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ORIGINAL CONTRIBUTIONS

Long-Term Effectiveness of Laparoscopic Conversion of Sleeve Gastrectomy to a Biliopancreatic Diversion with a Duodenal Switch or a Roux-en-Y Gastric Bypass due to Weight Loss Failure

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Abstract

Background Gastroesophageal reflux disease and inadequate weight loss (IWL) are long-term complications of laparoscopic sleeve gastrectomy (LSG) and indications for a laparoscopic conversion to an alternative bariatric procedure. The aim of this study is to report the long-term outcomes of biliopancreatic diversion with a duodenal switch (DS) or a Roux-en-Y gastric bypass (RYGB) as conversion procedures for weight loss failure after LSG.

Methods The data of all patients who underwent post-LSG conversion to either a RYGB or a DS at our institution between November 2006 and May 2016 was retrospectively analyzed. Included were all patients with > 1-year follow-up who were operated due to IWL or weight regain. Patients with the indication of reflux were excluded.

Results Sixty-six patients underwent conversion from LSG to RYGB, DS, or one-anastomosis gastric bypass during the study period. There were 21 revisions to DS and 18 to RYGB that met the inclusion criteria. The respective weight and body mass index (BMI) before and after LSG were 125 and 110 kg and 46 and 40.5 kg/m^2 in the RYGB group and 148 and 126 kg and 53.7 and 46 kg/m^2 in the DS group. At the last follow-up (> 2 years), 15 RYGB patients had a reduction in BMI of 8.5–31.9 kg/m^2 and 18 DS patients had a reduction in BMI of 12.8–31.9 kg/m^2. The mean follow-up was 48.5 months (range 24–76). All comorbidities improved or underwent complete remission.

Conclusion Conversion from SG to RYGB or DS is an efficient and effective treatment for IWL and improvement of comorbidities. Further studies are warranted to evaluate long-term weight regain.

Keywords Laparoscopic sleeve gastrectomy failure · Conversional bariatric surgery · Laparoscopic biliopancreatic diversion with duodenal switch · Laparoscopic Roux-en-Y gastric bypass

Introduction

Obesity is a major health and economic issue worldwide. Surgeons and patients continue to search for an "ideal" minimally invasive and easy-to-perform surgical procedure to overcome it. Longitudinal sleeve gastrectomy (LSG) is the most commonly practiced bariatric procedure and one that is experiencing a rapid growth rate worldwide [1, 2]. It is now considered a stand-alone primary procedure LSG is associated with good short-term results of weight loss and resolution of comorbidities [3, 4]. However, reports are beginning to appear in the literature showing high long-term failure rates with inadequate weight loss (IWL) or weight regain, as well as the development of gastroesophageal reflux disease (GERD) [5, 6].

Conversion of LSG to an alternative bariatric procedure is now on the rise in parallel with the increasing numbers of LSG procedures and long-term failure rate. The procedure of choice for converting a failed LSG must consider technical details, such as sleeve size and shape, operative risk, prior abdominal surgical interventions, as well as the patient's characteristics, such as dietary habits, emotional status, sources of support,

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and other factors. The current bariatric conversion armamentarium includes re-LSG, banding the sleeve, Roux-en-Y gastric bypass (RYGB), biliopancreatic diversion, single anastomosis duodenal switch (DS), one-anastomosis gastric bypass (OAGB), and more. The optimal approach has not yet been determined.

The aim of this retrospective study was to assess the efficacy and safety of laparoscopic conversion to RYGB or DS after primary LSG failure of inducing long-term weight loss.

Methods

Patient Selection

This study was conducted at a tertiary care university hospital. It includes part of the data from an earlier paper but now with a larger group and a longer follow-up [7]. All patients who underwent conversion from SG to either RYGB or DS between November 2006 and May 2016 were retrospectively selected from the computerized database. The patients who had been converted to OAGB were excluded due to their small number. Indication for revision was failure of weight loss (insufficient weight loss (IWL)) or weight regain reflected by a body mass index (BMI) > 35 kg/m^2.

Before undergoing revision surgery, the patients underwent a complete blood test that included vitamin levels, an upper gastrointestinal (GI) contrast study, and upper gastroscopy to evaluate gastric sleeve dilatation, Barrett's esophagus, and other pathologies. Their evaluation was conducted according to National Institutes of Health guidelines and by a multidisciplinary team of a surgeon, an internal medicine specialist, a nutritionist, and a psychologist. Every patient was discussed at a multidisciplinary team meeting during which there was an attempt to understand the mechanism of failure by analyzing eating habits before and after the LSG, reviewing the imaging studies, and considering the patient's social support.

Institutional Review Board approval was obtained for collection of the relevant information for each patient that had been prospectively collected in a database. Those data included demographic characteristics, indication for conversion, time from the original surgery to the rescue procedure, operative time, length of hospital stay, morbidity and mortality rates, and weight loss before the second intervention and at follow-up visits. Comorbidities at presentation and at follow-up visits, including blood test results and relevant medication prescriptions, were recorded as well. For this type of study, formal consent is not required.

Surgical Technique

All interventions were done laparoscopically using multiple (4–6) 12-mm ports. One 5-mm port was generally used in the left upper abdominal quadrant. A 30° 10-mm optic instrument was used. Only linear 45 or 60-mm staplers were employed (Endopath ETS-Flex 45 linear and Echelon, Ethicon Endo-Surgery Inc., Cincinnati, OH).

For the conversion of SG to RYGB, an (42 F) orogastric tube or bougie was inserted to delineate the location of the sleeve, and the staple line was identified. The liver was retracted, and the dissection of the liver and omentum off the sleeve was performed with a Harmonic Scalpel (Ethicon Endo-Surgery Inc). A narrow (20 mL) gastric pouch was created using a 45-mm linear stapler over the 42 F bougie. The rest of the stomach either remained in place or was resected, as needed. The jejunum was divided 50–70 cm distal to the ligament of Treitz, and a stapled side-to-side jejunojejunostomy anastomosis was performed with a Roux limb length of 150 cm. The Roux limb was positioned ante-colic to perform the gastrojejunal anastomosis as either a double-layer hand-sewn anastomosis or a 45-mm linear stapled. The anastomosis was tested with methylene blue instilled in the nasogastric tube. All mesenteric defects (Petersen's and at the jejunojejunostomy) were closed to avoid internal hernia. Oral fluid intake was started on the first postoperative day.

For the conversion of SG to DS, the small bowel (ileum) was divided 250–300 cm proximal to the ileocecal valve, with the proximal loop becoming the biliopancreatic limb and the distal loop becoming the alimentary limb. The first part of the duodenum was also divided 2 cm distal to the pylorus, and its continuity was established by a hand-sewn anastomosis to the distal end of the divided ileum (alimentary limb) to provide continuity for food passage. The cut end of the divided ileum that became the biliopancreatic limb (proximal end) and the alimentary limb were connected by anastomosis at the 60–100 cm point from the cecum to form the common channel where digestion and absorption occur. A re-SG was also performed in three patients in whom the sleeve was discovered as being excessively dilated. All mesenteric windows were then closed. The anastomosis was tested with the instillation of methylene blue in the nasogastric tube. Oral fluid intake was started if no leakage was present and smooth passage of contrast was demonstrated on an upper GI contrast swallow.

Comorbidities

The criteria for the diagnosis of comorbidities were deviations from the normal lab values. Remission was defined as the normalization of lab results without any medications. Improvement of comorbidities was defined by a decrease in medication dosage with improvement or no change in lab values, cessation of medication with improvement or no change in lab values, or significant improvement in lab values with no change in medication.

The criteria for remission for type 2 diabetes mellitus (T2DM) included HbA1c < 6 and fasting glucose < 100 mg/% without medications.

Results

A total of 39 patients with at least 12 months of follow-up who underwent revision after SG due to IWL or weight regain were included. The patients' characteristics are described in Table 1. The mean follow-up time was 47 ± 15 months for the RYGB group and 49 ± 14.4 months for the DS group. Twenty-one patients had undergone DS, and 18 had undergone RYGB. None of the patients were lost to follow-up. The mean initial BMI before SG was 46.1 ± 5 for the RYGB group and 53.7 ± 10.3 for the DS group. The mean weight was 125 ± 24 kg for the RYGB group and 148 ± 35 kg for the DS group. The mean interval between the primary SG and the second procedure was 35 ± 21 months for DS and 47 ± 20 months for RYGB. Before the conversion surgery, the respective mean weight and BMI were 126 ± 26 kg and 46 ± 7.2 kg/m^2 for the DS group, and 110 ± 26 kg and 40.5 ± 5.7 kg/m^2 for the RYGB group.

Weight Loss

All patients included in the study had over 1 year of follow-up, but long-term weight loss results included all patients with over 2 years of follow-up with a total of 15 RYGB patients and 18 in the DS group (Fig. 1).

After DS the patients' mean percentage of total weight loss (%TWL) was 26.3 ± 12% and the loss of BMI was 12 ± 5.4 kg/m^2 at 1 year. These results remained quite steady at the last follow-up at 49 months in which on average, the patients lost 28.5 ± 10% of %TWL and 12.8 ± 5.4 kg/m^2 of BMI to reach a mean BMI of 31.91 kg/m^2. The RYGB group reached a mean BMI of 31.88 kg/m^2 at the last follow-up, with a %TWL and loss of BMI of 18.7 ± 10% and 7.7 ± 4 kg/m^2, respectively, at 1 year and 21 ± 14% and 8.5 ± 6 kg/m^2, respectively, at last follow-up. The average follow-up was 47 ± 15 months. Failure to lose weight after the conversion was defined as a BMI > 35 kg/m^2. There were four failures in the DS group and 3 in the RYGB group.

Comorbidities

The data on comorbidities are listed in Table 2. Thirteen patients had T2DM of whom eight had complete remission, four had improvement, and no improvement was seen in one patient. There was no significant difference in resolution between the two conversion groups. Fifteen of the 23 patients with hypercholesterolemia had complete remission, 4 had improvement, and no improvement was seen in 4 patients. Fifteen of the 21 patients with hypertriglyceridemia had complete remission, and no improvement was seen in 6 patients. Only 5 patients of the 14 with HTN had complete remission, 1 had improvement, and no change was seen in the others. Five of the six patients with high levels of uric acid had complete remission and the remaining patient had no change.

Complications

There was no mortality. One patient in the RYGB group sustained early postoperative anastomotic leakage. He was treated conservatively with drainage and antibiotics and healed completely. There were a few late complications: one patient in the RYGB group had severe peptic ulcer disease in the gastric pouch (most probably secondary to aspirin usage)

Table 1 Baseline characteristics

	RYGB	DS	*p*
Gender M/F	8/10	9/12	
Age	43.94 ± 16.57	45.71 ± 9.03	0.689
Interval to conversion (months) (range)	47.44 (80–12)	35.06 (90–7)	0.073
BMI before SG (range)	46.13 (38.97–57.74)	53.7 (37.32–74.89)	0.005
BMI before second surgery (range)	40.49 (31.89–54.62)	46 (32.86–61.35)	0.031
BMI (mean) after second surgery			
One year	32.26 (*n* = 18)	32.45 (*n* = 21)	0.949
Last follow-up	31.91 (*n* = 18)	31.88 (*n* = 15)	0.931
Duration of surgery (min)	104.07 ± 33.2	158.92 ± 64.94	0.017
Hospitalization (days)	3 ± 1.13	5 ± 3.44	0.055
Mean follow-up (months)	47.33 ± 15.22	49.05 ± 14.46	0.743
Mean TWL% after 1 year	18.76 ± 10.12	26.29 ± 12.07	0.089
Mean TWL% at last follow-up	20.79 ± 14.3	28.06 ± 11.58	0.136

BMI body mass index, *SG* sleeve gastrectomy, *TWL* total weight loss

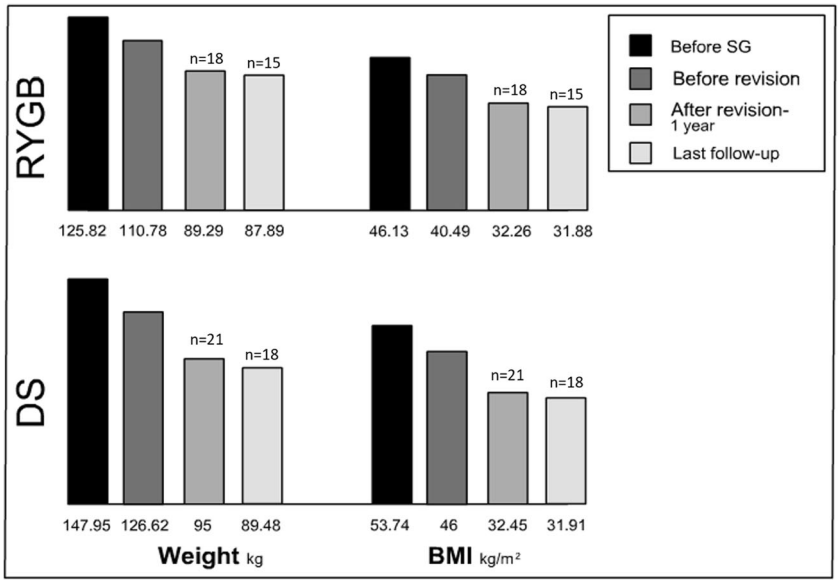

Fig. 1 Weight loss results. *BMI* body mass index, *RYGB* Roux-en-Y gastric bypass, *DS* duodenal switch

and was treated with high-dose oral proton pump inhibitors (PPIs). Two others in the RYGB group had an episode of small bowel obstruction that needed surgical intervention: one was due to an incarcerated bowel in Petersen's hernia, and the other was due to adhesion of the bowel that required small bowel segmental resection. Three patients in the DS group had nutritional complications: one had vitamin A deficiency that was treated successfully with oral supplementation, and two had severe malnutrition that required laparoscopic common channel lengthening.

Discussion

SG is associated with good and relatively uniform weight loss rates and improvement in comorbidities, and it has become the most popular bariatric procedure in current practice [2]. It is also considered technically simple, although it can result in numerous postoperative complications, such as leakage, strictures, and new-onset GERD [4]. Long-term follow-up studies after SG have demonstrated an appreciable rate of failure defined as IWL and weight regain. As a result, many patients will require revision or conversion surgery to ensure a sustained long-term weight lost and control of comorbidities.

Felsenreich et al.'s report on a 10-year follow-up of 53 patients after SG demonstrated a high incidence of significant weight regain and intractable reflux, and 36% of their patients were converted to RYGB or to DS [6]. Mandeville et al.'s over 8-year follow-up trial of 100 patients who underwent LSG showed that 26 of them subsequently underwent RYGB. Those authors noted a significant increase in GERD and PPI dependency after LSG, and reported new-onset GERD in more than 40% of their study population [5].

The failure rate of LSG elicits some urgency in delineating the bariatric procedure most suitable as a second procedure. There is currently no consensus, and long-term results from randomized clinical trials comparing gastric bypass with DS are lacking. Risstad et al. conducted a randomized clinical trial and compared outcomes after RYGB and DS in patients with a BMI of 50 to 60 [8]. The DS approach resulted in greater weight loss and greater improvements in low-density lipoprotein cholesterol, triglycerides, and glucose levels compared

Table 2 Comorbidities

	RYGB				DS			
	All	Resolved	Improved	No improvement	All	Resolved	Improved	No improvement
Diabetes mellitus	7	57% (4)	43% (3)	–	6	66% (4)	33% (1)	33% (1)
Hypertension	6	33% (2)	17% (1)	50% (3)	6	33% (2)	17% (1)	50% (3)
Hypercholesterolemia	13	77% (10)	(2) 15%	8% (1)	10	60% (6)	10% (1)	30% (3)
Hypertriglyceridemia	9	78% (7)	–	22% (2)	12	67% (8)	–	33% (4)
Hyperuricemia	2	100% (2)	–	–	4	75% (3)	–	25% (1)

RYGB Roux-en-Y gastric bypass, *DS* duodenal switch

with the gastric bypass approach at 5 years after surgery, while improvements in health-related quality of life were similar. However, DS was associated with more surgical, nutritional, and GI adverse effects. Biron et al. [9] have shown an increase in failure rate after primary DS in long-term follow-up and suggested two thresholds for defining failure: above BMI of 35 for morbidly obese and 40 for superobese patients before surgery. For this trial, we used BMI of 35 kg/m^2 as definition for failure since average BMI before conversion was 46 in the DS group and 40 in the RYGB group.

Our results are in agreement with those of Homan et al. [10] who conducted a trial involving 43 patients who underwent a second procedure after LSG: those authors showed that a DS is more effective in inducing weight loss compared with a RYGB after a failed LSG. Casillas et al. [11] reported 43 conversions of which 25 were to a DS and 18 were to a RYGB. Their patients had better weight loss with a DS. Weiner et al. [12] demonstrated that a DS as a secondary surgery is more effective in achieving weight loss than a RYGB, however, with a high complication rate. RYGB also provided sustainable weight loss and resolution of comorbidities, but the results in that report are derived from surgeries that were carried out due to a variety of indications, e.g., reflux, strictures, acute conversions and weight loss failure. Importantly, only weight loss failures were included in our current study. Quezada et al. [13] conducted a trial on 50 patients who had been converted from LSG to RYGB, and their results showed that over 90% of GERD patients had resolved or improved symptoms. The symptoms of all of their patients with gastric stenosis were resolved after conversion, with a 70% EWL% after 3 years of follow-up. Poghosyan et al. [14] reported 34 patients who underwent a RYGB after a previous LSG: the GERD was resolved, and improvement in weight loss was noted in all patients. Parmar et al. [15] reported an unremarkable weight loss 24 months after conversion of a failed SG to a RYGB due to IWL or weight regain, but their group of patients had an average BMI of 53 kg/m^2 prior to the LSG, similar to the DS group in our study. This report supports our more radical approach toward patients with high BMI prior to the LSG primary procedure. Combining patients with different indications and reporting the short-term results precluded the arrival at meaningful conclusions in most of these studies.

Possible options for patients who require conversion after a failed LSG are abundant, making the decision regarding which procedure to perform even more complicated. Those options include laparoscopic re-sleeve gastrectomy (LReSG), conversion to laparoscopic RYGB, OAGB, biliopancreatic diversion and DS, single anastomosis duodeno-ileal bypass, and butterfly gastroplasty (LBG) [16]. Cheung et al. [17] evaluated the efficacy of various revision surgical procedures by systematically reviewing the literature on revision surgery following a failed primary LSG procedure. Those authors showed that both LBG and LReSG were viable options, and that DS and RYGB were also feasible options with greater weight loss than both LReSG and LGB. Ultimately, however, most decisions to pursue revision bariatric surgery are based on the comfort and preference of individual surgeons and medical centers, rather than on evidence-based considerations.

Although LSG is considered a safe procedure that is easy to perform, it can lead to serious anatomical complications, including strictures, bleeding, and GERD [18]. Altered gastric anatomy following a LSG is a crucial consideration for choosing a second-step procedure. Several recent studies alerted to the development of a new complication after a LSG, that of Barrett's esophagus. Its presence may have a crucial effect in selecting the type of a conversion procedure, since the conversion to a DS does not prevent the reflux, and the metaplasia-dysplasia sequence will continue. Therefore, the best possibility for conversion would appear to be a RYGB. Nevertheless, the effect of conversion from a LSG to a single anastomosis gastric bypass on Barrett's esophagus should be explored. A few cases demonstrated regression of Barret's esophagus after a RYGB and surgical treatment for GERD. The RYGB approach reportedly improved GERD and Barrett's esophagus with proven reduction in body weight and BMI [19, 20]. A RYGB is also the procedure of choice in our institution when reflux is present concomitantly with a hiatal hernia.

The question arises as to whether it is obligatory to reduce the pouch volume by laterally resecting the enlarged fundus, with the added risks involved, or just divide the sleeve into two parts. In RYGB, we prefer to reduce the lateral pouch volume as we believe this will prevent the reflux, as well as a future weight regain.

It is well known that obesity is a significant independent risk factor for hiatal hernia. Most frequent anti-reflux techniques such as Nissen, Toupet, and others have a higher failure rate in the setting of morbid obesity, while the RYGB approach for the repair of a paraesophageal hernia has yielded good outcomes [21, 22]. A RYGB has the additional benefits of significant weight loss, improving GERD symptoms, improvement of comorbidities and hernia repair. It is our experience that patients with a higher BMI were more likely to undergo a DS. While a DS is more effective than a RYGB and produces a higher rate of weight loss, a RYGB has a lower complication rate and is technically easier to perform, with a shorter duration of surgery and length of hospital stay. Furthermore, nutritional deficiencies are more prominent after a DS compared to a RYGB.

We had earlier proposed a set of guidelines to assist in the decision-making process of choosing the most appropriate second procedure [12]. We believe that selecting the patients suitable for each procedure makes it possible to reduce the complication rate and to achieve better rates of long-term weight loss, quality of life, and control of comorbidities. The

current study extends our previous ones, now providing a long-term follow-up with a mean of 48.2 months. During that time, the patients from both groups achieved a BMI of 32 kg/m^2. We consider that the long-term success of the weight loss may be attributed, at least in part, to the appropriate selection of a procedure for a given patient. Choosing the best procedure for each patient, however, is complicated and while the results of randomized control trials would be highly contributory, they probably are not feasible.

There are some drawbacks in this study that prevent us from drawing solid conclusions. First, this cohort includes many patients that underwent their first (LSG) operation in other hospitals. In addition, patients who failed in weight loss after their first procedure tend not to come for regular clinic visits, and so we could not determine the true incidence of failure in our own LSG cohort. Some of the patients in the DS group presented with extremely high BMIs before the LSG, and therefore more of them would be expected to need a second procedure compared to the patients in the RYGB group. Lastly, our patient population is very nonhomogeneous (e.g., some were after laparoscopic adjustable gastric banding, the technique of their primary LSG was not uniform, and they were referred from different surgeons). The sleeve size and the reason for failure are also not uniform and were sometimes not known. All these shortcomings are part of the reality of the practice of bariatric surgery. The strength of this study is the long and concise follow-up of a single indication for conversion, that of weight loss failure and the conversion to only two procedures.

In summary, the results of this study showed that both the DS and RYGB approaches are effective choices of a conversion procedure after a failed SG due to IWL or weight regain. We have shown similar medium-term end point BMI results for two groups of patients with similar demographic characteristics but with significant difference in terms of the BMI before LSG. We believe that choosing the right procedure for each patient after taking into consideration his or her personal, nutritional, psychological, and anatomical aspects is the sole key for more long-lasting loss of weight and resolution of comorbidities.

Compliance with Ethical Standards

Conflicts of Interest The authors declare that they have no conflicts of interest.

Statement of Informed Consent A waiver from informed consent was obtained for this study.

Statement of Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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