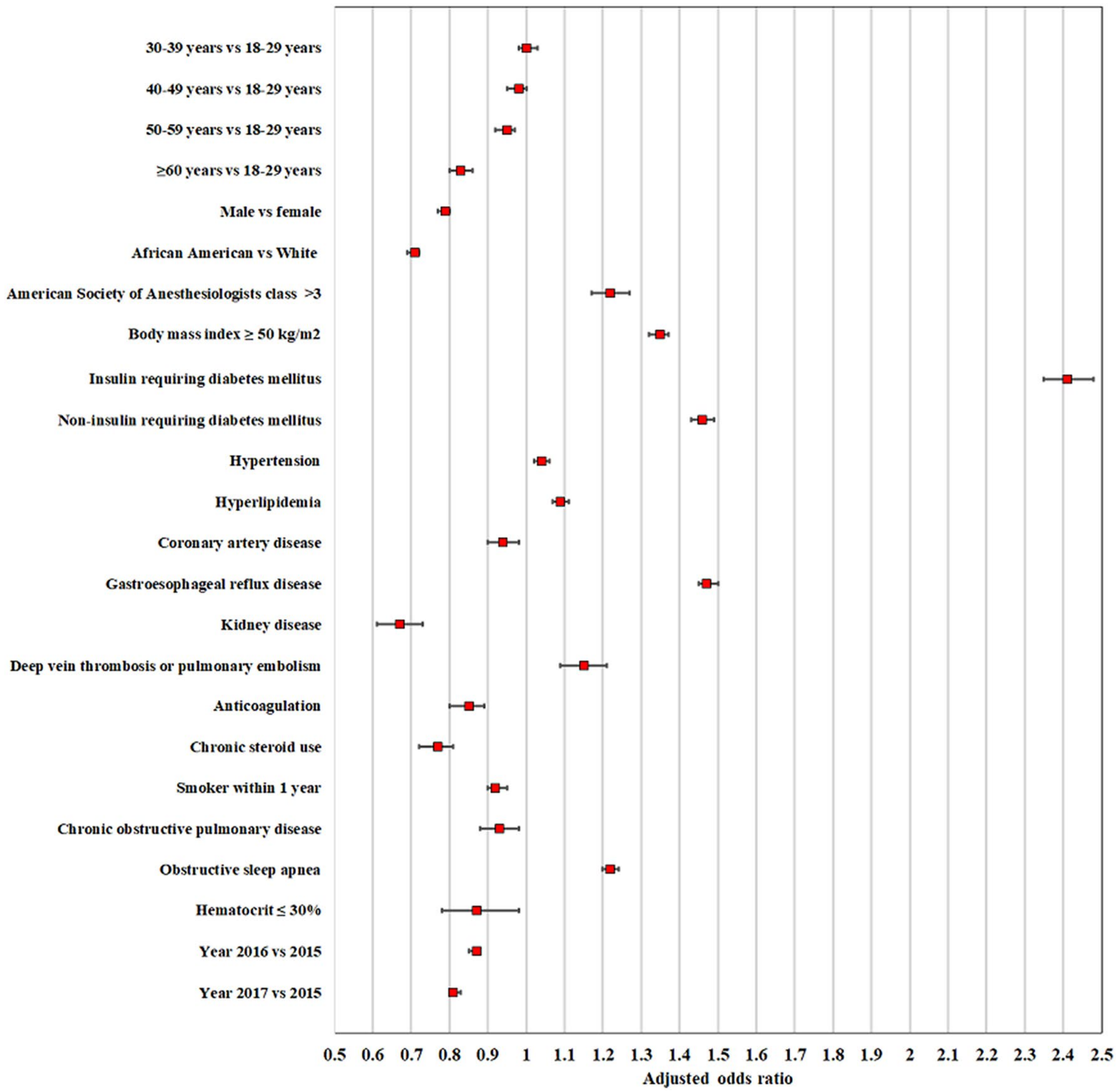

Fig. 1 Adjusted odds ratio for significant variables associated with undergoing laparoscopic Roux-en-Y gastric bypass compared to laparoscopic sleeve gastrectomy (reference)

with insulin-requiring diabetes mellitus. Moreover, patients with BMI ≥ 50 kg/m^2 were more likely to undergo LRYGB. On the other hand, comorbidities that are associated with a higher operative risk such as older age, coronary artery disease, kidney disease, smoking on initial evaluation, and chronic obstructive pulmonary disease were associated with undergoing LSG. Interestingly, male sex and African American race were more likely to undergo LSG compared to LRYGB.

The decision underlying the selection of a particular surgical procedure is multifactorial and includes a combined weighting of patient comorbidities, access to health care, financial factors, health care insurance, patterns of physician referral, patient and surgeon preferences [11–13]. With regards to the latter, outcomes after bariatric surgery are differentially prioritized between patients and providers highlighting the importance of shared decision-making to achieve not only tangible post-bariatric surgery outcomes such as weight loss but also to address patients' concerns and expectations [14, 15]. Rozier et al. identified three subgroups of patients based on responses in an internet-based survey in Michigan: patients most focused on costs (cost-sensitive), patients most concerned with excess weight loss and medical comorbidity remission (benefit-focused), and patients most concerned with how the treatment works including recovery and reversibility (procedure-focused) [16]. Kallies et al. evaluated how patient preferences impact the decision for LRYGB vs LSG using an electronic questionnaire and found that respondents selected LRYGB when evidence-based risks and benefits of the procedure were presented. In contrast, preference was equivalent when procedural images were shown [8]. With the strong patient preferences noted towards LRYGB rather than LSG in the questionnaire, the authors suggested that there are likely other drivers for the increasing LSG trend seen in the United States [8]. In another survey of Australian bariatric surgery patients, Opozda et al. found that patients who had undergone LRYGB supported their decision based on evidence and success rate [9]. In contrast, patients who had undergone LSG quoted the most common reason being the recommendation of the medical practitioner [9]. Bariatric surgeons may be more inclined to offer a patient one type of procedure over another depending on a clinical phenotype and physiological mechanisms of the operations [7, 17]. Moreover, compared to patients, surgeons are more likely to select procedures based on lower complication risks and are less sensitive to out-of-pocket costs [16]. Udelsman et al. found in their analysis that surgeon factors were more strongly associated with the selection of procedure rather than patient and hospital factors [7].

The efficacy of both LRYGB and LSG in weight loss and remission of obesity-related comorbidities has been well established [6, 18–25]. In a systematic review including 5264 patients from 14 studies with midterm (3–5 years) and long-term follow-up ($\geq$ 5 years), Shoar et al. showed better weight loss with LRYGB only in the long-term with no significant difference between LSG and LRYGB for remission of diabetes mellitus, hypertension, and hyperlipidemia [6]. On the other hand, in a meta-analysis of 62 studies published by Li et al. LRYGB was superior to LSG with regards to percentage excess weight loss as well as remission of hypertension and hyperlipidemia but not diabetes mellitus or OSA [26]; this difference may be related to the inclusion of studies with short-term follow-up in the latter study. In an observational nonrandomized cohort study of 544 patients undergoing LSG and LRYGB, Jimenez et al. found comparable effectiveness of both procedures on percentage total weight loss and excess weight loss at 10 years of follow-up [27]. Moreover, there is a lack of consensus on the efficacy of LSG compared to LRYGB in super-obese patients (BMI $\geq$ 50 kg/m^2). In a matched analysis of 57 LSG and 57 LRYGB super-obese patients with a 7-year follow-up, Ahmed et al. showed a significantly lower weight loss with the LSG cohort throughout the follow-up period [28]. On the other hand, Hong et al. compared 607 super-obese patients undergoing LSG or LRYGB and showed no difference in percent excess weight loss up to 3 years of follow-up [29]. Celio et al. found a higher proportion of resolution of diabetes mellitus, hypertension, GERD, hyperlipidemia, and obstructive sleep apnea at 1-year in LRYGB. Additionally, while no differences in overall 30-day morbidity were found, the LRYGB group had higher readmission and reoperation rates [30]. Despite the lack of clear benefit of LRYGB compared to LSG with regards to weight loss in super-obese patients and remission of obesity-related comorbidities in long-term studies, these comorbidities especially diabetes mellitus as well as a BMI $\geq$ 50 kg/m^2 seem to be associated with a higher AOR of LRYGB based on our analysis. This suggests that the notion that LRYGB is more effective with regards to weight loss and comorbidity remission may persist among bariatric surgeons.

Although the role of LSG in the management of obesity has been well established, there are concerns about its association with postoperative GERD [31]. The high incidence of GERD after LSG may be due to increased intragastric pressure and a hypotensive lower esophageal sphincter resulting in increased esophageal acid exposure [32, 33]. On the other hand, LRYGB is considered an ideal anti-reflux procedure for patients with morbid obesity and GERD [34]. In the Swiss Multicenter Bypass or Sleeve Study (SM-BOSS), LSG significantly worsened the incidence of preexisting GERD (20% vs 2%) and increased the development of de novo GERD (18% vs 2%) compared to LRYGB [25]. Mandeville et al. reported a 47.8% chance of developing de novo GERD after LSG with a mean follow-up of 8.48 years [35]. Moreover, a study of 110 patients undergoing LSG, revealed an alarming rate of 9.1% of class D esophagitis and 17.2% of nondysplastic Barrett's esophagus at 58 months postoperatively [36]. Although some studies show different results reporting that LSG may improve GERD symptoms [37], in light of the emerging literature raising the prior concerns, LRYGB is considered the ideal bariatric operation for patients with GERD [38]. This seems consistent with our finding as patients with preoperative GERD had 1.47 adjusted odds of undergoing LRYGB compared to LSG.

Our analysis notes a tendency to performing LSG in older patients, particularly $\geq$ 60 years of age. Although this may be related to the surgeons' inclination to offer the safer operation in the higher risk surgical candidates [39], it is unclear based on our analysis if there is another reason that can explain this trend. Moreover, the MBSAQIP does not capture patient characteristics beyond clinical parameters; other factors such as insurance and socioeconomic status play an essential role in the eligibility for bariatric surgery [40]. In one study, the most common reason patients eligible for bariatric surgery failed to undergo the procedure was insurance denial and unattainable coverage prerequisites [40]. Additional factors adversely impacting access to bariatric surgery include non-white race, uninsured or underinsured status, lower-income, and male sex [41–44]. Discrepancies among these factors may underlie the sex and racial disparities observed in this study. Higher socioeconomic and insurance status may potentially improve patients' chances of undergoing the procedure they prefer rather than what is offered.

During bariatric surgical consultation with prospective patients the authors of this manuscript utilize the free

Michigan Bariatric Surgical Collaborative "Weigh the Odds" application on their smartphone to assist with procedure selection [45]. This application provides estimates of weight loss, comorbidity remission, and 30-day complications for primary bariatric operations including comparison of outcomes for different procedures which facilitates and enhances joint decision-making by the patient and surgeon. Furthermore, our practice incorporates the following management guidelines for procedure selection which are consistent with the findings of this paper. At our program, LSG is considered a contraindication in patients with Barrett's esophagitis and a relative contraindication for severe erosive esophagitis or large hiatal hernia. On the other hand, LRYGB is considered a contraindication or relative contraindication in patients with these characteristics: chronic steroid use, long-term smoking history, iron deficiency anemia, and high-risk status. Based on the results from this application any complications, severe complications, and mortality are typically twice as high with LRYGB as compared to LSG.

There is a distinction between an elevated risk from a surgical standpoint and a patient comorbidity standpoint. For instance, steroids have been associated with increased complications after LRYGB including anastomotic stricture and marginal ulcers [46], thereby increasing the likelihood of selecting LSG in this patient population. Smoking cessation is required before bariatric surgery as it results in significant postoperative morbidity such as marginal ulceration in patients undergoing LRYGB [47]. Thus, these patients are more likely to undergo LSG. This may be driven by a surgeon's fear that patients with a preoperative smoking history may be at higher risk of smoking relapse. This relapse rate is 9.6% at 1-year and 14.0% at 7-years after LRYGB [48]. The high incidence of iron deficiency after LRYGB may influence surgeons towards performing LSG in patients with hematocrit $\leq$ 30% to avoid exacerbating their anemia [49]. As mentioned previously, in contrast to these primarily surgical procedure-related factors, patient comorbidities may also impact decision-making. Coronary artery disease and chronic obstructive pulmonary disease are well-known comorbidities for elevating the risk of surgery and anesthesia. Patients with chronic kidney disease and end-stage renal disease may be better candidates for LSG given their potential candidacy for renal transplantation in the future due to the need for steroid therapy and a reduction in the malabsorption of immunosuppressive medications as compared to LRYGB. Lastly, our analysis reveals an association between a higher ASA class and undergoing LRYGB. This is most likely driven by the higher likelihood of patients with obesity-related comorbidities undergoing LRYGB as data suggests better remission as compared to LSG [26, 30]. Furthermore, it is worth mentioning that ASA class is often subjective and inconsistent. It is also influenced by the severity of the comorbidities which is absent in the database. Thus, this association may also be the result of residual confounding.

This study is limited by its retrospective, nonrandomized study design with the potential for misclassification and selection bias. While the study's retrospective and descriptive nature allow evaluating associations between clinical variables and the procedure, it does not allow inferences regarding causation. The available data do not provide insight into the exact reason why a procedure was selected over another, given a set of patient characteristics. Furthermore, there are lack of data on the severity of comorbidities which factors into the procedure choice as well. There are likely other factors that drive decision-making for selecting a bariatric procedure that is not reflected in the variables reported by the database used and is thus a source of residual confounding. Moreover, there is no information on individual hospital systems or surgeons and their experiences and preferences for selecting one procedure over the other. These factors also influence the procedure choice and could not be included in our analysis. Nonetheless, this large multi-institutional national database study offers insight into potential factors that may influence and drive clinical decision-making for selection of LSG vs LRYGB.

In conclusion, preoperative patient characteristics are differentially associated with undergoing LRYGB compared to LSG. Patients with obesity-related comorbidities are more likely to undergo LRYGB, whereas higher risk patients are more likely to undergo LSG. Moreover, the presence of GERD was associated with having LRYGB. Our analysis also indicates the presence of gender and racial disparities in the performance of these two operations.

Compliance with ethical standards

Disclosures Dr. Arthur M. Carlin receives an honorarium from Blue Cross Blue Shield of Michigan as Executive Committee Chair of the Michigan Bariatric Surgery Collaborative. Dr. Hassan Nasser and Dr. Tommy Ivanics have no conflicts of interest or financial ties to disclose.

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