Comparative study between the complications of laparoscopic sleeve gastrectomy and laparoscopic mini-gastric bypass

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Background
Obesity is considered a preventable worldwide epidemic. It can cause high rates of morbidity and mortality. Laparoscopic sleeve gastrectomy (LSG) and laparoscopic mini-gastric bypass (LMGB) are both safe and effective procedures for the surgical management of morbid obesity. Bleeding and leakage are the most fearful life-threatening complications.
Patient and methods
This prospective study comprised 150 morbidly obese patients. The study was conducted between July 2015 and March 2016, after which there was a follow-up for 12 months among all the patients. The patients were divided equally into two groups: group A comprised LSG patients, whereas group B comprised LMGB patients.
Results
Among the Group A patients, four (5.3%) exhibited complications: hemorrhage (1.3%), gastric leakage (1.3%), and gall-bladder stones (2.6%). In group B, five (6.6%) patients had complications: biliary reflux (1.3%), deep venous thrombosis (1.3%), and gall-bladder stones (3.9%). No mortality occurred in the study.
Conclusion
Both LSG and LMGB are safe and effective procedures. The study found no statistically significant difference between either procedure, in the incidence of complications.

Keywords:
bariatric surgery, leakage, mini-gastric bypass, morbid obesity, sleeve gastrectomy

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Introduction

Obesity is a leading, although preventable, cause of death worldwide, with increasing rates of occurrence in both adults and children. It is one of the most serious public health problems of the 21st century [1]. In 1997, the WHO formally recognized obesity as a global epidemic [2]. In 2013, the American Medical Association classified obesity as a disease [3]. The most important health consequences of obesity include type II diabetes mellitus, osteoarthritis, obstructive sleep apnea, social stigmatization, cancer, cardiovascular disease, nonalcoholic fatty liver disease, and metabolic syndrome [4]. Bariatric surgery is a demonstrably effective and safe technique for the treatment of morbid obesity and obesity-associated comorbidities [5]. Laparoscopic sleeve gastrectomy (LSG), a restrictive form of bariatric surgery, is one of the most popular and effective bariatric operations worldwide [6]. Its complications include hemorrhage, staple-line leak, stricture, obstruction, nutritional deficiencies, gastroesophageal reflux disease (GERD), cholelithiasis, deep venous thrombosis (DVT), and failure of weight loss [7]. Laparoscopic mini-gastric bypass (LMGB) is a mixed restrictive and malabsorptive bariatric surgery. Complications are similar to those of LSG, in addition to anastomosis leakage, marginal ulcers, and chronic alkaline reflux [8]. The aim of the this study is to compare the complications among the LSG group with those among the LMGB group.

Patients and methods

This prospective comparative study was carried out at the Kasr Alainy and Beni Suef University hospitals between July 2015 and March 2016 and ethically approved. The follow-up procedures, among all the patients for 12 months thereafter, ended by March 2017. The cohort included 150 patients, who were divided into two equal groups. Group A included 75 patients who had undergone LSG, and group B included 75 patients who had undergone LMGB. Both groups had the same inclusion criteria: patients with BMI exceeding 40 kg/m^2 or BMI exceeding 35 kg/m^2, with associated comorbidities, such as hypertension, diabetes mellitus,

hyperlipidemia, arthritis, and cardiac disease. Heavy sweet-eaters were included in group B only. The exclusion criteria for both the groups were patients with previous bariatric surgery and previous upper-gastrointestinal surgery – open or laparoscopic. Other criteria included patients with a history of these conditions: laparoscopic cholecystectomy, hiatus hernias, heavy sweet-eating in group A only, drug or alcohol abuse, and psychiatric disorders. Only the patients whose ages were between 18 and 60 years were included in the study. All the patients' medical histories were recorded. Thorough physical examinations were conducted on all of them, to detect any associated comorbidities. The preoperative evaluation of all the patients included the routine laboratory investigations, as well as thyroid profiles. Abdominal ultrasound was done to assess the presence of gall-bladder stones. Chest radiography and pulmonary-function tests were used to detect chest comorbidities. ECG and echocardiography were performed on all the patients. Patients were informed about the possible complications, after which they signed an informed consent.

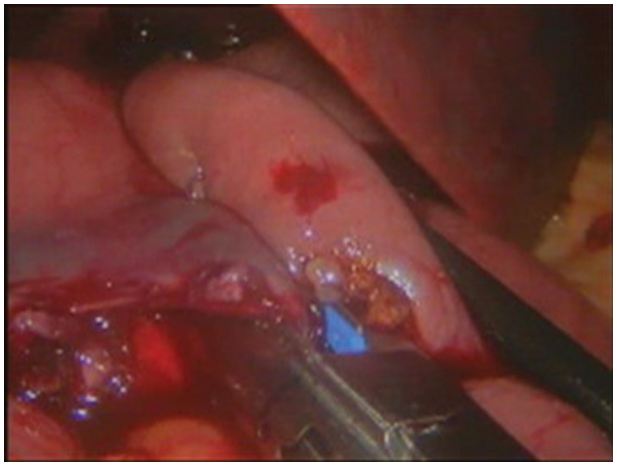
Operative steps of laparoscopic sleeve gastrectomy

The patients were placed in a supine position, with their arms and lower limbs spread apart. They were made to wear above-knee elastic stockings. A dose of 20 mg low-molecular-weight heparin (clexane) was administered subcutaneously as a prophylactic measure against DVT. Gastric decompression was achieved by the insertion of a nasogastric tube. Pneumoperitoneum was achieved using a closed technique that involved placing a Veress needle in the left-subcostal area of the abdomen. In total, five ports were applied as follows: one 10 mm port just below the xiphoid process, for liver retraction; one 10 mm port placed 15–20 cm below the xiphoid process, for a 30° scope; two 12 mm working ports placed in the left and the right mid-clavicular line, in line with the camera port; and one 5 mm port at the left anterior axillary line, a few centimeters below the left costal margin, for assistance. Mobilization of the greater curvature of the stomach was possible, using sealing devices, such as LigaSure (Valleylab a division of Tyco Healthcare Group LP Boulder, Colorado 80301-3299 USA) vessel sealing, 5 mm blunt tip (Covidien; Valleylab a division of Tyco Healthcare Group LP Boulder, Colorado 80301-3299 USA), proximally to the gastroesophageal junction, and, distally, 3 cm proximal to the pylorus. The anesthetist removed the nasogastric tube and inserted an orogastric 40 Fr bougie, extending it till the first part of the duodenum. To divide the stomach, a 60 mm endoscopic gastrointestinal stapler – Endo GIA Universal 12 mm Stapler, Covidien Auto Suture (Covidien) was used. This helped create a gastric tube, extending along the line with the bougie. The staple line was not oversewn. Endoclips were used to control the bleeding points along the staple line. The bougie was drawn proximally up to the gastroesophageal junction, and the pylorus was closed with a grasper. Methylene blue was injected through the bougie, to detect intraoperative leakage. Nelaton drain was applied close to the staple line. The excised part of the stomach was removed through the 12 mm port.

Operative steps of laparoscopic mini-gastric bypass

The position of the patient, prophylaxis against DVT, pneumoperitoneum, and the port sites are similar in both LMGB and LSG. The lesser omentum at incisura is divided at its attachment with the stomach. The stomach is divided transversely, using the Endo GIA 45 mm stapler that has the blue cartilage. The anesthetist passes down the 40 Fr bougie. The Endo GIA 60 mm stapler is used to create, proximally, an upward division of the stomach alongside the bougie. This division of the stomach extends till the gastroesophageal junction, creating a long, narrow, longitudinal gastric pouch. Endoclips are used to control the bleeding points along the staple line. The greater omentum is retracted from left to right, to enable the exact identification of the duodenojejunal junction. The small bowel is run to 200 cm distal to the duodenojejunal junction. The small bowel is then sutured, with the gastric pouch side to side, by vicryl 3/0 sutures, as a prophylactic step to prevent biliary reflux. The bougie is then removed. In the small bowel and in the distal part of the gastric pouch, two adjacent stomas are created. The pouch and the small bowel are anastomosed, using the 45 mm endogastrointestinal stapler (Fig. 1). The bougie is further pushed

Figure 1



The gastrojejunal anastomosis done using end GIA 45 mm stapler

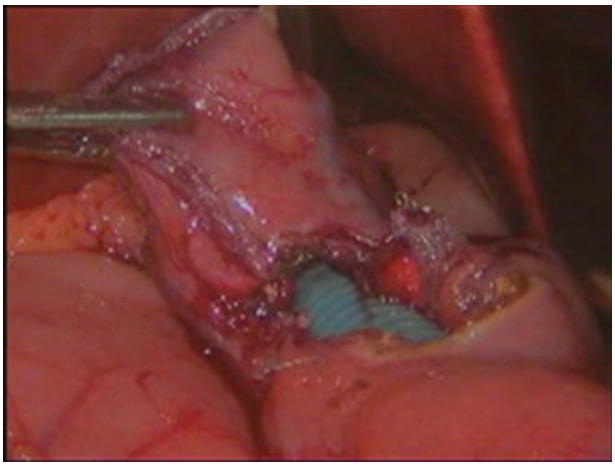
through the gastric pouch to the efferent jejunal limb (Fig. 2). The closure of the anastomotic opening is performed, using vicryl absorbable suture 3/0 in two layers. The bougie is drawn proximally up to the gastroesophageal junction. The afferent and efferent bowel loops are closed with atraumatic graspers. Methylene blue is injected through the bougie to detect intraoperative leakage. Nelaton drain is applied below the anastomosis, near the staple line.

Postoperative care in both groups

Postoperative care included the close monitoring of the vital signs, the urine output, and drains. Intravenous antibiotics, analgesics, proton-pump inhibitors (PPI), and intravenous fluid were administered. Subcutaneous low-molecular-weight heparin was continued. The patient was encouraged to be ambulant a few hours after surgery. Gastrografin meal was done on the next postoperative day, to detect leakage. If the test was negative, the patient was allowed to start oral sugar-free fluids. Uncomplicated cases were discharged after 48 h. Oral PPIs, as well as vitamin supplementations, were prescribed. The patients were instructed to receive the appropriate diet. Physical exercises were started in the second postoperative week. Patients were advised to participate in three sessions of exercise a week, the duration of each session being about 45–60 min.

Follow-up procedures were carried out every 2 weeks in the outpatient clinic, to monitor the weight loss and to highlight complications. All the patients were tested for complete blood count, serum iron, vitamin B_{12}, and serum calcium. They also underwent an abdominal ultrasound, at 6 and 12 months after surgery, to detect gall-bladder stones.

Figure 2



The bougie passing through the anastomosis

Results

This prospective comparative study included 150 morbidly obese patients, divided equally into two groups: group A, being LSG patients, and group B, being LMGB patients. Tables 1 and 2 summarize the demographic and clinical data of the patients in group A and group B, respectively.

Group A: laparoscopic sleeve gastrectomy group

The complications encountered in four patients who underwent LSG, numbered four (5.3%). Of these, two occurred early: one (1.3%) patient developed intraoperative hemorrhage on the first postoperative day, and one (1.3%) patient developed gastric leakage. A year after surgery, two (2.6%) patients developed gall-bladder stones. Table 3 summarizes the different types of complications that occurred in the LSG group.

Hemorrhage occurred in a 28-year-old woman, who had a BMI of 45 kg/m^2, with no associated comorbidity. Bleeding occurred intraoperatively, during the division of the short gastric vessels using a harmonic scalpel. Intraoperative control was difficult, and the patient began to develop tachycardia and

Table 1 Demographic and clinical data of the patients in group A

Number of LSG cases	Women	Men	Age range (years)	Age (mean)	BMI range (kg/m^2)	Comorbidities
75	57	18	18–55	38	35–55	10 (5 with diabetes, 3 with hypertension, and 2 with hyperlipidemia)

LSG, laparoscopic sleeve gastrectomy.

Table 2 Demographic and clinical data of the patients in group B

Number of LGMB patients	Women	Men	Age range (years)	Age (mean/ year)	BMI range (kg/m^2)	Comorbidities
75	39	36	18–53	34.7	35–57	14 (5 with diabetes, 4 with hypertension, 3 with osteoarthritis, and 2 with hyperlipidemia)

LMGB, laparoscopic mini-gastric bypass.

hypotension. Immediate midline laparotomy was done. Splenectomy, together with the under-running of the short gastric vessels, was done. Sleeve gastrectomy was completed, using linear staplers. The patient had a smooth postoperative course, and was discharged 4 days after surgery.

Gastric leakage occurred in a 32-year-old man with a BMI of 48 kg/m^2, with no associated comorbidities. The leakage was discovered on the first postoperative day by routine gastrografin meal, although the intraoperative methylene-blue test had been negative. Exploration was done through a left-subcostal incision, revealing a minor leak at the gastric fundus close to the gastroesophageal junction. Repair and drainage were done. The patient had a smooth postoperative course; the follow-up gastrografin meal revealed no leakage; and the patient was discharged 7 days after surgery.

Gall-bladder stones developed in two (2.6%) patients, 12 months after surgery. Both were women, with BMIs of 45 and 50 kg/m^2, respectively. The diagnosis was made by abdominal ultrasound, during the follow-up period. Both patients had abdominal pain. Laparoscopic cholecystectomy was done.

The laboratory results done during the follow-up period, to detect the nutritional deficiencies, did not reveal any abnormality. No complications, regarding GERD or gastric obstruction, occurred. All the patients achieved their expected weight loss at the expected times, with no incidence of weight-loss failure. No mortality occurred in this group.

Group B: laparoscopic gastric mini-bypass group

Complications were encountered in five (6.6%) patients. Biliary reflux presented in one (1.3%) patient postoperatively, after 1 month. Another patient (1.3%) developed DVT 6 months postoperatively. Of the patients, three (3.9%) developed gall-bladder stones, two of them, 6 months postoperatively, and the third patient, a year after the surgery.

The patient who developed biliary reflux was a woman with BMI 51 kg/m^2. The patient had epigastric pain, nausea, and bilious vomiting. Upper-gastrointestinal endoscopy was diagnostic. Resolution of the condition occurred, with conservative management (bile salt binders and PPI), over 3 months.

Only one (1.3%) patient developed DVT. Her BMI was 50 kg/m^2. The patient complained of pain and swelling in the calf muscles, and the examination revealed tender, swollen calf muscles. The diagnosis was confirmed by venous duplex. The patient started a therapeutic dose of anticoagulant.

Gall-bladder stones occurred in three (3.9%) women, with BMIs of 44, 49, and 51 kg/m^2, respectively. Whereas two of them were asymptomatic, the third presented with right hypochondrial pain. The diagnosis was made by abdominal ultrasound during the follow-up period. Laparoscopic cholecystectomy was done. Table 4 summarizes the different types of complications that occurred in the LMGB group.

The laboratory results, for the tests done during the follow-up period to detect the nutritional deficiencies, did not reveal any abnormality. No complications regarding leakage, bleeding, marginal ulcer, stenosis, or obstruction occurred at the gastrojejunal anastomosis. No weight-loss failure and no mortality occurred in this group. Table 5 and Chart 1 summarize the incidence of complications in both groups.

Table 3 Complications in the laparoscopic sleeve gastrectomy group (*n*=75)

Complications	*N* (%)
Total	4 (5.3)
Hemorrhage	1 (1.3)
Staple-line leakage	1 (1.3)
Gall-bladder stones	2 (2.6)

LSG, laparoscopic sleeve gastrectomy.

Table 4 Complications in the laparoscopic mini-gastric bypass group (*n*=75)

Complications	*N* (%)
Complications	
Total	5 (6.6)
DVT	1 (1.3)
Gall-bladder stones	3 (3.9)
Biliary reflux	1 (1.3)

DVT, deep venous thrombosis; LMGB, laparoscopic mini-gastric bypass.

Table 5 The incidence of complications in both the groups

Complications	LSG Group [*N* (%)]	LGMB Group [*N* (%)]	*P* value*
Total	4 (5.3)	5 (6.6)	1
Hemorrhage	1 (1.3)	0	1
Leakage	1 (1.3)	0	1
Gall-bladder stones	2 (2.6)	3 (3.9)	1
DVT	0	1 (1.3)	1
Biliary reflux	0	1 (1.3)	1

DVT, deep venous thrombosis; LSG, laparoscopic sleeve gastrectomy. *Statistically significant if $P<0.05$.

Discussion

The pandemic of our generation is, undoubtedly, the rise and prevalence of obesity. It is defined as a BMI greater than 30 kg/m^2 [9]. From a global perspective, an estimated 1.48 billion adults are thought to be overweight, of whom 502 million individuals are classified as obese [10]. The LSG was adopted as a primary procedure. Over time, it has become the most popular bariatric operation worldwide. It is effective for weight loss, and results in the improvement, even the resolution, of comorbidities like type-2 diabetes, and has low morbidity and mortality [7]. LMGB surgery is another safe and simple surgical intervention for treating morbid obesity and diabetes mellitus, and is now being performed more frequently [11].

Complications in both procedures include hemorrhage, staple-line leak, stricture, obstruction, nutritional deficiencies, GERD, cholelithiasis, and weight-loss failure. LMGB has additional complications, in the form of marginal ulcer, anastomotic leakage, and chronic alkaline reflux [8]. Compared with LMGB, LSG seems to have a smaller risk of complications, but the potential complications can be as severe as those associated with other techniques. The most feared complications after LSG and LMGB are leakage and hemorrhage [12].

The American Society for Metabolic and Bariatric Surgery Clinical Issues Committee statement quotes an overall complication rate for LSG of 0–24% and a mortality rate of 0.39% [13], whereas the highest overall complication rate in LMGB was 9% [14]. Tables 6 and 7 summarize the incidence of complications after LSG and LMGB, respectively, among different studies as well as this one.

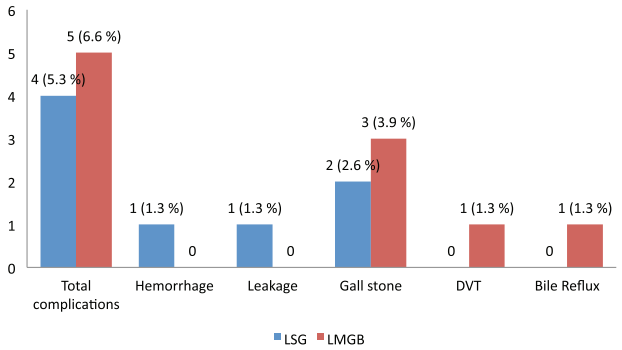
Leakage

Staple-line and anastomotic leakage continues to be the most serious, life-threatening complication, and the most frequent cause of death after bariatric surgery. It ranges from 1 to 3% [25].

Leaks after LSG commonly occur at the gastroesophageal junction [26]. The patho-physiology of staple-line leaks after LSG is unclear. Compromise of blood supply, especially at the angle of His near the crura, stapler-device failure, poor technique, and postoperative gastroparesis – with an intact pylorus causing increasing intragastric pressure – have all been implicated [27]. Patients may present with abdominal pain, tachycardia, nausea and vomiting, abdominal distention, and fever [28]. Reinforcement of the staple line does not reduce the incidence of leakage [26]. The treatment of leakage is challenging: early leaks are usually managed by surgical repair, and delayed leaks, conservatively, by intravenous antibiotics, drainage, and stenting [29].

In this study, one (1.3%) patient suffered from an early gastric leak (first postoperative day) at the gastroesophageal junction, confirmed by the routine gastrografin meal, and it was successfully managed by surgical repair and drainage. Oversewing the staple line is not followed routinely in this practice. Table 8 summarizes the percentage of leakages among the LSG group, in different studies compared with the current one.

Chart 1



The incidence of complications in the laparoscopic sleeve gastrectomy and laparoscopic mini-gastric bypass groups

Table 6 The incidence of complications among laparoscopic sleeve gastrectomy patients in different studies, including the current one

References	Number of patients (complication rate) [*N* (%)]
Cottam *et al.* [15]	126 (14)
Hamoui *et al.* [16]	118 (15)
Frezza [17]	53 (9.4)
Triantafyllidis *et al.* [18]	85 (12.9)
Mittermair *et al.* [19]	153 (8)
Kular *et al.* [20]	118 (46)
Lee *et al.* [21]	519 (1.6)
This study	75 (5.3)

Table 7 The incidence of complications among the laparoscopic mini-gastric bypass group in different studies, including the current one

References	Number of patients (complication rate) [*N* (%)]
Chevallier *et al.* [22]	451 (11)
Noun *et al.* [23]	923 (6.8)
Musella *et al.* [24]	974 (15.5)
Kular *et al.* [20]	1054 (5.9)
Lee *et al.* [21]	519 (9.5)
This study	75 (6.6)

Table 8 Leakage among the laparoscopic sleeve gastrectomy group in different studies, including the current one

References	Number of patients	Leakage [*N* (%)]
Frezza [17]	53	2 (3.7)
Lalor *et al.* [30]	148	1 (0.7)
Mittermair *et al.* [19]	153	3 (1.9)
Kular *et al.* [20]	284	0 (0)
Lee *et al.* [21]	519	6 (1.2)
This study	75	1(1.3)

Leak after LMGB may occur at the excluded stomach, gastric tube, or the gastrojejunal anastomosis, with an incidence of around 1% [24]. No leakage developed among the LMGB patients in this study. Table 9 summarizes the percentage of leakage among the LMGB group in different studies, including the current one.

Hemorrhage

Hemorrhage is one of the most serious and life-threatening complications. The risk of postoperative bleeding has been reported to be between 1 and 6% after LSG. The source of bleeding can be either intraluminal or extraluminal [17].

Bleeding can result from staple-line injuries, trocar-site injuries, splenic injuries, or liver lacerations caused by retractor injuries [16]. Patients present with tachycardia, hypotension, and a drop in serum hemoglobin. Intraluminal bleeding from the staple line usually presents with upper-gastrointestinal bleeding (hematemesis and melena). Intraluminal bleeding is managed by following resuscitative measures, and upper-gastrointestinal endoscopy may be required. Extraluminal bleeding may be managed conservatively; however, surgical re-exploration may be mandated [31].

In the LSG group in this study, one (1.3%) patient developed intraoperative bleeding during the division of the short gastric vessels. The bleeding was managed as described above. In the LMGB group, however, bleeding did not occur. Table 10 demonstrates the incidence of bleeding in LSG in different studies, including the current one.

Cholelithiasis

Rapid weight loss is associated with the formation of cholesterol gallstones, within 6–12 months of the operation [32]. The incidence was around 8.42% in the LSG group, and 12.7% in the LMGB group. The diagnosis is usually made by abdominal ultrasound during the follow-up period [33]. In this study, two patients developed gall-bladder stones after LSG, and three patients after LMGB. Diagnosis was achieved by abdominal ultrasound during the follow-up period. Laparoscopic cholecystectomy was done for all the patients, even the asymptomatic ones in the LMGB group, to prevent any occurrence of calcular obstructive jaundice in the absence of endoscopic access. Table 11 demonstrates cholilithiasis after LSG, compared with LMGB, in different studies, including the current one.

Table 9 Leakage among the laparoscopic mini-gastric bypass group in different studies, including the current one

References	Number of patients	Leakage [*N* (%)]
Noun *et al.* [23]	1000	5 (0.5)
Kular *et al.* [20]	1054	2 (0.2)
Musella *et al.* [24]	974	7 (0.7)
This study	75	0 (0)

Table 10 The incidence of bleeding in laparoscopic sleeve gastrectomy in different studies, including the current one

References	Number of patients	Bleeding [*N* (%)]
Frezza [17]	53	1 (1.8)
Lalor *et al.* [30]	148	1 (0.7)
Mittermair *et al.* [19]	153	5 (3.3)
Kular *et al.* [20]	118	4 (3.3)
Lee *et al.* [21]	519	1 (0.2)
This study	75	1 (1.3)

Table 11 Cholelithiasis after laparoscopic sleeve gastrectomy compared with laparoscopic mini-gastric bypass

	Percentage of gall-stone formation after LSG	Percentage of gall-stone formation after LMGB
Kular *et al.* [20]	10.5	8.3
Mishra *et al.* [33]	8.42	12.7
This study	2.6	3.9

LMGB, laparoscopic mini-gastric bypass; LSG, laparoscopic sleeve gastrectomy.

Biliary reflux

Bile reflux was defined as bilious vomiting and/or documented bile in the esophagus on upper-gastrointestinal endoscopy with the presence of GERD-like symptoms. The incidence of bile reflux has been 1.8% [34]. Kular *et al.* [20] reported 18 (2.0%) cases of bile reflux after LMGB. Conversely, according to authors performing LMGB, biliary reflux has rarely been found, and, if present, it has been symptomatic only in a small number of patients [24]. Patients with mild symptoms are successfully managed conservatively; however, those with severe symptoms are cured by stapling the afferent loop and by a laterolateral jejunojejunostomy [23].

In this study, one (1.3%) patient presented with mild symptoms that were successfully managed, using conservative methods.

Table 12 Deep venous thrombosis in different studies, including the current one

References	Number of patients	Complication rate [*N* (%)]
Kular *et al.* [20]	1054	0 (0)
Musella *et al.* [24]	974	0 (0)
Noun *et al.* [23]	923	1 (0.1)
This study	75	1(1.3)

Deep venous thrombosis

DVT and pulmonary embolism are frightening complications after any major surgery. After bariatric surgery, which is one of the operations for patients with high-risk factors, the risks of these two complications exist. Prophylaxis against DVT is recommended for every patient [35].

In the current study, one (1.3%) patient developed DVT, 6 months after surgery. Her BMI was 44 kg/m^2. The patient complained of pain and swelling in the calf-muscle area, and the examination revealed tender and swollen calf muscles. The diagnosis was confirmed by venous duplex. The patient started a therapeutic dose of anticoagulant. Table 12 summarizes the percentage of DVT among LMGB group in different studies as well as this one.

Nutritional deficiency, weight-loss failure, obstruction, marginal ulcer, GERD, and dumping syndrome were not encountered in the patients in this study.

Mortality

The incidence of mortality after LMGB ranged from 0 to 0.18%; however, it was reported to be about 1.5% after LSG [26,36]. No mortality occurred in this cohort.

Conclusion

LSG and LMGB are both safe and effective procedures for the surgical management of morbid obesity. Bleeding and leakage are the most common and most serious complications in both procedures. The incidence of complications between both procedures is not significantly different.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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