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ORIGINAL CONTRIBUTIONS

Conversion of Sleeve Gastrectomy to Roux-en-Y Gastric Bypass: Indications, Prevalence, and Safety

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Abstract

Background Sleeve gastrectomy (SG) frequently requires conversion to Roux-en-Y gastric bypass (RYGB) due to gastroesophageal reflux disease (GERD) or weight recurrence. Current evidence evaluating the safety of conversion from SG to RYGB and its indications is limited to single centers.

Methods The objective was to determine the rate of serious complications and mortality of conversion of SG to RYGB (SG-RYGB) compared to primary RYGB (P-RYGB). This was a retrospective analysis of the MBSAQIP database which includes 30-day outcomes. Individuals undergoing P-RYGB or SG-RYGB were included. Multivariable logistic regression was performed to determine if revisional surgery was an independent predictor of serious complications or mortality.

Results In 2020 and 2021, 84,543 (86.3%) patients underwent P-RYGB and 13,432 (13.7%) underwent SG-RYGB. SG-RYGB cohort had lower body mass index, lower rates of diabetes and hypertension, and higher rates of GERD. GERD was the most common indication for revision (55.3%) followed by weight regain (24.4%) and inadequate weight loss (12.7%). SG-RYGB had longer operative times (145 vs. 125 min, $p<0.001$) and a higher rate of serious complications (7.2 vs. 5.0%, $p<0.001$). This included higher rates of anastomotic leak (0.5 vs. 0.4%, $p=0.002$), bleeding (2.0 vs. 1.6%, $p<0.001$), and reoperation (3.0 vs. 1.9%, $p<0.001$) but not death (0.1 vs. 0.1%, $p=0.385$). On multivariable analysis, SG-RYGB was independently predictive of serious complications (OR 1.21, 95%CI 1.12 to 1.32, $p<0.001$) but not mortality ($p=0.316$).

Conclusions While SG-RYGB is safe with a low complication rate, SG-RYGB was associated with a higher rate of serious complications compared to P-RYGB.

Keywords Sleeve gastrectomy · Roux-en-Y gastric bypass · Conversion · Revision · Bariatric surgery · Complications

Introduction

Sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) are currently the two most commonly performed bariatric surgeries [1]. Their popularity has increased over the past decade due to research advances that demonstrate their safety and sustained weight loss efficacy [2]. While RYGB is considered the gold standard procedure for weight loss, SG is increasingly performed as it has fewer complications, requires less operative time, and has a lower risk of micronutrient deficiencies [3]. However, SG is more often associated with gastroesophageal reflux disease (GERD), weight recurrence, and inadequate weight loss when compared to RYGB [3], and these complications may necessitate revisional surgery.

Patients who undergo SG can require further surgical intervention to alleviate symptoms of GERD and weight recurrence [4–6]. The most common conversion choice for revisions after sleeve gastrectomy is RYGB, given its proven ability to relieve GERD and improve weight loss. However, revisional surgeries are more complex and have been associated with higher complication rates [5, 7, 8]. A systematic

Key Points

- Conversion from sleeve gastrectomy to Roux-en-Y gastric bypass (SG-RYGB) was compared to primary RYGB (P-RYGB).
- Main indications for revision were reflux (55.3%), weight recurrence (24.4%), and inadequate weight loss (12.7%).
- SG-RYGB had a higher rate of serious complications than P-RYGB (7.2 vs. 5.0%, $p < 0.001$).
- Mortality was rare and not different between SG-RYGB and P-RYGB (0.1 vs. 0.1%, $p = 0.385$).

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review in 2018 reported a higher risk of complications with revisional RYGB compared to primary RYGB. However, in this study, initial procedures were heterogenous and included few primary SG procedures [9].

Current evidence evaluating the safety of revisional RYGB is limited to single centers, and few studies compare primary versus secondary RYGB after SG. With the rise in revisional procedures, it becomes more crucial to evaluate the safety of one of the most popular revisional bariatric surgeries on a larger scale.

Due to the limitations of previous studies and the growing need to study the revisional surgery population, our study is aimed at determining the rate of 30-day serious complications and mortality of primary RYGB (P-RYGB) compared to sleeve gastrectomy converted to RYGB (SG-RYGB) using new variables added to the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database. Secondary objectives include identifying and characterizing indications for SG-RYGB conversion.

Methods

Data Source

A retrospective analysis of the MBSAQIP data registry was performed. Only the 2020 and 2021 years were included as there was a modification in 2020 that included additional details on revisional surgery that were previously not reported. The MBSAQIP currently captures clinical data from 902 accredited American and Canadian centers. The data registry prospectively collects data and contains standardized pre-, intra-, and post-operative variables specific to bariatric surgery patients. This study included laparoscopic and robotic-assisted P-RYGB and revisional SG-RYGB procedures. Open and endoscopic procedures were excluded.

Patient Variables

Basic demographic data including age, sex, race, and body mass index (BMI) were collected. Patient comorbidities included the following: type 2 diabetes, hypertension, GERD, chronic obstructive pulmonary disease (COPD), hyperlipidemia, chronic steroid use, chronic kidney disease, dialysis dependency, venous stasis, preoperative therapeutic anticoagulant use, and obstructive sleep apnea. Patient history included previous venous thromboembolism (VTE), myocardial infarction (MI), percutaneous coronary intervention, and major cardiac surgery. Functional status variables encompassed preoperative functional status (defined as independent, partially dependent, or fully dependent) and American Society of anesthesiologists (ASA) Physical Status classification.

Objectives

The primary objective of this study was to determine the rate of serious complications and mortality of SG-RYGB and P-RYGB. Patients with at least one of the following complications within 30 days of surgery were defined as having a serious complication:

- Anastomotic leak
- Postoperative bleeding
- Reoperation
- Non-operative intervention
- Cardiac event (cardiac arrest, MI, or cardiopulmonary resuscitation)
- Pneumonia
- Unplanned intubation
- Acute kidney injury
- Venous thromboembolism
- Deep surgical site infection or wound disruption
- Sepsis
- Cerebrovascular accident

We aimed to develop a multivariable logistic regression model to determine risk factors associated with serious complications and mortality for patients undergoing SG-RYGB and P-RYGB. Secondary objectives included identifying and characterizing indications for SG-RYGB conversion.

Statistical Analysis

The descriptive categorical data were expressed as percentages, and the continuous data as weighted mean + standard deviation (SD). Univariate analyses were used to determine baseline differences between groups, using chi-squared tests for categorical data and independent sample *t*-tests for continuous data. Univariate logistic regression was used to compare differences between patients in the P-RYGB and SG-RYGB cohorts.

A multivariable logistic regression analysis was used to identify predictive factors for serious complications and mortality within 30 days. The available case method addressed missing data as all variables had less than 5% missingness. Patient factors and operative time were included in the model. Any variable with a p value < 0.05 in univariate analysis was included in multivariable analysis. Variables were checked for collinearity via the variable inflation factors method. The area under the receiver-operating characteristic (AUROC) curve and Brier score were used to assess validity and calibration of the multivariable model. Statistical analysis was performed using Stata 17 [10].

Results

Patient Demographics

A total of 84,543 (86.3%) patients underwent P-RYGB and 13,432 (13.7%) underwent SG-RYGB. A higher proportion of SG-RYGB were female compared with P-RYGB (90.6 vs. 83.4%, $p<0.001$). There were more patients of black race in the SG-RYGB cohort compared to P-RYGB (27.0 vs. 15.5%, $p=0.001$). The mean age was slightly higher for SG-RYGB (45.8 ± 10.4 vs. 44.4 ± 11.5 years, $p<0.001$). Likely from the effects of their previous SG, patients undergoing SG-RYGB had lower preoperative BMIs (39.6 ± 7.8 vs. 45.5 ± 7.5 kg/m^2, $p<0.001$) and lower rates of comorbidities including diabetes, hypertension, hyperlipidemia, and obstructive sleep apnea (Table 1).

Conversion Indications

Rates of GERD were higher in the SG-RYGB cohort (72.3 vs. 42.1%, $p=0.004$), and this represented the most common indication for revision (55.3%). The other main indications for revision were weight recurrence (24.4%)

Table 1 Patient characteristics

	P-RYGB $n=84{,}543$	SG-RYGB $n=13{,}432$	p value
Age, years			
mean ± sd	44.4 ± 11.5	45.8 ± 10.4	< 0.001
% female	83.4	90.6	< 0.001
Race			
White	59,781 (70.7)	8270 (61.6)	
Black or African American	13,092 (15.5)	3627 (27.0)	0.001
Other	11,670 (13.8)	1535 (11.4)	
Body mass index (kg/m^2)			
mean ± sd	45.5 ± 7.5	39.8 ± 7.8	< 0.001
Functional status			
Independent	84,011 (99.5)	13,373 (99.6)	
Partially dependent	441 (0.5)	43 (0.3)	0.005
Fully dependent	19 (0.0)	5 (0.0)	
American Society of Anesthesiologists class			
1–2	12,798 (15.2)	3585 (26.7)	
3	68,242 (80.8)	9565 (71.3)	0.001
4–5	3445 (4.1)	266 (2.0)	
Smoker in previous year	5242 (6.2)	641 (4.8)	< 0.001
Diabetes			
None or diet controlled	59,231 (70.1)	11,967 (89.1)	
Non-insulin dependent	17,024 (20.1)	1117 (8.3)	0.002
Insulin dependent	8288 (9.8)	348 (2.6)	
Hypertension	40,613 (48.0)	4608 (34.3)	< 0.001
Gastroesophageal reflux disease	35,569 (42.1)	9717 (72.3)	0.004
Chronic obstructive pulmonary disease	1155 (1.4)	159 (1.2)	0.088
Hyperlipidemia	22,507 (26.6)	2294 (17.1)	< 0.001
Chronic steroids	1789 (2.1)	383 (2.9)	< 0.001
Chronic kidney disease	433 (0.5)	41 (0.3)	0.001
Dialysis dependent	156 (0.2)	21 (0.2)	0.475
History of venous thromboembolism	2418 (2.9)	462 (3.4)	< 0.001
Venous stasis	600 (0.7)	69 (0.5)	0.010
Preoperative therapeutic anticoagulant use	2451 (2.9)	405 (3.0)	0.458
Obstructive sleep apnea	36,739 (43.5)	3152 (23.5)	< 0.001
History of myocardial infarction	938 (1.1)	143 (1.1)	0.644
Previous percutaneous coronary intervention	1274 (1.5)	179 (1.3)	0.121
Previous major cardiac surgery	673 (0.8)	104 (0.8)	0.792

P-RYGB, primary Roux-en-Y gastric bypass; *SG-RYGB*, sleeve gastrectomy to Roux-en-Y gastric bypass and inadequate weight loss (12.7%). Less common indications included dysphagia (1.6%), other (1.4%), stricture or obstruction (1.4%), nausea or vomiting (1.0%), persistent comorbidities (0.7%), adhesions (0.6%), mechanical malfunction (0.3%), staple line leak (0.2%), or abdominal pain (0.2%).

Procedural Factors

SG-RYGB had longer operative times than P-RYGB (145.4 ± 67.9 vs. 125.2 ± 57.0 min, $p < 0.001$). There was a slightly higher proportion of robotic-assisted cases in the SG-RYGB cohort (23.3 vs. 21.3%, $p < 0.001$). The hospital length of stay was similar between the two procedures at a median of 1 day (interquartile range [IQR] 1 day) (Table 2).

Postoperative Complications and Mortality

SG-RYGB patients had a higher rate of serious complications compared to P-RYGB (7.2 vs. 5.0%, $p < 0.001$). This was comprised of higher rates of anastomotic leak (0.5 vs. 0.4%, $p = 0.002$), bleeding (2.0 vs. 1.6%, $p < 0.001$), reoperation (3.0 vs. 1.9%, $p < 0.001$), non-operative interventions (2.2 vs. 1.5%, $p < 0.001$), deep surgical site infections (1.0 vs. 0.5%, $p < 0.001$), sepsis (0.3 vs. 0.1%, $p < 0.001$), and cerebrovascular accidents (0.02 vs. 0.01%, $p = 0.326$). However, 30-day mortality was similar between SG-RYGB and P-RYGB (0.1 vs. 0.1%, $p = 0.385$) (Table 2).

Table 2 Perioperative factors and postoperative complications

	P-RYGB $n = 84{,}543$	SG-RYGB $n = 13{,}432$	p value
Operative time, minutes			
mean ± sd	125.2 ± 57.0	145.4 ± 67.9	< 0.001
Robotic assisted	18,045 (21.3)	3132 (23.3)	< 0.001
Length of stay, days			
Median (interquartile range)	1 (1)	1 (1)	< 0.001
Anastomotic leak	309 (0.4)	73 (0.5)	0.002
Postoperative bleeding	1331 (1.6)	268 (2.0)	< 0.001
Reoperation	1584 (1.9)	405 (3.0)	< 0.001
Non-operative intervention	1252 (1.5)	298 (2.2)	< 0.001
Readmission	4052 (4.8)	985 (7.3)	< 0.001
Cardiac events	117 (0.1)	16 (0.1)	0.573
Pneumonia	311 (0.4)	74 (0.6)	0.002
Unplanned intubation	134 (0.2)	20 (0.2)	0.443
Acute kidney injury	115 (0.1)	10 (0.1)	0.063
Venous thromboembolism	297 (0.4)	40 (0.3)	0.325
Deep surgical site infection	453 (0.5)	130 (1.0)	< 0.001
Wound disruption	64 (0.1)	16 (0.1)	0.120
Sepsis	120 (0.1)	39 (0.3)	< 0.001
Cerebrovascular accident	10 (0.01)	3 (0.02)	0.326
Serious complications	4240 (5.0)	964 (7.2)	< 0.001
Death	85 (0.1)	17 (0.1)	0.385

P-RYGB, primary Roux-en-Y gastric bypass; *SG-RYGB*, sleeve gastrectomy to Roux-en-Y gastric bypass

Multivariable Logistic Regression

Following adjustment with multivariable logistic regression, 16 variables were independently predictive of 30-day serious complications. Notably, indication for conversion was not significant on univariate or multivariable analysis. SG-RYGB was predictive of serious complications compared to P-RYGB (OR 1.21, 95%CI 1.12–1.32, $p < 0.001$) after adjusting for age, BMI, comorbidities, and operative time. The factors with the highest odds ratios (> 1.5) included partially dependent functional status, therapeutic anticoagulation, chronic kidney disease, and previous venous thromboembolism (Table 3). On multivariable analysis, SG-RYGB was not independently predictive of 30-day mortality (OR 1.34, 95%CI 0.76–2.35, $p = 0.316$, Table 4). This serious complication model had an AUROC of 0.60 and Brier score of 0.05 while the mortality model had an AUROC of 0.81 and Brier score of 0.001.

Discussion

To the best of our knowledge, this is the first large-scale study analyzing the rate of serious complications and mortality of revisional sleeve to bypass compared to primary bypass. Using the MBSAQIP database, we found that while SG-RYGB has a higher risk of serious complication compared to P-RYGB, the overall rate of complications remained low at 7.2%, and mortality was not significantly different from P-RYGB after adjusting for comorbidities.

Revisional bariatric surgery has traditionally been associated with a higher rate of complications, compared with primary procedures [11, 12]. Scar tissue and extensive adhesions from the primary operation increase the complexity and operative time of the secondary surgery, leading to higher complication rates [13]. In a systematic review by Jones et al., revisional bariatric surgery carried a 14% major complication rate and 0.86% mortality rate [14]. A recent single-center study reported a complication rate of 10.8% for revisional RYGB and 5.9% for primary RYGB [15].

The debate over the safety profile of primary versus secondary bariatric surgeries, however, has taken a turn in recent years. A number of patients who underwent SG in the past decade, during which SG became the most popular bariatric surgery, now return for revisional surgery citing inadequate weight loss, GERD, or complications [16–19].

Table 3 Significant risk factors for serious complications on multivariable logistic regression

Risk factor	Adjusted odds ratio*	95% confidence interval	*p* value
SG-RYGB vs. P-RYGB	1.21	1.12–1.32	< 0.001
Partially dependent functional status	1.77	1.32–2.37	< 0.001
Therapeutic anticoagulation	1.58	1.37–1.82	< 0.001
Chronic kidney disease	1.53	1.13–2.08	0.006
Previous venous thromboembolism	1.49	1.29–1.72	< 0.001
Chronic steroids	1.36	1.16–1.59	< 0.001
Previous percutaneous coronary intervention	1.33	1.08–1.63	0.007
Chronic obstructive pulmonary disease	1.31	1.07–1.59	0.009
Black race	1.29	1.20–1.39	< 0.001
ASA class 4 or 5	1.29	1.10–1.51	0.002
Previous cardiac surgery	1.29	1.00–1.65	0.047
Gastroesophageal reflux disease	1.20	1.13–1.27	< 0.001
Longer operative time (per hour)	1.15	1.13–1.19	< 0.001
Hypertension	1.09	1.02–1.16	0.009
Non-insulin dependent diabetes	0.90	0.83–0.97	0.008
Higher body mass index (per 10 kg/m^2)	0.89	0.86–0.93	< 0.001

*Adjusted for age, hyperlipidemia, obstructive sleep apnea, previous myocardial infarction, and dialysis-dependency

P-RYGB, primary Roux-en-Y gastric bypass; *SG-RYGB*, sleeve gastrectomy to Roux-en-Y gastric bypass

Table 4 Significant risk factors for mortality on multivariable logistic regression

Risk factor	Adjusted odds ratio*	95% confidence interval	*p* value
SG-RYGB vs. P-RYGB	1.34	0.76–2.35	0.316
Partially dependent functional status	4.70	2.04–10.8	< 0.001
Chronic kidney disease	3.05	1.15–8.11	0.025
Previous percutaneous coronary intervention	2.50	1.17–5.36	0.018
Gastroesophageal reflux disease	1.52	1.00–2.32	0.049
Longer operative time (per hour)	1.22	1.04–1.43	0.013
Older age (per year)	1.06	1.04–1.09	< 0.001
Female sex	0.53	0.34–0.84	0.007

*Adjusted for diabetes, American Society of Anesthesiologists physical status classification, hypertension, hyperlipidemia, chronic obstructive pulmonary disease, previous venous thromboembolism, therapeutic anticoagulation, obstructive sleep apnea, previous myocardial infarction, and previous cardiac surgery

P-RYGB, primary Roux-en-Y gastric bypass; *SG-RYGB*, sleeve gastrectomy to Roux-en-Y gastric bypass

In North America, the revisional surgery of choice is most often RYGB. Given that a sleeve has already been created, it is thought that this potentially decreases the technical difficulty of creating the pouch. Additionally, patients who have a previous SG had a lower BMI and lower rates of comorbidities including diabetes, hypertension, hyperlipidemia, and obstructive sleep apnea, which may reduce rates of postoperative complications. Taken in balance with the increased complexity of lysing adhesions, the risk of complications and mortality may be lower than other types of revisional bariatric procedures.

Importantly, the most common indication for revision was GERD, which is consistent with current literature [15, 20–22]. A recent study highlighted that de novo GERD developed in 48% of patients during an 8.5-year follow-up time after laparoscopic SG [23]. The high prevalence of GERD after SG should be considered with the wide use of SG as a primary bariatric procedure which accounted for 53.6% of worldwide bariatric procedures, rather than RYGB which accounted for only 30.1% [24]. A meta-analysis demonstrated that laparoscopic RYGB had a lower incidence of new onset GERD and was more effective for treating GERD in patients with obesity, compared to laparoscopic SG [25]. Given the effective management of GERD with RYGB and the higher risk of serious complications if done as a revisional procedure after SG, our study further suggests that primary RYGB is indicated for patients with GERD.

Multivariable analysis revealed that a key predictor of serious complications was SG-RYGB, compared to P-RYGB, which agrees with previous studies [26, 27]. Specifically, SG-RYGB carried higher rates of postoperative bleeding, reoperation, non-operative intervention, readmission, deep surgical site infection, and sepsis. However, in comparing mortality rates, SG-RYGB and P-RYGB were not significantly different. Clinicians and patients should consider the heightened risk of serious complications when electing revisional bariatric surgery after primary SG.

There was a higher representation of female and Black patients in the SG-RYGB cohort compared to P-RYGB. This may be related to lower weight loss outcomes in women [28] and Black patients [29] after SG which increases the need for revisional bariatric surgery. In our multivariable analysis, Black race was also an independent risk factor for complications with SG-RYGB. This was consistent with findings from Mocanu et al. which also demonstrated that Black race had higher rates of complications in primary bariatric surgery, although the etiology remains unclear [30].

Although RYGB is presently the most popular revisional surgery, other procedures may offer better weight loss outcomes. Biliopancreatic diversion with duodenal switch (BPD-DS) and single-anastomosis duodenoileal bypass (SADI-S) are two options after SG. BPD-DS and SADI-S have been touted to have better weight loss outcomes, which is important for patients who elect revisional surgery for inadequate weight loss or weight recurrence. A recent single-center study demonstrated that revisional BPD-DS after SG yielded greater weight loss compared to SG-RYGB with no difference in long-term complications [31]. Similarly, conversion from SG to SADI-S led to significantly more total body weight loss than conversion to RYGB. This study also found no difference in quality of life scores, complication rates, or micronutrient deficiencies [32]. However, performing distal RYGB with longer biliopancreatic limbs may be equivalent to BPD-DS or SADI-S [33, 34]. While most patients today receive RYGB after failed SG, these findings suggest that the decision-making of revisional procedures may be more nuanced. The type of revision depends on whether patients present with symptoms of GERD, in which RYGB is strongly indicated, or weight loss failure, in which RYGB, BPD-DS, and SADI-S are reasonable options.

There are limitations to consider in this study. Data was only available for 30 days, and long-term complications were not captured. The MBSAQIP database does not capture certain comorbidities, such as liver disease and heart failure, and does not include data on the severity of comorbidities. Verhoeff et al. demonstrated that patients undergoing bariatric surgery during COVID-19 years were younger and had less comorbidities [35], and there may be selection bias towards healthier patients in our data which was during the pandemic period. In addition, the wide heterogeneity in surgeon experience and technique could not be captured. Importantly, data on the number of revisions before the revisional RYGB and time between primary SG and conversion to RYGB was unavailable. This missing data could influence our findings, as an increased number of revisional surgeries may increase the technical difficulty of RYGB and lead to more postoperative complications.

Despite these limitations, our study is the first to compare rates of serious complications and mortality of SG-RYGB with P-RYGB on a large scale and presents the largest study to date which characterizes indications for revision after previous SG. A comparison of these two populations is not well-highlighted in current literature, despite both primary and revisional RYGB being popular bariatric procedures. As more patients require revisional surgery after complications and failure to lose weight following SG, the need to understand the risks of revisional RYGB after SG becomes increasingly important. Future studies should investigate risk factors associated with long-term complications of RYGB and compare the rates of serious complications between other revisional procedures after SG, to help determine the optimal revisional surgery based on individual patient profiles.

Conclusions

The most common indications for revision from SG to RYGB were GERD followed by weight recurrence and inadequate weight loss. Although revisional RYGB after SG is associated with a higher rate of serious complications than primary RYGB, the overall complication rate is low at 7.2% with no significant difference in 30-day mortality. These findings demonstrate that conversion to RYGB is safe, and clinicians and patients should consider associated risk factors for serious complications when choosing bariatric procedures.

Data Availability The data that support the findings of this study are available in in MBSAQIP participant use file at https://www.facs.org/quality-programs/accreditation-and-verification/metabolic-and-bariatricsurgery-accreditation-and-quality-improvement-program/participant-use-data-file-puf/.

Declarations

Consent to Participate For this type of study, formal consent is not required. Informed consent does not apply.

Conflict of Interest The authors declare no competing interests.

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