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Original article

Effectiveness of laparoscopic sleeve gastrectomy for weight loss and obesity-associated co-morbidities: a 3-year outcome from Mainland Chinese patients

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Abstract

Background: Laparoscopic sleeve gastrectomy (LSG) is becoming a stand-alone bariatric surgery for obesity, but its effectiveness for Mainland Chinese patients remains unclear.
Objectives: To evaluate the effectiveness and safety of LSG for Mainland Chinese patients
Setting: A tertiary hospital
Methods: Retrospective analysis of patients admitted for LSG between January 2011 and February 2012 was performed. Medium-term outcome measures were: total weight loss (%TWL), excess weight loss (%EWL), co-morbidities, improvement, and complications.
Results: Seventy patients (body mass index [BMI] 40.8 ± 5.9 kg/m^2) underwent LSG, comprising 40 women and 30 men. The most common co-morbidity was diabetes (n = 29, 41.4%). Lost to follow-up rate for weight loss was 15.7%, 31.4%, and 41% at 1, 2, and 3 years. The %TWL was 34.4 ± 6.1, 34.7 ± 6.2 and 33.7 ± 7.1 at 1, 2, and 3 years. The %EWL increased to 77.1 ± 13.0, 77.9 ± 12.2 and 77.2 ± 13.1 at 1, 2, and 3years. The proportions of patients having successful weight loss were 100% or 85% at 3 years according the definition of %TWL >10% or %EWL >50%. Approximately 79.3%, 51.7%, and 44.8% of patients completed follow-up for glycemic control at each time point, respectively. The proportions of patients with optimal glycemic control (fasting blood glucose [FBG] <5.6 mmol/L; hemoglobin A1C [HbA1C] <6.5%) were 47.9%, 60.0%, and 69.2% at 1, 2, and 3years. The weight loss and glycemic control effect may be greater in the high BMI group (≥40 kg/m^2). Early and late complications occurred in 8.6% and 7.1% of patients during follow-up.
Conclusions: LSG is effective in weight loss and glycemic control and is safe for Mainland Chinese obese patients, especially for patients with a BMI ≥40 kg/m^2. (Surg Obes Relat Dis 2016;12:1305–1311.)

Keywords: laparoscopic sleeve gastrectomy; obesity; Mainland Chinese patients

Under the prevailing sedentary lifestyle conditions today, obesity has gradually become a prevalent public health problem worldwide. According to the estimate of the World Health Organization, there are approximately 700 million people who are obese in 2015 [1]. China has also been experiencing a mounting epidemic of obesity, showing a

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rise in incidence from 1.8% in 1981 to 7.5% in 2010 [2]. As obesity increases the likelihood of various common chronic diseases, including type 2 diabetes mellitus (T2DM), hypertension, cardiovascular diseases, and various cancers, ultimately leading to death, an investigation of the approaches to promote weight loss and prevent the disease development has become an issue of broad current interest.

Lifestyle interventions (including diet, physical activity, and behavior therapy) are traditional treatment strategies for obese patients [3]. However, the high failure rate (95%) in the long term contributes to the need for a more effective approach (e.g., bariatric surgery) [4]. Laparoscopic sleeve gastrectomy (LSG) is a bariatric procedure that can induce weight loss mainly by reducing gastric capacity and changing hormone (ghrelin and obestatin) secretion to limit food intake and appetite [5]. LSG was initially performed as the first part of a 2-step approach in super-obese (body mass index, BMI >50 kg/m^2) patients [6]. In recent years, LSG has been established as a primary and reliable bariatric procedure for its favorable outcomes [7–9]. However, reports about the efficacy of LSG in Chinese patients are still few in number [10,11].

The goal of this study was to retrospectively evaluate the medium-term outcomes of Mainland Chinese patients who underwent LSG as a primary bariatric procedure in terms of perioperative outcomes, weight loss, and co-morbidity improvements over 36 months of postoperative follow-up.

Methods

Data collection

After institutional review board approval and written informed consent obtained from all patients, a retrospective review of the electronic database of all morbidly obese patients treated with LSG as a primary bariatric surgery in the General Surgery Department of Changhai Hospital of the Second Military Medical University in China between January 2011 and February 2012 was performed. Eligibility criteria for LSG were as follows: (1) BMI ≥ 30 kg/m^2 without associated co-morbid conditions; (2) BMI >28 kg/m^2 with at least 1 high-risk co-morbidity and unsuccessful medical treatment attempts; (3) having T2DM diagnosed by at least one of the following criteria: fasting blood glucose (FBG) ≥ 7.0 mmol/L; blood glucose after 2 hours ≥ 11.1 mmol/L on oral glucose tolerance test (OGTT); random finger stick glucose ≥ 11.1 mmol/L; glycosylated hemoglobin (HbA1C) $\geq 6.5\%$; (4) age between 16 and 60 years; (5) absence of chronic medical or psychiatric illness, substance abuse, and previous gastrointestinal surgery; and (6) willingness to accept allocation to LSG. The database included patients' preoperative demographic characteristics [age, sex, body weight (BW), BMI (kg/m^2), and obesity-related co-morbidities], operative time, conversion to open technique, surgical complications during or within 30 days after surgery as well as postoperative follow-up data including total weight loss (%TWL), excess weight loss (%EWL), fasting glucose (g/dL) and HbA1C (%) at 1, 3, 6, 12, 24, and 36 months, respectively. The %TWL was calculated using the formula: (weight loss / the initial weight) $\times$ 100. The %EWL was calculated using the formula: (weight loss / baseline excess weight) $\times 100$, where weight loss = preoperative weight $-$ initial weight; baseline excess weight = initial weight $-$ ideal weight (X), and where X = 23 $\times$ m^2. X was calculated using an ideal BMI, as the ideal BMI cutoff point has been demonstrated to be 23 kg/m^2 [12].

Surgical procedure

LSG surgery was performed by 3 surgeons experienced in bariatric surgery using a 5-trocar laparoscopic technique with the surgeon standing on the right side of the patient as previously described [13]. The greater curvature of the stomach was divided using a Harmonic scalpel (Ethicon Endo-surgery, Cincinnati, OH, USA) from the distal antrum (4 cm proximal to the pylorus) to the gastroesophageal junction, taking special care to expose the left crus and completely dissect the gastric fundus. A 36-Fr bougie was inserted transorally along the lesser curvature to calibrate the sleeve. Four to five 60-mm endoscopic staples (Echelon Endopath™ stapler, Ethicon Endo-surgery, Cincinnati, OH, USA) were fired to transect the excess stomach. Green, gold, and blue cartridges were used, depending on the thickness of the stomach. The stapler line was reinforced with a running absorbable suture. The transected gastric specimen was retrieved via a port site. This port site was closed at the sheath with an absorbable multifilament suture. The gastric tube was inserted, and the abdominal cavity drainage tube was placed.

Perioperative management and follow-up

On the second day after surgery, the patients could drink a little water and were administered intravenous rehydration according weight. On the third day, upper gastrointestinal iodine water contrast examinations were performed to exclude abnormalities. The stomach tube was unplugged after that and a liquid diet was administered. The peritoneal drainage tube was removed when the volume of peritoneal drainage was less than 15 mL. After a week, indicators were reviewed including weight, waist and hip circumference, fasting blood glucose, HbA1C, fasting lipids, and serum insulin. After 2 weeks, patients were permitted to eat a semi-solid diet and were gradually advanced to a normal diet over the following 2-4 weeks.

Outpatient follow-up visits were performed at 1, 3, 6, and 12 months after surgery followed by annual follow-up communication via outpatient visit, telephone call, and e-mail.

Statistical analysis

Statistical analysis was performed using SPSS 19.0 for Macintosh (SPSS, Inc., Chicago, IL, USA). Data are

expressed as the mean ± standard deviation for continuous variables or as the raw number with the percentage for nominal variables. Statistical differences were analyzed using the unpaired *t* test or a paired *t* test when appropriate. A *P* value $<.05$ was considered statistically significant.

Results

Demographic characteristics of patients

From January 2011 to February 2012, 70 Mainland Chinese patients underwent LSG treatment in our unit, comprising 40 women and 30 men with a mean age of 30.33 ± 8.61 years. Preoperative mean BW and BMI were 121.4 ± 27.2 kg and 40.8 ± 5.9 kg/m^2, respectively. The most common co-morbid conditions were T2DM (n = 29, 41.4%), followed by dyslipidemia (19, 27.1%), obstructive sleep apnea (13, 18.6%), nonalcoholic fatty liver disease (12, 17.1%), osteoarthritis (11, 15.7%), arterial hypertension (8, 11.4%) and hypothyroidism (7/, 10%) (Table 1).

Perioperative data

Most of the sleeve gastrectomy procedures were completed laparoscopically, except one conversion to open surgery due to hemoperitoneum (1.4%). The mean operative time was 105.0 ± 18.6 minutes and mean blood loss was 65.0 ± 30.4 mL. No mortality was reported during follow-up, but early complications occurred in 6 (8.6%) and late complications occurred in 5 (7.1%) patients, which were resolved by corresponding interventions (Table 2).

Weight loss

Median and mean follow-up times were 36 (range, 6-45) months and 28 ± 14 months, respectively. Lost to follow-up was 0% at 1 and 3 months and 7.1% (5 patients) at 6 months, 15.7% (11 patients) at 1 year, 31.4% (22 patients) at 2 years, and 41% (29 patients) at 3 years.

After LSG, the mean BW significantly declined to 112.3 ± 20.5 kg at 1 month, 101.96 ± 19.10 kg at 3 months, 92.5 ± 15.5 kg at 6 months, 80.8 ± 11.3 kg at 1 year, 79.7 ± 10.7 kg at 2 years, and 79.3 ± 11.1 kg at 3 years (P $<.05$, Fig. 1A). Postoperative BMI was 38.7 ± 5.9 kg/m^2 at 1 month, 35.2 ± 5.4 kg/m^2 at 3 months, 31.9 ± 4.4 kg/m^2 at 6 months, 27.9 ± 3.3 kg/m^2 at 1 year, 27.6 ± 2.9 kg/m^2 at 2 years, and 27.6 ± 3.0 kg/m^2 at 3 years, which were all significantly lower than the preoperative value (P $<.05$, Fig. 1A).

The mean %TWL achieved was 7.6 ± 2.1 at 1 month, 16.0 ± 3.4 at 3 months, 24.8 ± 4.5 at 6 months, 34.4 ± 6.1 at 1 year, 34.7 ± 6.2 at 2 years, and 33.7 ± 7.1 at 3 years

Table 1
Preoperative co-morbidities and resolution rates at 3 years

Co-morbidities	N (%)	Resolution rate (%) at 3 years
Arterial hypertension	8 (11.4)	62.5
Type 2 diabetes	29 (41.4)	69.2
Dyslipidemia	19 (27.1)	84.2
Hypothyroidism	7 (10)	71.4
Obstructive sleep apnea	13 (18.6)	76.9
Osteoarthritis	11 (15.7)	90.9
Nonalcoholic fatty liver disease	12 (17.1)	75

Table 2
Early/late complications and treatment

Complications	N (%)	Treatment
Early complications		
Hemoperitoneum	2 (2.9)	Endoscopic clipping
Leakage	1 (1.4)	Endoscopic stenting
Wound infection	2 (2.9)	Antibiotic treatment
Splenic injury	1 (1.4)	Splenorrhaphy
Late complications		
Cholelithiasis	2 (2.9)	Laparoscopic cholecystectomy
Gastroesophageal reflux	2 (2.9)	Revisional laparoscopic Roux-en-Y gastric bypass
Anemia	1 (1.4)	Vitamin supplementation

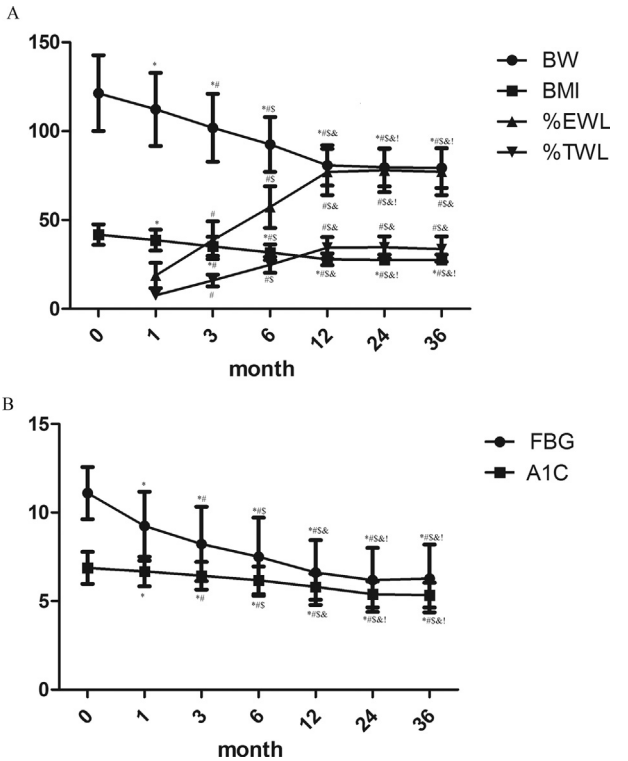

Fig. 1. (A) **Weight loss and** (B) **glycemic control preoperatively and during follow-up after laparoscopic sleeve gastrectomy.** BW, body weight; BMI, body mass index; %EWL, excess weight loss percentage; % TWL, total weight loss percentage; FBG, fasting blood glucose; HbA1C, glycosylated hemoglobin. * compared with preoperatively; compared with postoperatively 1 month; $ compared with postoperatively 3 months; & compared with postoperatively 6 months; ! compared with postoperatively 12 months.

(Fig. 1A). The proportions of patients having successful weight loss (%TWL >10%) [14,15] were 20.0% (n = 14) at 1 month, 91.5% (64) at 3 months, 100% from 6 months to 3 years. The %EWL gradually increased from 18.8 ± 7.1 at 1 month to 38.7 ± 10.6 at 3 months, 57.3 ± 11.8 at 6 months, 77.1 ± 13.0 at 1 year, 77.9 ± 12.2 at 2 years and 77.2 ± 13.1 at 3 years (Fig. 1A). The proportions of patients having successful weight loss (%EWL >50%) [11] were 25.7% (n= 18), 53.8% (35), 89.8% (53), 89.6% (43), and 85% (34) from 3 months to 3 years.

In addition, the patients were divided into high (≥40 kg/m^2, n = 43) and low BMI (<40 kg/m^2, n = 27) groups according to mean BMI. We also compared the therapeutic differences after LSG for these 2 subgroups. In line with the overall results, the BW and BMI were also significantly decreased, but the % TWL and %EWL were significantly increased for the high and low BMI groups. Nevertheless, contrary results to compare the weight loss effect for the high and low BMI groups were achieved when using %EWL or %TWL. The weight loss effect of LSG was more significant in the low BMI group when using %EWL (25.5 ± 5.2 vs 14.7 ± 6.5 at 1 month; 47.7 ± 8.5 vs 33.0 ± 11.0 at 3 months; 66.1 ± 10.8 versus 52.8 ± 13.1 at 6 months; 83.9 ± 17.6 versus 74.1 ± 15.2 at 1 year; 84.6 ± 20.4 versus 74.9 ± 13.9 at 2 years; and 83.0 ± 22.2 versus 74.1 ± 15.3 at 3 years). Otherwise, when using %TWL (15.7 ± 2.9 versus 16.2 ± 3.7 at 3 months; 22.4 ± 4.6 versus 26.1 ± 4.2 at 6 months; 29.2 ± 5.9 versus 36.7 ± 5.0 at 1 year; 29.1 ± 5.5 versus 37.2 ± 5.1 at 2 years; and 28.1 ± 6.1 versus 36.7 ± 6.0 at 3 years; Fig. 2).

Co-morbidity improvements

Improvement in co-morbidities is the most important effect of bariatric surgery [16] and thus we also investigated the effect of LSG on co-morbidities, especially on glycemic control in T2DM patients overall (n = 29, BMI = 41.2 ± 8.0 kg/m^2) and according to high (≥40 kg/m^2, n = 19) and low BMI (<40 kg/m^2, n = 10).

There were 29 patients (100%) at 1 month, 29 patients (100%) at 3 months, 28 patients (96.6%) at 6 months, 23 patients (79.3%) at 1 year, 15 patients (51.7%) at 2 years and 13 patients (44.8%) at 3 year completed follow-up. The mean preoperative FBG and A1C of T2DM patients was 11.0 ± 1.5 mmol/L and 6.9 ± 0.9 %, which were significantly dropped to 9.2 ± 1.9 mmol/L and 6.7 ± 0.8% at 1 month, 8.2 ± 2.1 mmol/L and 6.4 ± 0.8% at 3 months, 7.5 ± 2.2 mmol/L and 6.2 ± 0.8% at 6 months, 6.6 ± 1.8 mmol/L and 5.8 ± 0.7% at 1 year, 6.2 ± 1.8 mmol/L and 5.4 ± 0.7% at 2 years, and 6.3 ± 1.9 mmol/L and 5.3 ± 0.7% at 3 years, respectively (P <0.05; Fig.1 B). The proportions of patients with optimal glycemic control (FBG <5.6 mmol/L and HbA1C <6.5%) increased significantly from 0% preoperatively to 17.9% (5/28) at 6 months, 47.9% (11/23) at 1 year, 60.0% (9/15) at 2 years, and 69.2% (9/15) at 3 years.

Furthermore, we also compared glycemic control after LSG. In accordance with the overall result, the FBG and HbA1C also significantly decreased for both the high and low BMI subgroups. However, compared with the low BMI group, the glycemic control effect of LSG was greater in the

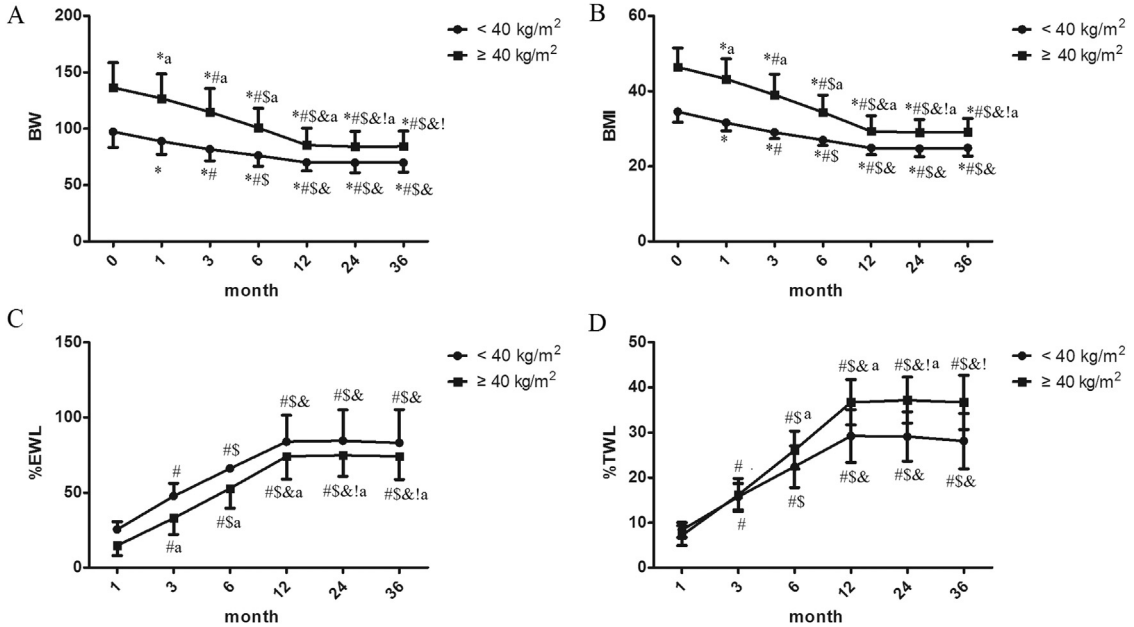

Fig. 2. **Weight loss comparison between patients with preoperative BMI <40 kg/m^2 and BMI ≥40 kg/m^2.** (A) BW, body weight; (B) BMI, body mass index; (C) %EWL, excess weight loss percentage; (D) %TWL, total weight loss percentage. * compared with preoperatively; # compared with postoperatively 1 month; $ compared with postoperatively 3 months; & compared with postoperatively 6 months; ! compared with postoperatively 12 months; a compared with patients with preoperative BMI <40 kg/m^2 at each time point.

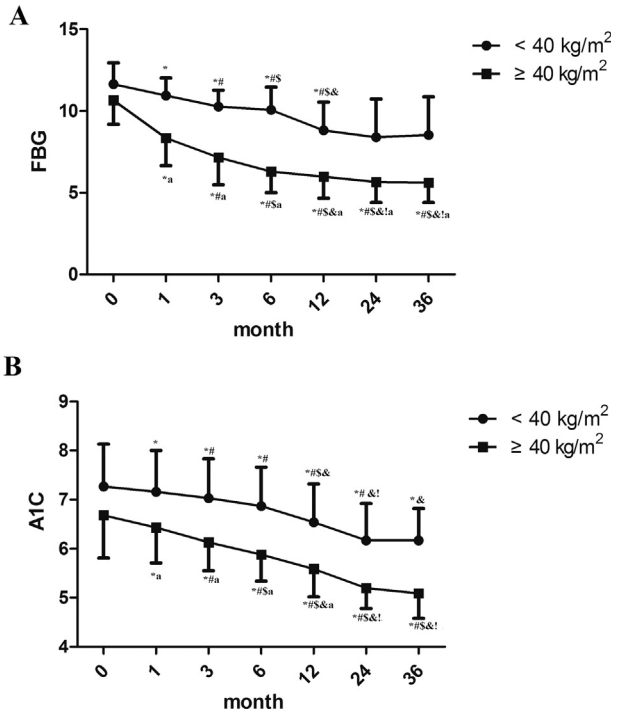

Fig. 3. **Glycemic control comparison between patients with preoperative BMI <40 kg/m^2 and BMI ≥40 kg/m^2.** (A) FBG, fasting blood glucose; (B) HbA1C, glycosylated hemoglobin * compared with preoperatively; # compared with postoperatively 1 month; $ compared with postoperatively 3 months; & compared with postoperatively 6 months; ! compared with postoperatively 12 months; a compared with patients with preoperative BMI <40 kg/m^2 at each time point.

high BMI group (FBG: 8.3 ± 1.7 versus 11.0 ± 1.1 at 1 month; 7.2 ± 1.7 versus 10.3 ± 1.0 at 3 months; 6.3 ± 1.3 versus 10.1 ± 1.4 at 6 months; 6.0 ± 1.3 versus 8.8 ± 1.7 at 1 year; 5.7 ± 1.2 versus 8.4 ± 2.3 at 2 years; and 5.6 ± 1.2 versus 8.3 ± 2.3 at 3 years; HbA1C: 6.4 ± 0.7 versus 7.2 ± 0.8 at 1 month; 6.1 ± 0.6 versus 7.0 ± 0.8 at 3 months; 5.9 ± 0.5 versus 6.9 ± 0.8 at 6 months; 5.6 ± 0.6 versus 6.5 ± 0.8 at 1 year; 5.2 ± 0.4 versus 6.8 ± 0.8 at 2 years; and 5.1 ± 0.5 versus 6.2 ± 0.7 at 3 years; Fig. 3).

Improvement in the control of other co-morbidities at 3 years was observed and is shown in Table 1, such as for osteoarthritis in 90.9%, dyslipidemia in 84.2%, and obstructive sleep apnea in 84.2% of patients, etc. (Table 1).

Discussion

With income increasing and the changes in food structure, the incidence of obesity and type II diabetes has grown in Mainland China in recent years. More and more people accepted the view that morbid obesity is a disease, which greatly harms health and needs medical intervention. In addition to diet control and physical exercise, surgery has become a choice for some intractably obesity patients Table 3.

However, compared with the large number of obese people, few of them have had surgical treatment suggested. Obesity features in the Mainland China population differs from other reported populations. The standard BMI of Mainland China population is 23 kg/m^2, and the average BMI of patients with T2DM is about 25 kg/m^2 both of which are lower than the American population. The lack of reports about the effectiveness and safety of surgical treatments for obesity in the Mainland Chinese population is an important reason that has limited the application.

LSG is a recently recommended bariatric option for long-term weight loss [7,17,18]; however, it seemed not to be widely utilized in China, with reports of the use of LSG as an obesity treatment in China, Taiwan [19], and the Hong Kong area [10,11]. In the present study, we conducted a long-term observational analysis over 36 months on our own patients recruited from Mainland China. Consistent with many previous studies[10,11], our results also suggested that LSG was effective in achieving substantial weight reduction over medium-term follow-up, with a mean percent excess BW loss of 77.1 ± 13.0 at 1 year, 77.9 ± 12.2 at 2 years, and 77.2 ± 13.1 kg/m^2 at 3 years, respectively. Apart from weight control, our results also showed the resolution of obesity-associated co-morbidities, such as T2DM (69.2%), osteoarthritis (90.9%), and dyslipidemia (84.2%) at the medium-term assessment. The proportions of patients with optimal glycemic control (FBG < 5.6 mmol/L and A1 C < 6.5%) maintained

Table 3
Weight loss in patients after laparoscopic sleeve gastrectomy

	Follow-up time					
	1 month	3 months	6 months	1 year	2 years	3 years
%EWL						
low BMI group	25.5 ± 5.2	47.7 ± 8.5	66.1 ± 10.8	83.9 ± 17.6	84.6 ± 20.4	83.0 ± 22.2
high BMI group	14.7 ± 6.5	33.0 ± 11.0	52.8 ± 13.1	74.1 ± 15.2	74.9 ± 13.9	74.1 ± 15.3
%TWL						
low BMI group		15.7 ± 2.9	22.4 ± 4.6	29.2 ± 5.9	29.1 ± 5.5	28.1 ± 6.1
high BMI group		16.2 ± 3.7	26.1 ± 4.2	36.7 ± 5.0	37.2 ± 5.1	36.7 ± 6.0

low body mass index (BMI) group: BMI < 40 kg/m^2; high BMI group: BMI ≥ 40 kg/m^2

almost well above 60% at 2 years and 3 years. These were also consistent with previous studies [11,18].

Although LSG has been suggested as a primary and reliable bariatric procedure, several studies show the difference in therapeutic effects for different BMIs. For example, Mui et al. demonstrated that patients with a BMI <35 kg/m^2 seemed to obtain more significant weight loss from LSG compared with patients with a BMI >35 kg/m^2 (%EWL: 73.0 $\pm$ 44.8 versus 39.9 $\pm$ 11.7 at 3 months; 99.4 $\pm$ 44.1 versus 61.1 $\pm$ 21.1 at 6 months; 88.3 $\pm$ 15.8 versus 60.9 $\pm$ 29.5 at 12 months) [10]. Park et al. also reported that %EWL in the lower BMI (30-35 kg/m^2) group was significantly greater than in the higher BMI group (>35 kg/m^2) (86.1% versus 61.9%, $P<.001$) at mean follow-up of 24 months [20]. Boza et al. found that the patients with a preoperative BMI >40 kg/m^2 achieved significant lower % EWL in comparison with the patients with BMI <40 kg/m^2 (50.2% versus 72.7%) at 5 years [21]. Considering the mean BMI of our patients was 40.8 $\pm$ 5.9 kg/m^2, we divided our patients into high and low BMI groups using 40 kg/m^2 as the threshold. As expected, we also found that patients with a BMI <40 kg/m^2 could achieve significant weight loss from LSG compared with patients with a BMI ≥ 40 kg/m^2 (%EWL: 25.5 $\pm$ 5.2 versus 14.7 $\pm$ 6.5 at 1 month; 47.7 $\pm$ 8.5 versus 33.0 $\pm$ 11.0 at 3 months; 66.1 $\pm$ 10.8 versus 52.8 $\pm$ 13.1 at 6 months; 83.9 $\pm$ 17.6 versus 74.1 $\pm$ 15.2 at 1 year; 84.6 $\pm$ 20.4 versus 74.9 $\pm$ 13.9 at 2 years; and 83.0 $\pm$ 22.2 versus 74.1 $\pm$ 15.3 at 3 years). In addition to %EWL, recent studies also used %TWL to assess weight loss after a bariatric procedure [22,23]. It is reported that the %TWL gradually increased along with the increase in BMI (gastric bypass: 26% for BMI of 30–35 kg/m^2 and 32% for BMI of 35–40 kg/m^2; sleeve gastrectomy: 24% for BMI of 30–35 kg/m^2 and 28% for BMI of 35–40 kg/m^2 at 1 year after operation [24]; 38.77 % for a BMI >60 and 36.64% for a BMI <60 at 2 years after operation [22]). In line with these studies, we also found that the %TWL was higher in patients with BMI >40 kg/m^2 after LSG treatment. Nevertheless, these findings from the %TWL seemed to be opposite those from the %EWL. This may be explained by the following 2 reasons: (1) the high BMI group had a significant reduction in weight but did not get as close to their ideal weight as the low BMI patients [22]; and (2) the %EWL may be more affected by baseline weight than % TWL [24,25]. Thus, it is still controversial to evaluate the weight loss effect according to the %EWL and the %TWL may be more believable.

Although Park et al. investigated the resolution of comorbidities (T2 DM, hypertension or dyslipidemia) of LSG [20], no significant difference was observed between lower (30-35 kg/m^2) and higher BMI ($>$ 35 kg/m^2) groups. However, in our study, we found the glycemic control effect of LSG was greater in the high BMI group (≥ 40 kg/m^2) in the low BMI group ($<$ 40 kg/m^2). Thus, we believe a BMI of 40 kg/m^2 may be more suitable threshold for the definition of obesity and selection of therapeutic method [26].

Compared to Americans and Europeans, surgical treatment of obesity is performed relatively later in Mainland China. To date, 4 kinds of surgical procedures have been practiced in Mainland China, including LAGB (Laparoscopic Adjustable Gastric Banding), BPD/DS (Biliopancreatic Diversion with Duodenal Switch), LRYGB (Laparoscopic Roux-en-Y Gastric Bypass), and LSG. In the early years, the majority of patients underwent LAGB and LRYGB. However, some disadvantages were revealed in LAGB and LRYGB gradually such as strict follow-up demands and relatively more complications. More and more patients have undergone LSG in recent years. The choice of surgical procedures remained controversial in Mainland China, which mainly depends on the experience of the surgical team and patient's willingness after informed consent for every procedure has been obtained.

Regarding the weight loss effectiveness of surgical procedures, it is widely agreed that LSG and LRYGB are more effective than LAGB, while comparison of the weight loss effectiveness of LSG versus LRYGB is controversial. Yang H et al. [27] reported 140 LRYGB surgeries in Mainland China. The percentages of excess weight loss in 1, 3, 6, and 12 month after operation were (26.4 $\pm$ 8.6)%, (53.3 $\pm$ 6.7)%, (75.3 $\pm$ 7.9)%, (78.5 $\pm$ 8.5)%, respectively. The improvement rates of fatty liver, hyperlipidemia, hypertension and T2DM were 84.6% (n = 33), 92.3%(12), 77.3%(17) and 82.4%(14). Zhang Y et al. [28] compared the safety and effectiveness of LSG and LRYGB in 64 eligible patients from Mainland China. At 5 years after operation, %EWL for LSG and LRYGB was 63.2 $\pm$ 24.5% and 76.2 $\pm$ 21.7% (P = .02), respectively, which led to the conclusion that LRYGB possesses the superiority in terms of weight loss. In our study, the mean % EWL of LSG was 77.1 $\pm$ 13.0 kg/m^2 at 1 year, 77.9 $\pm$ 12.2 kg/m^2 at 2 years, and 77.2 $\pm$ 13.1 kg/m^2 at 3 years, which is similar to reported results of LRYGB in the Mainland Chinese population.

It has been reported that LSG has a lower complication rate than other bariatric surgeries [29,30]. In line with these studies, we observed early and late complications in 6 (8.6%) and 5 (7.1%) patients during follow-up in this study. Most complications were mild and were relieved with conservative therapy, leading to no mortality. Taken together, our report added objective evidence in support that LSG is an effectiveness and safe surgical procedure in the Mainland Chinese population.

There are several limitations to our study. The first limitation of this work is the small number of patients. The small number of patients with a lower BMI (30-35 kg/m^2) is attributed to the fact that the indication for operation was strictly controlled and most patients have not accepted surgical treatment of metabolic diseases in China. Consequently, we also cannot compare the difference between LSG and other treatments. Secondly, the patient follow-up rate fell to 50% after 3 years or more, which may cause bias

in therapeutic outcomes because patients with poor outcomes may be lost to follow-up. The third limitation of our study is its retrospective nature. Finally, we cannot rule out the influence on the effect of diet for weight loss because the differences in dietary habit are great between every region in China.

Conclusions

LSG is an effective and safe weight loss procedure for Mainland Chinese patients, showing favorable outcomes in terms of %EWL, %TWL, and resolution of co-morbidities at 3 years' follow-up. Better weight loss and superior glycemic control results may be seen in patients with a preoperative BMI $\geq$40 kg/m^2. However, further prospective studies with larger sample sizes are needed to confirm our conclusions.

Conflict of Interest Disclosure Statement

The authors declare that they have no conflict of interest.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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