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ORIGINAL CONTRIBUTIONS

Comparison of Repeat Sleeve Gastrectomy and Roux-en-Y Gastric Bypass in Case of Weight Loss Failure After Sleeve Gastrectomy

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Abstract

Background Few series are available on the results of repeat sleeve gastrectomy (re-SG) and Roux-en-Y gastric bypass (RYGB) performed to manage the failure of primary sleeve gastrectomy (SG). The objective of this study was to compare the short- and medium-term outcomes of re-SG and RYGB after SG.

Material & Methods Between January 2010 and December 2017, patients undergoing re-SG ($n = 61$) and RYGB ($n = 83$) for failure of primary SG were included in this study. Revisional surgery was proposed for patients with insufficient excess weight loss (EWL ≤ 50%) or weight regain. The primary endpoint was the comparison of weight loss in the re-SG group and the RYGB group at the 1-year follow-up. The secondary endpoints were overall mortality and morbidity, specific morbidity, length of stay, weight loss, and correction of comorbidities.

Results The mean interval between SG and re-SG was 41.5 vs. 43.2 months between SG and RYGB ($p = 0.32$). The mean operative time was 103 min (re-SG group) vs. 129.4 min (RYGB group). One death (1.7%; re-SG group) and 25 complications (17.4%; 9 in the re-SG group, 16 in the RYGB group) were observed. At the 1 year, mean body mass index was 31.6 in the re-SG group and 32.5 in the RYGB group ($p = 0.61$) and excess weight loss was 69.5 vs. 61.2, respectively ($p = 0.05$).

Conclusion Re-SG and RYGB as revisional surgery for SG are feasible with acceptable outcomes and similar results on weight loss on the first postoperative year.

Keywords Sleeve gastrectomy · Revisional surgery · Roux-en-Y gastric bypass · Repeat sleeve gastrectomy · Weight loss · Outcomes

Abbreviations

SG	Sleeve gastrectomy
Re-SG	Re-sleeve gastrectomy
RYGB	Roux-en-Y gastric bypass
RS	Revisional surgery
GERD	Gastroesophageal reflux disease
OSA	Obstructive sleep apnea
T2DM	Type 2 diabetes mellitus

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Introduction

Bariatric surgery has been demonstrated to be the most effective therapy for achieving sustained weight loss and managing obesity-related complications such as type 2 diabetes mellitus (T2DM), blood hypertension, dyslipidemia, and cardiovascular disease [1]. Laparoscopic sleeve gastrectomy (SG) is currently the most common bariatric surgery in France [2] and the USA [3] because of its excellent weight loss success at short-term follow-ups and its relative technical ease, especially compared to Roux-en-Y gastric bypass (RYGB). It also appears that there are fewer short- and long-term complications after SG than after RYGB [4, 5].

As the number of SG procedures increases, the significant issue of weight regain is becoming more prevalent. Arman et al. [6], in their long-term follow-up of patients undergoing SG (first patients of their experience), showed a revisional rate of 21% for insufficient weight loss or weight regain. Limited evidence exists for selection of the appropriate revisional operation. However, SG has the advantage over RYGB because it is somewhat simpler. Many revisional procedures have been described, including re-sleeve gastrectomy (re-SG) [7], RYGB [8], biliopancreatic diversion with a duodenal switch [9], and, more recently, single-anastomosis gastric bypass [10] and single-anastomosis duodeno-ileal bypass [11].

A literature review suggests that most cited procedures performed as revisional faced with weight regain after SG are for re-SG and RYGB. Re-SG was first described in 2006 by Baltasar et al. [7], but few series have been published since this initial report [12, 13]. Studies concerning re-SG have reported contradictory results in terms of morbidity rates [14], with limited data on weight loss. Only one series has retrospectively evaluated the best indications for performing re-SG [15].

RYGB as a revisional procedure after SG have been described in cases of severe gastroesophageal reflux disease (GERD) [16], management of gastric stenosis after SG [16], and inadequate weight loss or weight regain. Malinka et al. [17] reported that revisional RYGB was a feasible and is a practical approach that allows effective weight loss at a 3-year follow-up after failed SG. Other authors [18] reported that revision was effective for GERD symptoms, but not to reduce further weight loss. Only one retrospective analysis [19] exists in a small number of cases in which the authors compare the results in terms of weight loss after re-SG and RYGB when performed as revisional procedures of SG failure. The objective of the present study was to retrospectively compare the results in terms of weight loss of re-SG and RYGB performed as revisional procedures for failure of SG at three French university hospitals.

Materials and Methods

Population

From January 2010 to December 2017, all patients undergoing re-SG and RYGB for weight regain or insufficient weight loss following SG ($n = 144$) were included in this multicenter (three French university hospitals) retrospective observational study.

Preoperative Screening

Indications for bariatric surgery were validated in accordance with French national guidelines and in a multidisciplinary obesity staff meeting. The patient endocrine status was systematically assessed in order to detect thyroid and adrenal disease requiring treatment prior to surgery. A psychiatric or psychological assessment was used to screen for personality disorders that would contraindicate (or that could be decompensated by) bariatric surgery. Preoperative nutritional support consisting of multiple consultations with a dietician and participation in obesity surgery-specific workshops was routinely provided. Hiatal hernia, Barrett's esophagus, and *Helicobacter pylori* infections were evaluated by esophagogastroduodenoscopy. Pulmonary function tests, including sleep polysomnography, were used to screen for obstructive sleep apnea (OSA) syndrome in all patients prior to surgery. Obstructive apneas were defined as cessation of airflow for at least 10 s; hypopnea was defined as a period of reduction of superior to 30% oronasal airflow for at least 10 s and a 4% drop in oxygen saturation for more than 10 s.

Technical Preoperative Assessment

Gastric volumetry was routinely performed in all three centers. At two centers, an additional preoperative barium swallow test was performed to look for large gastric pouches. In the third center, large gastric pouches were evaluated using gastric volumetry imaging.

Gastric Volumetry

The residual gastric volume was measured by filling the gastric remnant with carbon dioxide as follows. The patient was asked to drink a sodium bicarbonate solution (4 g in 100 mL of water) followed by a tartaric acid solution (4 g in 100 mL of water). Low-dose computed tomography (CT) acquisitions were performed at 30 and 60 s after tartaric acid intake. The residual gastric volume was defined as the volume situated between the gastroesophageal junction and the pylorus (anatomic structures that can be easily identified on a CT scan) [20]. The volume was measured separately by two radiologists using Myrian software (Microsoft; USA) and were expressed

in mL. Differences of opinion between radiologists were resolved by consensus. The larger of two estimated volumes was considered to be closest to the patient's true residual gastric volume.

Indications for Revisional Surgery Following SG

Revisional surgery was proposed in patients with inadequate weight loss EWL ≤ 50% or weight regain after SG. The type of revisional surgery, re-SG or RYGB, was chosen according to radiologic data, although other criteria were assessed, notably evidence of GERD or other comorbidities, such as T2DM (Fig. 1). Re-SG was generally proposed for patients with an excessively high residual gastric volume (> 250 mL, as assessed by gastric CT volumetry) [12] and/or with gastric pouch dilatation (as assessed by barium swallow). In all centers, symptomatic GERD and/or Barrett's esophagus [21] was a contraindication for re-SG.

RYGB was proposed for a residual gastric volume of < 250 mL, residual gastric volume of > 250 mL with symptomatic GERD (mild esophagitis on esophagogastroduodenoscopy despite proton pump inhibitor therapy), and/or the presence of Barrett's esophagus.

Assessment of GERD after SG and before performing revisional surgery was routinely performed at one center using a 24-h pH meter prior to revisional surgery. At the two other centers, 24-h pH-meter assessment was not routinely performed and the choice between RYGB and re-SG depended on clinical signs and endoscopy data. For some cases, a 24-h pH-meter assessment was selectively performed when discordance existed between clinical signs and endoscopic data.

Surgical Techniques

Re-SG Technique

Re-SG was standardized using a four-trocar technique as described elsewhere [12]. The first step of the procedure consists of removing adhesions between the stomach and the liver and the anterior surface of the pancreas and then releasing the entire left side of the gastric tube, starting with release of the gastric tube below the first staple of the primary SG. A 36-French bougie was used when transecting the greater gastric curvature. Gastric resection was initiated at 6 cm proximal to the pylorus (in the antrum). In the presence of a large gastric pouch (primary dilatation), only stapling of the gastric pouch was performed.

For patients on whom SG was performed between January 2004 and December 2009, stapling was performed using ENDO GIA Universal XL 60 with 2 3.5-mm blue reloads, then 4 or 5 4.8-mm green reloads (Medtronic; France). Purple Tri-Staple reloads (Medtronic; France) were used for patients in whom SG was performed between January 2010 and December 2013. For patients operated after this period, black Tri-Staple reloads (Medtronic; France) were used for revisional SG.

Since 2014, staple line reinforcement has been performed using bovine pericardium such as Peri-Strips Dry with Veritas

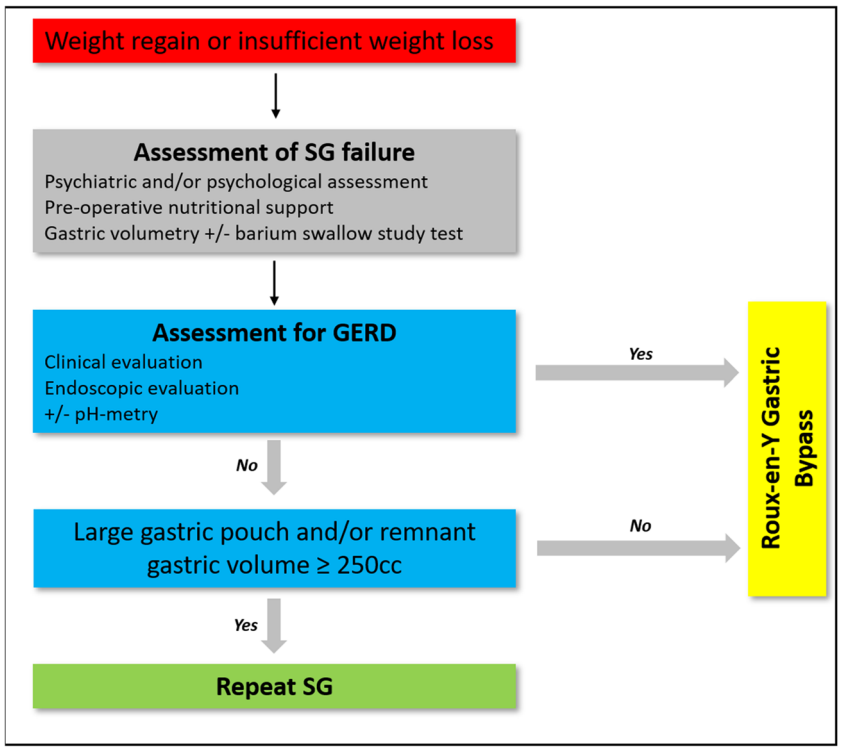

Fig. 1 Study synopsis. RYGB, Roux-en-Y gastric bypass. SG, sleeve gastrectomy. GERD, gastroesophageal reflux disease

(Baxter France; France) or synthetic copolymer-polyglycol acid trimethylene carbonate (Gore Seamguard) depending on the surgeon's preference. A methylene blue test was always performed at the end of the surgical procedure. Abdominal drainage was not routinely performed for re-LSGs.

RYGB Technique

All RYGB were performed using a five or six-trocar technique. Dissection of adhesions between the stomach and the liver was first performed to identify the gastroesophageal junction. The stomach was divided by stapling utilizing purple Tri-Staple reloads (Medtronic; France) 6 cm below the gastroesophageal junction, and additional vertical stapling of the stomach was also performed in the case of a large gastric pouch.

A greater omentum partition was routinely performed using a harmonic scalpel (Johnson & Johnson) in order to facilitate the creation of an antecolic gastrojejunal anastomosis. The gastrojejunostomy was an antecolic side-to-side anastomosis using linear stapler purple Tri-Staple reloads (Medtronic; France) and hand sewing of the anterior wall. Next, a side-to-side jejuno-jejunostomy was created by using white cartridges, creating a bilio-pancreatic limb of 70 cm and an alimentary limb of 150 cm. Mesenteric defects were routinely closed utilizing a nonabsorbable suture. A methylene blue test was always performed at the end of the surgical procedure. Routine drainage was not performed.

Inclusion and Exclusion Criteria

The inclusion criteria were being 18 to 70 years of age and having a previous history of SG, inadequate weight loss (EWL > 50%), or weight regain. The exclusion criteria were absence of previous history of SG, RYGB performed for reasons other than insufficient weight loss or weight regain (such as GERD), and bariatric procedures other than re-SG and RYGB. Patients with a history of gastric banding before primary SG were not excluded.

Endpoints and Parameters Recorded

The primary efficacy endpoint was comparison of weight loss in the re-SG group and in the RYGB group at the 1-year follow-up. The secondary endpoints were overall mortality and morbidity at postoperative day (POD) 30, specific morbidity, reoperation, length of hospital stay, and correction of comorbidities related with obesity. The two groups were compared in terms of the following parameters:

- Demographic data before primary SG: age, gender, body mass index (BMI), comorbidities (hypertension, T2DM, dyslipidemia, metabolic syndrome, obstructive sleep apnea syndrome) and history of previous gastric banding.
- Demographic data before re-SG or RYGB: SG, preoperative comorbidities, minimum weight loss after SG (BMI, EWL, percentage of weight loss), weight and comorbidities at time of performing revisional surgery.
- Indication for revisional surgery: inadequate weight loss or weight regain, history of GERD.
- Operative data: operative time, conversion rate, abdominal drainage rate.
- Outcomes: mortality rate, complication rate according to the Clavien-Dindo classification [22] during the first three postoperative months (major complications with a Clavien score ≥ 3), type of postoperative complications, length of hospital stay, readmission rate.
- Follow-up data: weight loss after revisional surgery (BMI, EWL), correction of comorbidities, rate of redo revisional surgery, postoperative GERD.

Statistics

Patient baseline characteristics are expressed as mean ± standard deviation (SD) and median (interquartile range) for continuous data and number (frequency) for categorical data. Univariate analysis was based on the Student *t* test results for quantitative variables. A Mann–Whitney *U* test was used for nonparametric variables. The limit for statistical significance was $p < 0.05$. All statistical tests were performed with SPSS software (v. 15.0 for Windows).

Results

Population Study

From January 2010 to December 2017, 144 patients underwent re-SG ($n = 61$) or RYGB ($n = 83$) for weight regain or inadequate weight loss following SG. The re-SG group consisted of 61 patients (women: $n = 48$, 78.7%) with a mean age of 48 ± 11 years (27–66). Prior to the SG, the mean preoperative BMI was 46.8 kg/m^2 (35–63.6). Fifteen patients (24.6%) had a history of gastric banding implementation. After SG, the mean minimum BMI was 36.6 kg/m^2 (23.3–50.8), representing a mean EWL of 46.1% (13.3–103.2) and a percentage of weight loss of 21.7% (5.1–47.9). The maximum weight loss after SG was obtained after a mean time interval of 16.9 months (2–47).

The RYGB group consisted of 83 patients (women: $n = 69$, 83.1%) with a mean age of 47 years ± 9 (28–68). Twenty-one patients (25.3%) had previously undergone gastric banding. After SG, the mean minimum BMI was 36.8 kg/m^2 (24.2–51.3) representing a mean EWL of 46.4% (21.2–77.9) and a

mean percentage of weight loss of 22.7% (11.2–42.1). The maximum weight loss after SG was obtained after a mean time interval of 12.7 months (3–31). Therefore, no significant differences between groups for the primary SG data were recorded and the two groups were homogeneous (Table 1).

Preoperative Data

In the re-SG group, the mean preoperative BMI before re-SG was 40.5 kg/m^2 (29–53.3). Five patients (8.2%) had a BMI ≥ 50 kg/m^2. Indications for re-SG were inadequate weight loss (EWL ≤ 50%) for 54.1% of patients and weight regain for 45.9%. A total of 69 comorbidities were recorded in 39 patients (69.9%). Fifty-nine patients underwent preoperative gastric volumetry. The mean gastric volume was 415 mL (250–609). A large proximal gastric pouch was visible in 12 patients (19.7%) and a homogenous dilation of the gastric tube was present in all other patients (80.3%). One patient (1.6%) had a hiatal hernia and refused RYGB; thus, re-SG with an associated hiatal hernia repair (Hill procedure) was performed. The mean time interval between SG and re-LSG was 41.5 months (10–106).

In the RYGB group, the mean preoperative BMI before RYGB was 41.7 kg/m^2 (29.4–60.1). Twelve patients (14.4%) had a BMI ≥ 50 kg/m^2. Indications for RYGB were inadequate weight loss (EWL ≤ 50%) for 21.7% of patients and weight regain for 78.3%. Twenty-five patients (30.1%) had symptomatic GERD and one patient (1.2%) had a Barrett's esophagus. Fifty-seven patients underwent preoperative gastric volumetry. Twenty-four out of the 25 patients with symptomatic GERD did not undergo preoperative gastric volumetry. One patient with symptomatic GERD underwent gastric volumetry, with a residual gastric volume of 450 mL. The only patient with Barrett's esophagus also underwent gastric volumetry with a residual gastric volume of 400 mL. For these two patients, RYGB was preferred. All other patients underwent preoperative gastric volumetry with a residual gastric volume < 250 mL. Seventy-four comorbidities were recorded in 43 patients (51.8%). The mean time interval between SG and RYGB was 43.2 months (16–132).

Intraoperative Data (Table 2)

In the re-SG group, no conversion to laparotomy occurred. Mean operating time was 103 min (60–205) and an abdominal drainage was used in 11 patients (18%). In the RYGB group, 14 conversions to laparotomy occurred (16.9%). Mean operating time was 129.4 min (60–280) and an abdominal drainage was used in 21 patients (25.3%).

Outcomes (Table 2)

In the re-SG group, there was one postoperative death (1.6%) related to gastric leak (GL) associated with pulmonary embolism on POD 30. Nine postoperative complications (14.5%) were observed, including seven major complications (11.5%). Six patients underwent early reoperation (9.8%). The mean length of hospital stay was 3.6 days (1–30).

In the RYGB group, 16 postoperative complications (19.3%) were observed. Seven patients were reoperated (8.4%). The mean length of hospital stay was 4.8 days (1–19). When patients were analyzed with and without history of

Table 1 Preoperative data before performing re-SG and RYGB

	Re-SG group ($n = 61$)	RYGB group ($n = 83$)	p index
Mean age (years; range)	48 (27–66)	47 (28–68)	*0.55*
Male gender (n; %)	13 (21.3%)	14 (16.9%)	*0.50*
BMI before SG (mean; range)	46.8 (34.4–63.6)	47.8 (31–71.9)	*0.51*
BMI before RS (mean; range)	40.5 (29–53.3)	41.7 (29.4–60.1)	*0.28*
Previous history of GB (n; %)	15 (24.6%)	21 (25.3%)	*0.92*
Preoperative comorbidities (n; %)	39 (63.9%)	43 (51.8%)	*0.15*
Blood hypertension (n; %)	22 (36.1%)	30 (36.1%)	*0.99*
T2DM (n; %)	22 (36.1%)	13 (15.7%)	*0.005*
OSAS (n; %)	16 (26.2%)	21 (25.3%)	*0.90*
Dyslipidemia (n; %)	9 (14.7%)	10 (12%)	*0.64*
Metabolic syndrome (n; %)	9 (14.7%)	9 (10.8%)	*0.48*
GERD (n; %)	0 (0%)	25 (30.1%)	*< 0.001*
Barrett esophagus (n; %)	0 (0%)	1 (1.2%)	*0.39*

SG, sleeve gastrectomy; *Re-SG*, repeat sleeve gastrectomy; *RYGB*, Roux-en-Y gastric bypass; *BMI*, body mass index; *RS*, revisional surgery; *GB*, gastric banding; *OSAS*, obstructive sleep apnea syndrome; *GERD*, gastro-esophageal reflux disease; *T2DM*, type 2 diabetes mellitus

Bold are for significant results. Italic is for p values

Table 2 Intra and postoperative data on re-SG and RYGB groups

	Re-SG group ($n = 61$)	RYGB group ($n = 83$)	p index
Intraoperative data			
Operative time (min; range)	103 (60–205)	129.4 (60–280)	*0.06*
Conversion rate (n; %)	0 (0)	14 (16.9)	***< 0.001***
Abdominal drainage (n; %)	11 (18)	21 (25.3)	*0.30*
Simultaneous cholecystectomy	0 (0)	15 (18)	***0.005***
Postoperative data			
Mortality (n; %)	1 (1.6)	0 (0)	*0.24*
Overall complications (n; %)	9 (14.5)	16 (19.3)	*0.48*
Major complications (n; %)*	7 (11.5)	11 (13.2)	*0.75*
Leaks (n; %)	5 (8.2)	3 (3.6)	*0.24*
Bleeding (n; %)	1 (1.6)	1 (1.2)	*0.83*
Stenosis (n; %)	1 (1.6)	1 (1.2)	*0.83*
Internal hernia (n; %)	0 (0)	1 (1.2)	*0.39*
Anastomotic ulcer (n; %)	0 (0)	1 (1.2)	*0.39*
Incarcerated incisional hernia (n; %)	0 (0)	1 (1.2)	*0.39*
Intraabdominal collection (n; %)	0 (0)	1 (1.2)	*0.39*
Parietal abscess (n; %)	0 (0)	1 (1.2)	*0.39*
Minor complications (n; %)	2 (3.3)	5 (6)	*0.45*
Reoperation rate (n; %)	6 (9.8)**	7 (8.4)***	*0.77*
Length of stay (days; range)	3.6 (1–30)	4.8 (1–19)	*0.10*
Readmission rate (n; %)	4 (6.5)	9 (10.8)	*0.38*

Re-SG, repeat sleeve gastrectomy; *RYGB*, Roux-en-Y gastric bypass

* Major complication was defined as a Clavien score ≥ 3 according to the Clavien-Dindo classification [22]

**Reoperation in case of re-SG was performed for four gastric leaks, one explorative laparoscopy for suspicion of gastric leak (without leak), and one for bleeding

***Reoperation in case of RYGB was performed for one surgical drainage of intraabdominal collection, one bleeding on jejuno-jejunostomy, one for leak on jejuno-jejunostomy, one for stenosis of the jejuno-jejunostomy, one early strangulated internal hernia requiring small bowel resection, one strangulated trocar site hernia without need for small bowel resection, and one parietal abscess

gastric banding, the overall complication rate for re-SG was 13.3% (2 out of 15) vs. 15.2% (7 out of 46), respectively ($p = 0.21$). For RYGB, the overall complication rate was 28.5% (6 out of 21) vs. 16.1% (10 out of 62), respectively ($p \leq 0.05$).

Weight Loss and Comorbidities

In the re-SG group, at 1-year follow-up, the mean BMI was 31.6 kg/m^2 (18.8–46.3) representing a mean EWL of 69.5% (24.9–124.9). Ten patients had normal BMI (16.4%), while no patients had BMI ≥ 50 kg/m^2. One patient required an additional duodenal switch (1.6%) 2 years after re-SG. In the RYGB group, at 1-year follow-up, the mean BMI was 32.5 kg/m^2 (19.1–45.6), representing a mean EWL of 61.2% (− 10–142.9). Six patients had normal BMI (7.2%), while no patients had BMI ≥ 50 kg/m^2. No significant differences were found between re-SG and RYGB during the first postoperative year (Table 3). For postoperative GERD at 1-year follow-up, seven patients (11.4%) had clinical GERD in the re-SG group while no GERD was found in RYGB group.

Discussion

SG is an effective procedure for long-term follow-up as demonstrated by many recent studies [23, 24]. Juodeikis et al. [25] reviewed the literature and found a mean EWL of 62.5% at 11-year follow-up and, at 5-year follow-up, remission or improvement of obesity-related comorbidities ranged from 65.9 to 77.8% depending on the type of comorbidity. However, like any other bariatric procedure, SG showed cases of failure with inadequate weight loss or weight regain some years after surgery. Arman et al. [6], in their series evaluating the first SG performed in their institution, showed that 21% of patients subsequently underwent another surgical procedure due to weight regain. There is a high probability that we are entering a new era, the era of revisional surgery. English et al. [26]

Table 3 Data on weight loss following re-SG and RYGB

	Re-SG group			RYGB group		
	All re-SG ($n = 61$)	Re-SG with history of GB ($n = 15$)	Re-SG without history of GB ($n = 46$)	All RYGB ($n = 83$)	RYGB with history of GB ($n = 21$)	RYGB without history of GB ($n = 62$)
Before RS						
Weight	113.4 (74–170)	108.9 (88–140)	114.8 (74–170)	115.3 (84–179)	107.8 (87–127)	117.6 (84–179)
BMI	40.5 (29–53.3)	39.3 (32–47.6)	40.9 (29–53.3)	41.7 (29.4–60.1)	40.2 (31.5–46.8)	42.2 (29.4–60.1)
EWL%	31.2 (0–77.6)	32.6 (0–64.9)	30.8 (0–77.6)	20.7 (0–65.9)*	25.7 (0–65.9)	19.1 (0–52.9)
6 months follow-up						
Weight	90.4 (57–146)	90 (83–106)	90 (57–146)	97.5 (49.9–149)*	85 (70–100)	101 (49.9–149)
BMI	32.5 (21.5–45.1)	32.1 (29.1–38)	32.6 (21.5–45.1)	35.2 (20.5–48.7)	32.4 (27–39)	36 (20.5–48.7)
EWL%	64.3 (27.1–118)	61.2 (36.5–77.9)	65.3 (27.1–118)	47.9 (11.3–132)*	51.3 (19.6–77)	46.9 (11.3–132)
12 months follow-up						
Weight	89 (50–150)	85 (71–97)	90 (50–150)	91.4 (47–144)	86 (72–115)	92 (47–144)
BMI	31.6 (18.8–46.3)	30.2 (25–37.2)	32 (18.8–46.3)	32.5 (19.1–45.6)	32 (28.2–38.4)	32.5 (19.1–45.6)
EWL%	69.5 (24.9–124.9)	71.2 (26.8–95.3)	69 (24.9–124.9)	61.2 (− 10–142.9)*	59.5 (18.8–85.5)	61.7 (− 10–142.9)

Re-SG, repeat sleeve gastrectomy; *RYGB*, Roux-en-Y gastric bypass; *RS*, revisional surgery; *BMI*, body mass index; *EWL*, excess weight loss

*Significant difference ($p \leq 0.05$) between all re-SG and all RYGB

reviewed the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program database and found that the rate of revisional surgery increased from 6% in 2011 to 13.9% in 2016.

To assess which revisional surgery is better indicated for weight loss failure after SG, surgeons need to know why a patient regains weight and if there is a mechanical reason explaining such regain or inadequate weight loss. For this reason, a simple algorithm has been prescribed for preoperative screening [13, 19] based on the upper gastrointestinal contrast study and gastric volumetry. This algorithm shows if there is a normal gastric volume (residual gastric volume < 250 mL) or if there is gastric dilatation caused by primary causes such as technical failure during primary SG, or secondary caused by patient eating habits, narrowing of the gastric incisura or the use of a large bougie during primary SG.

This series shows that re-SG has an increased rate of complication compared to current series of primary SG where the fistula rate is of 2.2% [27]. The rate of major complications was 11.5%, including 8.2% of gastric leakage. These results likely can be explained by the fact that favorable indications for performing re-SG were unknown [15]. The only case of mortality was due to pulmonary embolism at POD 30 for postoperative gastric leak that had been difficult to manage. On the other hand, RYGB after SG was not necessarily simpler, as demonstrated by the major complication rate of 13.2% (higher than in re-SG) similar to other published series [8, 28]. Performance of RYGB after a previous history of SG increased the risk of postoperative complications compared to primary RYGB [29]. Even at a lower risk of postoperative leak, RYGB adds other complications that do not exist after a SG or a re-SG [30]. Also, in our series, there was increased rate of conversion to laparotomy, which, in 11 cases, was occurred due to small bowel adhesions. Of the remaining three cases, two were converted to laparotomy because of intraoperative bleeding and one because of difficulty during performing gastrojejunostomy.

The use of RYGB for inadequate weight loss or weight regain allows weight loss to restart, as shown in this study. Our series showed similar results to published articles [8, 16] and are contrary to the series by Nevo et al. [31]; it appears that RYGB is more beneficial. One important finding of this series is that RYGB is no more efficient than re-SG, if it is possible to carry out the re-SG. At the 12-month follow-up, the BMI was similar for both groups and the difference in terms of EWL tended to be smaller (Table 3).

Only one study compared the results of re-SG and RYGB as revisional procedures after SG [19]. Their algorithm for preoperative screening differed from ours (Fig. 1), as no gastric volumetry was performed, but only the upper gastrointestinal contrast study associated with upper gastrointestinal endoscopy to assess the presence of a normal or dilatated remnant gastric tube. In their series, RYGB was performed when remnant gastric tube diameter measured less than 3 cm on the contrast study; otherwise, a re-SG was performed.

Al-Sabah et al. [19] showed that, at 1-year follow-up, EWL was similar between the re-SG and RYGB groups (57.6% vs. 61.3%, respectively; $p = 0.63$). The current results were quite similar, with an EWL in the RYGB group of 61.2% and a higher EWL in the re-SG group (69.5%). Our results could

be impacted by the fact that EWL before performing RYGB was less important than in the re-SG group and finally the difference decreased during follow-up. Also, poorly performed initial SG could not explain such results as only 19.7% of re-SG have a large gastric pouch at the upper third of the sleeve tube. Al-Sabah et al. [19] also showed that patients experienced better results if revisional surgery is performed for inadequate weight loss after SG rather than regain weight. This could be explained by the fact that the initial SG was less well done in those cases.

This series had several limitations, such as the retrospective design and the short follow-up. There also was possible bias in the interpretation of the results concerning the use of a material device for performing "good" re-SG with a decrease in postoperative complications. This evolved over time with increased surgical experience and better knowledge of gastric tissue, in particular in the context of revisional surgery. Furthermore, not all patients for whom an RYGB was decided had a preoperative gastric volumetry; at the time we started performing re-SG, we considered that GERD was a contraindication for such a procedure. Since, and thanks to other studies [13], re-SG can be proposed even in case of GERD. Despite these limitations, this study confirmed that re-SG and RYGB are valuable treatment options after the failure of primary SG. Another important point highlighted by this study was that RYGB is not superior to re-SG. Re-SG is a good alternative to RYGB. In some cases, it has the advantage of avoiding long-term complications, excluding GERD. The major point of this study was to show that in the era of revisional surgery, the revision of primary SG failures must be tailored to patient and anatomical data.

Conclusion

Our study showed that revision of SG after weight regain or inadequate weight loss by a re-SG or a RYGB is feasible but carries increased risk of complications compared to the primary surgical procedure. In patients with inadequate weight loss or weight regain after primary SG, if the second operation choose correctly, the rate of complication and outcomes are comparable. Indications for revisional surgery must be properly assessed in order to decrease morbidity and mortality.

Compliance with Ethical Standards

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

Ethical Approval 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.

Informed Consent Informed consent was obtained by all individual participants included in the study.

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