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ORIGINAL CONTRIBUTIONS

Revision Procedures After Failed Adjustable Gastric Banding: Comparison of Efficacy and Safety

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Abstract
Background Laparoscopic adjustable gastric banding (LAGB) was one of the commonly performed bariatric operations; however, it carries a high revision rate. The aim of the present study was to report the long-term outcomes of LAGB and compare the outcomes between the different revision procedures.
Methods All patients who underwent LAGB in a large bariatric center in Asia between May 2002 and April 2011 were included. Interval between primary LAGB to the revision operation, the reason and type of revision surgery were identified and analyzed.
Results A total of 275 consecutive patients were included. All of the procedures were completed laparoscopically with no major complications. The percentage of excess weight loss (%EWL) at 10-year follow-up was 45%. In this study, 53 patients (19.3%) had revision surgery, including with 26 single anastomosis (mini-) gastric bypass (R-LSAGB) (49%), 17 sleeve gastrectomy (R-LSG) (32.1%), 9 Roux-en-Y gastric bypass (R-LRYGB) (17%), and 1 other procedure (1.9%). A major complication occurred in 6 patients (11.3%). All of the follow-up patients with revision surgeries had %EWL > 50% at the 2-year follow-up. R-LSAGB patients achieved better weight loss than those who underwent R-LSG and R-LRYGB ($p = 0.001$).
Conclusions The long-term result for weight loss after LAGB is unsatisfactory. The revision of failed LAGB to other bariatric surgeries is safe and can be performed in one stage with a low complication rate. Patients who underwent R-LSAGB had better weight loss results than the R-LSG or R-LRYGB patients.

Keywords Laparoscopic adjustable gastric banding · Bariatric surgery · Reoperation · Revision surgery

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Introduction

Laparoscopic adjustable gastric banding (LAGB) has generally been accepted as the safest bariatric operation with satisfactory short-term results [1]. It was once regarded as one of the most common bariatric operations that carries a very low mortality rate, approximately 0.05% in last decade [2]. Although LAGB is a very safe procedure, many studies have reported its unreliable long-term results needing revision surgery in about 30–60% of cases [3–6]. The reasons for revision surgery are band-related complications (e.g., band slippage, dilatation of the gastric pouch, or gastric erosion), port-related complications (e.g., port infection or dislodgement), insufficient weight loss, and weight regain [7, 8]. For a failed LAGB, removal of the implant is usually necessary, but previous studies showed that patients who underwent LAGB band removal only later developed weight regain [8–10]. Therefore, surgeons usually convert the operation to other bariatric procedures, such as laparoscopic Roux-en-Y gastric bypass (LRYGB) [10–13, 16], laparoscopic single anastomosis (mini-) gastric bypass (LSAGB) [14, 15], laparoscopic sleeve gastrectomy (LSG) [10, 12, 16], and biliopancreatic

diversion with duodenal switch (BPD-DS) [16, 17]. Currently, the best revision procedure from LAGB remains controversial. In addition, most of the studies about the long-term results of LAGB are from Western countries. Very few studies were published from Asia. In this study, we present our experience on long-term follow-up of LAGB and focus on the outcomes, efficacy, and safety of revision surgery for failed LAGB in an Asian Center of Excellence.

Methods

A retrospective review of prospectively collected data was conducted at the Endoscopic Bariatric Center of Min-Sheng General (MSG) Hospital, which included patients who received LAGB by our bariatric surgical team between May 2002 and April 2011. A total of 275 consecutive patients with morbid obesity underwent LAGB. We also included five patients who had LAGB in other hospitals but received revision surgery by our team during the same period (Fig. 1). The operative technique for LAGB was through the pars flaccida and was described in detail in an earlier publication [7]. All revision surgeries were performed as a one-stage procedure except for one patient with band erosion. That patient received R-LSG 2 years after band removal. All data were collected to compare the operative time, blood loss, the length of the hospital stay, and postoperative complications. All of the patients underwent regular yearly follow-up examinations, and all data were prospectively collected. We compared BMI, weight loss, and %EWL after revision (R-LRYGB, R-LSAGB, and R-LSG).

A "major complication" was defined as any adverse event that occurred within 30 days after the operation with Clavien Dindo class 3 and above. The patients' BMI and percentage of excess weight loss (%EWL) were calculated in the patient database of the Endoscopic Bariatric Center of the MSG Hospital, and we used the ideal body weight of patients as upper limit of ideal body weight classified by WHO [18].

All statistical analyses were performed using the STATA program, with baseline comparisons made using an analysis of variance (ANOVA); continuous variables were expressed as means (standard deviation). A two-sided p value of <0.05 was considered statistically significant.

Results

Primary LAGB

Between May 2002 and April 2011, LAGB was performed on 275 consecutive patients. There were 131 men and 144 women, with a mean age of 32 years (range 15–63 years) and a mean BMI of 39.2 ± 8 kg/m^2. No major complication occurred in this cohort, and all operations were successfully performed laparoscopically. Table 1 presents the weight loss of 217 patients following gastric banding. The patients were followed up 5 to 10 years. Data for 74 patients (34.1%) of eligible 217 patients for 5-year follow-up were available. At 5 years after LAGB, the percentage of weight loss (%WL), the %EWL, and the mean BMI reduction were 14.3%, 33.6 ± 29.3%, and 6.5 ± 6.03 kg/m^2, respectively. At 10 years, the %WL, the %EWL, and the mean BMI reduction were 14.7 ± 11.7, 45 ± 30.3%, and 4.5 ± 4.8 kg/m^2, respectively. However, 37 patients (30.6%) out of 121 patients were eligible for a 10-year follow-up examination (Table 1). At 10 years, only 8 patients (21.6%) out of the 37 patients had successful weight loss as defined by the %EWL > 50%. The %EWL and the mean BMI reduction had stabilized since 1 year after the operation (Fig. 3).

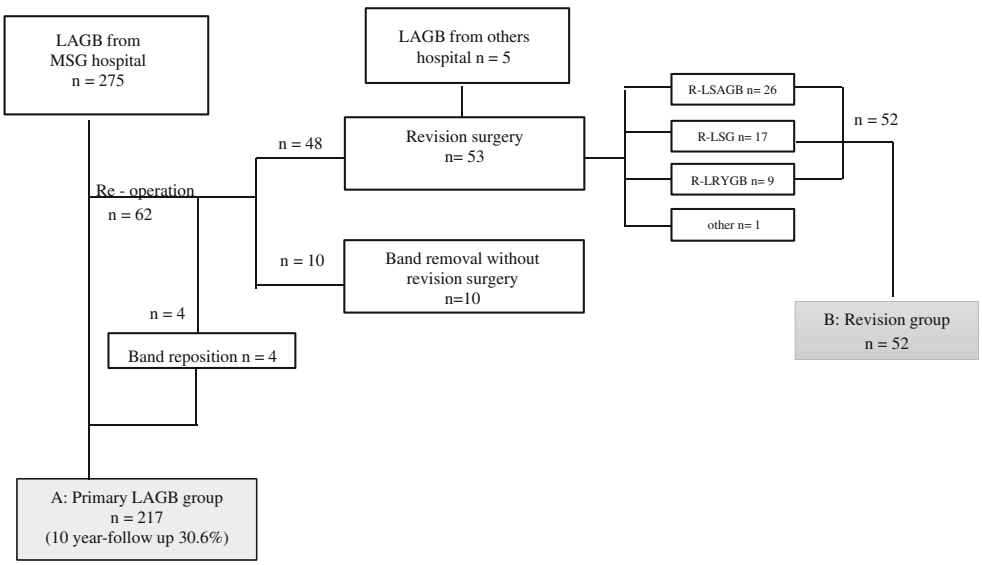

Fig. 1 Patients with LAGB and revision surgery. *Box A* Inclusion patients for follow-up in primary LAGB group. *Box B* Inclusion patients for follow-up in revision surgery group. *LAGB* laparoscopic adjustable gastric banding, *R-LRYGB* laparoscopic revision to Roux-en-Y gastric bypass, *R-LSAGB* laparoscopic revision to single anastomosis (mini-) gastric bypass, *R-LSG* laparoscopic revision to sleeve gastrectomy and *MSG* Min-Sheng General

Table 1 10-year follow-up data for LAGB (n = 217)

Follow-up	Preop	6 months	1 year	3 years	5 years	10 years
Eligible patient to follow-up n (%)		166/217 (76.5%)	160/217 (73.7%)	82/217 (37.8%)	74/217 (34.1%)	37/121 (30.6%)
%BW loss (kg)		9.8 ± 6%	12.9± 8.3	12.9 ± 15.9	14.3 ± 13.3	14.7 ± 11.7
%EWL (%)		24.6 ± 16	31.3 ± 17.8	30.4 ± 28.2	33.56 ± 29.3	45 ± 30.8
BMI	39.9 ± 7.7	37.5 ± 28.3	34 ± 6.7	33.3 ± 6.9	32.9 ± 7.3	29 ± 5.8
		12	30	22	17	8
		7.2%	18.8%	26.8%	33.8%	21.6%

LAGB laparoscopic adjustable gastric banding, *%BW loss* percentage of body weight loss, *%EWL* percentage of excess weight loss, and *BMI* body mass index

Band-related complications occurred in 10 patients (3.6%). Of these patients, four patients had band slippage and needed band reposition and fixation, and three patients had stoma obstruction likely due to gastric wall edema and were successfully treated by conservative treatments. There was one patient with intractable postoperative vomiting requiring band removal at 3 months after LAGB. In addition, one patient had band erosion, and another patient had pain at the port site. Both of these patients had band removal later.

Revision for LAGB

Out of 275 patients, 62 patients (22.5%) underwent reoperation during the follow-up period. Of these patients, four patients had band reposition, which we included in the primary LAGB follow-up group, while 58 patients (21.1%) required elective band removal with or without revision surgery. Among them, ten patients received band removal without any additional revision procedure. The reasons for band removal were as follows: patient request for concern of foreign body reaction (four patients), achalasia-like symptoms or esophageal dyskinesia (two patients), band slippage (two patients), port site pain (one patient), and intractable vomiting without mechanical obstruction (one patient). At 3 years, all ten patients with band removal without conversion to any other procedure had weight regain.

A total of 53 patients (48 patients who had LAGB in our hospital and 5 patients who had LAGB in other hospitals) had laparoscopic band removal with conversion to another bariatric procedure. Among them, 26 patients (49%) had conversion to single anastomosis (mini-) gastric bypass (R-LSAGB), 9 patients (17.6%) had conversion to roux-en-Y gastric bypass (R-LRYGB), 17 patients (31.4%) had conversion to sleeve gastrectomy (R-LSG), and 1 patient (2%) had gastric plication added to the band. This particular patient had a 10% weight loss at the 3-year follow-up. We excluded this patient in our further analysis. The preoperative data and the perioperative outcomes of all of the other conversion patients are shown in Table 2. The time between LAGB and revision surgery is shown in Fig. 2. The most common reason for revision surgery was insufficient weight loss or weight regain (77.4%, n = 41), followed by achalasia-like symptoms (11.3%, n = 6), reflux symptoms (7.5%, n = 4), and non-applicable data (3.8%, n = 2). The R-LRYGB group had the longest operation time (p = 0.032). The R-LSAGB group had the longest hospital stay (p = 0.001) because 2 patients (3.8%) had prolonged hospitalization due to anastomotic leaks. These patients were treated with laparoscopic exploration, repair, and drainage. There was no mortality in our series. All of the patients with different conversion surgeries had significant BMI reduction with the %WL varied between about 15 and 30%; however, the best BMI reduction with the %WL was in the R-LSAGB group, followed by the R-LSG and R-LRYGB groups, as shown in Fig. 3. Results of revision surgery on weight loss, resolution of metabolic syndrome, and nutritional outcomes at 1 and 2-year follow-up are shown in Table 3. R-LSAGB group had significantly lower Hb level at 1 year, compared to other procedures.

Discussion

The long-term follow-up data of LAGB from Asia has confirmed that LAGB is the safest bariatric operation and can be performed with a 0% major surgical complication rate in a high-volume center of excellence. The reported perioperative major complication rate varies from 0 to 3% in the literature [2]. In a report of 2909 patients, Carelli et al. showed a 0.34% mortality rate with only 0.06% being surgery-related death [19] The reason for zero major perioperative complication rate in our patients may be contributed by the fact that we used the pars flaccida technique, and that our team had experienced with more than 1000 laparoscopic bariatric surgeries before we started LAGB. At follow-ups, band-related complications were observed in 10 patients (3.6%) which is significantly lower than the previously reported 4–20% band-related complication rates [6, 8, 20, 21]. Commonly reported band-related complications were band slippage, followed by stoma obstruction and port-related complications [20, 21]. We had only one case (0.4%) of band erosion. Our operative technique was described in detail in the earlier publication [7].

Table 2 Data of revisions surgery patients

	R-LRYGB (n = 9)	R-LSAGB (n = 26)	R-LSG (n = 17)	p value
Preoperative data for revision procedure				
Age (mean + SD)	40.6 ± 11.5	35.9 ± 8.8	42.8 ± 7.9	0.048
Sex ratio (F:M)	7:2	16:10	10:7	0.608
BMI at primary (kg/m^2)	38.8 ± 10	39.9 ± 10.5	34.6 ± 11	0.26
BMI before revision surgery (kg/m^2)	36.9 ± 6.8	39.3 ± 8.9	33.8 ± 7.3	0.123
Metabolic syndrome (%)	2(22%)	16(61.5%)	6(35.3%)	0.069
Waist circumference (cm)	111.3 ± 17.6	118.6 ± 21.8	105.6 ± 14.2	0.205
Albumin (mg/dl)	4.3 ± 0.3	4.3 ± 0.5	4.3 ± 0.2	0.837
Hemoglobin (g/dl)	13.8 ± 1.3	13.6 ± 2.0	14.3 ± 1.5	0.288
Perioperative data of revision operations				
Mean operative time (min)	218.9 ± 48.1	180.2 ± 58.7	172.7 ± 70.6	0.032
Intraoperative blood loss (ml)	43.3 ± 23.9	160.9 ± 368.5	55.3 ± 43.0	0.057
Postoperative flatus passage (day)	2.00 ± 0.5	2.04 ± 0.8	1.81 ± 0.5	0.642
Postoperative hospital stay (day)	3.56 ± 1.0	7.1 ± 5.6	5.7 ± 11.4	0.001
Early postoperative major complication	1	5	0	
Leakage	0	2	0	
Small bowel ileus	1	2	0	
Major bleeding	0	1	0	
Respiratory failure	0	0	0	
Renal failure	0	0	0	
Stricture of anastomosis	0	0	0	
% of major complication rate	11.1%	19.2%	0%	
Mortality	0	0	0	–

R-LRYGB laparoscopic revision to Roux-en-Y gastric bypass, *R-LSAGB* laparoscopic revision to single anastomosis (mini-) gastric bypass, *R-LSG* laparoscopic revision to sleeve gastrectomy, and *BMI* body mass index

p value <0.05

However, long-term weight loss is unsatisfactory for LAGB. Our results show a modest, stable BMI loss at 5–10 years. BMI loss at the 5 and 10 years were 6.5 ± 6.03 and 4.5 ± 4.8, respectively, with a %WL of 14.3 ± 13.3 and 14.7 ± 11.7. Less than one third of patients achieved 50%EWL or more at 1 (18.75%), 5 (33.8%), and 10 years (21.6%). The %EWL was

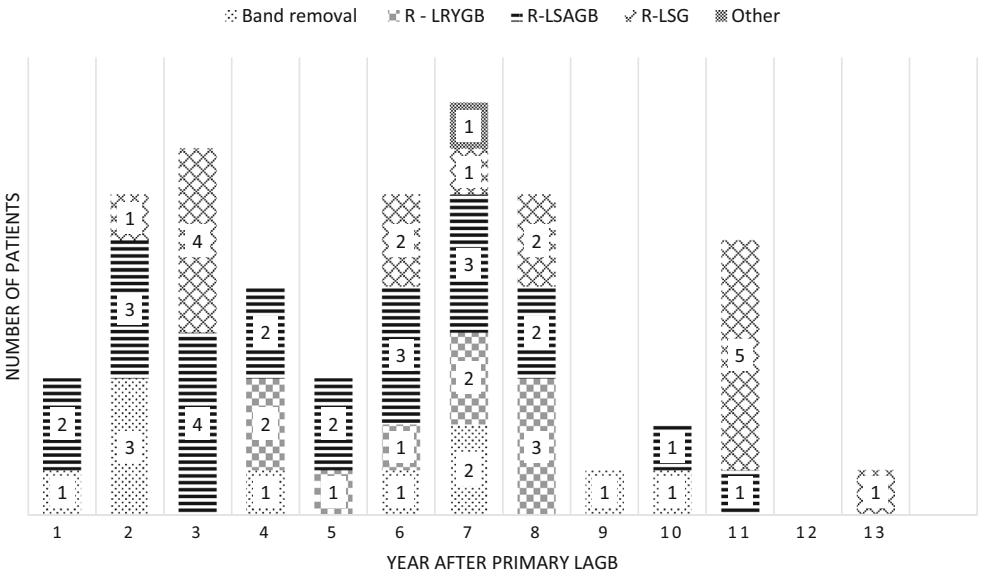

Fig. 2 Time between LAGB and revision surgery. *LAGB* laparoscopic adjustable gastric banding, *R-LRYGB* laparoscopic revision to Roux-en-Y gastric bypass, *R-LSAGB* laparoscopic revision to single anastomosis (mini-) gastric bypass, *R-LSG* laparoscopic revision to sleeve gastrectomy

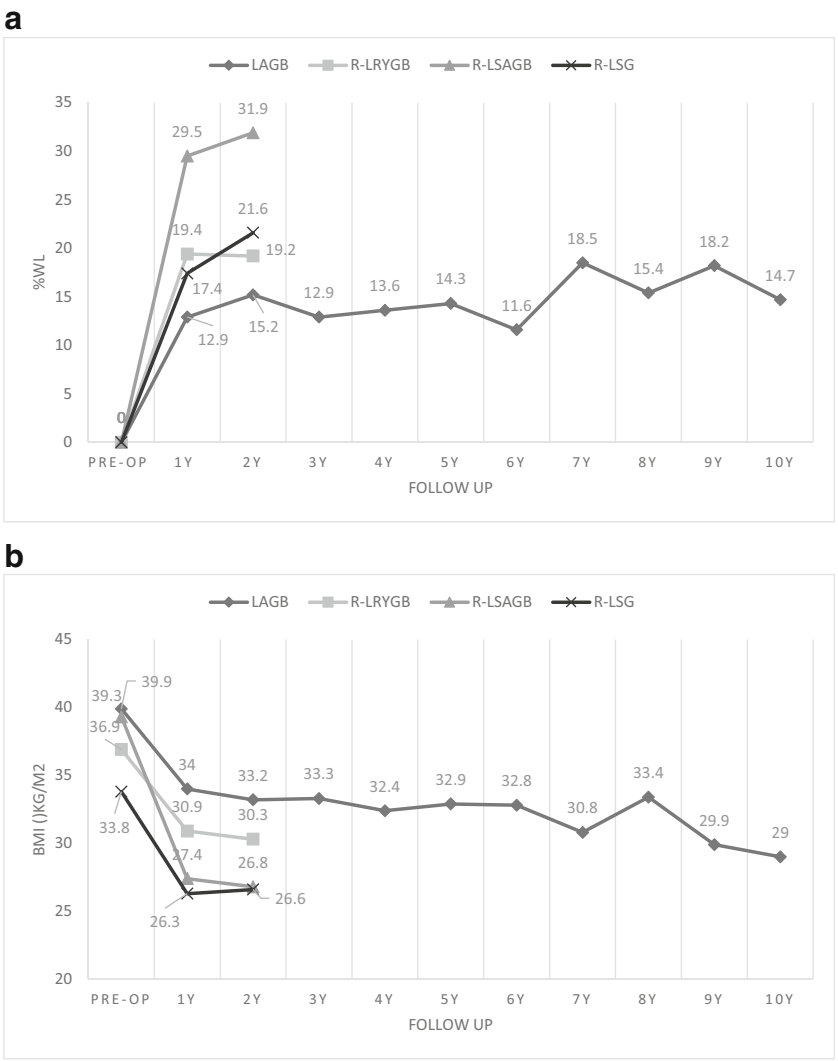

Fig. 3 **a** % Body weight loss (%WL) for each procedure. **b** Mean BMI follow-up for each procedure. *LAGB* laparoscopic adjustable gastric banding, *R-LRYGB* laparoscopic revision to Roux-en-Y gastric bypass, *R-LSAGB* laparoscopic revision to single anastomosis (mini-) gastric bypass, *R-LSG* laparoscopic revision to sleeve gastrectomy

around 30% at 5-year follow-up. Forty five percent of EWL at 10 years is because most of the poor result patients had the revision surgery. Previous studies showed less than half of LAGB patient achieved a more than 50%EWL at 10 years [6, 8, 21]. This weight loss is far less than other restrictive-type procedures, such as laparoscopic vertical banded gastroplasty or LSG.[21–23]. In addition, some patients may have unpleasant symptoms, such as reflux and achalasia-like symptoms. In this study, about 4% of the patients requested band removal and refused conversion to other bariatric procedures.

The revision rates of LAGB were reported high because of band-related problems and variation in techniques, and many patients failed to experience enough weight loss [3, 19, 22]. The reported reoperation rate after LAGB varied from 17.5–69.3% [10–17]. Recently, Chiapaikeo et al. reported a reoperation rate of 13.8% in 3 years [24]. Tog et al. showed that port- and tube-related problems were the most common complications of LAGB and carried a revision rate of 8.7% [25]. In a study with 1791 patients, Favretti et al. showed that the band removal rate was 3.7%, and the band repositioning rate was 2.7%, which is similar to our study [20]. For a long-term study, Mikael et al. showed that out of 60 patients with a mean 14-year follow-up period, 40% had more than 50% EWL, and 20% had less than 25% EWL [8]. The reoperation rate in our study was progressively elevated with increasing follow-up time, 7.3% in 3 years, 10.5% in 5 years, 18.5% in 10 years, and 22.5% in 14 years, in accordance with the above studies.

Revision bariatric surgery may be associated with higher surgical morbidities. Operative time in our study varied from 40 to 435 min depended on the degree of adhesion and gastric band erosion. Previous studies showed the complication rate of reoperation after LAGB was 1.1–56.4% [12–15, 26, 27]. Therefore, some surgeons recommended stage operations for converting bands to other bariatric surgeries but controversies exist. In this study, all of the revision surgeries were performed in one stage except for one patient with band erosion. In our series, 6 patients

Table 3 Results of 2-year follow-up after revision surgery

Variable 1-year follow-up 2-year follow-up	R-LRYGB (*N* = 7) (*N* = 7)	R-LSAGB (*N* = 19) (*N* = 16)	R-LSG (*N* = 10) (*N* = 6)	*p* value
BMI (kg/m^2)				
1-year follow-up	30.9 ± 6.3	27.4 ± 5.2	26.3 ± 5.3	0.313
2-year follow-up	30.3 ± 7.0	26.8 ± 4.8	26.6 ± 5.4	0.529
Excess weight loss (%)				
1-year follow-up	54.5 ± 23.5	73.6 ± 25.2	76.5 ± 54.5	0.299
2-year follow-up	51.6 ± 26.2	76.7 ± 24.1	101.7 ± 124.4	0.163
Weight loss (%)[a]				
1-year follow-up	19.4 ± 4.4	29.5 ± 9.7	17.4 ± 11.2	0.005
2-year follow-up	19.2 ± 5.1	31.9 ± 10.4	21.6 ± 18	0.024
Metabolic syndrome (%)				
1-year follow-up	0 (0%)	2 (13%)	0 (0%)	0.388
2-year follow-up	0 (0%)	1 (6.3%)	0 (0%)	0.657
A1bumin (g/dl)				
1-year follow-up	4.3 ± 0.2	4.0 ± 0.6	4.4 ± 0.2	0.535
2-year follow-up	4.1 ± 0.3	3.8 ± 0.8	4.3 ± 0.4	0.568
Hemoglobin (g/dl)				
1-year follow-up	14.0 ± 0.7	11.7 ± 2.2	15.9 ± 1.6	0.046
2-year follow-up	12.8 ± 1.0	12.1 ± 1.6	15.1 ± 1.7	0.209

R-LRYGB laparoscopic revision to Roux-en-Y gastric bypass, *R-LSAGB* laparoscopic revision to single anastomosis (mini-) gastric bypass, *R-LSG* laparoscopic revision to sleeve gastrectomy, and *BMI* body mass index

[a] *%WL* percentage of weight loss from weight before revision surgery

(11.3%) had major complication. Two patients (3.8%) had anastomotic leaks. All of them were successfully treated by laparoscopic abdominal toilet and drainage. From our experience, conversion LAGB to other bariatric surgeries in one stage was not associated with higher complication rate and it supported single-stage strategy. A recent review article also suggested that one-stage or two-stage revision bariatric surgeries are both safe options for LAGB revisions.[28]

Among the different revision surgeries, R-LRYGB has been accepted for revision of restrictive procedures for a long time. Many studies showed safety and positive outcomes after R-LRYGB [11, 12]. Roller J.E. et al. showed that the complication rate of patients who had a primary revision and multiple revisions to R-LRYGB was 9.3 and 16.7%, respectively, and that the %EWL at 2 years was 60.6 and 54.3%, respectively [13]. M. Emous et al. showed no differences in morbidity and mortality in the one-stage and two-stage procedures for R-LRYGB with the %EWL at 53 and 67% for the one-stage and two-stage procedures, respectively [26]. In this study, we performed more R-LSAGB procedures than R-LRYGB procedures because we had extensive experience with LSAGB and published excellent weight loss results after primary LSAGB procedures [29, 30]. There are several advantages of R-LSAGB than R-LRYGB in failed LAGB patients. Firstly, it is a relatively simpler and easier procedure than R-LRYGB with good weight loss. Moreover, the low-pressure system created in R-LSAGB helps in avoiding the high risk of stapler line leakage at the scarred band area, and it reduces the risk of gastroesophageal reflux. Thirdly, the anastomosis at the healthy distal stomach in R-LSAGB is more preferable than high anastomosis at the scarred area at removed band site in R-LRYGB. There are few studies that showed results of R-LSAGB. Bruzzi et al. showed results of 30 patients who had prior restrictive bariatric surgery underwent R-LSAGB compared with 96 patients who had primary LSAGB. There was no significance difference of %excesssive BMI loss in both group (66 vs 73%). But in R-LSAGB group had lower quality of life score (GIQLI 104.1 + 17.6 vs 112.5 + 16.8, $p = 0.025$) [14]. Piazza et al. reported 48 patients with R-LSAGB for LAGB and showed a decreased BMI from 43.4 ± 4.2 kg/m^2 to 34.1 ± 3.77 kg/m^2 6 months after the operation with an 88% diabetic remission rate [15]. In this study, the mean %EWL of R-LSAGB at the 1-year and 2-year follow-up were 73.6 and 76.7%, respectively, which are similar to %EWL reported in previous studies.

Converting to LSG is another new option for LAGB revision, while LSG is becoming the leading primary bariatric surgery. However, controversy remained about a patient with reflux symptoms as revision to sleeve gastrectomy may make worsening of preexisting GERD. It may be wise to select procedures other than R-LSG in patients with GERD symptoms. The unhealthy scarred gastric tissue around gastric band could be a risk factor for anastomosis leakage. The study by Berende et al. found a high complication rate for R-LSG at 32% in the one-stage procedure and 7.7% in the two-stage procedure; the percentage of excessive BMI loss (%EBL) was at 49.3% [27]. Utech M. et al. showed a 7.7% complication rate with the %EWL at 1, 2, and 3 years as 51, 52, and 60%, respectively [31]. William RJ Car et al. suggested the revision to LSG should be done as a two-stage procedure to allow the stomach to recover after band removal, which can improve staple line integrity and provide easier hemostasis [12]. In our experience, all of the 15 patients who underwent R-LSG as a one-stage operation had uneventful operations without complication. Although weight loss is inferior to the bypass surgery, most of the patients are satisfy with outcomes. Our experience suggested R-LSG could be safely done in patients who have indications for band removal and refuse bypass surgery.

The limitations of this study are that it is a retrospective study and there is low follow-up data at 10 years. However, the 30% 10-year follow-up rate in a large cohort of patients still can provide relatively reliable results. Additional studies are recommended to provide more details about revision procedures for failed LAGB.

Conclusion

LAGB is a safe procedure, but it presents poor long-term effects on weight reduction, resulting in a high revision rate. One-stage converting LAGB to other bariatric procedures can be safely performed by experienced surgeons. R-LSAGB, R-LSG, and R-LRYGB all had good outcomes and are recommended as revision procedures. Patients who underwent R-LSAGB had better weight loss results than the R-LSG or R-LRYGB.

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 This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study, formal consent is not required. Informed consent does not apply to this submission.

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