Laparoscopic sleeve gastrectomy for morbid obesity: does the size of the bougie matter?

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Background
Laparoscopic sleeve gastrectomy (LSG) is a safe and effective surgical treatment modality for morbid obesity. Variations in surgical technique could affect the results. The optimal size of the bougie remains controversial. The aim of this study was to evaluate the first-year outcome of LSG using two different sizes of bougies.

Patients and methods
Between March 2011 and January 2014, 102 morbidly obese patients underwent LSG. These patients were divided into two groups: group 1 (50 patients) and group 2 (52 patients). In group 1, 32-Fr bougies (orogastric calibration tube) were used, and in group 2 40-Fr bougies were used. Patients completed at least 6 months of follow-up visits.

Results
The excess body weight loss percentage in group 1 was 53.6 ± 10.96% at 6 months and 69.4 ± 15.6% at 1 year postoperatively, whereas in group 2 it was 52.7 ± 11.27% at 6 months and 66.4 ± 13.4% at 1 year postoperatively, with no statistically significant difference between the two groups. There were neither intraoperative complications nor postoperative mortalities. The overall complication rate was 14.7% (15 patients) with no statistically significant difference between the two groups (14% in group 1 vs. 15.4% in group 2). The postoperative hospital stay was 2.3 days in group 1 versus 2.2 days in group 2. There was 58.8% complete resolution of diabetes mellitus, 60% resolution of hypertension, and 87.5% resolution of sleep apnea 6 months after sleeve gastrectomy with no statistically significant difference between the two groups.

Conclusion
LSG is a safe and effective treatment method for morbid obesity. Bougie size does not affect the short-term outcomes.

Keywords:
bariatric surgery, bougie, laparoscopy, morbid obesity, sleeve gastrectomy

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Introduction

The number of laparoscopic sleeve gastrectomies (LSGs) performed worldwide has increased markedly in the past few years and it has earned a place as a primary bariatric surgery. It was initially performed as the first of a two-step surgery, biliopancreatic diversion with a duodenal switch. However, it proved to be effective as a stand-alone procedure for both weight loss and comorbidity resolution [1–4]. LSG produces early satiety by reducing the ability of the residual stomach to distend and resulting in a reduced level of plasma ghrelin. Levels of ghrelin are decreased after the LSG procedure as the predominant part of the ghrelin-producing gastric fundus is resected out, resulting in less stimulation of hunger and greater appetite suppression [5].

The fact that this technique has been considered simple and easy has led to its adoption by a large number of surgeons. Compared with gastric bypass and biliopancreatic diversion, and given that the procedure is performed under laparoscopy; it may seem to involve less risk [6]. Among the advantages of this surgical method is the lack of digestive anastomosis, mesenteric defects that may cause internal hernias and foreign material such as gastric bands [7,8].

The resection of a part of the stomach is done along a calibrating orogastric tube or bougie with diameter from 32 to 60 Fr [9–11]. The success of this restrictive bariatric operation may be limited by dilatation of the remaining gastric tube at longer follow-up, thus diminishing the restrictive effect [12].

This study aimed to evaluate our results of LSG as a single treatment for morbid obesity and to assess the effect of the bougie size on the outcomes.

Patients and methods

This is a prospective randomized study using the closed envelop technique, and includes 102 patients with morbid obesity. These patients underwent LSG

from March 2011 to January 2014. These patients completed at least 1-year follow-up visits. Inclusion criteria were BMI greater than 40 kg/m^2 or BMI greater than 35 kg/m^2 with comorbidity in which surgically induced weight loss is expected to improve the disorder [diabetes mellitus (DM), hypertension (HTN), cardiorespiratory diseases, severe joint disease, …] and failure of a conservative treatment program (diet, exercise, behavior therapy, and drug therapy). Patients with major psychiatric dysfunction or substance abuse, severe inflammation of the esophagus or the stomach, severe organ dysfunction or sweet-eating disorders were excluded.

The patients were divided into two groups: group 1 (50 patients) and group 2. In group 1 32-Fr bougies (orogastric calibration tube) were used, and in group 2 40-Fr bougies were used.

Approval was taken from the Ain Shams ethical committee. The patients were informed in detail about the risk and benefits of the operation. Written consent was obtained from each patient. The patients had a thorough preoperative evaluation that included upper gastrointestinal (GI) endoscopy, ECG, chest radiography, abdominal ultrasonography, echocardiography, pulmonary functional tests, serum cortisol level, thyroid function tests, liver function tests, kidney function tests, complete blood count, prothrombin time, HbA1c level, and fasting blood sugar.

Patients with BMI of at least 50 kg/m^2 were given a low-calorie, high-protein diet for at least 2 weeks before surgery to make the liver pliable at the time of surgery, and this helps in retraction and exposure of the gastroesophageal junction, which is crucial for total fundal mobilization and excision.

Patients with comorbidities were considered cured if all medications for DM, HTN, or dyslipidemia were discontinued, and considered improved with discontinuation or decrease in the dose of one or more drugs but not all. Diabetic patients on insulin were considered improved if they were able to discontinue insulin.

Prophylactic dose of low-molecular-weight heparin was used 12 h preoperatively and then daily for 10 days.

The operative time, postoperative hospital stay, early and late postoperative complications, mortality, effect on comorbidities, and excess body weight loss percentage (EBWL%) were monitored in each group and were compared between the two groups.

Surgical technique

Under general endotracheal anesthesia, the patients were positioned in 30° anti-Trendelenburg position with legs abducted. The lower extremities were supported and secured with a belt and tape. Compression stockings were applied. A nasogastric tube was inserted in all cases.

The monitor was placed at the head end. The surgeon stood between the legs, the camera assistant on the right side, and the second assistant on the left side of the patient. Five trocars were used. An optical port (10 mm) was introduced one and half hand-breadths below the xiphoid just to the left of the midline. Mediflex Nathanson's Liver Retractor (Cook Medical Inc., Bloomington, Indiana, USA) was introduced just below xiphoid and to the left (Fig. 1). The retractor was fixed to the operating theater table. Two 5-mm ports were inserted, one at the left midclavicular line 2 cm below the costal margin and the other at the left anterior axillary line at the level of the optical port. A fifth 15-mm trocar was placed at the right midclavicular line 2 cm above the level of the optical port.

The division of the vascular supply of the gastric greater curvature was started 4 cm from the pylorus and proceeded upward until the angle of His and was performed with radiofrequency (Harmonic Scalpel; Ethicon Endo-Surgery, Cincinnati, Ohio, USA) or with LigaSure 5 mm blunt tip Vessel Sealing (Covidien, Boulder, Colorado, USA) devices (Fig. 2). The upper part of the fundus was mobilized completely from the left crus of the diaphragm (Fig. 3).

Before stapling, the anesthetist passed down a 32- or 40-Fr-sized bougie to guide the gastric division. Using laparoscopic EndoGIA linear staplers (Covidien) the stomach was divided parallel to the gastric calibration

Figure 1

Liver retractor.

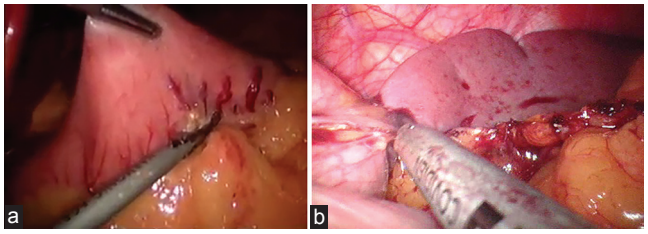
tube along the lesser curvature. The first cartridge was 6 cm long and green (4.8 mm) and the others were 6 cm long and blue (3.5 mm). Care was taken not to create a stricture at the level of the incisura angularis (Figs. 4–6).

The bougie was removed and a nasogastric tube was inserted. A methylene blue test was then carried out. The resected stomach was extracted through the right midclavicular port wound (Fig. 7). A tube drain was placed at the left subdiaphragmatic space under vision.

Postoperative care

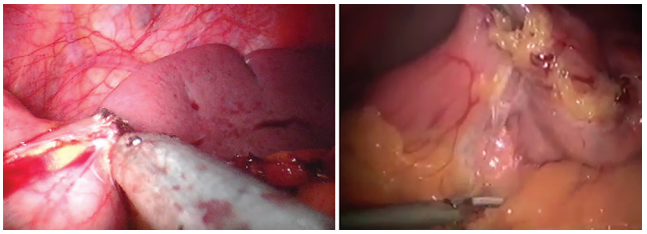
On the first postoperative day, the patients received a clear liquid diet. A gastrografin study was performed

Figure 2



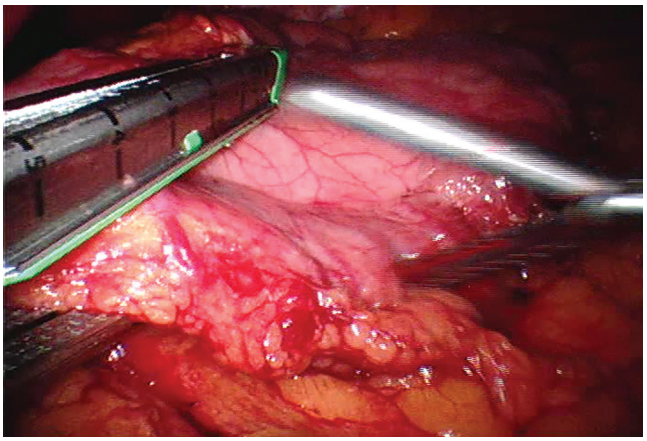
(a) Harmonic Scalpel (Ethicon Endo-Surgery); (b) LigaSure Vessel Sealing (Covidien).

Figure 3



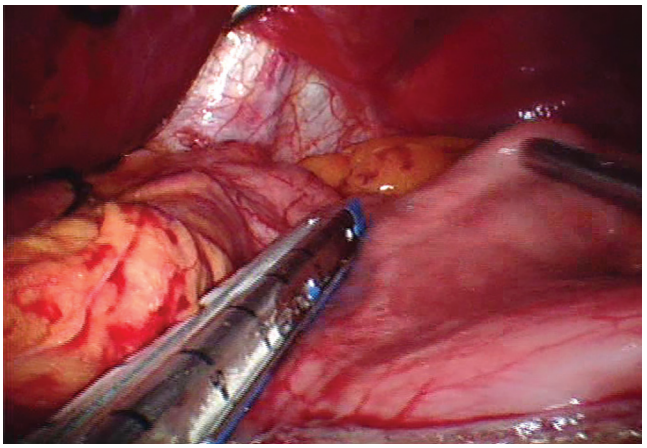
The upper part of the fundus was mobilized completely from the left crus of the diaphragm.

Figure 4



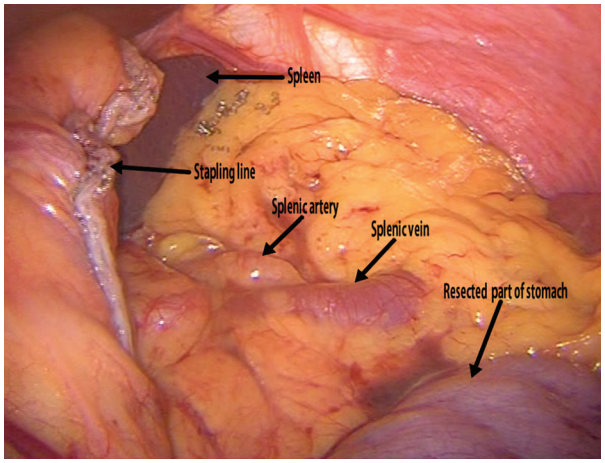
Six-cm-long green cartridge.

Figure 5



Six-cm-long blue cartridge.

Figure 6



Completion of laparoscopic sleeve gastrectomy (LSG).

Figure 7

Resected stomach.

only if there was suspicion of leakage. The drain was removed on the second postoperative day. The patients were discharged usually by the second postoperative day. The patients received a clear liquid diet for 10 days and then were progressed to a soft diet for 3 weeks.

The patients were seen by the surgeon on day 10 and at 1, 3, 6, 9, and 12 months postoperatively. Proton pump inhibitors were used in all patients for the first 2 months postoperatively. They were encouraged to have a high-protein diet. Vitamin and mineral supplements were prescribed for 1 year after LSG.

Statistical analysis

IBM SPSS software (Statistical Program for Social Science version 22) (2013; IBM Corp., Cairo, Egypt) was used for data analysis. Data were expressed as mean ± SD for quantitative parametric measures, in addition to both number and percentage for categorized data. The Student *t*-test was used to compare two independent mean groups for parametric data. The χ^2-test was used to study the association between two variables or to make a comparison between two independent groups as regards the categorized data. The results were significant (S) with *P* value less than 0.05 and highly significant (HS) with *P* value less than 0.01. *P* values greater than or equal to 0.05 were regarded nonsignificant (NS).

Results

A total of 102 patients [83 women (81.4%) and 19 men (18.6%)] underwent LSG between March 2011 and January 2014. All patients were followed up for 1 year. Patients had a mean age of 32 ± 9.5 years (range 20–59 years). The mean preoperative weight was 135.98 ± 18.5 kg (range 95–184 kg). The mean BMI was 48 ± 5.98 kg/m^2 (range 37.4–65.7 kg/m^2).

Preoperative evaluation showed that 15 patients (14.7%) had HTN, 17 patients (16.6%) had type 2 DM, eight patients (7.8%) had obstructive sleep apnea, and 20 patients (19.6%) had degenerative osteoarthritis.

The mean operative time was 91 ± 20.3 min (range 64–240 min). The mean postoperative hospital stay (2.3 days in group 1 vs. 2.2 days in group 2) was nearly similar between the two groups. None of our patients required conversion to open surgery (Table 1).

Gastroesophageal reflux disease was diagnosed preoperatively in two patients using upper GI endoscopy, esophageal manometry, barium meal in Trendelenburg position, and 24 h pH monitoring. Reduction of sliding hiatus hernia was done, followed by sleeve gastrectomy and crural repair. Postoperatively, symptoms of gastroesophageal reflux disappeared completely. Laparoscopic cholecystectomy was performed at the same session for four patients with asymptomatic gall bladder stones.

There were neither intraoperative complications nor postoperative mortalities. The overall complication rate was 14.7% (15 patients). There were four patients (3.9%) with major complications and 11 patients (10.7%) with minor complications. Table 2 shows complications after sleeve gastrectomy in this study.

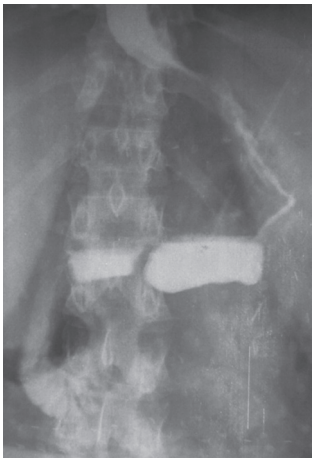
In group 1 (32-Fr bougie) one patient complained of abdominal pain and fever three days after operation. The patient was readmitted; a pelvic-abdominal computed tomography (CT) scan and gastrografin study (Fig. 8)

Table 1 Demographic data

Demographic data	Group 1 (*n* = 50)	Group 2 (*n* = 52)	*P* value
Age			
Mean ± SD	33 ± 10.3	31 ± 8.25	0.280
Range	22–59	20–58	
Sex [*n* (%)]			
Males	8 (16.0)	11 (21.2)	0.678
Females	42 (84.0)	41 (78.8)	
Mean preoperative weight (kg)	135.6 ± 18.4	136.3 ± 18.6	0.86 (NS)
Mean preoperative BMI (kg/m^2)	47.6 ± 6.1	48.4 ± 5.9	0.28 (NS)
Mean operative time (min)	89.5 ± 22.3	94.4 ± 19.5	0.239
Postoperative hospital stay (days)	2.3 ± 0.85	2.2 ± 0.83	0.549
Comorbidities [*n* (%)]			
HTN	9 (18.0)	6 (11.5)	0.521
DM	8 (16.0)	9 (17.3)	0.929
OSA	5 (10.0)	3 (5.8)	0.670

DM, diabetes mellitus; HTN, hypertension; OSA, obstructive sleep apnea.

Figure 8



Normal gastrografin study after sleeve gastrectomy.

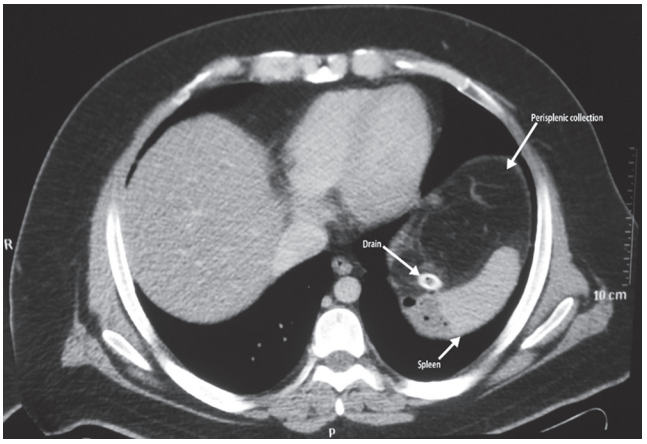
were carried out, which revealed no leakage but only mild left pleural effusion and perisplenic collection in which a CT-guided pigtail drain was placed. On reviewing the video of the operation no problems were seen except for spillage of gastric mucosa intra-abdominally during extraction of the resected stomach. Culture and sensitivity for purulent discharge from the drain was done. The patient received intravenous imipenem and amikin until the result of the culture and sensitivity was available and then she was continued on intravenous antibiotic as per the culture and sensitivity result. After 1 week of readmission, there was neither fever nor abdominal pain and the pelvic-abdominal CT scan was normal; the drain was removed and the patient was discharged.

One patient had postoperative bleeding. Bleeding started on the first postoperative morning as 500 ml blood was noticed in the drain. The patient was vitally stable. The patient received 2 U of blood and 2 U of fresh frozen plasma and managed conservatively.

In group 2 (40-Fr bougie), one patient had postoperative bleeding, which required blood transfusion and abdominal exploration on the first day postoperatively. There was bleeding from short gastric vessels, which was controlled, and the patient recovered smoothly. One patient had high-grade fever (39.2°C) and tachycardia on the third postoperative day. This patient was readmitted and a gastrografin study was conducted, which revealed the presence of gastric leakage. Laparoscopic exploration was performed on the fourth day postoperatively. There were no abnormalities except a small amount of perigastric purulent fluid. Methylene blue was injected into the stomach. There was no leakage of the dye. Aspiration of the purulent fluid was done and a drain was inserted. Gastrografin study was done 3 days after the exploration, which revealed no apparent leakage. The patient was discharged on a clear liquid diet. Two days later, there was continuous pus discharge from the drain. Pelvic-abdominal CT showed large perigastric and perisplenic collection with the tube drain inside (Fig. 9). A self-expandable fully covered metal stent (Mega esophageal stent; Taewoong Medical Co., Pennsylvania, USA) was introduced by upper GI endoscopy. Ten days after stent introduction, the collection resolved and the drain was removed. The stent was removed after 2 months by upper GI endoscopy.

There was port site infection in eight patients (7.8%); of them one patient (group 1) had persistent vomiting and upper abdominal pain that started 5 days after the operation, which improved after drainage of abscess at the site of the 15-mm trocar (at right midclavicular line) where the resected stomach was extracted. Three patients (2.9%) were readmitted after surgery because of persistent severe nausea, vomiting, and dehydration. The gastrografin study was normal. These patients resolved with inpatient medical treatment.

Figure 9



Pelvic-abdominal computed tomography (CT) scan showing large perisplenic collection with the tube drain inside.

Table 2 Complications after sleeve gastrectomy

Complications	Group 1 [*n* (%)]	Group 2 [*n* (%)]	*P* value	Significance
Postoperative bleeding	1 (2)	1 (1.9)	>0.05	NS
Leakage	0	1 (1.9)	>0.05	NS
Stricture (stenosis)	0	0	—	—
Abdominal abscess	1 (2)	0	>0.05	NS
Angioneurotic edema	0	0	—	—
Deep vein thrombosis	0	0	—	—
Pulmonary embolism	0	0	—	—
Postoperative GERD	0	0	—	—
Postoperative vomiting and dehydration	2 (4)	1 (1.9)	>0.05	NS
Port site wound infection	3 (6)	5 (9.6)	>0.05	NS
Total complications	7 (14)	8 (15.4)	>0.05	NS

The overall EBWL% was 53.2 ± 11.1% at 6 months and 67.95 ± 14.5 at 1 year postoperatively. The overall postoperative mean BMI decreased to 35.5 ± 4.5 kg/m^2 at 6 months and to 32.5 ± 5.1 kg/m^2 at 1 year postoperatively. The overall absolute weight loss was 35.6 ± 10.7 kg at 6 months and 46.4 ± 12.2 kg at 1 year postoperatively. Table 3 shows mean preoperative weight, EBWL%, mean preoperative BMI, and BMI and absolute weight loss at 6 months and 1 year after LSG in both groups.

Among 15 patients with preoperative HTN, in group 1 five of nine (55.5%) and in group 2 four of six (66.7%) patients showed complete resolution of HTN with complete discontinuation of medications by 6 months postoperatively. The mean blood pressure decreased from 131.2 mmHg preoperatively to

110.4 mmHg postoperatively. For patients with DM in group 1 four of eight (50.0%) and in group 2 six of nine (66.7%) patients showed complete cessation of medical treatment with normal fasting blood sugar and HbA1c. The mean preoperative fasting blood sugar and HbA1c were 130.3 mg/dl and 7.4%, which decreased to 87 mg/dl and 5.2%, respectively, postoperatively. There was 80.0 and 100% resolution of obstructive sleep apnea in groups 1 and 2, respectively (Table 4).

Discussion

LSG is increasingly being performed as a potentially stand-alone bariatric operation, performed with some ease laparoscopically. In 2009, the American Society for Metabolic and Bariatric Surgery issued an updated statement on sleeve gastrectomy, accepting LSG as an approved bariatric surgical procedure primarily because of its potential value as a first-stage operation for high-risk patients, with the full realization that successful long-term weight reduction in an individual patient after LSG would obviate the need for a second-stage procedure [13].

LSG may have some advantages compared with other established bariatric procedures. In contrast to laparoscopic adjustable gastric band (LAGB), no foreign material is implanted, avoiding complications such as band migration [14,15]. Compared with a Roux-en-Y gastric bypass or biliopancreatic diversion with duodenal switch, the complete upper GI tract remains accessible to endoscopy after LSG. Furthermore, LSG does not alter absorption of orally administered drugs, which may transpire after Roux-en-Y gastric bypass or biliopancreatic diversion with duodenal switch. After vertical band gastroplasty (VBG), a high rate of reoperation of 14–43% has been reported [16].

LSG is followed by less nutritional deficiencies over the long term compared with gastric bypass or malabsorptive operations. Nevertheless, multivitamin, mineral, and adequate protein supplements are necessary [17].

In a study comparing LSG with LAGB, superior EBWL% was found after 6 months (61 vs. 29%). It was theorized that the resection of the fundus after sleeve gastrectomy reduced a large area of ghrelin-producing stomach. Langer and colleagues found decreased levels of ghrelin in sleeve gastrectomy patients after 1 and 6 months and no change after LAGB. The removal of large hormonally active areas of the stomach may account for the superior results seen after sleeve gastrectomy [18].

Most surgeons use a calibration tube of anywhere between 32 and 60 Fr to measure the size of the retained stomach. There is also the issue of where one should put the stapler, snug with the calibration tube or a little away. Regardless of this, it has been reported that there is similar weight loss, at least early postsurgery, with calibration size between 32 and 44 Fr [9]. It is only when the size reaches 60 Fr that differences appear. Most surgeons report the use of a calibration tube of 30–40-Fr size [19]. Table 5 shows the relation of the size of the bougie and EBWL% in different studies.

In this study, the EBWL% for group 1 (32-Fr bougie) was 53.6 ± 10.96% at 6 months and 69.4 ± 15.6% at 1 year postoperatively. The EBWL% for group 2 (40-Fr bougie) was 52.7 ± 11.27% at 6 months and

Table 3 EBWL%, BMI and absolute weight loss at 6 months and 1 year after LSG

EBWL%, BMI and absolute weight loss	Group 1 (32-Fr bougie)	Group 2 (40-Fr bougie)	*P* value
Mean preoperative weight (kg)	135.6 ± 18.4	136.3 ± 18.6	0.86 (NS)
Mean preoperative BMI (kg/m^2)	47.6 ± 6.1	48.4 ± 5.9	0.28 (NS)
EBWL% at 6 months (%)	53.6 ± 10.96	52.7 ± 11.27	0.7 (NS)
EBWL% at 1 year (%)	69.4 ± 15.6	66.4 ± 13.4	0.45 (NS)
Mean BMI at 6 months (kg/m^2)	35.4 ± 4.4	35.7 ± 4.7	0.67 (NS)
Mean BMI at 1 year (kg/m^2)	32.1 ± 5.2	32.9 ± 4.99	0.56 (NS)
Absolute weight loss at 6 months (kg)	36.1 ± 11.1	35.2 ± 10.3	0.69 (NS)
Absolute weight loss at 1 year (kg)	46.1 ± 12.7	46.7 ± 11.8	0.86 (NS)

EBWL%, excess body weight loss percentage; LSH, laparoscopic sleeve gastrectomy.

Table 4 Resolution of comorbidities after sleeve gastrectomy

Comorbidities	Group 1		Group 2		*P* value	Significance
	Patients	Resolved (%)	Patients	Resolved (%)		
HTN	9	5 (55.5)	6	4 (66.7)	>0.05	NS
DM	8	4 (50.0)	9	6 (66.7)	>0.05	NS
OSA	5	4 (80.0)	3	3 (100.0)	>0.05	NS

DM, diabetes mellitus; HTN, hypertension; OSA, obstructive sleep apnea.

Table 5 Relation of the size of bougie and EBWL% in different studies

References	Size of bougie (Fr)	EBWL% at 6 months (%)	EBWL% at 1 year (%)
Lee *et al.* [20]	32	—	59 ± 17
Baltasar *et al.* [21]	32	56	71
Saul *et al.* [22]	34	47	54
Farías *et al.* [23]	36	107 ± 41	116 ± 38
Sammour *et al.* [24]	36	—	63
Chowbey *et al.* [25]	36	52.3	59.13
Nocca *et al.* [26]	36	48.97	59.45
Prasad *et al.* [27]	36	—	67.5 ± 13.0
Skrekas *et al.* [28]	36	53	67
Lee *et al.* [29]	38	56.7	—
Langer *et al.* [12]	48	46	56
Han *et al.* [30]	48	71.6 ± 21.9	83.3 ± 28.3
Roa *et al.* [31]	52	52.8	—

EBWL%, excess body weight loss percentage.

66.4 ± 13.4% at 1 year postoperatively. There was no statistically significant difference between the two groups as regards EBWL% at 6 months and 1 year postoperatively.

The published literature shows a general trend toward smaller diameters of calibration tubes, as evidence suggests that the volume of the resected stomach correlates with long-term weight loss and that dilation of the gastric sleeve may be a cause of weight regain. It is noteworthy that there are concerns regarding stricture formation when smaller diameter bougies are used to calibrate the sleeve segment. Strictures can contribute to gastric leak and fistula after LSG [9].

A recent systematic review and meta-analysis of 9991 patients who underwent LSG showed otherwise: using greater than 40-Fr calibration may decrease leakage without impacting excess weight loss percentage (EWL%) up to 36 months postoperatively compared with smaller bougies (<40 Fr) [32].

Kasalicky and colleagues reported that a 38-Fr bougie leaves the residual gastric sleeve volume of about 100 ml. Such a volume is sufficient to produce excellent weight loss results, and almost eliminates the possibility of narrowing the sleeve diameter too much. However, the diameter of the sleeve created by some authors on a 32-Fr bougie may actually result in the gastric sleeve diameter being narrower than the diameter of the esophagus. This fact could importantly contribute to gradual development of gastric cardia stenosis [33]. In contrast, the stomach sleeve created on a 40-Fr and larger bougie may lead to sleeve dilation within several years after the operation [9,33,34].

Jacobs and colleagues retrospectively reviewed the data on 247 patients who underwent LSG and they found that there is no significant difference between 46-, 40-, and 36-Fr bougies with respect to weight loss, BMI, or EWL%. Likewise, there is no difference between 7- and 4-cm antral pouches [35].

Spivak *et al.* [36] in their study suggested that using a 42- or 32-Fr bougie does not influence first-year weight loss on LSG or resolution of comorbid conditions. Also Cal *et al.* [37] comparing 27- versus 39-Fr calibration bougies found no significant effect on the size of the resected stomach, morbidity, or weight loss at 1 year after LSG, although a trend was seen toward better weight loss with the smaller bougie. Hawasli *et al.* [38] found that the smaller bougie resulted in a longer hospital stay, with a tendency toward increased nausea, more emergency department visits, and readmissions. Long-term weight loss was not affected.

Gumbs *et al.* [33] in their review of the relevant literature found that among the 646 patients having undergone LSG the mortality rate was 0.6%, with a variety of complications, including reoperation (in 4.5%), leak (in 0.9%), stricture (in 0.7%), bleeding (in 0.3%), pulmonary embolism (in 0.3%), delayed gastric emptying (in 0.3%), intra-abdominal abscess (in 0.1%), wound infection (in 0.1%), splenic injury (in 0.1%), and trocar site hernia (in 0.1%).

In a retrospective review and analysis of 185 consecutive LSGs that had completed at least 6 months of follow-up using a 34-Fr calibrating bougie, Chopra *et al.* [39] reported that mean EWL was 44.76, 55.52, 59.22, and 58.92% at 6, 12, 24, and 36 months, respectively. Perioperative complications occurred in 26 patients (14.05%): four staple-line leaks (2.16%), four bleeds (2.16%), four obstructions (2.16%), five cases of vomiting/dehydration (2.70%), six new onsets of gastro oesphagel reflux disease (GERD) symptoms (3.24%), two cases of pneumonia (1.08%), and one case of pulmonary embolism (0.54%).

In a series published by Han *et al.* [30] on the results of 130 patients who underwent LSG using 48 Fr, five patients had complications. Two patients had major complications: one leakage (0.7%) and one delayed bleeding (0.7%). There were two minor complications (1.5%): one patient developed atelectasis, and the other patient experienced nausea and vomiting for 21 days after surgery. One death occurred 3 weeks after surgery (0.7%); according to the autopsy, no leakage or strangulation was found, but primary peritonitis was diagnosed. One patient (0.7%) was converted to laparotomy due to short gastric artery bleeding.

Lee *et al.* [20] reported the results of 216 patients with an average BMI of 49 kg/m^2 who were undergoing

sleeve gastrectomy using a 32-Fr bougie. A perioperative complication rate of 6.3% was seen; leakage occurred in three patients (1.4%) and a reoperation rate of 2.8% was reported.

In this study, there were neither intraoperative complications nor postoperative mortalities. The overall complication rate was 14.7% (15 patients). There were four patients (3.9%) with major complications: two patients (1.96%) developed postoperative bleeding, one patient developed leakage, and one patient had perisplenic collection. Eleven patients (10.7%) had minor complications: eight patients (7.8%) had port site wound infection, and three patients (2.9%) had postoperative vomiting and dehydration.

There was no statistically significant difference between the two groups as regards the incidence of complications (14% in group 1 vs. 15.4% in group 2; $P > 0.05$) and postoperative hospital stay (2.3 days in group 1 vs. 2.2 days in group 2; $P > 0.05$).

Improvement in comorbidities of obesity, such as HTN and DM, has been reported to occur in the majority of patients, with resolution in 60–100% [1,21,40]. Hady *et al.* [41] demonstrated regression of diabetes at 1-year follow-up in 53.66% of patients who underwent LSG and improvement in 43.34% of patients, which confirmed the effectiveness of LSG in the treatment of diabetes in obese patients with metabolic syndrome. In another study, regression of type 2 diabetes after LSG was seen in 27% of patients 2 months after the surgery and in 63% of patients after 6 months [42].

This study shows 58.8% complete resolution of DM, 60% resolution of HTN, and 87.5% resolution of sleep apnea at 6 months postoperatively.

The report from the American College of Surgeons shows a resolution or improvement of 55% for patients with diabetes, 68% for patients with HTN, and 35% resolution for patients with hyperlipidemia after LSG [43,44].

Conclusion

LSG is a safe and effective operation for treatment of morbid obesity and obesity-related comorbidities with significant short-term weight loss and an acceptable complication rate. Bougie size does not affect short-term outcomes. We need to extend our study to determine the effect of the bougie size on the long-term outcomes.

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Conflicts of interest

There are no conflicts of interest.

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