Surgical Outcomes of Bariatric Surgery in Siriraj Hospital for the First 100 Morbidly Obese Patients Treated

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ABSTRACT

Objective: Bariatric surgery is considered the most effective treatment for morbid obesity, and is increasingly performed in Thailand and globally. We aimed to establish the outcomes of bariatric surgery performed at Siriraj Hospital, Bangkok.

Materials and Methods: This was a retrospective study of patients who underwent bariatric surgery between January 2012 and June 2016.

Results: The records of the first 100 patients who underwent bariatric surgery were reviewed, comprising 58 patients who underwent laparoscopic sleeve gastrectomy (LSG) and 42 patients who underwent laparoscopic Roux-en-Y gastric bypass (LRYGB). The median patient age, preoperative body weight, and BMI were 36 years old, 129 kg, and 46.3 kg/m^2. All the procedures were performed by a laparoscopic approach. The median operative times for LSG and LRYGB were 156 [85-435] and 265 [180-435] minutes. The median hospital stay was 3 days [3-14]. The major complication rate was 4%. There was no mortality in the 30-day postoperative period. The mean %excess weight loss (%EWL) of LSG was 56.8 ± 19.8%, 59.9 ± 21.7%, and 55.1 ± 21.3%, at 1, 2, and 3 years after surgery. The mean %EWL of LRYGB was 67 ± 18.3%, 66.2 ± 21.4%, and 63.6 ± 19.9%, at 1, 2, and 3 years after surgery. In the patients with type-II diabetes mellitus, 67% had complete diabetic remission at 1 year. The median FBS dropped from 127 to 99 mg/dL ($p < 0.001$) and HbA1c from 6.6% to 5.5% ($p < 0.001$). The remission rates of hypertension and dyslipidemia were 58% and 73%.

Conclusion: The bariatric procedures are safe with a low complication rate. The procedures also provide good outcomes in postoperative weight loss and comorbidity resolution.

Keywords: Bariatric surgery; laparoscopic sleeve gastrectomy; laparoscopic Roux-en-Y gastric bypass; outcomes (Siriraj Med J 2022; 74: 769-777)

INTRODUCTION

Obesity increases the risk of many serious health problems, including diabetes mellitus (DM), hypertension, and dyslipidemia. It is also a major cause of death, particularly attributable to cardiovascular disease, stroke, and cancers. The prevalence of obesity has been increasing worldwide in recent decades, linked to the trends of excessive food intake and lack of physical activity. The most common treatment strategies are behavioral changes through healthy diet and exercise. In addition to the principle of

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behavioral changes, the three main treatment option for morbid obesity consist of lifestyle modification, medical therapy, and bariatric surgery.

Bariatric surgery has been proven to be the most effective treatment in weight loss and comorbidity resolution in the long term. Many studies have shown that bariatric surgery enables better weight reduction, comorbidity resolution, and quality of life compared to non-surgical methods. The current standard approach for bariatric surgery is the laparoscopic approach. This offers the benefits of faster recovery, a lower complication rate, and shorter hospital stay compared with open approaches.

In Thailand, the annual prevalence of obesity has been increasing dramatically over the past few decades. By 2009, the prevalence of obesity class II (BMI >30 kg/m^2) in Thai adults had reached 7% in men and 12% in women[1], prompting the promotion of many lifestyle modification strategies, as well as the introduction of more effective treatments in Thailand, including bariatric surgery.

Since then, bariatric procedures have been increasingly performed; however, while outcome assessment is also important it has been less reported. Consequently, in this study we aimed to establish the surgical outcomes of the initial experience of bariatric surgery in Siriraj Hospital, regarding the efficacy of weight loss, comorbidity resolution, and complications.

MATERIALS AND METHODS

This study was approved by the Siriraj Institutional Review Board. (Si 813/2016) The first 100 patients who underwent bariatric surgery as treatment for morbid obesity between January 2012 and June 2016 in Siriraj Hospital were enrolled in the study.

The criteria for bariatric surgery in Siriraj Hospital, and according to the Asia-Pacific Bariatric Surgery society consensus 2005, are obese patients who: (1) have a BMI > 37 kg/m^2; (2) have a BMI > 32 kg/m^2 with diabetes or two significant obesity-related comorbidities; (3) have been unable to lose weight through dietary or medical treatment; and (4) are 18–65 years old.[2] Also, all the patients must be absent of any endocrine disorder causing massive obesity, psychologic instability, and alcohol or drug abuse. Revisional bariatric procedures were also excluded from this study.

The main procedures for bariatric surgery performed in Siriraj Hospital are laparoscopic sleeve gastrectomy (LSG) and laparoscopic Roux-en-Y gastric bypass (LRYGB). After preoperative counseling, the patients choose the surgical procedure by themselves, providing there are no contraindications.

The patients' demographic data and clinical characteristics, including age, gender, preoperative body weight, preoperative body mass index (BMI), obesity-related comorbidities, preoperative laboratory studies, operative time, intraoperative blood loss, length of hospital stay, overall complications, and 30-day morbidity and mortality were reviewed. Concomitant cholecystectomy was performed if preoperative abdominal ultrasound showed any gallstones, regardless of the patient's symptoms.

For the patient's comorbidities, we recorded both preoperative and postoperative HbA1c, fasting blood glucose (FBG), blood pressure, serum cholesterol, triglycerides, LDL, HDL, and medications.

The outcomes of the surgery were studied in two aspects: (1) postoperative weight loss and (2) comorbidity resolution. Postoperative weight loss was reported as percent total weight loss (%TWL), and percent excess weight loss (%EWL), calculated as shown in Fig 1.

There are various definitions of successful weight loss after bariatric surgery. In our center, we use the definition of >20% TWL or >50%EWL in the first year after bariatric surgery. These are the most widely used definitions based on the evidence of comorbidities and cardiovascular risk improvement.[3]

The outcome of comorbidity resolution was reported according to the American Society of Metabolic and

$$\%\text{Total weight loss} = \frac{(\text{Initial weight}) - (\text{Postop weight})}{(\text{Initial weight})} \times 100$$

$$\%\text{Excess weight loss} = \frac{(\text{Initial weight}) - (\text{Postop weight})}{(\text{Initial weight}) - (\text{Ideal weight})} \times 100$$

Fig 1. Calculation of postoperative weight loss

Bariatric Surgery (ASMBS) reporting standards 2015. For type-2 diabetes mellitus (DM), complete remission was stated if HbA1c < 6% and FBG < 100 mg/dL, and partial remission was considered when HbA1c = 6.0–6.5% and FBG = 100–125 mg/dL for at least 1 year with the absence of anti-diabetic medication. Disease improvement was considered when HbA1c and FBS were significantly reduced but did not meet the criteria for remission or were decreased but with anti-diabetic medication required. Hypertension remission was documented if BP < 120/80 mmHg without medication. Dyslipidemia remission was considered when LDL < 100 mg/dL, total cholesterol < 200 mg/dL, and triglycerides < 150 mg/dL.

Postoperative complications were reported as early (<30 days) and late (>30 days postoperative) complications. Major complications, according to the ASMBS outcome reporting standards 2015, were defined as any complications that prolonged the hospital stay beyond 7 days, receiving anticoagulant therapy, reintervention, or reoperation.[3]

Before surgery, all patients must be evaluated by a multidisciplinary team, including a bariatric surgeon, nutritionist, cardiologist, pulmonologist, psychiatrist, and physical therapist. An education session covering the principles of a healthy diet and physical activity is provided for patients during the preoperative visits. Preoperative checklist, according to AACE/TOS/ASMBS Clinical Practice Guidelines 2013, was evaluated including cardiopulmonary evaluation with sleep apnea screening if indicates.[4] For the patients with severe obstructive sleep apnea (OSA), Optimizing CPAP treatment must be achieved at least 4 weeks prior to surgery. A very low calorie diet (600–800 kcal/day) is suggested to all patients 2 weeks before surgery for preoperative weight loss if there is no contraindication. We recommend 5–10 kg preoperative weight loss in every patient before surgery.

Surgical techniques

Laparoscopic sleeve gastrectomy

In laparoscopic sleeve gastrectomy (LSG), the patient is placed in a supine position. A 36-French orogastric tube is inserted, and 5000 units of unfractionated heparin are injected subcutaneously to prevent deep vein thrombosis. A Veress needle is inserted into the abdomen at Palmer's point for insufflation. A 12 mm camera port is placed 20 cm below the xiphoid and 4 cm to the left of the midline, using an Optiview trocar and a 10 mm zero-degree laparoscope. Then, the camera is exchanged for a 30-degree laparoscope. The patient position is changed to a reverse Trendelenburg position. Nathanson's liver retractor is applied to the left lobe of the liver via a small incision at the epigastrium. Two 5 mm ports are placed at the left anterior axillary line and right midclavicular line about 15 cm below the xyphoid process. Then, a 15 mm port is placed 20 cm inferior to the xiphoid and 2 cm to the right of the midline.

The omentum of the greater curvature of the stomach is divided using a Ligasure advanced bipolar device (Medtronic) from 4 cm proximal to the pylorus up to the angle of His. The blood supplies along the greater curvature, including the short gastric arteries, are ligated completely. Using the orogastric tube as a calibrator, a hook cautery is used to mark the resection line of the stomach. The Medtronic Autostapler (iDrive) is introduced via the 15 mm port. Then, the stomach is transected over the orogastric tube calibrator using 60 mm black cartridges at the antrum and purple cartridges at the body. The posterior wall of the gastric tube is fixed to the posterior side with interrupted 3-0 Prolene stitches in order to prevent the gastric tube from twisting. Leak tests with methylene blue dye and drain placement are performed in selected cases. Hemostasis is checked, and then the resected stomach is removed via an endobag. The 12 and 15 mm port sites are closed using 1-0 Vicryl on a suture passer, Then, the skin is closed in the standard fashion.

Laparoscopic Roux-en-Y gastric bypass

In Laparoscopic Roux-en-Y gastric bypass (LRYGB), the patient position and preoperative preparation are similar to in LSG as mentioned above. A 12 mm camera port is placed 22 cm below the xiphoid and 2 cm to the left of midline. Nathanson's liver retractor is applied to the left lobe of the liver. A 5 mm port is placed at the left anterior axillary line as an assistant port. Three 12 mm ports are placed on the right midclavicular line, 2 cm to the right of midline and left midclavicular line.

The transverse mesocolon is retracted caudally to expose the ligament of Treitz. The jejunum is measured to 100 cm distal to the DJ junction. Then, the jejunum is transected, including its mesentery, using a 60 mm autostapler (iDrive) tan cartridge to create a 100 cm biliopancreatic limb (BP limb). Another 100 cm of the jejunum is measured. Then, by using a 45 mm tan cartridge, a stapled side-to-side jejunojejunostomy is made between the biliopancreatic limb and jejunum to create a 100 cm Roux limb. The enterotomy site is closed using a running 3-0 Vicryl and the mesenteric defect is closed to its base with a running 3-0 Prolene.

Then, the greater omentum is split in a left paramedian plane to 1 cm away from the transverse colon using a harmonic scalpel. The lesser omentum of the stomach is entered at the level of 6 cm from the EG junction to

create the gastric pouch. Then, a 3-cm horizontal firing is made across the stomach using a 45 mm autostapler purple cartridge. Sequential vertical firings by EndoGIA 60 mm purple cartridges are used to carry on the staple line upward to a point just lateral to the angle of His. This ensures the complete gastrogastric division. The blunt tip of an oral anvil of a 25 mm transoral circular stapler (EEA OrVil, Medtronic) is inserted into the distal part of the gastric pouch.

The 12 mm port at the left midclavicular line is replaced with the handle of the transoral circular stapler (EEA XL). The staple line at the end of the Roux limb is divided and the tip of the stapler handle is inserted. The Roux limb with the circular stapler is brought upward to the gastric pouch, and then the circular gastrojejunostomy anastomosis is created. The blind end including the enterotomy of the Roux limb is cut off using a 45 mm autostapler tan cartridge. A leak test is performed by instilling 50 mL of dilute methylene blue (2 mL per 100 mL of NSS) into the orogastric tube.

The Petersen's defect is closed by suturing the mesentery of the Roux limb to the mesentery of the transverse mesocolon using a running 3-0 Prolene. A 10-French JP drain is placed near the gastrojejunostomy through the LUQ port site. The 12 and 15 mm port sites are closed using a 1-0 Vicryl on a suture passer and the skin is closed in the standard fashion.

Postoperative care

A dietary program is initiated with a clear liquid diet on postoperative day 1, and then advanced to a full liquid diet (high-protein supplement) on postoperative day 3. IV-PCA (intravenous patient-controlled analgesia) with an opioid is given to patients for postoperative pain control. A sequential compression device is used as routine for DVT prophylaxis. Then after early ambulation is initiated on postoperative day 1, the compression device can be removed.

After discharge, the patients return to the bariatric clinic for a follow-up visit at 2 weeks after surgery and will be advised on a diet comprising 3 small meals with micronutrient supplementation. A proton pump inhibitor is given to the patients for use for 3 months after surgery for marginal ulcer prevention; especially in patients who underwent LRYGB. Ursodeoxycholic acid is given to the patients for 6 months for gall stone prevention.

Follow-up appointments for clinical and nutritional assessment are scheduled at 3 months, 6 months, 9 months, 12 months, and then annually. Routine postoperative esophagogastroduodenoscopy (EGD) is performed in every patient at 1 year after surgery.

Statistical analysis

Categorical data were reported using the number and percentage. Continuous data were expressed as the mean with the standard deviation and median value with a range of the minimum and maximum. The mean and median preoperative and postoperative parameters were compared using the paired sample t-test and Wilcoxon signed rank test, respectively. IBM SPSS Statistics version 26.0 (SPSS, Chicago, Illinois, USA) for Mac was used for all the statistical analyses. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

Among the first 100 bariatric surgery patients in Siriraj Hospital, 69% were female and 31% male. The median age was 36 years old [16-64]. The median preoperative body weight and BMI were 129 kg [88-270] and 46.3 kg/m^2 [34.0-83.3], respectively. For pre-existing comorbidity, 45% of patients had been diagnosed with type 2 diabetes mellitus (DM), 65% with hypertension, 38% with dyslipidemia, 4% with coronary artery disease, 35% with obstructive sleep apnea (OSA), and 10% with osteoarthritis of the knee. The patients' demographic data are summarized in Table 1.

There were 58 cases of laparoscopic sleeve gastrectomy (LSG) and 42 cases of laparoscopic Roux-en-Y gastric bypass (LRYGB). All the operations had been performed by laparoscopic approach successfully without conversion to the open approach. The median operative time for LSG

TABLE 1. Patients' demographic data.

	(N = 100)
Sex (F:M)	69:31
Age, year	36 [16–64]
Preoperative body weight, kg	129 [88–270]
Preoperative BMI, kg/m^2	46.3 [34.0–83.3]
Pre-existing comorbidity	
DM (type 2)	45 (45%)
Diet control (2/45)	
Oral hypoglycemic drug (37/45)	
Insulin therapy (6/45)	
Hypertension	65 (65%)
Dyslipidemia	38 (38%)
Coronary artery disease	4 (4%)
Obstructive sleep apnea	35 (35%)
Osteoarthritis of knees	10 (10%)

was 156 minutes [85-435] and 265 minutes [180-435] for LRYGB. The concomitant procedures generally took longer operative time than normal bariatric procedures. The longest operation of LSG (435 minutes) was firstly attempted for LRYGB but was failed due to severe adhesion from previous abdominal surgery and then was converted to LSG. The mean estimated blood loss was 20 ml and 25 ml for LSG and LRYGB, respectively. The median postoperative length of hospital stay was 3 days [3-14], as shown in Table 2.

TABLE 2. Operative and postoperative data of the bariatric surgery patients.

Operative data	(N = 100)
Operative time (min)	
LSG	156 [85–435]
LRYGB	265 [180–435]
Concomitant procedure (%)	
Cholecystectomy	16
IPOM*	1
Adrenalectomy	1
Conversion to open approach	0
Estimated blood loss (ml)	
LSG	20 [5–300]
LRYGB	25 [5–400]
Length of hospital stay (days)	3 [3–14]
Postoperative complication (case)	
Early (≤ 30 day)	
Lung atelectasis	2
Pulmonary embolism	1
Deep vein thrombosis	1
Anastomotic leakage	0
Intra-abdominal hemorrhage	0
Intra-abdominal collection	1
Surgical site infection	3
Other	1
Late (> 30 days)	
GERD	
No reflux esophagitis	3
Mild (grade A, B)	16
Severe (grade C, D)	1
Barrett's esophagus	1
Dumping syndrome	2
Marginal ulcer	7
Incisional hernia	1

Abbreviation: IPOM; Intraperitoneal onlay mesh repair; laparoscopic hernia repair for ventral hernia

Weight loss outcome

The follow-up rates at 1 year, 2 years, and 3 years after surgery were 76%, 57%, and 55%, respectively. The mean %TWL and mean %EWL at 3 months, 6 months, 9 months, 1 year, 2 years, and 3 years are shown in Table 3, Table 4 and Fig 2.

The mean %TWL of the patients who underwent LSG at 1 year, 2 years, and 3 years were 30.2 ± 10.4%, 30.9 ± 11.2%, and 28.4 ± 11.3%, respectively. The mean %EWL of the LSG patients at 1 year, 2 years, and 3 years were 56.8 ± 19.8%, 59.9 ± 21.7%, and 55.1 ± 21.3%, respectively. As for the patients who underwent LRYGB, the mean %TWL at 1 year, 2 years, and 3 years were 33.4 ± 7.5%, 33.2 ± 9.6%, and 31.9 ± 8.6%, respectively. The mean %EWL of the LRYGB patients at 1 year, 2 years, and 3 years were 67 ± 18.3%, 66.2 ± 21.4%, and 63.6 ± 19.9%, respectively.

Comorbidity outcomes

For the 45 patients with pre-existing type-II diabetes, 33 patients reached the follow-up time at 1 year, comprising 9 LSG cases and 24 LRYGB cases. All 6 of the patients who had received insulin therapy had underwent LRYGB.

At 1 year after surgery, the median fasting blood glucose (FBG) dropped from 127 to 99 mg/dL ($p < 0.001$) and HbA1c also dropped from 6.6% to 5.5% ($p < 0.001$) with statistical significance. Of these 33 patients, 67% of the patients (22/33) had complete diabetic remission, while 6% of the patients (2/33) had partial remission, and 21% of the patients (7/33) showed disease improvement. Five of the six patients (5/6) who received insulin therapy prior to surgery could be successfully weaned off insulin and 4 of them achieved complete diabetic remission.

Among the 65 patients with hypertension, 38 reached the follow-up time at 1 year. The remission rate of hypertension was 58% (22/38). There were significant differences between preoperative and postoperative blood pressure. The mean systolic BP dropped from 138 ± 18 mmHg to 129 ± 13 mmHg ($p = 0.004$) and diastolic BP from 81 ± 15 mmHg to 77 ± 10 mmHg ($p = 002$).

As for the 38 patients with dyslipidemia, 22 reached the follow-up time at 1 year. The remission rate of dyslipidemia was 73% (16/22). The median serum LDL was 101 mg/dl [65-165], and the median serum triglyceride was 80 mg/dl [38-168] at 1 year after surgery, as also shown in Table 5.

Overall complications

The overall 30-day postoperative complication rate was 9%, and the rate of major complications was 4% (Table 2). There were 2 cases of venous thromboembolic

TABLE 3. Weight loss outcome of laparoscopic sleeve gastrectomy (LSG).

	3 months (N = 54)	6 months (N = 49)	9 months (N = 48)	1 year (N = 46)	2 years (N = 31)	3 years (N = 29)
%TWL	20.2 ± 7.1	25.6 ± 8.9	29.1 ± 9.7	30.2 ± 10.4	30.9 ± 11.2	28.4 ± 11.3
%EWL	38.2 ± 14.5	48.7 ± 18.3	55 ± 18.7	56.8 ± 19.8	59.9 ± 21.7	55.1 ± 21.3

TABLE 4. Weight loss outcome of laparoscopic Roux-en-Y gastric bypass (LRYGB).

	3 months (N = 41)	6 months (N = 31)	9 months (N = 31)	1 year (N = 30)	2 years (N = 26)	3 years (N = 26)
%TWL	21.2 ± 5.1	28.1 ± 6	32.3 ± 7.4	33.4 ± 7.5	33.2 ± 9.6	31.9 ± 8.6
%EWL	42.1 ± 10.2	56.5 ± 13.1	64.5 ± 16.4	67 ± 18.3	66.2 ± 21.4	63.6 ± 19.9

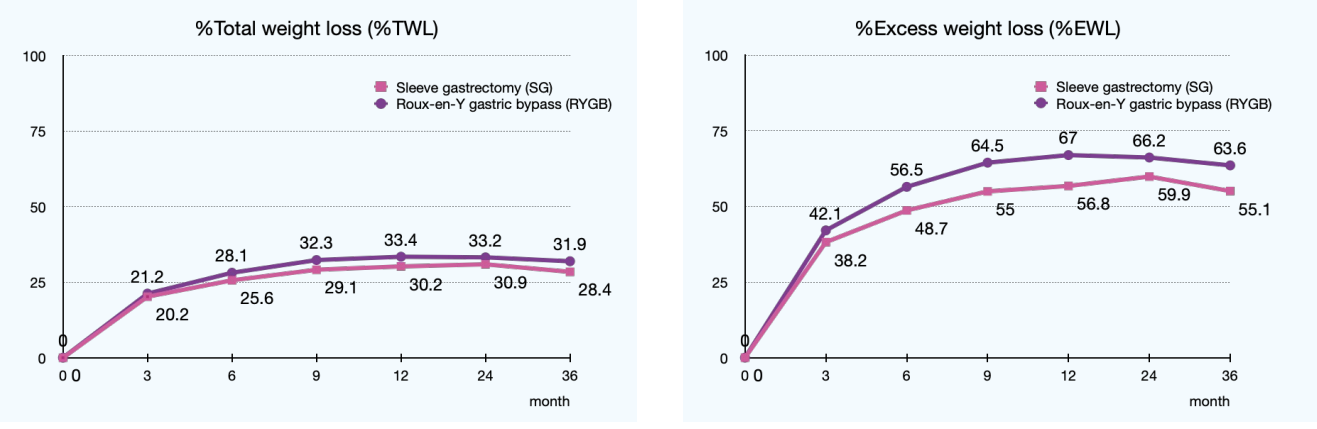

Fig 2. Weight loss outcome after bariatric surgery.

TABLE 5. Preoperative and 1-year postoperative parameters of patients in the comorbidity group.

	Preoperative	1-year postoperative	P-value
FBG (mg/dl)	127 [82–379]	99 [78–230]	< 0.001
HbA1C (%)	6.6 [5.3–15.9]	5.5 [4.4–8.7]	< 0.001
SBP (mmHg.)	138 ± 18	129.1 ± 13.1	0.004
DBP (mmHg.)	80.6 ± 14.8	76.7 ± 9.9	0.002
HDL (mg/dl)	55 [27–191]	65 [40–89]	0.205
LDL (mg/dl)	112 [58–292.4]	101 [65–165]	0.145
TG (mg/dl)	113 [30–280]	80 [38–168]	0.036

event (comprising 1 case of pulmonary embolism and 1 case of deep vein thrombosis), where anticoagulant therapy was given to the patients. One patient who underwent LRYGB developed a small intra-abdominal collection at postoperative day 7 without anastomotic leakage, as confirmed by a contrast study. The patient was successfully treated with intravenous antibiotics. There was 1 case of reoperation, in which a patient who had underwent LRYGB developed an intestinal obstruction on postoperative day 7 due to jejunojejunostomy stenosis. Laparoscopic adhesiolysis with jejunojejunostomy revision was performed at that time. There was no mortality in the 30-day postoperative period.

Regarding late complications, among the 42 patients who underwent LRYGB, 2 patients (4.8%) developed dumping syndrome in which the symptom could be improved by dietary modification. Seven patients (16.7%) had marginal ulcer detected in surveillance endoscopy at 1 year after surgery. Proton pump inhibitor (PPI) therapy was given to those patients without endoscopic intervention or surgery required.

Among the 58 patients who underwent LSG, 21 patients (36.2%) developed gastroesophageal reflux, including 1 patient (1.7%) with severe reflux esophagitis (LA classification grade C) and 1 patient (1.7%) with Barrett's esophagus. Nine patients (15.5%) with gastroesophageal reflux complication had a concomitant sliding hiatal hernia detected by EGD at 1 year after surgery.

Moreover, 7 of the patients (12.1%) later received conversion surgery from sleeve gastrectomy to Roux-en-Y gastric bypass due to an indication of severe gastroesophageal reflux symptom (3 cases), inadequate weight loss or weight regain (3 cases), and sleeve tube stricture (1 case). The median time to conversion surgery was 3 years (ranging from 3–5 years) after the primary surgery.

DISCUSSION

Obesity has become a global health concern as its prevalence has been rising in many countries. The impact of obesity is not only an individual health problem but also the economic burden of the treatment cost for obesity-related illnesses. The goal of treatment is to reduce the risk of developing complications related to obesity and to improve the quality of life of the patients.

In morbidly obese patients, bariatric surgery is considered to be the most effective treatment to achieve long-term outcomes both in weight loss and comorbidity resolution. Several studies have shown that bariatric surgery has significantly better outcomes for weight loss, comorbidity resolution, and quality of life compared with non-surgical methods both in the short term and long term.[5-7] A recent meta-analysis demonstrated the durable outcomes of bariatric surgery with a 10-year follow-up. The mean %EWL of sleeve gastrectomy was 58.3% in 2 studies, while Roux-en-Y gastric bypass was 56.7% in 18 studies.[8]

In this study, we demonstrated the short-term outcomes of bariatric surgery performed in Siriraj Hospital. Our center has demonstrated good weight loss outcomes with mean %EWL for LSG and LRYGB as 56.8% and 67% at 1 year after surgery, and maintenance of a mean %EWL of >50% at the follow-up time of 3 years after surgery. Other studies have reported the 1-year %EWL of LSG at between 56%–72.6%[9-11], and LRYGB at 62.6%-80.4%.[12-14] These indicate that the results of our center are comparable with the outcomes of the other studies.

Preoperative comorbidity, including type-2 DM, hypertension, and dyslipidemia, were found to be improved after surgery at our center. As for type 2 DM, our center has reported excellent outcomes, with a complete remission rate of 67% at 1 year after surgery. This result is comparable to other studies, in which the complete diabetic remission rate after bariatric surgery has been reported to be between 50.6%-67.9%.[15,16] Several studies have shown that bariatric surgery has a significant better outcome for glycemic control compared with non-surgical methods, both in the short term and long term.[6,7]

Regarding the operation safety, the complication rate of our center was considerably low. The major complication rate was reported at 4% without mortality. Ibrahim *et al.* reported the serious complication rate from 165 bariatric excellence centers in the United States ranged from 0.6%-4.9% in high-volume centers and 0.6%–10.3% in medium-volume centers.[17] Anastomotic leakage, which is the most serious complication of bariatric surgery, was not detected in our study.

Gastroesophageal reflux disease (GERD) is the most common complication after sleeve gastrectomy. The incidence was reported at 36.2% in our study. In our literature review, the incident of de novo GERD was reported at 40%–60%[18-20], based on clinical symptoms and endoscopic findings. Even so, the relationship between GERD and sleeve gastrectomy has long been controversial. Many studies have shown that the anatomical changes of LSG may worsen the existing GERD or cause GERD in some patients without pre-existing symptoms.[21] Meanwhile, some studies have also shown that LSG can improve GERD after surgery.[9,22] Some studies mentioned that the surgical technique and the shape of the gastric tube play important roles in preventing GERD after sleeve gastrectomy. Daes *et al.* proposed standardized

techniques and identified the technical errors that can lead to the development of GERD, including a narrowing at the junction of the vertical and horizontal part of the sleeve.[22] Therefore, in our center, we routinely use a 36-French bougie as the calibrator and keep the area at the incisura angularis >2 cm to make sure that the angle between the vertical and horizontal parts of the sleeve is not too narrow. Moreover, we believe that another mechanism associated with GERD is the disruption of the phrenoesophageal ligament around the esophagogastric junction (EGJ). So we only dissect the gastric fundus to the level of the left diaphragmatic crus and avoid circumferential dissection around the EGJ.

Another predisposing factor related to GERD after sleeve gastrectomy is a pre-existing hiatal hernia.[22,23] Many experts have suggested that a hiatal hernia should be repaired at the same time as sleeve gastrectomy.[24] In our center, we found that 15.5% of the patients who underwent LSG had a hiatal hernia at the endoscopy performed 1-year after surgery. The reason for this might be because the lesions were too small and may have been missed during the surgery, or the sleeve tube itself may have later migrated upward into the chest. Therefore, we think that careful identification of a hiatal hernia, both preoperatively and during surgery, and adding concomitant hiatal hernia repair would help reduce the incidence of GERD after sleeve gastrectomy in the future.

One specific complication that can occur after RYGB is a marginal ulcer. The rate of marginal ulcers varies from 7%-34%.[25-27] In our center, we found 16.7% of the RYGB patients had marginal ulcers at the routine postoperative endoscopy. Most of the patients were asymptomatic, so no early endoscopy had been performed before 1 year after surgery.

A marginal ulcer is believed to be associated with many local factors, such as inflammation, ischemia, and high acid production. A larger size of gastric pouch contains more parietal cells, causing more acidity and a greater risk of ulceration. Azagury *et al.* demonstrated that the gastric pouch length of the patients with marginal ulcers was significantly larger compared with a non-marginal ulcer group (5.6 ± 2 vs 4.9 ± 1.7, OR 1.2, p = 0.02).[28] Edholm *et al.* also showed that a smaller gastric pouch can reduce the risk of marginal ulcers.[29] So, in our center, we measure the gastric pouch length at 5–6 cm, so that the gastric pouch would not be >6 cm and <4 cm in length. We believe that a gastric pouch length of less than 4 cm might increase the tension around the gastrojejunostomy anastomosis, which could lead to acute ischemia and become a risk of leakage or the formation of a marginal ulcer afterward.

Moreover, there are multiple risk factors related to marginal ulcers, including smoking[27,28,30], chronic non-steroidal anti-inflammatory drugs (NSAIDs) use[27,30], *Helicobacter pylori* infection[30], untreated obstructive sleep apnea[30], and immunosuppression.[27] Therefore, to reduce the risk of marginal ulcer formation, we aim to ensure that all the risk modifications must be achieved before a Roux-en-Y gastric bypass procedure is performed.

This study has demonstrated safety and feasibility of bariatric procedures in Siriraj Hospital performed between 2012 and 2016 by the standard laparoscopic approach. With the good results of surgical outcomes and low complication rate in this study, we established the standard protocol of preoperative and postoperative care for bariatric procedures in our center, including the robotic bariatric procedures which was later performed in 2017.[31,32] In addition, The long-term results should be considered in a further study.

Limitations of this study

There are some limitations in this study to note. Our follow-up rate appeared to be less than in other studies, which might be due to the ineffectiveness of the follow-up system at the time of our initial experience. Moreover, this study was conducted in the early period of our experience. Therefore, the operative time was perhaps longer compared with other centers. However, despite the longer operative time, the complication rate of our center was also considerably low. Lastly, this was a retrospective study based on a chart review, which may means of some missing data.

CONCLUSION

Bariatric surgery, both laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass, can provide good outcomes in weight loss and comorbidity resolution. In Siriraj Hospital, the overall and major complication rates are low and comparable to other bariatric excellence centers.

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