Original research

Long term predictors of success after laparoscopic sleeve gastrectomy


1 Department of Surgery, Mansoura University Hospital, Gihan El Sadat St., Dakahliya, Mansoura, Egypt
2 Hepatobiliary Surgical Department, National Liver Institute, Menoufya University, Egypt
3 Department of Digestive Surgery, TBI, Cairo, Egypt
4 Department of Surgery, Jahra Hospital, Kuwait

A R T I C L E   I N F O

Article history:
Received 26 September 2013
Received in revised form 8 January 2014
Accepted 15 February 2014
Available online 18 February 2014

Keywords:
Morbid obesity
Bougie size
Gastrectomy
Leak

A B S T R A C T

Background: To evaluate early, mid and long term efficacy of laparoscopic sleeve gastrectomy as a definitive management of morbid obesity and to study factors that may predict its success.

Materials and methods: A retrospective study was conducted by reviewing the database of patients who underwent LSG as a definitive bariatric procedure, from April 2005 to March 2013. Univariate and multivariate analysis were performed.

Results: 1395 patients were included in this study. Mean age was 33 years and women:men ratio was 74:26. The mean preoperative BMI was 46 kg/m². Operative time was 113 ± 29 min. Reinforcement of staple line was done only in 447 (32%) cases. 11 (0.79%) cases developed postoperative leak, with total number of complications 72 (5.1%) and 0% mortality. Percentage of excess weight loss (%EWL) was 42%, 53%, 61%, 73%, 67%, 61%, 59% and 57% at 6 months, 1, 2, 3, 4, 5, 6, 7 years. Remission of diabetes (DM), hypertension (HTN) and hyperlipidaemia (HLP) occurred 69%, 54% and 43% respectively.

Conclusion: This study supports safety, effectiveness and durability of LSG as a sole definitive bariatric procedure. Smaller bougie size and shorter distance from pylorus were associated with significant %EWL. Bougie ≤36F remained significant in multivariate analysis.

© 2014 Surgical Associates Ltd. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Laparoscopic sleeve gastrectomy (LSG) was first used as 1st stage of two staged bariatric surgery for those with high surgical risk severely obese patients (BMI ≥ 60 kg/m²). In the past few years, on the basis of several studies, LSG is becoming a sole bariatric procedure due to its effectiveness on weight loss and comorbidities resolution [1-4].

LSG is a restrictive procedure in which up to 80% of the stomach is vertically resected leaving a gastric tube or conduit preserving the vagi and pylorus. LSG is proved to have a weight loss effect within the range between gastric banding and bypass surgery. Moreover, it is a simple procedure with low morbidities and negligible long term nutritional deficiencies [5,6]. We conducted this retrospective study to review our experience with application of LSG as a definitive procedure for morbidly obese patients.

2. Materials and methods

Our study is a retrospective multi-center study through reviewing the database of the morbidly obese patients admitted at our institutions, (Jahra Hospital-Kuwait, King Faisal Hospital- KSA, and Mansoura University Hospital- Egypt) who underwent LSG as a definitive bariatric procedure from April 2005 through March 2013.

Patients with age 18–65 years, BMI >40, or >35 with co-morbidities after failure of many dietetic regimen, acceptable levels of surgical risk, a clear understanding of the surgery and its impact on patient's life were included in the study after having an informed signed consent. We excluded patients with prohibitive surgical risk, indications of lack of compliance with perioperative regimen, uncontrolled alcohol or drug abuse, uncontrolled depression or other mental disorders, and lack of family support or significant discord within the family about the planned surgery.
Each patient underwent a complete history and physical examination to assess the co-morbidities. Diagnostic workup includes gastroscopy, abdominal ultrasonography, X-ray chest film, electrocardiogram, complete blood count, coagulation profile, thyroid profile, electrolytes, blood urea nitrogen (BUN), creatinine, and evaluations of liver functions and lipid levels. Consultation with cardiologists, pulmonologists and anesthetists was done. Patients received one injection of 1st generation cephalosporin during induction and deep vein thrombosis prophylaxis (DVT) in the form of enoxaparin and elastic stockings.

3. Surgical technique

The greater curve was devascularized using Harmonic scalpel or LigaSure devices going up to angle of Hiss. Distance proximal from the pylorus to the 1st staple firing was formally measured by a ruler or a length of suture, (2—4 cm in 586 and 5—7 cm in 809 patients). A conduit of stomach was tailored over the pylorus to the 1st staple using endo GIA linear staplers starting with 1—2 green cartridges at the antrum and 2—4 blue ones at the body and the fundus.

At the early stage of study, the staple line was reinforced (447 cases) to prevent leakage and bleeding. Running stitch reinforcement was used in 307 cases starting from gastroesophageal junction downward and bovine pericardium (Peri-strips Dry [PSD]) reinforcement was used in 140 cases. In the remaining cases we stopped using reinforcement. Integrity of the staple line was checked intraoperatively by injecting a methylene blue before going to remove the bougie. Redivac drain (in 319 cases) was left at the body and the fundus.

At the early stage of study, the staple line was reinforced (447 cases) to prevent leakage and bleeding. Running stitch reinforcement was used in 307 cases starting from gastroesophageal junction downward and bovine pericardium (Peri-strips Dry [PSD]) reinforcement was used in 140 cases. In the remaining cases we stopped using reinforcement. Integrity of the staple line was checked intraoperatively by injecting a methylene blue before going to remove the bougie. Redivac drain (in 319 cases) was left at the body and the fundus.

79 (5.6%) patients had concomitant cholecystectomy for symptomatic gall bladder stones, and 59 patients had hiatal hernia (stitching both diaphragmatic cura by means of 2 or 3 non-absorbable stitches leaving at least 1 cm space for the esophagus with a bougie inside to avoid postoperative dysphagia), and 56 patients with umbilical hernia had suture repair by the conventional approach.

On the 1st postoperative day (POD), leakage was further checked by gastrografin meal study, then patients were encouraged to start oral fluid for 4 days and progress to semi-solid for further 3 weeks then solid foods were allowed after the 4th week, according to the dietician instructions. Anticoagulant was continued while staying in hospital and at home for 2 weeks till he/ she is full ambulant. Patients were discharged if they were going well and advised to take multivitamins and proton pump inhibitor for one month and when needed thereafter.

The 1st follow up visit was one week later to check wounds and any complications. Multivitamins and calcium supplementations were prescribed for all patients. Ursidiol 300 mg twice daily was prescribed as a gall stone prophylaxis for 6 months to patients with intact bladder. Next follow up visits were scheduled every 3 months in the 1st year, every 6 months in the 2nd year, and yearly thereafter. Laboratory investigations for protein, mineral and vitamin deficiency was done yearly. Mean follow up duration was 76 ± 19 (range: 6—103) months.

Patients’ data were collected into a data sheet for statistical purpose including clinical, radiologic, laboratory, operative and postoperative findings.

3.1. Statistical analysis

The statistical analysis of the data in this study was done using the SPSS version 10. For continuous variables, descriptive statistics were calculated and were reported as mean ± SD. Categorical variables were described using frequency distributions. The Student’s t- test for paired samples was used to detect differences in the means of numerical variables, Chi-square test or Fisher’s exact test (when necessary) was used for qualitative variables. P values >0.05 were considered to be significant. Significant variables were entered into a logistic regression model to determine independent significant variables. They were expressed as odds ratios (OR) with their 95% CI.

4. Results

1419 patients underwent LSG as a definitive bariatric procedure at our institutes. 1395 patients were included in this study as 24 patients were lost for follow up. 1395 (100%) patients were followed up for 6 months, 1339 (96%) patients for 1 year, 1156 (83%) for 2 years, 1089 (78%) patients for 3 years, 983 (70%) patients for 4 years, 859 (62%) patients for 5 years, 731 (53%) patients for 6 year, 519 (37%) patients for 7 years, and 307 (22%) patients for 8 years (Fig. 1). Mean age was 33 ± 7 (range: 18—65) years and women:men ratio was 74:26. BMI was 46 ± 9 (range: 40—70) kg/m², with mean body weight 109 ± 25 (range: 100—178) kg. Diabetes mellitus (DM) was found in 41%, hypertension (HTN) in 57%, obstructive sleep apnea syndrome (OSAS) in 22%, degenerative joint disease (DJD) in 32%, and hyperlipidemia (HLP) in 43% patients. All operations were completed laparoscopically with mean operative time 113 ± 29 (range: 79—139) minutes. Time to resume oral intake was1.7 ± 0.8 (range: 0.9—2.9) days, and hospital stay was 3.9 ± 1.7 (2.1—25) days (Table 1).

Co-morbidities were assessed every follow up visit and improvement was considered if the dosage of medication were reduced or patient needed fewer drugs to control his/her disease. Resolution of disease was considered if patient is no longer requiring medication. At 3 years, DM, HTN, OSAS, DJD, and HLP were remitted in 69%, 54%, 51%, 61% and 43% respectively.

5. Intraoperative complications

Bleeding from short gastric vessels at the upper pole of spleen occurred in 3 patients that was solved laparoscopically and spleen was preserved. 35 patients had bleeding at the staple line that was controlled sufficiently by endo-clips or reinforcing stitches. One patient had left liver lobe injury during introduction of the
epigastric port which stopped after compression by the Nathan-
son’s retractor. 28 patients showed intraoperative staple line leak
diagnosed by methylene blue that was treated by over-sewn
stitches.

6. Postoperative complications

72 (5.1%) cases had complications with 0% mortality. 11 (0.78%)
patients had leak; all of them had leakage from gastroesophageal
junction. 6 patients had acute leak (within 7 days of the primary
procedure). Five of them were treated by relaparoscopy, re-suture
of the staple line, abdominal lavage, and abdominal drains. The
6th patient had leakage that was diagnosed on the 4th POD with
signs of sepsis despite of the initial gastrograftin study was nega-
tive. Re-laparoscopy and thorough peritoneal lavage was done with
stitching of the site of leakage and intraoperative methylene blue
test was negative. 2 days later, drain showed evidence of leakage.
An intraluminal wallstent was inserted endoscopically. The pa-
tient’s general condition started to improve finally and was dis-
charged home 25 days later.

Four cases with early leak (1–6 weeks of the primary procedure)
were managed successfully with endoscopic wallstent and percu-
taneous drainage. The 11th patient had late leak (after 6 weeks of
the primary procedure). This patient was managed by endoscopic
wallstent and percutaneous drainage. Gastrografin study on the
5th day showed leakage which was unsuccessfully treated by one
more stent at the same day. His problem has been finished by
gastroscopy and oesophagoj-enostomy.

35 patients had repeated admissions for vomiting, nausea, and
dehydration. 13 patients were readmitted with persistent vomiting,
nausea, and dehydration, upper endoscopy and contrast study
revealed no pathology. They improved on intravenous fluid (IVF)
and were discharged home. 5 patients had more readmissions with
3–5 months interval with the same picture. Repeated endoscopy
revealed ulcer on the staple line and they were kept on proton
inhibitor for 3 months with resolution of their symptoms. 6 pa-
tients had repeated admissions with the same picture and every
time they underwent investigations which always came normal.
They were improved on oral domperidone suggesting that the
underlying cause was gastric dysmotility. Upper gastrointestinal
contrast study showed narrowing at the site of incisura in 4 pa-
tients which was treated by 2–3 sets of endoscopic dilatation.
The other 7 cases were diagnosed by endoscopy as severe reflux disease
and they were treated by proton pump inhibitor.

Total number of patients developed de novo GERD after sleeve
 gastrectomy was 159 (11.4%) patients during the 1st year. These
declined significantly to 29 (2%) after 4 years of follow up. They
need proton pump inhibitor for long period to treat their severe
reflux symptoms.

Five patients had pulmonary embolism. They were treated
successfully by anticoagulant. Seven patients had pneumonia and
were treated medically. Another 9 patients had retrieval wound
infection which was treated medically. Five patients had retrieval
port-site hernia and were managed by mesh hernioplasty 6 months
later.

7. Weight loss results

Postoperative BMI was 41 ± 9, 39 ± 7.2, 36 ± 6.6, 33 ± 5.6,
29 ± 4.7, 30 ± 5.9, 31 ± 6 and 31 ± 7.2, and percentage of excess
weight loss (%EWL) was 42%, 53%, 61%, 73%, 67%, 61%, 59% and 57%
at 6 months, 17 years, respectively. 37 patients showed inadequate
weight loss (<30–50% of %EWL at least 2 years out) or significant
weight regain that necessitate revisional surgery (laparoscopic
re-sleeve was done in 19 patients, laparoscopic banding in 13 pa-
tients, and laparoscopic gastric bypass in 5 patients) (see Table 2).

We found relationship between some technical points and weight
loss result. When stratifying the weight loss outcome (%
EWL) by bougie size (≤36 versus ≥44Fr) and distance form pylorus,
we found that the bougie size of ≤36 Fr and shorter distance
from pylorus did not result in significantly greater %EWL in the
early postoperative period up to the 3rd year (47,56,62,69 Vs
39,51,59,64; P > 0.5) (43,55,61,67, Vs 39,48,60,58; P > 0.5
respectively) (Tables 3, 4). However, univariate analysis demonstrated that
those with smaller bougie and shorter distance from pylorus
maintained weight loss in the long term (71,74,67,63 Vs 57,53,51,50
with P = 0.001)(71,73,72,69 Vs 56,53,51,50; P = 0.001) respectively.
Big sizing Bougie and longer distance from pylorus result in greater
weight regain in the long term, 29 (3.5%) Vs 8 (1.4%); P = 0.001.
These significant variables identified in univariate analysis were
further analyzed in multivariate analysis. Smaller bougie (≤36Fr)
remained independent significant long term pridctors of success
for weight loss and weight regain in the multivariate analysis
(Table 5).

Reinfornement of staple line was done only in 447 (32%) cases
for fear of leakage and bleeding complications. We had 0.67% (3 out
of 447) leakage rate in the patient with reinforcement versus to
0.84% (8 out of 948) in the patients without reinforcement sug-
gest that reinforcement of the staple line has no value (Table 6).
Neither the distance of the first stapler from the pylorus nor the
 caliber of the bougie was related to postoperative complications
(Tables 3 and 4).

56 (4%) patients underwent revision surgery, 37 patients were
revised for insufficient weight loss and/or weight regain (<50 %
EWL) and severe reflux symptoms (n = 19). Resleeve was done in 19
patients, laparoscopic banding in 13 patients, and laparoscopic
gastric bypass in 24 patients (for weight loss, n = 5 and GERD,
n = 19). All were successful laparoscopically with minimal complica-
tions. The mean interval between the two procedures was
almost 32 months.

Histology of the resected segment was normal in 429 (30.7%).
Chronic follicular gastritis was present in 407 (29.2%), chronic non-
specific gastritis in 350 (25.1%), and chronic lymphoid gastritis in 81
(5.8%). Helicobacter Pylori was found in 128 (9.2%).

8. Discussion

After Gagner has performed LSG in 1999 as a 1st stage in super-
obese persons, several papers were published confirming the good
results of this procedure. At present, LSG is well accepted as a
definitive bariatric procedure with low morbidities and acceptable
weight loss results. Before we started this operation in 2005, there
were 2 bariatric operations available for our patients (gastric
banding and gastric bypass). Thereafter, it became the default
procedure offered to our patients. Most of our patients were in the
3rd decade, women were nearly triple number of men (74:26). The

Table 1
Patients’ characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N = 1395</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33 ± 7 (range: 18–65 years)</td>
</tr>
<tr>
<td>Sex (Women:Men %)</td>
<td>74:26</td>
</tr>
<tr>
<td>Preoperative BMI (kg/m²)</td>
<td>46 ± 9 (range: 40–70 kg/m²)</td>
</tr>
<tr>
<td>Preoperative Weight (kg)</td>
<td>109 ± 25 (range: 100–178 kg)</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>113 ± 29 (range: 79–139 minutes)</td>
</tr>
<tr>
<td>Oral intake (days)</td>
<td>1.7 ± 0.8 (range: 0.9–2.9 days)</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>3.9 ± 1.7 (2.1–35 days)</td>
</tr>
<tr>
<td>Follow up (months)</td>
<td>46 ± 19 (range: 6–103) months</td>
</tr>
</tbody>
</table>

BMI body mass index.
Percentage of excess weight loss (%EWL), GERD, gastroesophageal reflux. 

Table 2
Weight loss result.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Postop. BMI (Kg/m²)</th>
<th>% EWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
<td>41 ± 9</td>
<td>42%</td>
</tr>
<tr>
<td>1 year</td>
<td>39 ± 7.2</td>
<td>53%</td>
</tr>
<tr>
<td>2 years</td>
<td>36 ± 6.6</td>
<td>61%</td>
</tr>
<tr>
<td>3 years</td>
<td>33 ± 5.6</td>
<td>73%</td>
</tr>
<tr>
<td>4 years</td>
<td>29 ± 4.7</td>
<td>67%</td>
</tr>
<tr>
<td>5 years</td>
<td>30 ± 5.9</td>
<td>61%</td>
</tr>
<tr>
<td>6 years</td>
<td>31 ± 6</td>
<td>59%</td>
</tr>
<tr>
<td>7 years</td>
<td>31 ± 7.2</td>
<td>57%</td>
</tr>
</tbody>
</table>

Percentage of excess weight loss (%EWL).

Table 3
Value of caliber of the bougie.

<table>
<thead>
<tr>
<th>Variable</th>
<th>≤ 36 Fr 837 (60%)</th>
<th>≥44 Fr. 558 (40%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWL % at 6 m</td>
<td>47 ± 19</td>
<td>39 ± 14</td>
<td>0.3</td>
</tr>
<tr>
<td>EWL % at 1 year</td>
<td>56 ± 19.7</td>
<td>51 ± 19</td>
<td>0.3</td>
</tr>
<tr>
<td>EWL % at 2 years</td>
<td>62 ± 17</td>
<td>59 ± 23</td>
<td>0.8</td>
</tr>
<tr>
<td>EWL % at 3 years</td>
<td>69 ± 25</td>
<td>64 ± 25</td>
<td>0.34</td>
</tr>
<tr>
<td>EWL % at 4 years</td>
<td>71 ± 27</td>
<td>57 ± 25</td>
<td>0.001</td>
</tr>
<tr>
<td>EWL % at 5 years</td>
<td>74 ± 29</td>
<td>53 ± 21</td>
<td>0.001</td>
</tr>
<tr>
<td>EWL % at 6 years</td>
<td>67 ± 28</td>
<td>51 ± 19</td>
<td>0.001</td>
</tr>
<tr>
<td>EWL % at 7 years</td>
<td>63 ± 21</td>
<td>50 ± 17</td>
<td>0.001</td>
</tr>
<tr>
<td>Weight regain</td>
<td>29 (3.5%)</td>
<td>8 (1.4%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Complications</td>
<td>45 (5.3%)</td>
<td>27 (4.83%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Leak</td>
<td>7 (0.83%)</td>
<td>4 (0.71%)</td>
<td>0.26</td>
</tr>
<tr>
<td>GERD</td>
<td>98 (11.7%)</td>
<td>68 (12.1%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Vomiting</td>
<td>21 (2.5%)</td>
<td>14 (2.5%)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Percentage of excess weight loss (%EWL), GERD, gastroesophageal reflux.

average BMI of our patients was 40–70 kg/m² with 179 patients above 50.

GERD symptoms appeared immediately in the majority of patients which can be explained by alteration of the natural anti-reflux mechanisms such as angle of His and phrenoesophageal membrane. Himpens et al. [6] found incidence of 21.8% of patients had GERD symptoms at 1 year follow up compared to 3.1% at 3 year, suggesting that GERD would be a temporary problem after LSG. In our study, 11.4% patients had reflux symptoms at 1 year follow up, which decreased progressively till reach 2% at 4 years. Conversion from LSG to gastric bypass was necessary in 19 (1.4%) of our patients due to persistence of reflux symptoms after a mean interval of 32 months following LSG. Crookes [7] reported conversion from LSG to bypass surgery with complete resolution of symptoms in 11 patients who had persistent GERD symptoms.

Incidence of leakage in the literature is between 0% and 5.7% [8–10], with high rate reported by Stroh et al. [11] in their nationwide survey in Germany. They showed leakage rate of 7%, with total complication rate 14% and mortality rate 1.6%. They even concluded that LSG is not a safe procedure unlike others have reported. In our series, 11 (0.78%) had leakage. We had 0.67% (3 out of 447) leakage rate in the patients with reinforcement versus to 0.84% (8 out of 948) in the patients without reinforcement suggesting that reinforcement of staple line is of no value. The same result was reported by others [12,13]. On the opposite, Ser et al. [14] found that staple-line reinforcement is strongly recommended for laparoscopic sleeve gastrectomy to decrease complications. We also found that there was no association between reinforcement and bleeding complication.

The most common site for post-sleeve leakage is the gastroesophageal junction. Increased intra-luminal pressure due to decreased stomach compliance after resection of the fundus is the most accepted explanation. The other reported site for leakage is the antrum with different explanation that the increased gastric wall thickness at that region (mean 3.1 mm) could have compromised the full closure of the staples, even the longest available ones (green) [15].

Bellanger and Greenway believe that there are two main tenets to adopt in order to minimize leaks. First, and of utmost importance, is to avoid creating a physiologic stricture at the incisura angularis, and second, avoid stapling too close to the esophagus in the area of the cardia [16]. In addition, we advocate longer time for compression of the gastric tissue with the stapling device, thus promoting proper staple formation and reducing both serosal trauma and bleeding.

Majority of our patients did not require a second stage operation because they had satisfactory results with their LSG surgery regarding the weight loss effect and improvement or resolution of their co-morbidities, in addition to the negligible nutritional complications they had. During the follow up period, 29 (2%) patients who had persistent GERD symptoms after a mean interval of 32 months following LSG to bypass surgery with complete resolution of symptoms in 11 patients who had persistent GERD symptoms.

Table 4
Value of distance from the pylorus.

<table>
<thead>
<tr>
<th>Variable</th>
<th>2–4 cm S86 (42%)</th>
<th>5–7 cm S809 (58%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>%EWL at 6 m</td>
<td>43 ± 19</td>
<td>39 ± 14</td>
<td>0.47</td>
</tr>
<tr>
<td>%EWL at 1 year</td>
<td>55 ± 19.7</td>
<td>48 ± 16</td>
<td>0.35</td>
</tr>
<tr>
<td>%EWL at 2 years</td>
<td>61 ± 17</td>
<td>60 ± 19</td>
<td>0.57</td>
</tr>
<tr>
<td>%EWL at 3 years</td>
<td>67 ± 23</td>
<td>58 ± 21</td>
<td>0.35</td>
</tr>
<tr>
<td>%EWL at 4 years</td>
<td>71 ± 19</td>
<td>56 ± 25</td>
<td>0.001</td>
</tr>
<tr>
<td>%EWL at 5 years</td>
<td>73 ± 27</td>
<td>53 ± 23</td>
<td>0.001</td>
</tr>
<tr>
<td>%EWL at 6 years</td>
<td>72 ± 21</td>
<td>51 ± 17</td>
<td>0.001</td>
</tr>
<tr>
<td>%EWL at 7 years</td>
<td>69 ± 19</td>
<td>50 ± 18</td>
<td>0.001</td>
</tr>
<tr>
<td>Weight regain</td>
<td>9 (0.8%)</td>
<td>28 (3.5%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Complications</td>
<td>27 (4.6%)</td>
<td>45 (5.5%)</td>
<td>0.65</td>
</tr>
<tr>
<td>Leak</td>
<td>5 (0.85%)</td>
<td>6 (0.74%)</td>
<td>0.18</td>
</tr>
<tr>
<td>GERD</td>
<td>68 (11.6%)</td>
<td>91 (11.2%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Vomiting</td>
<td>14 (2.38%)</td>
<td>21 (2.59%)</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Percentage of excess weight loss (%EWL), GERD, gastroesophageal reflux.

Table 5
Multivariate analysis of significant variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>%EWL at 4 years</th>
<th>%EWL at 5 years</th>
<th>%EWL at 6 years</th>
<th>%EWL at 7 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Distance from pylorus</td>
<td>15.17</td>
<td>9.103–31.349</td>
<td>0.271</td>
<td></td>
</tr>
<tr>
<td>- Caliber of bougie</td>
<td>23.45</td>
<td>14.291–53.923</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>- Distance from pylorus</td>
<td>19.23</td>
<td>12.135–34.239</td>
<td>0.372</td>
<td></td>
</tr>
<tr>
<td>- Caliber of bougie</td>
<td>27.29</td>
<td>15.984–41.274</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 6
Value of suture line reinforcement.

<table>
<thead>
<tr>
<th>Variable</th>
<th>With 447 (32%)</th>
<th>Without 948 (68%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time</td>
<td>135 ± 23 min.</td>
<td>91 ± 17 min.</td>
<td>0.001</td>
</tr>
<tr>
<td>Postop. morb.</td>
<td>21 (4.7%)</td>
<td>51 (5.4%)</td>
<td>0.37</td>
</tr>
<tr>
<td>Leak</td>
<td>3 (0.67%)</td>
<td>8 (0.84%)</td>
<td>0.83</td>
</tr>
<tr>
<td>Luminal hge</td>
<td>0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>Staple line hge</td>
<td>9 (2%)</td>
<td>26 (2.7%)</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Postop. postoperative; morb., morbidity; hge, hemorrhage.
developed vitamin B12 deficiency and were corrected by injectable supplement. Level of vitamin D, folate, and calcium remained within their normal range. Deficiency of vitamin B12 after LSG may be explained by inadequate vitamin B12 uptake due to the lower production of hydrochloric acid which is important to release bound vitamin B12 in food [17]. Prasad et al. reported 2.7% patients with deficient vitamin B12 level after LSG [18].

In terms of weight loss, we reported excellent responses. 37 (2.6%) patients required a second operation due to insufficient weight loss and/or weight regain. Our results are comparable to other reports [14,19–21]. We found relationship between some technical points and the weight loss results. Close distance of the staple line to the pylorus and application of a thinner bougie during the calibration of the stomach tube were significantly related to the %EWL in the long term (P = 0.001) without significant difference regarding the postoperative complications. Gagner et al., on the contrary, reported an inverse relationship between bougie size and leak rate and recommended a bougie size between 50 and 60 French to minimize this complication [22].

In comparison to the overall published mortality associated to laparoscopic gastric bypass (LRYGB) of 0.5% or bilio-pancreatic diversion (BPD) of 1.1%, we observed a 0% mortality rate among 1395 patients who underwent laparoscopic sleeve gastrectomy. This reflects the high safety of this procedure. Complication rate (5.1%) was also lower than the overall published complication rate following LRYGB or BPD (10–20%) [22–24].

Points of strength of the present study include the relatively large number of patients it involves, multicenter, and its long follow up period. Despite these study's strength points, its major limitations was the characteristic of retrospective studies as it lacks the capability of randomization and precise categorization of patients regarding how precisely far from the pylorus and also how big should be the bougie size which were the main study factors. We recommend for a prospective randomized study with the same strength points of the present study to answer these puzzled questions.

9. Conclusion

LSG is safe and effective as a sole definitive bariatric procedure with less complication rate and no mortality. It is effective for co-morbidities resolution. We noticed no significant benefit from the staple line reinforcement. Close application of the staple line to the pylorus and calibration of the gastric tube around bougie <36 Fr were significantly correlated to the good results of %EWL, without significant difference regarding the postoperative complications. Further prospective studies are necessary to confirm these findings.

Conflict of interest

Drs. Mohamed Abd Ellatif, Ayman Elezabzy, Asaad Fayrouz, Mahmoud Wahby, Mohamed Aboushayb, Emad Abdallah, Amro El Hadidi, Waleed Thabet, Waleed Askar, Ahmed Moatamed, Ashraf Abbas and Ibrahim Dawoud have no conflicts of interest or financial ties to disclose.

References