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ORIGINAL CONTRIBUTIONS

Conversions After Sleeve Gastrectomy for Weight Regain: to Single and Double Anastomosis Duodenal Switch and Gastric Bypass at a Single Institution

Rena C. Moon[1] · Aura Sofia Fuentes[1] · Andre F. Teixeira[1] · Muhammad A. Jawad[1]

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Abstract

Background With the increase in popularity of laparoscopic sleeve gastrectomy (LSG), the number of patients experiencing weight regain has increased as well. This study aims to demonstrate the outcomes of LSG conversions to Roux-en-Y gastric bypass (RYGB), double anastomosis duodenal switch (DS), and single anastomosis duodeno-ileal sleeve (SADI-S) due to weight regain.

Methods A retrospective chart review was performed on 21 patients who underwent a conversion of LSG due to weight regain between March 1, 2013, and April 30, 2017. A longitudinal analysis was performed for the body mass index (BMI) measures, using multilevel model for change.

Results Of 21 patients, 6 underwent a conversion to RYGB, 9 underwent a conversion to SADI-S, and 6 underwent a conversion to double anastomosis DS. Mean percentage of total weight loss was 16.0% at 6 months, 20.1% at 12 months, 18.8% at 24 months, and 21.8% at 36 months after the procedure. The final model suggests that preoperative BMI is the most significant indicator for initial status and the rate of change in BMI. Adjusting for preoperative BMI, type of procedure significantly affected the rate of change in BMI. The rate of decrease was fastest in RYGB patients, adjusting for preoperative BMI. One patient was readmitted 26 days after the conversion for pulmonary embolism and intraabdominal hematoma, and no patient required a reoperation within 30 days after the conversion.

Conclusion Conversions of LSG to RYGB, double anastomosis DS, and SADI-S are safe and can provide significant additional weight loss.

Keywords Sleeve gastrectomy · Conversion · Weight regain · Failure of weight loss · Duodenal switch · Gastric bypass

Introduction

Bariatric procedures have proved to be efficient in maintenance of significant weight loss as well as resolution of comorbidities among the morbidly obese [1, 2]. Nevertheless, a small portion of patients experience failure of weight loss or complications that require a revision or a reoperation [3, 4]. The number of revisional procedures is on the rise, and insufficient weight loss or weight regain is one of the most common indications for a revision [4]. Weight loss failure can be due to a number of factors, including poor surgical technique, inadequate operative intervention selection, as well as physiologic and psychologic adaptations to the newly created surgical anatomy [5].

The laparoscopic sleeve gastrectomy (LSG), initially described as the restrictive part of the biliopancreatic diversion with a DS, has gained a wide acceptance as an alternative weight loss operation and is currently most common standalone bariatric procedure in the USA [6–8]. However, as with other bariatric procedures, LSG is not immune to weight regain. With its increase in popularity, the incidence of patients experiencing weight loss failure has increased as well [9]. Currently, the revision rate reported as high as 18% in recently published series. True magnitude of the LSG failure is difficult

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✉ Muhammad A. Jawad
muhammad.jawad@orlandohealth.com

[1] Department of Bariatric Surgery, Orlando Regional Medical Center, Orlando Health, 89 W Copeland Dr, 1st Floor, Orlando, FL, USA

to quantify as most series only report outcomes for a 5-year follow-up [10]. When suboptimal weight loss results are attained postoperatively, salvage options include sleeve revision, conversion to RYGB, a minigastric bypass or biliopancreatic diversion (BPD), and duodenal switch (DS).

This study aims to demonstrate the rate and outcomes of LSG conversions to RYGB, double anastomosis DS, and single anastomosis duodeno-ileal sleeve (SADI-S) due to weight loss failure or weight regain.

Methods

After institutional review board (IRB) approval and following the Health Insurance Portability and Accountability Act guidelines, the authors performed a retrospective chart review of a prospectively maintained database of 21 patients who underwent a conversion of sleeve gastrectomy due to weight regain between March 1, 2013, and April 30, 2017. Patients who underwent the conversion within 1 year of primary sleeve gastrectomy were excluded.

Conversion of LSG was performed by two surgeons according to the National Institutes of Health criteria for the surgical management of morbid obesity. Both surgeons performed all three conversion procedures. For RYGB, the length of the biliopancreatic limb was 60 cm, and the length of the Roux alimentary limb was 100 cm for patients with BMI less than 50 kg/m^2 and 150 cm for BMI over 50 kg/m^2. For the SADI-S, the length of the common limb was 250 cm. For the double anastomosis DS, the length of the Roux limb was 125 cm, and the length of the common limb was 125 cm.

Patients were followed up at our office clinic at 1, 3, 6, and 12 months postoperatively and yearly thereafter. Follow-up visits included weight measurement, clinical history and examination, and laboratory tests for blood glucose as well as nutrition deficiency.

Statistical Analysis

All data for age and body mass index (BMI) are demonstrated as mean ± standard deviation, unless otherwise noted. Statistical analysis was performed using SAS software, and two-tailed Student's *t* test, chi-square test, and Fisher's exact test were utilized where appropriate. A *p* value less than 0.05 was regarded as statistically significant. For the weight analysis, due to the small number of cases and the number of patients lost to follow-up, comparison among different types of conversion was not possible using cross-sectional analysis method. Therefore, a longitudinal analysis was performed for BMI measures using the multilevel model for change. This method is possible to analyze the changes in BMI with missing follow-up values using predictive values and predict values using less than 6 months of follow-up data. Simple error covariance structure was used for the model.

Missing Data

Of 137 patients eligible for 12-month follow-up, 61 had missing weight and laboratory data information. However, the mean preoperative BMI and age were not significantly different for patients who followed up and who did not follow up at 12 months ($p = 0.29$ and 0.50, respectively). Of 82 patients eligible for 24-month follow-up, 82 had missing weight and laboratory data information. Likewise, the mean preoperative BMI and age were not significantly different for patients who followed up and who did not follow up at 24 months ($p = 0.34$ and 0.43). Therefore, we do not believe our follow-up information has informative missingness, and exclusion of these patients has resulted in either underestimation or overestimation of changes in BMI and laboratory values.

Results

A total of 21 patients underwent a conversion of sleeve gastrectomy during the study period. Of these, 6 underwent a conversion to RYGB, 9 underwent a conversion to SADI-S, and 6 underwent a conversion to double anastomosis DS. Fifteen patients (71.4%) were females, and 18 were white (85.7%). Mean age of these patients was 43.1 years old, and their mean BMI was 44.3 kg/m^2 at the time of conversion. Mean period from primary LSG to a conversion procedure was 87.2 months. Characteristics of patients for each conversion procedure are shown in Table 1.

Weight Loss

Mean percentage of total weight loss (%TWL) was 16.0 ± 6.3% (range, 7.9–28.8) at 6 months (15/21), 20.1 ± 9.3% (range, 9.4.3–31.5) at 12 months (17/7), 18.8 ± 6.6% (range, 12.2–27.0) at 24 months (5/8), and 21.8% at 36 months (1/2) after the procedure. Percentage of excess BMI loss (%EBMIL) was 42.1 ± 16.9% (range, 19.7–70.8) at 6 months, 47.0 ± 16.9% (range, 27.9–68.2) at 12 months, 46.9 ± 11.9% (range, 27.2–58.0) at 24 months, and 46.7% at 36 months after the procedure (Table 2).

In the multilevel model for change analysis of BMI, comparing the unconditional means model (model A) and the unconditional growth model (model B) showed that 59.4% of the within-person variation in BMI was associated with linear time (Table 3). This suggests that the BMI decreased significantly for each patient after the conversion. Also, 8.6% of the total variation in BMI was explained by linear time. Using the deviance test, model B was also a significantly better fit than model A ($p < 0.0001$).

Table 1 Demographics of patients undergoing conversions from sleeve gastrectomy

	All ($n = 21$)	RYGB ($n = 6$)	SADI-S ($n = 9$)	Double DS ($n = 6$)
Female, *n* (%)	15 (71.4)	6 (100.0)	5 (55.6)	4 (66.7)
White, *n* (%)	18 (85.7)	5 (83.3)	8 (88.9)	5 (83.3)
Age (years), mean ± SD	43.1 ± 9.3	47.3 ± 14.7	41.1 ± 6.4	42.0 ± 5.9
Period from sleeve to conversion (months), mean ± SD	87.2 ± 53.9	80.0 ± 62.5	82.3 ± 57.4	103.2 ± 46.3
BMI (kg/m^2) at sleeve[a], mean ± SD	52.7 ± 15.5	44.8 ± 7.0	53.4 ± 9.7	59.4 ± 26.8
Preoperative BMI (kg/m^2), mean ± SD	44.3 ± 8.3	39.5 ± 6.0	45.8 ± 6.6	46.7 ± 11.4
Comorbidities, *n* (%)				
Hypertension	9 (42.9)	0 (0)	5 (55.6)	4 (66.7)
GERD	10 (47.6)	6 (100.0)	2 (22.2)	2 (33.3)
Diabetes	6 (28.6)	0 (0)	4 (44.4)	2 (33.3)
Sleep apnea	8 (38.1)	0 (0)	6 (66.7)	2 (33.3)
Hyperlipidemia	10 (47.6)	2 (33.3)	5 (55.6)	3 (50.0)

BMI body mass index, *GERD* gastroesophageal reflux disease, *RYGB* Roux-en-Y gastric bypass, *SADI-S* single anastomosis duodeno-ileal sleeve, *Double DS* double anastomosis duodenal switch

[a] Available in 19 patients (9 SADI-S, 5 Double DS, and 5 RYGB)

When procedure type (reference level was RYGB, compared to SADI-S (DS1) and double anastomosis DS (DS2)) was added to the model (model C), the procedure type explained 17.1% of variation in initial status and 66.7% of variation in the rate of change. However, initial status of BMI did not have a significant effect between RYGB and SADI-S ($p = 0.22$), as well as between RYGB and double anastomosis DS ($p = 0.08$). This suggests that the mean BMI at conversion was not significantly different between RYGB and SADI-S, and between RYGB and double anastomosis DS. Although the procedure type was not associated with initial status of BMI by itself, it was kept in the model because procedure type was the primary exposure variable. Using the deviance test, model C was a significantly better fit than model B ($p = 0.03$).

Because preoperative BMI is a significant indicator for weight loss after bariatric procedure, a dichotomized preoperative BMI (PRE-BMI) (BMI less than 50 kg/m^2 vs. BMI greater than or equal to 50 kg/m^2) variable was added to the model (model D). Time, procedure type, and dichotomized preoperative BMI together explained 64.3% of total variation in BMI. Using the deviance statistic, model D was a much better fit than model C ($p < 0.0001$).

The final model suggests that preoperative BMI is the most significant indicator for initial status and the rate of change in BMI. In addition, patients who underwent double anastomosis DS had a mean BMI of 6.22 kg/m^2 higher than that of RYGB patients, and this difference was statistically significant ($p = 0.02$). The difference between mean preoperative BMI was not significant between SADI-S patients and RYGB patients. Adjusting for preoperative BMI, type of procedure significantly affected the rate of change in BMI. The rate of decrease was 0.83 slower in SADI-S patients than in RYGB patients ($p < 0.01$), and the rate of decrease was 0.54 slower in double anastomosis DS patients than in RYGB patients ($p = 0.03$), adjusting for preoperative BMI (Fig. 1).

Table 2 Weight reduction in patients following conversion of sleeve gastrectomy

	Conversion of sleeve gastrectomy ($n = 21$)			
	n available for follow-up	*n* followed up[a]	%EBMIL	%TWL
6 months	21	15	42.1	16.0
12 months	17	7	47.0	20.1
24 months	8	5	46.9	18.8
36 months	2	1	46.7	21.8

%EBMIL percentage of excess body mass index loss, *% TWL* total percentage of weight loss

[a] The number of patients available with weight information at each check point

Comorbidities

A total of 9 patients presented with hypertension at the time of conversion. Of these patients, follow-up data was available for 6 patients, and 2 (33.3%) had resolution of hypertension at their last follow-up. A total of 10 patients presented with reflux symptoms at the time of conversion. Of these patients, follow-up data was available for 6 patients, and 2 (33.3%) had resolution of reflux symptoms at follow-up. One patient who did not complain of reflux symptoms at conversion developed reflux symptoms after the conversion.

A total of 15 patients presented with type II diabetes at the time of procedure. Of these patients, follow-up data was available for 10 patients, and all 10 patients (100%) had resolution

Table 3 Results of fitting multilevel models for change of body mass index

		Parameter	Model A ($n = 21$)	Model B ($n = 21$)	Model C ($n = 21$)	Model D ($n = 21$)
Fixed effects						
Initial status, π_{0i}	Intercept	γ_{00}	40.59*** (1.62)	42.31*** (1.65)	39.06*** (2.84)	36.82*** (1.84)
	DS1	γ_{01}	–	–	3.64 (3.65)	2.60 (2.29)
	DS2	γ_{02}	–	–	6.40 (4.00)	6.22* (2.51)
	PRE-BMI	γ_{03}	–	–	–	14.12*** (2.38)
Rate of change, π_{1i}	Intercept	γ_{10}	–	− 0.56*** (0.09)	− 1.10*** (0.25)	− 1.10*** (0.24)
	DS1	γ_{11}	–	–	0.72** (0.26)	0.83** (0.24)
	DS2	γ_{12}	–	–	0.46 (0.28)	0.54* (0.27)
	PRE-BMI	γ_{13}	–	–	–	− 0.25* (0.11)
Variance components						
Level 1	Within-person	σ_ε^2	13.12*** (2.25)	5.34*** (1.06)	5.27*** (1.00)	5.63*** (0.97)
Level 2	In initial status	σ_0^2	51.63** (17.16)	54.85** (17.69)	45.46*** (14.58)	16.26*** (5.55)
	In rates of change	σ_1^2	–	0.06 (0.05)	0.02 (0.02)	–
Pseudo-R^2 statistics and goodness of fit						
		$R_{Y,Yhat}^2$		0.086	0.225	0.643
		R_ε^2		0.594	0.598	0.571
		R_0^2			0.171	0.704
		R_1^2			0.667	–
	Deviance		540.7	491.9	481.3	459.4
	AIC		546.7	501.9	499.3	479.4
	BIC		549.8	507.2	508.7	489.9

DS1, variable name for single anastomosis duodeno-ileal sleeve, compared to Roux-en-Y gastric bypass; *DS2*, variable name for double anastomosis duodenal switch, compared to Roux-en-Y gastric bypass; *PRE-BMI*, variable name for dichotomized preoperative body mass index (BMI), coded 0 for BMI less than 50 kg/m^2 and coded 1 for BMI greater than or equal to 50 kg/m^2

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

of their diabetes. A total of 8 patients had sleep apnea at the time of conversion, and follow-up data was available for 7 patients. One patient (14.3%) reported resolution of sleep apnea. A total of 10 patients had hyperlipidemia at the time of conversion, and follow-up data was available for 9 patients. Five (55.6%) patients reported resolution of hyperlipidemia.

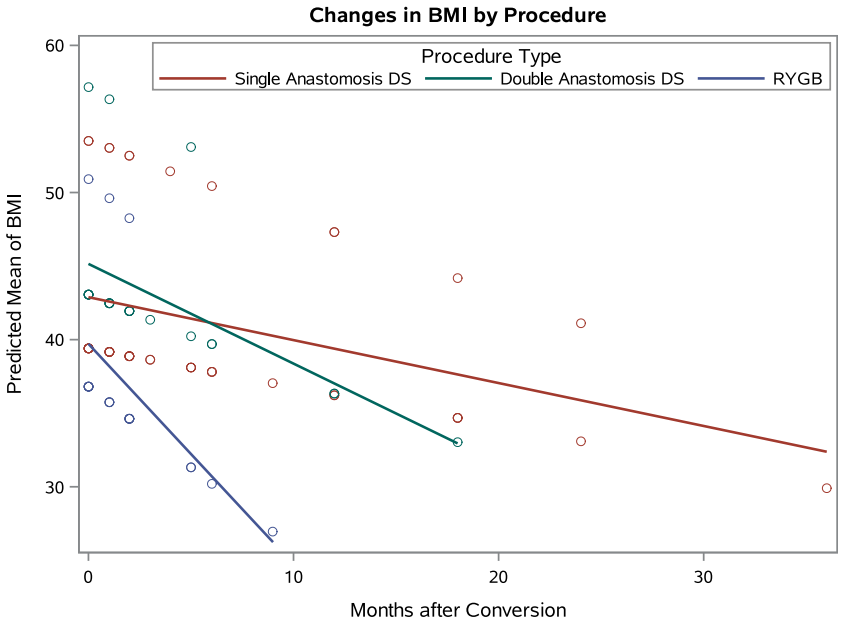

Fig. 1 Predictive changes in body mass index (BMI) by procedure. BMI, body mass index; DS, duodenal switch; RYGB, Roux-en-Y gastric bypass

Thirty-Day Readmission and Reoperation

One patient (4.8%) was readmitted 26 days following the conversion to double anastomosis DS for pulmonary embolism and intraabdominal abscess. The hematoma was treated with ultrasound-guided drainage, and the patient was placed on Lovenox afterwards. The patient was discharged 3 days later under stable condition. No patient required a reoperation within 30 days after the conversion.

Discussion

Our findings suggest that conversions of LSG to RYGB, double anastomosis DS, and SADI-S due to weight loss failure or weight gain can be effective with minimal complications. Regardless of the procedure chosen, all patients lost a significant amount of weight after the conversion.

LSG has gained great popularity in recent years. However, as Matin et al. [11] noted, true success of a bariatric procedure is "measured in terms of decades" and the incidence of weight loss failure is a significant portion of this long-term measurement. Felsenriech et al. [12] reported that 23% ($n = 12$) of their 53 LSG patients with a 10-year follow-up underwent a conversion to RYGB or DS due to weight regain. When suboptimal weight loss results are attained post-LSG, salvage options include re-sleeve, conversion to RYGB, a minigastric bypass or biliopancreatic diversion (BPD), and duodenal switch (DS). Retrospective studies have shown that re-sleeved patients have suboptimal weight loss outcomes when compared to patients undergoing other revisional weight loss procedures. Retrospective series on re-sleeve procedures have reported percentage of excess weight loss (%EWL) of 43 to 58% at 2 years [13]. Himpens et al. [14] reported 19 conversions of LSG to DS and 7 re-sleeves, noting a greater weight loss percentage after the DS procedure than after a re-sleeve (%EWL of 74% vs. 44%, respectively).

Some investigators have advocated that failed LSG should be treated with RYGB, and current literature suggests that conversions to a RYGB should be undertaken in patients with GERD.

Abdemur et al. [15] reported that a mean %EWL of 47% was achieved at a mean period of 10 months after the conversion of LSG to RYGB due to inadequate weight loss. Langer et al. [16] reported that 8 patients undergoing conversion from LSG to a RYGB had a mean weight reduction of 15 kg at a mean follow-up of 33 months. Gautier et al. [17] performed a retrospective analysis of 18 patients who underwent conversion to a RYGB and reported %EWL of 65% at 15 months along with complete resolution of reflux symptoms. On the other hand, Parmar et al. [9] suggested that conversion to a RYGB is not effective for LSG patients with inadequate weight loss, because they only observed a 2.5 point drop in BMI 2 years after the conversion.

Other studies have shown a higher weight loss percentage with DS when compared to RYGB. Homan et al. [18] analyzed the outcomes of 43 patients who underwent a revisional surgery after LSG (25 BPD/DS and 18 RYGB) and reported EWL of 59% in the DS group versus 23% in the RYGB group at 34 months of follow-up. Shimon et al. [19] also reported that conversion to a DS was superior than conversion to a RYGB in terms of weight loss (%TWL 26% vs. 19%, respectively).

In the current study, the overall mean %EBMIL was 42.1% at 6 months, 47.0% at 12 months, 46.9% at 24 months, and 46.7% at 36 months after the conversion, which were more moderate than what have been reported. We also found that the type of procedure significantly affected the rate of change in BMI. However, it was interesting to see that the rate of decrease was greatest among the RYGB patients than double anastomosis DS or SADI-S patients, adjusting for preoperative BMI. One possible explanation is that our RYGB patients had a shorter follow-up period. Because none of the RYGB patients had a 3-year follow-up, the slope could not be extended to where the RYGB patients would be at 3 years and ignored the possibility of weight regain after the conversion. Nevertheless, at least during early postoperative years after the conversion, our findings suggest that RYGB can be as effective as double anastomosis and SADI-S procedures in terms of weight loss. Another interesting finding is that all of the ten type II diabetes patients with follow-up data had resolution of the disease. This is remarkable in that conversions can also be effective in treating diabetes that persisted or came back after primary LSG. This is also consistent with a Canadian series by Yorke et al. [5] that 4 out of their 5 conversion patients with diabetes became medication-free.

We would also like to note that the weight loss of our patients was smaller than what primary RYGB, double anastomosis DS, and SADI-S procedures are reported to provide. This is consistent with the literature that revisional procedures provide less weight loss than primary procedures [20, 21]. Zingg et al. [21] reported a case-matched analysis of 61 primary RYGB and 61 revisional RYGB, and found that the excess weight loss was significantly less in the revisional group, compared to the primary group. Rebibo et al. [22] compared 15 patients who underwent re-sleeve procedures and matched them to 30 patients who underwent primary LSG, and found the re-sleeve patients had less weight loss. Langer et al. [16] also reported that some of the patients with a failed LSG might turn out to be "weight regainers" after 33 months. For this reason, the authors believed that a more malabsorptive procedure than RYGB was warranted for lack of weight loss after a LSG. This may also apply to our study cohort should the follow-up period become longer than 3 years.

As with primary procedures, but especially for revisional procedures, patients and surgeons must take complications into

account [23]. Re-sleeve procedures are known to carry the risk of fistula and leak development [24], and Rebibo et al. [22] reported a postoperative leak rate of 13% after re-sleeve procedures. Parmar et al. [9] reported early reoperation rate of 9% (1/11) due to internal herniation, and early readmission rate of 10% (1/10) due to abdominal pain, nausea, and vomiting that was treated conservatively after converting LSG to RYGB. However, in the current study, only one patient required a readmission within 30 days after a conversion to double anastomosis DS. Although long-term complication rates need to be examined, immediate postoperative profile was relatively safe for our patients. We should note that compared to DS, RYGB was reported to have lower complication rates as well as less long-term issues pertaining to malabsorption [16, 25].

This study is limited due to the retrospective nature of the study and small sample size. Many patients also did not have sufficient follow-up information. However, all follow-up information was utilized by modeling a longitudinal analysis, and we were able to present a predicted trend for weight loss after the conversion for each procedure. A prospective, randomized study on LSG conversions would provide more strength to our results.

Conclusion

Conversions of LSG to RYGB, double anastomosis DS, and SADI-S are safe and can provide significant additional weight loss.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval For this type of study, formal consent is not required.

Informed Consent Does not apply.

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