Obesity Surgery (2019) 29:2255–2262
https://doi.org/10.1007/s11695-019-03838-z

ORIGINAL CONTRIBUTIONS

Secondary Bariatric Procedures in a High-Volume Centre: Prevalence, Indications and Outcomes

Mohamed Elshaer[1,2] · Karim Hamaoui[1] · Parushak Rezai[1] · Kasim Ahmed[1] · Nadira Mothojakan[1] · Omer Al-Taan[1]

Published online: 21 March 2019

Abstract

Background Secondary bariatric procedures represent a challenge to both patients and surgeons. The objective of this study was to explore the patterns of recurrence and modalities of secondary bariatric procedures in a tertiary bariatric centre.

Materials and Methods A retrospective analysis of patients who underwent secondary bariatric procedures after laparoscopic adjustable gastric band (AGB), sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) from April 2007 to March 2017.

Results Overall, 3266 bariatric procedures were performed, and secondary bariatric procedures were required for 45 (1.4%) patients (28 AGB, 14 SG, 3 RYGB). Twenty-six (57.8%) patients underwent conversion to RYGB, eight (17.8%) patients underwent conversion to SG, seven (15.6%) patients were converted to duodenal switch (DS), two (4.4%) patients had revision of gastrojejunal anastomosis, one (2.2%) patient underwent revision of gastric pouch and one (2.2%) patient had replacement of AGB. Mean change in BMI and %TWL at 18 months were 8.5 ± 3.9 kg/m^2 and 17.6 ± 8.2 respectively after revision of AGB. Mean change in BMI and %TWL at 18 months were 11.7 ± 11.2 kg/m^2 and 18.4 ± 13.2 respectively after revision of SG. Mean change in BMI and %TWL at 18 months were 2.6 ± 3.0 kg/m^2 and 6.9 ± 6.8 respectively after revision of RYGB. No mortality was reported after revision procedures.

Conclusion Weight regain, inadequate weight loss and reflux were the main reasons for performing secondary bariatric procedures. The main revision procedures performed were RYGB and SG especially for failed AGB.

Keywords Roux-en-Y gastric bypass · Sleeve gastrectomy · Revisional surgery

Introduction

Obesity incidence has tripled since 1975, with 650 million obese population representing 13% of adults aged 18 years old or older worldwide [1]. Obesity increases the risk of depression, type 2 diabetes, hypertension, cardiovascular diseases, some cancers and mortality. It has been reported that 2.8 million people die every year as a result of obesity and being overweight [1, 2].

The number of primary bariatric procedures for obesity is rising and has been shown to be effective in achieving weight loss and improving co-morbidities such as diabetes [3]. The UK national bariatric surgery registry (NBSR) reported 16,956 primary bariatric procedures and 1327 secondary or planned second stage procedures from 2011 to 2013 [4]. Roux-en-Y gastric bypass (RYGB) was the most commonly performed procedure followed by adjustable gastric band (AGB) and sleeve gastrectomy (SG) [4].

Secondary bariatric procedures include any revision, conversion or reversal of vertical banded gastroplasty (VBG), AGB, SG or RYGB [5]. It has been reported that 10–50% of patients who underwent restrictive bariatric procedure will require another operation due to inadequate weight loss or weight regain [6]. AGB can be converted to SG or RYGB to treat complications or achieve weight management. SG is usually converted to RYGB or biliopancreatic diversion with duodenal switch (BPD/DS) and revision following RYGB usually involves the gastric pouch, gastrojejunal anastomosis or creating distal RYGB.

Some secondary procedures can be challenging, and studies compared outcomes of these procedures versus primary

✉ Mohamed Elshaer
mohamedelshaer_1@hotmail.com

[1] Department of Upper GI and bariatric Surgery, Luton and Dunstable University Hospital, Luton, UK

[2] Department of Surgery, Luton and Dunstable University Hospital, Lewsey road, Luton LU4 0DZ, UK

bariatric operations showed satisfactory results and weight loss [7–9]. However, some authors reported longer operative times, longer length of stay (LOS) and increased risks of complications rates than those found in association with primary procedures [10, 11].

The objective of this study was to assess patterns of relapse following primary bariatric procedures, as well as evaluating the outcomes of secondary bariatric procedures performed at a tertiary bariatric centre.

Patients and Methods

A retrospective review was undertaken of prospectively collected data of consecutive obese patients who underwent revisional surgery after primary bariatric procedures at Luton and Dunstable University Hospital from April 2007 to March 2017. Luton and Dunstable University Hospital is a tertiary referral centre for bariatric surgery with a catchment population of 5.8 million.

Patients who underwent a secondary bariatric procedure (revision, conversion, or reversal) within 10-year period after laparoscopic AGB, SG or RYGB were included. Patients who returned to theatre for band removal, postoperative haemorrhage or obstruction without any other procedure were excluded. Patients underwent a medical weight management programme run by dieticians, psychologists, bariatric specialist nurses and a dedicated physician. All patients were required to lose 5.0% of their excess weight before referral to a bariatric surgeon for an operation. Preoperative investigations included routine blood tests, chest x-ray and an electrocardiogram. Echocardiogram, sleep studies, abdominal ultrasound and oesophagogastroduodenoscopy (OGD) were performed for some patients depending on symptoms and signs. After achieving the expected weight loss, patients were started on a liver shrinking, low-calorie liquid diet that is rich in proteins, minerals, multivitamins and electrolytes but low in carbohydrates. Low molecular weight heparin and histamine 2 (H2) blocker were commenced 12 h before the operation and were continued postoperatively for 2 and 12 weeks, respectively.

Patients were followed up in outpatient clinic every 3 months for 2 years by a multidisciplinary team consisting of a surgeon, dietitian and obesity specialist nurse. Additional follow-up information has been gathered from the Hospital electronic records for patients who underwent revision after 2 years.

SG was performed in a standard technique. Greater curvature of the stomach was dissected from the omentum and then resected snug to a 38 F calibration tube with endoscopic linear cutting stapler reinforced with seamguard (synthetic bioabsorbable buttressing material) or Peri-Strips dry with Veritas (acellular, non-cross-linked collagen matrix derived from bovine pericardium). RYGB was performed in a standard way by creating a 30-cc gastric pouch (an estimate using a 36 F orogastric calibration tube). Antecolic gastrojejunostomy and jejunojejunostomy were performed with alimentary limb measured 100–120 cm and biliary limb measured 60 cm.

The decision to proceed from the primary procedure to the revisional procedure was based on indication, patient BMI, patient preference, anatomical and patient suitability and was decided upon by a Bariatric multidisciplinary team (MDT).

For patients who successfully fulfilled the inclusion criteria, case notes and the hospital's electronic database were searched. Age, gender, preoperative body mass index (BMI), comorbidities, surgical procedure, operating time, LOS, postoperative BMI, 30-day morbidity and mortality data were collected. The primary outcome measures were postoperative change in BMI, percentage total weight loss (%TWL) and comorbidities resolution or improvement. The secondary outcome measures were 30-day morbidity and mortality, LOS and readmission rate. Inadequate weight loss or weight regain is defined as < 50% of percentage excess weight loss (%EWL) or BMI > 35 m/kg^2 at 24 months. Type 2 diabetes (T2D) remission is defined as normal HgA1c or stoppage of diabetes medications. A large gastric pouch is defined as pouch size > 30 cm^2.

Statistical Analysis

Data were analysed with the Statistical Package for the Social Sciences Windows version 20.0 (SPSS, Chicago, IL, USA). For continuous parametric variables, we used the mean and standard deviation, and for continuous non-parametric variables, we used the median and range. For categorical variables, the frequencies were used. Normality assumptions were demonstrated with histograms and the Kolmogorov/Smirnov test. Comparison between groups was conducted with *t* test for continuous parametric variables and Mann-Whitney *U* test for non-parametric variables. Chi-square test and Fisher's exact test were used to compare between categorical variables. A *p* value of less than 0.05 was considered statistically significant.

Results

Patients' Characteristics and Demographics

Between April 2007 and April 2017, 3266 bariatric procedures were performed at Luton and Dunstable University Hospital (Fig. 1). Of these, there were 52 (1.6%) revision, conversion and reversal secondary bariatric operations. Six patients underwent port revision and one patient had reversal of RYGB were excluded and only 45 (1.4%) patients were included in the final analysis. There were 34 (75.6%) females and 11 (24.4%) males, with a median age of 48 years (range

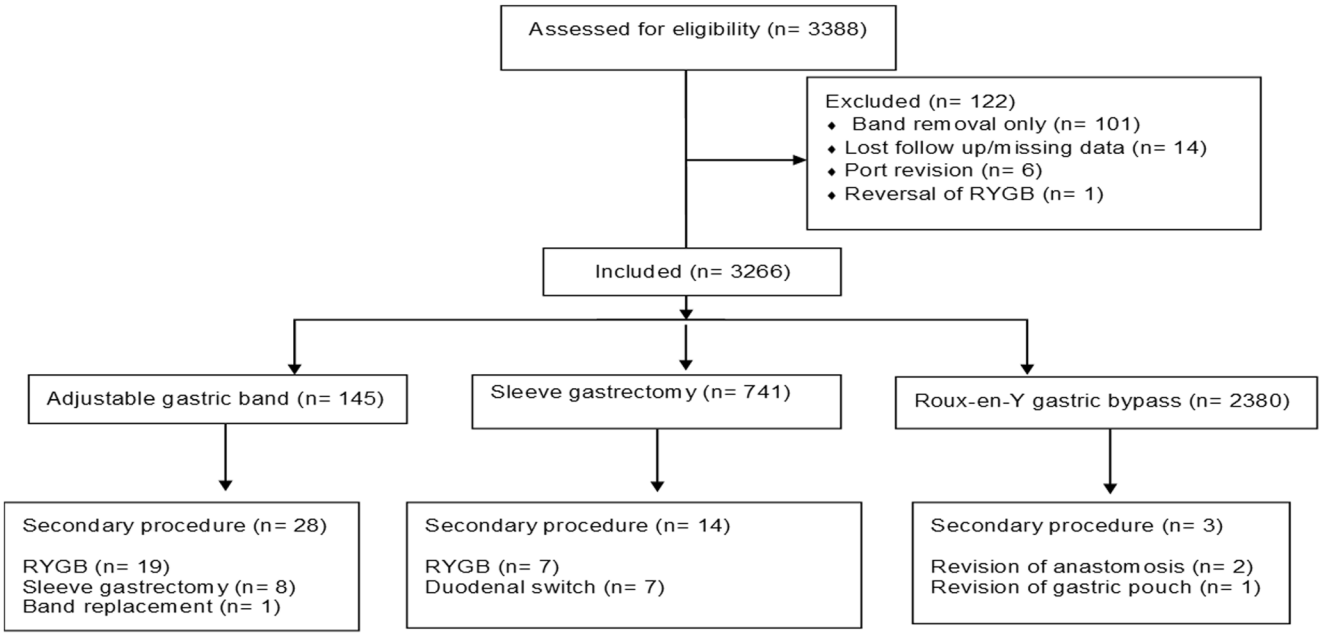

Fig. 1 Flow chart of study. RYGB Roux-en-Y gastric bypass

26–67) and mean BMI of 48.4 ± 12.9 kg/m^2. Sixteen (35.6%) patients suffered from hypertension, 16 (35.6%) had arthritis, 15 (33.3%) had sleep apnoea, 10 (22.2%) had dyslipidaemia and 9 (20.0%) were diabetic.

Revision After Laparoscopic Adjustable Gastric Band

A total of 145 (4.4%) AGB insertions were performed, with 28 (19.3%) patients undergoing revision surgery. Of the latter, 19 (67.9%) patients underwent conversion to RYGB and eight (28.6%) patients had their AGB converted to SG (Table 2) as one stage laparoscopic procedure, and one (3.6%) patient had their band replaced. Indications for revision are recorded in Table 1.

Conversion to SG

There were two (25.0%) males and six (75.0%) females with a median age of 53 years (range 26–67), and mean BMI of 52.9 ± 13.4 kg/m^2. Three (37.0%) patients had hypertension, two (25.0%) suffer from sleep apnoea and one (12.5%) patient was diabetic. Two (25%) patients experienced dysphagia after conversion to SG, and one (12.5%) patient had wound infection. Two (25.0%) patients were readmitted within 30 days with dysphagia and vomiting. Median LOS was 3 days (range 2–4). Mean change in BMI and %TWL at 18 months were 9.0 ± 3.5 kg/m^2 and 17.9 ± 7.8 respectively. No remission of diabetes, hypertension or sleep apnoea was noticed. No mortality was reported in this group.

Conversion to RYGB

There were two (10.5%) males and 17 (89.5%) females with a median age of 47 years (range 36–65) and mean BMI of 48.9 ± 7.2 kg/m^2. Seven (36.8%) patients suffered from hypertension, six (31.6%) patients were diabetic and six (31.6%) had sleep apnoea. Postoperative bleeding and haematemesis occurred in two (10.5%) patients after RYGB, one (5.3%) patient had wound infection, one (5.3%) had urinary retention and one (5.3%) developed a port site incisional hernia. No readmission was seen after RYGB. Median LOS was 4 days

Table 1 Patterns of recurrence and indications for revision. *AGB* adjustable gastric band, *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass. Inadequate weight loss ≤ 50% of %EWL, weight regain = BMI > 35 m/kg^2 at 24 months

Variables	AGB (n = 28)	SG (n = 14)	RYGB (n = 3)
Band erosion	2 (7.1%)	–	–
Displaced band	3 (10.7%)	–	–
Chronic vomiting	1 (3.6%)	1 (7.1%)	0 (0%)
Functional stricture	0 (0%)	1 (7.1%)	0 (0%)
Weight regain	11 (39.3%)	4 (28.6%)	0 (0%)
Inadequate weight loss	8 (28.6%)	3 (21.4%)	0 (0%)
Reflux	2 (7.1%)	5 (35.7%)	0 (0%)
Fistula formation	0 (0%)	0 (0%)	1 (33.3%)
Anastomotic stricture	–	–	1 (33.3%)
Large pouch	0 (0%)	0 (0%)	1 (33.3%)
Oesophageal dilatation	1 (3.6%)	0 (0%)	0 (0%)
Malnutrition and diarrhoea	0 (0%)	0 (0%)	1 (33.3%)

(range 1–8). Mean change in BMI and %TWL at 18 months were 9.4 ± 4.2 kg/m^2 and 19.3 ± 8.9 respectively. Diabetes remission was noted in three (50.0%) patients, reduction in diabetic medication in two (33.3%) patients. Sleep apnoea remission was seen in three (50.0%) patients. No mortality was reported in this group.

Revision After Laparoscopic Sleeve Gastrectomy

There were 741 (22.7%) SG performed for weight reduction, following which 14 (1.9%) patients underwent a secondary bariatric procedure. Of these, seven (50.0%) had conversion to RYGB and seven (50.0%) were converted to BPD/DS (Table 3). Indications for revision are recorded in Table 1.

Conversion to RYGB

There were one (14.3%) male and six (85.7%) females with a median age of 47 years (range 37–55) and mean BMI of 37.9 ± 8.4 kg/m^2. Two (28.6%) patients were diagnosed with sleep apnoea, two (28.6%) patients had hypertension and one (14.3%) was diabetic. Postoperative ileus occurred in one (14.3%) patient. There were no readmissions or return to theatre in this group. Median LOS was 3 days (range 1–6). Mean change in BMI and %TWL at 18 months were 5.1 ± 4.1 kg/m^2 and 11.3 ± 8.6 respectively. An improvement in diabetes was observed in one (100.0%) patient and one (50.0%) patient experienced hypertension remission. No mortality was reported in this group.

Conversion to BPD/DS

There were five (71.4%) males and two (28.6%) females with a median age of 42 years (range 35–51) and mean BMI of 67.7 ± 9.3 kg/m^2. Four (57.1%) patients were diagnosed with sleep apnoea, and two (28.6%) patients had hypertension. One (14.3%) patient had rectal bleeding in the postoperative period, wound infection was seen in one (14.3%) patient and one (14.3%) patient experienced diarrhoea. There were no readmissions or return to theatre in this group. Median LOS was 3 days (range 2–3). Mean change in BMI and %TWL at 18 months were 18.4 ± 12.3 kg/m^2 and 25.5 ± 13.5 respectively. No remission in hypertension or sleep apnoea was observed. No mortality was reported in this group.

Revision After Laparoscopic Roux-En-Y Gastric Bypass

RYGB was performed in 2380 (72.9%) patients. Three (0.1%) patients underwent a secondary bariatric procedure following RYGB. Two (66.7%) patients had revision of gastrojejunal anastomosis and one (33.3%) patient underwent revision of gastric pouch. Indications for revision are recorded in Table 1. Median age was 58.5 years (range 47–65) and mean BMI was 31.8 ± 10.0 kg/m^2. Two (66.7%) patients suffer from hypertension, one (33.3%) patient was diabetic and one (33.3%) had sleep apnoea. Postoperative pneumonia occurred in one (33.3%) patient. Two (66.7%) patients were readmitted within 30 days with abdominal pain. Median LOS was 3.5 days (range 3–15). Mean change in BMI and %TWL at 18 months were 2.6 ± 3.0 kg/m^2 and 6.9 ± 6.8 respectively. Hypertension remission was noticed in two (100.0%) patients and one (100.0%) patient experienced improvement of his sleep apnoea. No mortality was reported in this group.

Discussion

Secondary bariatric procedures have become a necessary adjunct to primary procedures. AGB was initially viewed as an attractive surgical option due to its simplicity, low morbidity and good short term EWL outcomes [12]. Nevertheless, in the long term, it has been associated with a high incidence of failure—in particular, poor weight loss, weight regain and complications (band migration, erosion and slippage) [13]. Moreover, recent reports have suggested that almost 50% of AGB patients will require a revisional procedure [14].

AGB complications have been recorded extensively in the literature. AGB migration and erosion was reported in 16 (2.1%) patients after 23 months, by Abu-Abeid et al. (2005) with successful simultaneous removal and replacement [15]. Van Wageningen et al. reported 47 failed AGB procedures that subsequently required conversion to RYGB. The rate of early postoperative complications was 17.0%, with one patient experiencing an incisional hernia. In their series, conversion to RYGB was not associated with mortality, and patients achieved the required weight loss [16]. Topart and co-workers showed successful weight loss following conversion of AGB to RYGB or BPD/DS in 53 patients with failed AGB. In their series, BPD/DS was associated with an increased operative time, complications and more weight loss compared with RYGB [17]. In a more recent study by Almalki et al. (2017), 116 patients with failed AGB and VBG underwent conversion to mini-gastric bypass or RYGB. The incidence of major complications was similar (10.0%) despite the achievement of more weight loss following a mini-gastric bypass, albeit the presence of anaemia at 5 years follow-up [6].

Analysis of the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database for 2708 patients who underwent AGB conversion to RYGB or SG was conducted in 2017. Operative time, anastomotic leak, blood loss, reoperation rate, readmission rate and length of stay were higher in RYGB patients than SG patients. Weight loss and co-morbidity remission rates were not provided in this large observational analysis [10]. Bruzzi et al. studied the outcomes of converting

22 failed AGB to one anastomosis gastric bypass (OAGB) and compared this with patients who underwent primary OAGB. They found no significant difference in BMI and excess BMI loss as well as postoperative complications [18]. In our series, revision after AGB was performed primarily due to weight regain (39.3%) or inadequate weight loss (28.6%); the main form of revision was RYGB (67.9%) followed by SG (28.6%). There was no difference between the two groups in %TWL at 18 months ($p = 0.717$) and 30-day complications ($p = 0.561$). However, conversion to SG was associated with reduced median LOS ($p = 0.035$) and higher readmission rate ($p = 0.024$) than RYGB (Table 2). Conversion of AGB to SG can be performed as one stage procedure or in 2 stages. There is limited evidence that the 2-stage procedure is associated with less leak rates [19]. Staple line leak could be related to the scar tissue at the angle of His that results from the band. A study by Spaniolas et al. (2017) showed that a single stage conversion of AGB to SG was associated with low postoperative morbidity and they reported staples line leak rate of less than 1% [20].

SG has rapidly gained popularity as it is less technically demanding, with shorter operative times, as well as fewer complications and metabolic deficiencies than RYGB [21]. Despite this, complications do exist, and SG poses the possibility for persistent symptomatic reflux and challenges related to managing leaks near the gastro-oesophageal junction [22]. Furthermore, some patients will experience inadequate weight loss or weight regain (10–20%), and the persistence of comorbidities [11].

Early reports of revisional surgery in obese patients who underwent gastric restrictive surgery or bypass, showed more postoperative complications than in primary procedures. Nevertheless, weight loss after revisional procedures was similar to primary procedures [23]. SG is a predominately restrictive procedure and reoperation for long term complications such as sleeve stenosis, severe reflux or inadequate weight loss and regain predominately involves revision of the gastric tube or conversion to a re-routing procedure such as RYGB or DS. A retrospective registry review of 1781 SG in New York State between 2004 and 2010 revealed an overall reoperation rate of 9.8% [24]. An updated analysis of registry data included 14,080 patients from 2011 to 2013 showing a rapid increase in the numbers of SG undertaken, with a lower overall reoperation rate of 0.32% (0.11% and 0.21% for SG revision and conversion to RYGB respectively) [25]. Unfortunately, their analysis did not provide reasons for reoperation.

Revisional surgery rates following SG are variable among published international cohorts from individual units; 1.1% (13/1224) over 6 years in Sweden, 1.7% (48/2806) over 6 years in a high volume centre in the US, up to 4.2% (7/168) in Norway over 5 years, 6.4% (32/500) in a study from Turkey over 7 years and 6.6% (18/273) over 7 years in a Canadian study [11, 22, 26–28]. In this series, the rate of revisional surgery following SG was 1.9% with the most common cause of revision being reflux, followed by weight regain. Reflux has been shown to be prevalent in up to 20–30% of primary SG patients at long-term follow-up. It was an indication for conversion to RYGB in 26% to 66% of patients, and conversion to RYGB or DS can improve reflux in 90–100% of patients [22, 27, 29–31].

A Dutch retrospective review of 43 SG patients undergoing conversion to RYGB or DS, reported better %EWL with conversion to DS (59.0%) than RYGB (23.0%) [32]. In our experience, conversion of SG to either RYGB or DS was

Table 2 Sleeve gastrectomy vs. RYGB for revision of AGB. *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass. *T2D* type 2 diabetes, *%TWL* percentage total weight loss, *LOS* length of stay

Variables	SG ($n = 8$)	RYGB ($n = 19$)	p value
Age (years, median)	53 (range 26–67)	47 (range 36–65)	0.024
Sex			
Male	2 (25.0%)	2 (10.5%)	0.334
Female	6 (75.0%)	17 (89.5%)	
BMI (kg/m^2)	52.9 ± 13.4	48.9 ± 7.2	0.042
T2D	1 (12.5%)	6 (31.6%)	0.302
Hypertension	3 (37.0%)	7 (36.8%)	0.974
Sleep apnoea	2 (25.0%)	6 (31.6%)	0.732
Change in BMI (kg/m^2) 18 months ($n = 27$)	9.0 ± 3.5	9.4 ± 4.2	0.736
%TWL 18 months ($n = 27$)	17.9 ± 7.8	19.3 ± 8.9	0.717
T2D remission	0 (0%)	5 (83.3%)	0.088
Hypertension remission	0 (0%)	0 (0%)	–
Sleep apnoea remission	0 (0%)	3 (50.0%)	0.206
30-day complications	3 (37.5%)	5 (26.3%)	0.561
LOS (days, median)	3 (range 2–4)	4 (range 1–8)	0.035
Readmission	2 (25.0%)	0 (0%)	0.024

Table 3 RYGB vs. BPD/DS for revision of sleeve gastrectomy. *RYGB* Roux-en-Y gastric bypass, biliopancreatic diversion with duodenal switch (BPD/DS). *T2D* type 2 diabetes, *%TWL* percentage total weight loss, *LOS* length of stay

Variables	RYGB ($n = 7$)	BPD/DS ($n = 7$)	p value
Age (years, median)	47 (range 37–55)	42 (range 35–51)	0.732
Sex			
Male	1 (14.3%)	5 (71.4%)	0.031
Female	6 (85.7%)	2 (28.6%)	
BMI (kg/m^2)	37.9 ± 8.4	67.7 ± 9.3	0.948
T2D	1 (14.3%)	0 (0%)	0.299
Hypertension	2 (28.6%)	2 (28.6%)	1.0
Sleep apnoea	2 (28.6%)	4 (57.1%)	0.280
Change in BMI (kg/m^2) 18 months ($n = 14$)	5.1 ± 4.1	18.4 ± 12.3	0.029
%TWL18 months ($n = 14$)	11.3 ± 8.6	25.5 ± 13.5	0.041
T2D remission	1 (100.0%)	0 (0%)	0.580
Hypertension remission	1 (50.0%)	0 (0%)	0.580
Sleep apnoea remission	0 (0%)	0 (0%)	–
30-day complications	1 (14.3%)	3 (42.9%)	0.237
LOS (days, median)	3 (range 1–6)	3 (range 2–3)	0.068
Readmission	0 (0%)	0 (0%)	–

associated with significant difference in 18 months change in BMI ($p = 0.029$), %TWL ($p = 0.041$) and no difference in 30-day complications (Table 3). Improvements in BMI and %TWL post revision procedures may be tempered by the initial indication for revisional surgery such as inadequate weight loss or regain. This may act as a surrogate marker and indicator for insufficient weight loss with any type of bariatric procedure, due to a combination of biological or psychosocial reasons and subsequent failure to accommodate lifestyle changes.

RYGB has been the gold standard bariatric and metabolic procedure for the last 2 decades, to which newer procedures are compared. A meta-analysis by Kang et al., including 11 RCTs comparing AGB, SG and RYGB, reported %EWL at 1 year of 40.6%, 71.2% and 67.3% respectively [33]. It is the likely final procedure considered in revisional bariatric surgery from AGB or SG. Despite its overall success, complications are reported in the early stage (16.0%) and include bleeding, obstruction and surgical site infections. Late complications (33.1%) include nutritional deficiencies, obstruction, marginal ulcer and reflux [33]. Some patients experience inadequate weight loss or weight regain as early as 2 years after surgery and thus require further revisional surgery [34]. Surgical options depend on the indication; for weight regain, the intention would be to increase restriction or to alter absorption. This is feasible via a plethora of techniques such as refashioning the gastric pouch, addition of AGB, redoing the distal anastomosis or conversion to DS. For nutritional deficiencies, altering the length of the common channel, conversion to DS or SG or reversal and restoration of normal anatomy have all been described [29, 35]. There is no consensus on the best technique, and outcomes following revision of RYGB are variable; a range of %EWL are reported from 21 to 82%, but with demonstrated improvement in diabetes in more than 70% of patients [36].

This study demonstrates that 1.4% of our patients required a secondary bariatric procedure within a 10-year period. AGB was the main procedure requiring revision (19.3%), followed by SG (1.9%) and RYGB (0.1%). The main reasons we came across for this were weight regain (33.3%), inadequate weight loss (24.4%) and reflux (15.6%). The main revision procedure performed was RYGB (57.8%), followed by SG (17.8%) and BPD/DS (15.6%). Revision to RYGB after AGB removal was associated with improved BMI at 18 months with no statistically significant difference in comparison to conversion to SG ($p = 0.717$). Moreover, it was correlated with longer LOS ($p = 0.035$) and no readmissions. On the other hand, conversion to BPD/DS versus RYGB following failed SG was associated with significant difference in %TWL, and no difference in postoperative complications or LOS. However, this subgroup contained relatively small number of patients. Our results have highlighted an important issue in bariatric surgery and provided a retrospective analysis of long-term outcomes. However, the study was limited by its retrospective nature, low sample size, particularly for sleeves and bypasses. Other limitations are that it was a single institution study and it was possible that patients went to other institutions for their revisional bariatric surgery.

Conclusion

Secondary bariatric procedures are technically demanding, and careful choice of the appropriate procedure is crucial. In

our experience, it was not associated with significant mortality, morbidity or postoperative complications.

Compliance with Ethical Standards

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

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.

Statement of Informed Consent For this retrospective study, formal consent is not required.

References

1. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766–81.
2. Arroyo-Johnson C, Mincey KD. Obesity epidemiology worldwide. Gastroenterol Clin N Am. 2016;45(4):571–9.
3. Courcoulas AP, Yanovski SZ, Bonds D, et al. Long-term outcomes of bariatric surgery: a National Institutes of Health symposium. JAMA Surg. 2014;149(12):1323–9.
4. Hopkins J, Welbourn R. The importance of national registries/databases in metabolic surgery: the UK experience. Surg Obes Relat Dis. 2016;12(6):1178–85.
5. Kuzminov A, Palmer AJ, Wilkinson S, et al. Re-operations after secondary bariatric surgery: a systematic review. Obes Surg. 2016;26(9):2237–47.
6. Almalki OM, Lee WJ, Chen JC, et al. Revisional gastric bypass for failed restrictive procedures: comparison of single-anastomosis (mini-) and Roux-en-Y gastric bypass. Obes Surg. 2017;
7. Chowbey PK, Soni V, Kantharia NS, et al. Laparoscopic Roux-en-Y gastric bypass: outcomes of a case-matched comparison of primary versus revisional surgery. J Minim Access Surg. 2018;14(1):52–7.
8. Ghosh S, Bui TL, Skinner CE, et al. A 12-month review of revisional single anastomosis gastric bypass for complicated laparoscopic adjustable gastric banding for body mass index over 35. Obes Surg. 2017;27(11):3048–54.
9. Pires Souto K, Meinhardt NG, de Azevedo Dossin I, et al. Revisional malabsorptive bariatric surgery: 29-year follow-up in a Brazilian public hospital. Obes Surg. 2017;
10. Janik MR, Rogula TG, Mustafa RR, et al. Safety of revision sleeve gastrectomy compared to Roux-Y gastric bypass after failed gastric banding: analysis of the MBSAQIP. Ann Surg. 2017;
11. Yilmaz H, Ece I, Sahin M. Revisional surgery after failed laparoscopic sleeve gastrectomy: retrospective analysis of causes, results, and technical considerations. Obes Surg. 2017;27(11):2855–60.
12. Dakour Aridi HN, Wehbe MR, Shamseddine G, et al. Long-term outcomes of Roux-en-Y gastric bypass conversion of failed laparoscopic gastric band. Obes Surg. 2017;27(6):1401–8.
13. Elnahas A, Graybiel K, Farrokhyar F, et al. Revisional surgery after failed laparoscopic adjustable gastric banding: a systematic review. Surg Endosc. 2013;27(3):740–5.
14. de Gara C, Falk V. Over half of the patients who undergo adjustable gastric banding may require revision bariatric surgery. Evid Based Med. 2017;22(5):191.
15. Abu-Abeid S, Bar Zohar D, Sagie B, et al. Treatment of intra-gastric band migration following laparoscopic banding: safety and feasibility of simultaneous laparoscopic band removal and replacement. Obes Surg. 2005;15(6):849–52.
16. van Wageningen B, Berends FJ, Van Ramshorst B, et al. Revision of failed laparoscopic adjustable gastric banding to Roux-en-Y gastric bypass. Obes Surg. 2006;16(2):137–41.
17. Topart P, Becouarn G, Ritz P. Biliopancreatic diversion with duodenal switch or gastric bypass for failed gastric banding: retrospective study from two institutions with preliminary results. Surg Obes Relat Dis. 2007;3(5):521–5.
18. Bruzzi M, Voron T, Zinzindohoue F, et al. Revisional single-anastomosis gastric bypass for a failed restrictive procedure: 5-year results. Surg Obes Relat Dis. 2016;12(2):240–5.
19. Gangemi A, Russel S, Patel K, et al. Conversion to laparoscopic sleeve gastrectomy after failure of laparoscopic gastric band: a systematic review of the literature and cost considerations. Obes Res Clin Pract. 2018;12(5):416–20.
20. Spaniolas K, Bates AT, Docimo Jr S, et al. Single stage conversion from adjustable gastric banding to sleeve gastrectomy or Roux-en-Y gastric bypass: an analysis of 4875 patients. Surg Obes Relat Dis. 2017;13(11):1880–4.
21. Benaiges D, Mas-Lorenzo A, Goday A, et al. Laparoscopic sleeve gastrectomy: more than a restrictive bariatric surgery procedure? World J Gastroenterol. 2015;21(41):11804–14.
22. Yorke E, Sheppard C, Switzer NJ, et al. Revision of sleeve gastrectomy to Roux-en-Y gastric bypass: a Canadian experience. Am J Surg. 2017;213(5):970–4.
23. Owens BM, Owens ML, Hill CW. Effect of revisional bariatric surgery on weight loss and frequency of complications. Obes Surg. 1996;6(6):479–84.
24. Gibbs KE. Paired editorial: rate of revisions or conversions after bariatric surgery over 10 years in the state of New York. Surg Obes Relat Dis. 2018;14(4):507–8.
25. Altieri MS, Yang J, Groves D, et al. Sleeve gastrectomy: the first 3 years: evaluation of emergency department visits, readmissions, and reoperations for 14,080 patients in New York state. Surg Endosc. 2018;32(3):1209–14.
26. Axer S, Szabo E, Naslund I. Weight loss and alterations in comorbidities after revisional gastric bypass: a case-matched study from the Scandinavian Obesity Surgery Registry. Surg Obes Relat Dis. 2017;13(5):796–800.
27. Casillas RA, Um SS, Zelada Getty JL, et al. Revision of primary sleeve gastrectomy to Roux-en-Y gastric bypass: indications and outcomes from a high-volume center. Surg Obes Relat Dis. 2016;12(10):1817–25.
28. Flolo TN, Andersen JR, Kolotkin RL, et al. Five-year outcomes after vertical sleeve gastrectomy for severe obesity: a prospective cohort study. Obes Surg. 2017;27(8):1944–51.
29. Brethauer SA, Kothari S, Sudan R, et al. Systematic review on reoperative bariatric surgery: American Society for Metabolic and Bariatric Surgery Revision Task Force. Surg Obes Relat Dis. 2014;10(5):952–72.
30. Quezada N, Hernandez J, Perez G, et al. Laparoscopic sleeve gastrectomy conversion to Roux-en-Y gastric bypass: experience in 50 patients after 1 to 3 years of follow-up. Surg Obes Relat Dis. 2016;12(8):1611–5.
31. Iannelli A, Debs T, Martini F, et al. Laparoscopic conversion of sleeve gastrectomy to Roux-en-Y gastric bypass: indications and preliminary results. Surg Obes Relat Dis. 2016;12(8):1533–8.
32. Homan J, Betzel B, Aarts EO, et al. Secondary surgery after sleeve gastrectomy: Roux-en-Y gastric bypass or biliopancreatic diversion with duodenal switch. Surg Obes Relat Dis. 2015;11(4):771–7.

33. Kang JH, Le QA. Effectiveness of bariatric surgical procedures: a systematic review and network meta-analysis of randomized controlled trials. Medicine (Baltimore). 2017;96(46):e8632.
34. Magro DO, Geloneze B, Delfini R, et al. Long-term weight regain after gastric bypass: a 5-year prospective study. Obes Surg. 2008;18(6):648–51.
35. Elnahas AI, Jackson TD, Hong D. Management of Failed Laparoscopic Roux-en-Y Gastric Bypass. Bariatr Surg Pract Patient Care. 2014;9(1):36–40.
36. Yan J, Cohen R, Aminian A. Reoperative bariatric surgery for treatment of type 2 diabetes mellitus. Surg Obes Relat Dis. 2017;13(8):1412–21.