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ORIGINAL CONTRIBUTIONS

Short or Long Biliopancreatic Limb Bypass as a Secondary Procedure After Failed Laparoscopic Sleeve Gastrectomy

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Abstract

Purpose Laparoscopic sleeve gastrectomy (SG) may be associated with long-term problems such as insufficient weight loss or weight regain, persistence or relapse of comorbidities, and gastroesophageal reflux disease (GERD). This study analyzes the outcome of patients that underwent conversion of SG to a gastric bypass procedure.

Materials and Methods All patients that underwent conversion from SG to the following four different gastric bypass procedures were analyzed: short biliopancreatic limb (BPL) bypass types such as proximal Roux-en-Y gastric bypass (PRYGB) or type 2 distal Roux-en-Y gastric bypass (type 2 DRYGB) and long BPL types such as long BPL RYGB or one anastomosis gastric bypass (OAGB).

Results Between 2012 and 2016, 52 patients received the following revisional procedures after primary SG: proximal RYGB ($n = 12$, 23.1%), type 2 DRYGB ($n = 8$, 15.4%), long BPL RYGB ($n = 20$, 38.5%), and OAGB ($n = 12$, 23.1%). The long BPL type procedures (long BPL RYGB, OAGB) resulted in a significant long-term additional %EWL (33.8%; 33.2%) at 3 years. In the PRYGB, the effect lasted only for 2 years. In all patients with GERD and dysphagia as the dominant post-SG symptoms, the conversion to a bypass procedure resulted in the complete resolution of these.

Conclusion In case of weight regain or insufficient weight loss after SG, revisional surgery with a long BPL should be considered. The OAGB provides effective additional weight loss, with low morbidity and malnutrition rates, respectively. Conversion to the malabsorptive long BPL RYGB with a total alimentary limb length below 400 cm should be avoided. Patients that suffer primarily from post-SG GERD or dysphagia should undergo conversion to PRYGB.

Keywords Revisional bariatric surgery · Failed sleeve gastrectomy · Weight regain · Reflux

Introduction

In the last decade, laparoscopic sleeve gastrectomy (SG) has become the most frequently performed bariatric procedure worldwide. According to the recent IFSO registry report, SG accounts for more than 40% of all bariatric operations [1]. First systematic reviews and meta-analyses of long-term outcomes show a percentage excess weight loss (%EWL) of more than 50% over follow-up times of 10 years and more as well as a significant reduction of comorbidities such as type 2 diabetes mellitus (T2DM), hypertension, and dyslipidemia [2, 3]. However, the laparoscopic proximal Roux-en-Y gastric bypass (LRYGB) seems to provide still better results in terms of weight loss and resolution of comorbidities in the long-term compared with the SG [4, 5]. Furthermore, SG is associated with long-term problems such as insufficient weight loss, weight regain due to secondary sleeve dilation, stenosis, fistula, and gastroesophageal reflux disease (GERD). Also, according to recent data, the incidence of de novo Barrett's

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esophagus is high [6–8]. Reported reoperation rates vary from 12 to 32% [8–10]. In case of conservatively uncontrollable post-SG problems, revisional surgery may be the most appropriate treatment option. The most qualified revisional procedure after failed SG has yet to be defined. Revisional surgery options are as follows: re-sleeve gastrectomy, conversion to standard Roux-en-Y gastric bypass (RYGB), distal gastric bypass variants such as the type 2 distal Roux-en-Y gastric bypass (T2 DRYGB), long biliopancreatic limb RYGB (BPL RYGB), one anastomosis gastric bypass (OAGB), single-anastomosis duodeno-ileal bypass, or biliopancreatic diversion with or without duodenal switch [11]. The aim of this study is to review the safety and outcome of patients who underwent revisional surgery due to failure of SG.

Methods

Design and Subjects

In accordance with the guidelines of the Swiss Society for the Study of Morbid Obesity and Metabolic Disorders (SMOB), all relevant data on bariatric procedures and follow-up results at the Limmattal Hospital Bariatric Center, the second largest in Switzerland, is prospectively collected in a database (Microsoft Excel®). In the present study, all patients who underwent revisional surgery after initial SG for weight loss failure or other associated complications (reflux, stricture, dysphagia) were analyzed. Weight loss failure was defined as a %EWL < 50% or a body mass index (BMI) > 35 kg/m^2 with persistence or recurrence of comorbidities. The database has been approved by the local ethics committee and is regularly audited by the SMOB.

Preoperative Assessment of Patients and Surgical Technique

All patients undergoing revisional surgery were assessed by our multidisciplinary care team consisting of endocrinologists, gastroenterologists, dieticians, psychiatrists, and bariatric surgeons according to the SMOB guidelines. Preoperative examinations included laboratory tests, upper endoscopy, and computed tomography (CT) or contrast studies to rule out anatomical abnormalities such as dilation or stricture. Twenty-four-hour pH-impedance studies and high-resolution manometry were selectively performed in patients with suspected GERD or dysphagia.

The technique of the sleeve procedure has been described previously [12, 13]. According to our institutional range of primary bypass procedures with either long or short biliopancreatic limbs, we offered four different revisional procedures: short biliopancreatic limb bypass types such as standard RYGB or type 2 DRYGB and long biliopancreatic limb bypass types such as long BPL RYGB or one anastomosis gastric bypass (OAGB) (Fig. 1). Conversion from SG to RYGB was achieved by creating a small pouch and a biliopancreatic limb (BPL) of 60 cm and an alimentary limb (AL) of 150 cm. For type 2 DRYGB, BPL length was 60 cm, and the common limb (CL) was 100 cm, thus a variably very long Roux limb according to Brolin et al. and Tran et al. [14, 15]. For long BPL RYGB, BPL length was between 100 and 150 cm and CL length 100 cm. In these three procedures, gastroenterostomy was performed using a circular stapler (Covidien Premium Plus CEEA™ 25 mm). Enteroenterostomy was performed using a linear stapler (Ethicon Echelon Flex Powered Plus™ 60 mm), closing the enteric defect with a running Ethicon PDS™ 3-0 suture. Intermesenteric defects were closed using non-absorbable Ethicon Prolene™ 3-0 interrupted sutures. OAGB was performed by creating a long pouch beginning below the crow's foot. A 200-cm biliopancreatic limb was measured starting at the ligament of Treitz. The gastro-jejunal, side-to-side 45-mm anastomosis was again performed by using the linear stapler. Peterson's space was closed with non-absorbable Ethicon Prolene™ 3-0 interrupted sutures in all OAGB cases as well.

Outcome Measures and Postoperative Management

Follow-up was obtained in the bariatric center at 6 weeks and every 6 months thereafter on an outpatient basis.

Outcome measures included details of the primary and the revisional bariatric procedure, early and late complications according to the Clavien-Dindo classification, changes in weight, BMI, laboratory findings, and comorbidities. Weight outcomes were recorded as follows: mean initial BMI, change in ΔBMI (initial BMI – postoperative BMI), %TWL defined as ((Initial Weight) – (Postoperative Weight)]/(Initial Weight) × 100) and %EWL defined as ((Initial Weight) – (Postoperative Weight)]/[(Initial Weight) – (Ideal Weight)). The weight corresponding to a BMI of 25 kg/m^2 was considered as ideal. Pre- and postoperatively evaluated comorbidities included T2DM, arterial hypertension, abnormal lipid profile, and GERD. Definitions of the comorbidities were arterial hypertension = systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg with/without use of antihypertensive medication, T2DM = HbA1c > 6.5% with/without the use of antidiabetic medication, hyperlipidemia = elevated cholesterol and/or triglycerides, and GERD = esophagitis ≥ grade B according to the Los Angeles classification.

Statistical Analyses

All data are presented as mean values ± standard deviation or median with 95% confidence interval (CI), as applicable. For continuous data, the Student's *t* test and the Mann Whitney *U*

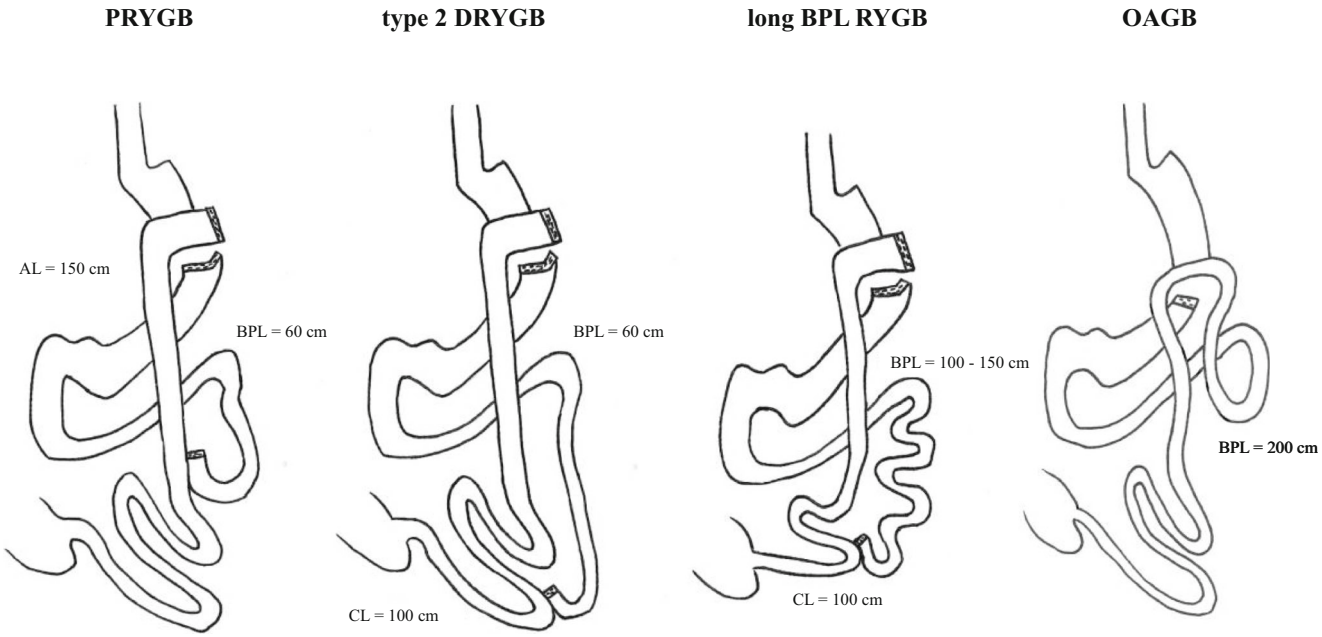

Fig. 1 Schematic illustration of different revisional procedures offered to patients with failed sleeve gastrectomy, PRYGB, proximal Roux-en-Y gastric bypass; type 2 DRYGB, type 2 distal Roux-en-Y gastric bypass; long BPL RYGB, long biliopancreatic limb Roux-en-Y gastric bypass; OAGB, one anastomosis gastric bypass; AL, alimentary limb; BPL, biliopancreatic limb; CL = common limb

test were used, as appropriate. Comparison of categorical data was performed with the Chi-square test. Statistical significance was defined by $p < 0.05$. All statistical analyses were performed using SPSS Statistics, Version 23.0.0.0.

Results

Preoperative Descriptives

Between 2012 and 2016, 52 patients (15.7%) received revisional surgery after primary SG. Table 1 demonstrates the basic weight descriptives of the different revisional procedures. Prerevisional BMI differed significantly ($p < 0.001$) between short and long BPL bypass groups. Follow-up rates were 98.0% after 1 year, 94.0% after 2 years, and 83.3% after 3 years, respectively. Drop-out reasons were loss to follow-up ($n = 6$) and death in a car accident ($n = 1$). Mean age at revision was 45.2 ± 10.1 years; 61.5% were female. Median time from primary SG to revision was 31.0 months (95% CI 27.8–37.5). Persistence of comorbidities after initial SG was as follows: T2DM in 12 patients (23.1%), hypertension in 24 patients (46.2%), and hyperlipidemia in 15 patients (28.8%). Eleven patients (21.2%) had GERD symptoms. Reasons for

Table 1 Preoperative data on patients undergoing revision for failed laparoscopic sleeve gastrectomy

n	PRYGB 12	Type 2 DRYGB 8	Long BPL RYGB 20	OAGB 12	Short BPL bypass 20	Long BPL bypass 32
Weight loss/BMI changes						
Initial BMI (kg/m^2)	40.2 (39.1–43.8)	44.9 (40.1–51.8)	52.9 (49.4–57.7)	53.0 (49.1–57.8)	43.4 (40.4–46.1)	53.0 (50.5–56.5)
Minimal BMI (kg/m^2)	27.9 (26.1–31.2)	30.6 (27.8–33.7)	38.8 (36.4–42.7)	38.0 (34.9–42.6)	29.4 (27.5–31.4)	38.7 (36.8–41.6)
Maximal ΔBMI (kg/m^2)	12.7 (11.1–14.6)	15.1 (10.9–19.5)	12.9 (11.4–16.6)	14.6 (13.0–16.4)	13.1 (11.8–15.8)	14.1 (12.5–16.0)
Maximal %EWL	79.7 (67.7–95.6)	68.0 (62.1–81.9)	50.4 (43.3–57.8)	52.0 (44.6–64.0)	72.4 (68.5–87.1)	51.1 (26.2–57.7)
Maximal %TWL	31.3 (27.0–35.1)	32.9 (25.3–38.8)	24.3 (22.2–29.4)	26.7 (24.5–31.1)	31.3 (27.9–35.0)	26.0 (24.0–29.1)
Prerevisional BMI (kg/m^2)	29.6 (27.5–33.0)	32.7 (31.2–40.5)	42.0 (39.1–44.5)	40.2 (38.3–46.5)	32.0 (29.8–35.2)	40.8 (39.8–44.3)
Prerevisional ΔBMI (kg/m^2)	9.9 (9.3–13.0)	9.9 (6.7–13.5)	10.2 (8.9–14.5)	10.9 (8.5–13.7)	9.9 (9.0–12.5)	10.4 (9.5–13.4)
Prerevisional %EWL	70.8 (57.8–83.7)	55.8 (37.8–62.4)	39.0 (35.2–45.7)	40.3 (32.0–47.3)	58.4 (52.4–72.5)	39.4 (35.8–44.4)
Prerevisional %TWL	24.3 (22.5–31.5)	23.1 (15.8–27.4)	19.8 (17.6–24.5)	21.1 (16.4–24.9)	24.2 (21.2–28.5)	20.4 (18.2–23.6)

BMI body mass index; *%EWL* excess weight loss; *%TWL* total weight loss

Values are shown as median (95% CI)

revisional surgery are insufficient excess weight loss or weight regain, sleeve-associated complications, inadequate resolution of comorbidities, and new onset morbidity (Fig. 2). In case of insufficient weight loss or weight regain after initial SG, patients were primarily offered a long BPL bypass such as long BPL RYGB or OAGB. In case of reflux symptoms, patients were rather converted to long BPL RYGB. Patients with only reflux or dysphagia but sufficient weight loss were offered a short BPL bypass such as PRYGB or type 2 DRYGB. Some patients with less pronounced weight regain were converted to type 2 DRYGB, thus leaving a constant TALL and avoiding severe protein calorie malnutrition.

Perioperative Data

In 50 patients (96.2%), the operation was performed laparoscopically; in two patients, a combined laparoscopic-open approach due to severe adhesions was used. Twelve patients (23.1%) received PRYGB, eight patients (15.4%) type 2 DRYGB, 20 patients (38.5%) long BPL RYGB, and 12 patients (23.1%) OAGB.

Morbidity and Mortality

In the short-term follow-up period up to 30 days, four Clavien-Dindo II and two Clavien-Dindo III complications were observed. Two Clavien-Dindo II, 14 Clavien-Dindo III, and three Clavien-Dindo IV complications were recorded in the long term (> 30 days). Detailed morbidity data are presented in Table 2. One patient with type 2 DRYGB had to be reoperated again due to steatorrhea and underwent lengthening of the common limb. Two patients with long BPL RYGB developed severe protein malnutrition. Those patients were reoperated by lengthening of the CL and thus shortening of the biliopancreatic limb. Further five patients with long BPL RYGB were admitted to the hospital with malnutrition and received total parenteral nutrition and were managed conservatively. In the OAGB group, two patients were converted to a long BPL RYGB. The reasons were insufficient weight loss and persistent biliary reflux.

Weight and BMI Loss Changes

Data on postoperative weight loss are shown in Table 3. Overall, three revisional procedures (PRYGB, long BPL RYGB, OAGB) resulted in a significant long-term additional %EWL. In the long BPL type procedures, this significance was present up to 3 years of follow-up, whereas in the PRYGB, the effect lasted only for 2 years. Patients undergoing revisional surgery by type 2 DRYGB showed an additional %EWL; however, this was statistically not significant.

Comparison between each group and the short and long BPL bypass options in terms of additional ΔBMI and %EWL is shown in Table 4.

Comorbidities and SG-Associated Morbidity

Of the 12 patients with persistent T2DM after SG, ten (83.35) had a complete remission 2 years after revision. These patients with prerevisional T2DM were converted to PRYGB ($n = 2$), long BPL RYGB ($n = 5$), and OAGB ($n = 5$). One patient with persistent T2DM after revisional surgery underwent a PRYGB; the other patient had a long BPL RYGB but was lost to follow-up due to death. Remission rate of hypertension was 50% (12 out of 24 patients) after 2 years. Four patients received a PRYGB, two patients a type 2 DRYGB, and nine patients each a long BPL RYGB and an OAGB. Two patients with persistent hypertension after revision were converted to PRYGB, one to type 2 DRYGB, two to long BPL RYGB, and four to OAGB. Data were missing in three patients. Hyperlipidemia resolved in 14 out of 15 patients (93.3%). One patient did not have follow-up at 2 years. All 15 patients with preoperative GERD or dysphagia had complete

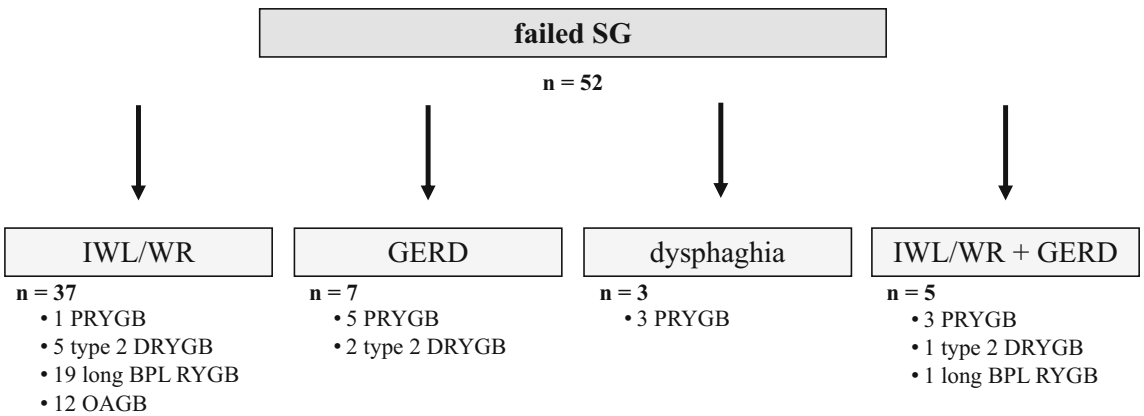

Fig. 2 Current strategy in case of laparoscopic sleeve gastrectomy failure, SG, sleeve gastrectomy; IWL/WR, insufficient weight loss/weight regain; GERD, gastroesophageal reflux disease

Table 2 Early and late surgery-related morbidity over the study period

n	PRYGB 12	Type 2 DRYGB 8	Long BPL RYGB 20	OAGB 12
Early morbidity				
Leak	0	0	0	0
Bowel obstruction	0	0	0	0
Bleeding	0	0	1	0
SSI	1	1	0	0
Other	1	0	3	0
Total	2	1	4	0
Late morbidity				
Bowel obstruction	1	1	0	0
Internal hernia	1	1	4	0
Incisional hernia	0	1	1	0
Stricture	1	0	0	0
Ulcer	2	0	0	0
Dumping syndrome	2	1	0	0
Revision	0	1	2	2
Total	9	5	7	3
Nutritional deficiencies				
Hypoalbuminemia	0	1	2	0
Iron	6	3	5	7
Vitamin B12	8	5	8	5
Folic acid	1	0	1	1
Vitamin D	12	8	18	11
Calcium	11	7	18	10
Zinc	3	1	8	2

SSI surgical site infection

resolution of symptoms at all follow-up time points postoperatively. All patients had a bypass version with a minimal alimentary limb length of 150 cm, and none of these patients underwent OAGB.

Discussion

The main finding of this study assessing all potential revisional bypass procedures after failed SG was a sustained additional weight loss, control of comorbidities, and correction of sleeve-associated complications. Conversion to long BPL bypass, e.g., long BPL RYGB or OAGB, led to a significant additional weight loss for patients presenting with insufficient weight loss or weight regain. Conversion to PRYGB or type 2 DRYGB in case of GERD or dysphagia led to improvement of symptoms with only moderate weight change. The degree of additional weight loss in our cohort is comparable with other studies investigating conversions from SG to bypass procedures [11, 12, 16]. However, we observed a high rate of calorie protein malnutrition in malabsorptive type conversions, especially in long BPL RYGB, which raises considerable concerns in regard to the widespread applicability and safety of this type of revisional technique.

Since SG has surpassed LRYGB as the primary procedure of choice worldwide, conversions to bypass procedures due to inadequate weight loss/weight regain, and reflux with or without associated Barrett's esophagus, may well increase in the near future. The consensus on the preferable conversion technique has yet to be reached. PRYGB is frequently selected as a revisional procedure after failed SG [17]. Abdemur et al. report a total %EWL and additional %EWL of 76.5% and 30.9%, respectively, at a mean follow-up of 18.3 months [18]. In a group of 27 patients who underwent conversion to PRYGB after weight loss failure, Casillas et al. observed a peak of 38.2% additional EWL at 1 year, with a drop to 32.4% and 16.4% at 2 and 3 years, respectively [19]. Accordingly, in our group of patients receiving PRYGB as a revisional procedure, the additional %EWL was 23.7% 3 years after revision, while total %EWL was 75.3%.

To our knowledge, this study is the first to describe the conversion to type 2 DRYGB for SG failure. In this subgroup, the mean additional %EWL after 3 years was 21.8%, representing the lowest additional %EWL among all

Table 3 Postoperative weight loss over the study period

	PRYGB ($n = 12$)		Type 2 DRYGB ($n = 8$)		Long BPL RYGB ($n = 20$)		OAGB ($n = 12$)	
Weight loss/BMI changes at 1 year								
BMI (kg/m^2)	25.8 (24.4–28.2)		29.6 (26.6–36.4)		31.8 (27.6–38.0)		33.0 (27.1–40.9)	
Additional ΔBMI (kg/m^2)	4.1 (2.6–5.3)*	$p = 0.006$	5.2 (2.7–6.0)	p = 0.115	8.4 (7.1–11.3)*	$p < 0.001$	7.5 (5.3–11.9)*	$p < 0.001$
Additional EWL (%)	23.7 (16.8–30.9)*	$p = 0.018$	28.5 (14.0–32.4)*	$p = 0.074$	33.8 (26.6–40.6)*	$p < 0.001$	27.2 (20.7–44.6)*	$p < 0.001$
TWL (%)	36.4 (33.0–39.8)*	$p = 0.006$	29.6 (24.9–37.7)*	$p = 0.115$	39.8 (31.4–44.7)*	$p < 0.001$	37.6 (29.5–42.9)*	$p < 0.001$
Weight loss/BMI changes at 2 years								
BMI (kg/m^2)	26.6 (24.8–28.7)		31.5 (27.8–36.2)		31.7 (24.4–37.8)		32.4 (26.5–40.8)	
Additional ΔBMI (kg/m^2)	3.9 (1.7–5.5)*	$p = 0.028$	4.2 (2.1–5.6)	$p = 0.208$	10.3 (8.5–15.3)*	$p < 0.001$	9.8 (5.7–12.2)*	$p < 0.001$
Additional EWL (%)	23.1 (9.9–30.6)*	$p = 0.038$	20.7 (9.1–30.1)	$p = 0.142$	38.2 (30.2–51.7)*	$p < 0.001$	38.7 (20.6–49.3)*	$p < 0.001$
TWL (%)	36.6 (30.8–39.8)*	$p = 0.021$	28.9 (23.3–36.4)	$p = 0.093$	42.4 (33.7–53.0)*	$p < 0.001$	36.3 (30.0–44.2)*	$p < 0.001$
Weight loss/BMI changes at 3 years								
BMI (kg/m^2)	29.5 (24.8–28.7)		30.8 (27.9–35.7)		34.5 (29.2–35.8)		34.6 (29.6–36.8)	
Additional ΔBMI (kg/m^2)	4.3 (1.7–5.5)	$p = 0.146$	4.6 (1.5–5.6)	$p = 0.245$	8.0 (5.8–16.0)*	$p < 0.001$	9.4 (5.5–11.9)*	$p < 0.001$
Additional EWL (%)	23.7 (9.9–30.6)	$p = 0.373$	21.8 (6.3–27.0)	$p = 0.156$	33.8 (19.9–44.5)*	$p < 0.001$	33.2 (20.3–45.6)*	$p < 0.001$
TWL (%)	31.3 (30.8–39.8)	$p = 0.122$	31.6 (21.5–37.3)	$p = 0.121$	45.0 (36.8–50.8)*	$p < 0.001$	34.9 (32.7–40.7)*	$p < 0.001$

BMI body mass index; *%EWL* excess weight loss; *%TWL* total weight loss

*$p < 0.05$ compared with prerevisional

Values are shown as median (95% CI)

revisional procedures without any significant difference in terms of additional weight loss compared with PRYGB despite the shorter CL. In addition, previous reports concerning type 2 DRYGB showed the risk of nutritional deficiencies requiring oral supplementation and diarrhea [20]. In view of our experience with primary type 2 DRYGB and revisional type 2 DRYGB for failed sleeve, we do not recommend this technique as a conversional option for failed sleeve due to the absence of additional weight loss benefit and exposure to the risk of diarrhea and nutritional deficiencies, which is in accordance with the data published by Risstad et al. [21].

Mahawar et al. analyzed different small bowel limb lengths and showed that long biliopancreatic limb gastric bypass offers a substantial weight loss at the cost of an increased risk of protein calorie malnutrition [22]. Various intestinal limb lengths have been reported for this procedure [23–25]. In our cohort, the long BPL RYGB was also the revisional procedure with the highest additional %EWL of 33.8% and with the highest rate of malnutrition after 3 years of follow-up. Several studies have reported severe malnutrition after long BPL RYGB and suggest a total alimentary limb length (TALL) of at least 350–400 cm in order to keep calorie protein malnutrition at a low rate [23, 26, 27]. Conversely, OAGB with its long BPL seems to be rather an acceptable alternative as a revisional procedure after failed SG. Because of the increasing evidence from randomized control trials as a primary surgical option, OAGB is gaining general acceptance worldwide, being the third most common procedure at present [28]. Chiappetta et al. have shown higher weight loss and lower complication rates in patients converted from SG to OAGB compared with patients who were converted to PRYGB [12]. Regarding severe protein calorie malnutrition requiring revisional surgery, its incidence is low and has been suggested to correlate with a length of biliopancreatic limb of > 250 cm [29]. However, the recently published multicenter YOMEGA trial has shown higher rates of protein calorie malnutrition with a biliopancreatic limb length of 200 cm in primary OAGB, a finding which is inconsistent with our results after conversion of SG to OAGB [30]. In our cohort, none of the patients experienced protein calorie malnutrition after 3 years of follow-up. Furthermore, patients with OAGB showed a median additional %EWL of 33.2% at 3 years postoperatively with an acceptable complication rate. Similarly, we did not see any worrying outcomes in regard to severe protein calorie malnutrition as experienced in the present revisional OAGB patients with a 200-cm BPL length. Therefore, based on the above-mentioned results and experience, OAGB offers excellent mid-term weight loss and control of comorbidities in selected patients with strict compliance to follow-up visits without the risk of severe calorie protein malnutrition in need of revision, in contrast to the long BPL RYGB.

Conversion to PRYGB is considered to be the optimal approach for treating GERD symptoms after SG, when

Table 4 Comparison between different revisional procedures and between short (PRYGB and VVLL RYGB) and long (long BPL RYGB and OAGB) biliopancreatic limb gastric bypass in terms of weight loss shown as median (95% CI) with corresponding *p* values

	PRYGB			Type 2 DRYGB		Long BPL RYGB
	vs. type 2 DRYGB	vs. long BPL RYGB	vs. OAGB	vs. long BPL RYGB	vs. OAGB	vs. OAGB
1 year						
Additional ΔBMI	0.521	< 0.001	0.009	0.001	0.048	0.514
Additional EWL	1.000	0.043	0.379	0.115	0.492	0.947
2 years						
Additional ΔBMI	0.866	< 0.001	0.009	< 0.001	0.026	0.231
Additional EWL	0.851	0.006	0.104	0.011	0.238	0.544
3 years						
Additional ΔBMI	0.699	0.113	0.145	0.026	0.036	0.931
Additional EWL	0.485	0.456	0.328	0.181	0.088	1.000
		Short BPL gastric bypass ($n = 20$)		Long BPL gastric bypass ($n = 32$)		*p* value
1 year						
Additional ΔBMI		4.1 (3.1–5.2)		9.0 (7.4–10.5)		< 0.001
Additional EWL		23.6 18.1–29.1)		33.2 (28.0–38.5)		0.035
2 years						
Additional ΔBMI		3.7 (2.4–5.0)		10.7 (8.6–12.7)		< 0.001
Additional EWL		20.0 (12.7–27.3)		38.5 (31.3–45.7)		0.003
3 years						
Additional ΔBMI		4.2 (2.4–5.0)		9.8 (6.8–12.8)		0.029
Additional EWL		20.5 (11.4–29.7)		32.6 (24.0–41.1)		0.099

PRYGB proximal Roux-en-Y gastric bypass; *type 2 DRYGB* type 2 distal Roux-en-Y gastric bypass; *long BPL RYGB* long biliopancreatic limb Roux-en-Y gastric bypass; *OABG* one anastomosis gastric bypass; *BPL* biliopancreatic limb; *BMI* body mass index; *%EWL* excess weight loss

additional weight loss is not the main intention of the revisional procedure. Several authors reported a very high improvement rate of reflux symptoms in SG patients with GERD who underwent conversion to PRYGB after primary SG [12, 19, 31], which is in accordance with our data. All patients suffering from prerevisional GERD showed complete resolution from symptoms during the follow-up after conversion from SG to PRYGB and long BPL RYGB. The role of OAGB for patients with preoperative GERD is unclear. A late incidence of GERD in 4.0% has been reported in a series of 2678 patients; however, in a subgroup of 18 patients presenting with preoperative GERD, 4 patients (22.2%) needed revisional surgery because of intractable symptoms [32]. In our cohort of 12 patients that underwent OAGB as a revisional procedure, one patient (8.3%) had to undergo conversion from OAGB to long BPL RYGB due to severe biliary reflux. Intraoperatively the patient showed a too short pouch of less than 10 cm which was probably the reason for biliary reflux. More data on the effect of OAGB on GERD has to be awaited to draw definitive conclusions on its role in conversional procedures for SG. We suggest that patients with reflux symptoms without further need for weight loss improvement or comorbidity control should undergo PRYGB [16, 33]. In case of symptomatic GERD and need for substantial additional weight loss, the most beneficial procedure might be the long BPL RYGB. However, this type of RYGB harbors a high rate of protein calorie malnutrition, due to the combination of a small pouch and a long biliary limb [27]. As shown by several studies, in case of long BPL RYGB, a long enough TALL is of outmost importance [23, 34, 35]. Therefore, this type of conversion should only be offered to highly selected patients, and a TALL of at least 400 cm should be respected [23]. Additionally, these patients must be included in a lifelong surveillance program. If in doubt, these patients with combined weight and reflux problems should rather undergo PRYGB.

One important outcome of our data is the overall low to moderate morbidity rate. No mortality occurred. This implies that revisional surgery after failed SG can be performed safely and should not be denied to patients with weight regain, insufficient weight loss, or SG-associated morbidity. However, patients must be evaluated thoroughly by a multidisciplinary care team prior to conversion. After the decision for revisional surgery is made, the main question remaining is the type of procedure. If weight issues are dominant, a long BPL bypass type is to be considered; in case of reflux, the choice should be a PRYGB. In view of the potential risk of calorie protein malnutrition, emphasis should be placed on strict compliance and regular follow-up in case of long biliary bypass options, especially in the long BPL RYGB.

The limitations of this study include its retrospective character and the small sample size of the subgroups. To our

knowledge, this cohort is the first reported including all the various types of revisional bypass procedures with a follow-up of 3 years. This is not a randomized study; thus, a certain selection bias could affect the results. Indication for a revisional long BPL bypass procedure was mostly set in failed SG due to weight issues, and that for short BPL bypass was set in SG-associated comorbidities such as GERD or dysphagia. The long BPL bypass group had a higher BMI before revisional surgery. Thus, one needs to interpret the postoperative weight loss data with caution. However, revisional surgery must be tailored to the individual patient's needs, and malabsorptive procedures will always result in a higher %EWL in comparison with restrictive techniques. Prospective randomized controlled trials are required to compare the different revisional procedures in terms of long-term weight loss and complication rates, in order to draw safe conclusions and establish guideline-based algorithms for the management in case of SG failure.

Conclusion

Revisional surgery after failed SG is safe. In case of weight regain or insufficient weight loss, a revisional procedure with a long BPL should be considered. The OAGB provides very effective additional weight loss with low morbidity and manageable nutritional deficiencies if strict follow-up in a multidisciplinary care team can be provided. Conversion to the malabsorptive long BPL RYGB with a TALL below 400 cm should be avoided due to unacceptable protein calorie malnutrition rates. Patients with post-SG reflux or dysphagia without weight loss failure after SG should undergo conversion to a PRYGB.

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 does not apply.

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