Severity assessment of gastroesophageal reflux disease symptoms before and after sleeve gastrectomy

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Background
The effect of laparoscopic sleeve gastrectomy (LSG) on gastroesophageal reflux disease (GERD) has been a controversial issue. Studies on this aspect are limited, and most of the published studies are not conclusive. Therefore, a prospective study was designed for further assessment of the problem. The objective of this study was to assess the effect of LSG on GERD symptoms using a questionnaire.
Patients and methods
Thirty morbidly obese patients undergoing LSG were assessed for GERD severity using the Carlsson-Dent Questionnaire (CDQ) before and after surgery at monthly intervals for 3 months postoperatively.
Results
The mean preoperative weight and BMI were 131.7 kg and 46.76 kg/m^2, respectively. The mean percent excess weight loss was 10.8% at 1 month, 18.8% at 2 months, and 25.5% at 3 months. Postoperative CDQ scores had exhibited a highly significant decline at different times of measurement, and its percentage of change values was –19.07 ± 33.61, –56.39 ± 44.13, and –70.60 ± 46.31 at 1, 2, and 3 months, respectively. There was no significant correlation comparing either CDQ score or CDQ score percent of change with weight and BMI change at 1, 2, and 3 months postoperatively. However, a correlation study was done between CDQ scores at 1, 2, and 3 months with the other studied parameters, and it declared the presence of a significant positive correlation between CDQ score % of change after 2 months and fasting blood sugar (P=0.020) and albumin (P=0.004).
Conclusion
There is an improvement in GERD as assessed by the symptom questionnaire (CDQ) in morbidly obese patients after LSG. Accordingly, the presence of GERD should not be considered a contraindication for sleeve gastrectomy. However, it remains a crucial debate and needs objective evaluation and long-term follow-up.

Keywords:
gastroesophageal reflux disease, laparoscopic sleeve gastrectomy, morbid obesity

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Introduction

In the developed world, obesity is one of the most prevalent medical conditions. It is a medical condition in which excess body fat has accumulated to the point where it may have adverse health effects [1]. People are considered morbidly obese when their BMI is greater than or equal to 40 kg/m^2. These patients are nearly constantly accompanied by pathological alteration of specific metabolic and hormonal pathways, thus resulting in various comorbid disorders [2]. Gastroesophageal reflux disease (GERD) is a common complication that affects the general health of morbidly obese patients. Its development with progressively rising BMI is multifactorial. It may be attributed to several mechanisms affecting the dynamics of the cardia, including accumulation of visceral fat at the gastroesophageal junction, increased accumulation of hormones (e.g. estrogen) in somatic fat, increased intragastric pressure due to increased intra-abdominal pressure, and the potential of presence of concomitant hiatus hernia [3]. Although most of the common metabolic comorbid conditions that often accompany morbid obesity are shown to improve significantly after bariatric surgeries, little is still established regarding the effect of these procedures on GERD [4].

Laparoscopic sleeve gastrectomy (LSG) has become one of the most relevant and popular weight loss procedures for morbidly obese patients. Its relative simplicity, reproducibility, high success rate, low relapse rate, and reduced morbidity/mortality rates have contributed to its ongoing validation [5]. However, comorbid conditions, including GERD,

hiatus hernia, reflux esophagitis, and Barret's esophagus, play a significant role in selecting the most suitable surgical procedure for each patient to ensure the best short-term and long-term outcome [6]. Reviewing literature revealed no consensus on the exact correlation between LSG and GERD on both short-term and long-term assessment protocols and whether it is improving, deteriorating, or must be a contraindication for surgery [7]. Furthermore, there is evidence that GERD may develop as a de novo postoperative consequence [8]. In view of such debate, this study shall be conducted for the purpose of clarifying the actual effect of weight reduction surgery in the morbidly obese, namely, LSG, on one of the common complications of obesity, that is GERD. The present work would potentially aid in solving this crucial problem.

Aim and objectives

Using a scientifically validated questionnaire, the primary objective of this study was to examine the efficacy of LSG on the severity of pre-existing GERD symptoms in morbidly obese patients. This is in order to settle down more reliable, evidence-based data about the fate of this comorbidity postsurgically in the future.

Patients and methods

Patients

This is a cross-over study conducted at Helwan University hospital on 30 morbidly obese patients (BMI≥35) admitted to the General Surgery Department throughout 6 months, from April to November 2021, who complained of GERD and were subjected to LSG. Helwan's University Ethical Committee approved the protocol of this study. Inclusion criteria entailed patients aged between 25 and 60 years with no sex predilection and heartburn of 6 months or longer. Exclusion criteria included hypothyroidism, Cushing syndrome, previous bariatric surgery, upper endoscopy showing hiatal hernia or erosive esophagitis, cardiac achalasia, and any comorbidity that contraindicates general anesthesia and/or surgery. Each patient in the study signed an informed consent upon his/her agreement to participate in the study.

Data collected

Careful history was taken from all patients, emphasizing weight gain progress through fulfilling the pre-weight loss surgery (WLS) evaluation form (Form 1). Preoperative laboratory investigations, chest radiograph, abdominal ultrasound, and ECG were performed on all patients participating in the study.

Assessments

The patient's GERD assessment was done preoperatively by answering the Carlsson-Dent Questionnaire (CDQ) [9] (Form 2). Assessment of patients' reflux symptoms was re-evaluated three times postoperatively by submitting the same questionnaire to the patients and calculating the CDQ score at 1-month intervals for 3 months. Statistical comparison between preoperative and postoperative data was done to manifest the presence or absence of significant differences in variables studied. The primary outcomes were the percentage of excess weight loss and the improvement or resolution of comorbidities, for example, GERD. The percentage of excess weight loss was determined as follows: (preoperative weight minus follow-up weight)/preoperative excess weight multiplied by 100. After surgery, the resolution of GERD was determined by the CDQ score, with improvement defined as a score reduction of at least 25%. Consideration was given to comorbidity resolution if the disease could be managed without medication.

Operative technique

A single surgeon operated using general anesthesia. The patient's position was French. The patient was placed in a forced anti-Trendelenburg position on the operating table, with the surgeon positioned between the patient's legs. Under direct vision, the abdomen was entered using an Excel 12-mm optical trocar (Ethicon US, llc, Newjersy, USA) ~20 cm below the xiphoid process and 3 cm to the left of the midline. With 15 mmHg of carbon dioxide, pneumoperitoneum was achieved. Four additional ports were placed within the visual range. The procedure began with the devascularization of the stomach's greater curvature using a harmonic scalpel (Ultracision; Ethicon Endo-Surgery Inc., Johnson & Johnson). After reaching the gastroesophageal junction, the dissection was continued. To avoid leaving a posterior pouch when constructing the sleeve in this region, all attachments to the left cru were completely severed. The stomach and pancreas' posterior attachments were then divided. The stomach was then tabularized over a 36-Fr calibration tube, beginning 6 cm proximal to the pylorus, using a linear stapler (Echelon 60; Ethicon Endo-Surgery Inc., Johnson & Johnson, Ethicon US, llc, Newjersy, USA). We perform a running suture all over the staple line. The stomach was then removed through a 12-mm left midclavicular port after being transected. Methylene blue was used to test the water-tightness of the staple line.

After surgery

Ambulation and clear liquids were initiated the night before surgery. Thrombosis prophylaxis (enoxaparin

40 mg once daily) was administered beginning on the first postoperative day and continuing for 2 weeks. An inhibitor of the proton pump was administered for 4 months after surgery. Patients are evaluated as outpatients 2 weeks after surgery and then once per month. Patients who developed symptoms between their follow-up visits were also seen at the outpatient clinic. A low-calorie, protein-rich liquid diet is maintained for the first month, after which other elements are introduced sequentially under the strict supervision of a dietitian, and multivitamins and vitamin D3 are prescribed routinely. Patients are encouraged to begin physical activity within the first week following surgery. Every patient received a complete blood test every 3 months. Patients were asked to list their current medications, including the use of multivitamins.

Statistical analysis

Data were collected, revised, coded, and entered into version 23 of the IBM Statistical Package for the Social Sciences (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). The quantitative data with parametric distribution were presented as the mean, SDs, and ranges, whereas those with a nonparametric distribution were presented as the median and interquartile range. Spearman correlation coefficients were used to assess the correlation between two quantitative parameters in the same group. *P* value more than 0.05 was considered nonsignificant, *P* value less than 0.05 significant, and *P* value less than 0.01 highly significant.

Form 1: pre-WLS evaluation.

(1) Patient data.

•	Name	•	Age		•	Occupation	
•	Residence	•	Telephone				
•	Weight	•	Height		•	BMI	
•	Waist Circum.	•	Hip Circum.		•	WHR	
•	Type of Obesity	Apple Shape	☐	Pear Shape	☐		

(2) Comorbidities

•	DM	☐	•	Hypertension	☐	•	OSAS ☐
•	GERD	☐	•	Asthma	☐	•	Osteoarthritis ☐
•	Allergy	☐	•	Hypothyroidism	☐	•	Cushing ☐
•	Systemic Diseases		Cardiac ☐	Hepatic ☐		Renal ☐	

(3) Past surgical history:

(4) Medications:

(5) History of obesity:

• Onset			
• Chronology: Lowest Adult Weight	kg	Highest Adult Weight	kg
• Dietary Habits			
• Family History			
• Prior weight loss trials: surgery ☐	Diet ☐	Medications ☐	

(6) Lifestyle:

•	Work Time	Active	☐	Passive	☐
•	Leisure Time	Active	☐	Passive	☐
•	Physical Exercise	Mild ☐	Moderate ☐	Intense ☐	

Form 2: CDQ.

Please answer the following questions by ticking one box only except for question 3, where you must tick one box for each statement.

1.	Which one of these four statements BEST DESCRIBES the main discomfort you get in your stomach or chest?		
(5)	☐	A burning feeling rising from your stomach or lower chest up towards your neck	
(0)	☐	Feeling of sickness or nausea	
(2)	☐	Pain in the middle of your chest when you swallow	
(0)	☐	None of the above, please describe below:	
2.	Having choosing one of the above, please now choose which one of the next three statements BEST DESCRIBES the timing of your main discomfort?		
(-2)	☐	Any time, not made better or worse by taking food	
(3)	☐	Most often within 2 h of taking food	
(0)	☐	Always at a particular time of day or night without any relationship to food	
3.	How do the following affect your main discomfort?		
	Worsens	Improves	No effect/unsure
Larger than usual meals	(1) ☐	(-1) ☐	(0) ☐
Food rich in fat	(1) ☐	(-1) ☐	(0) ☐
Strongly flavored or spicy food	(1) ☐	(-1) ☐	(0) ☐
4.	Which one of the following BEST DESCRIBES the effect of indigestion medicines on your main discomfort?		
(0)	☐	No benefit	
(3)	☐	Definite relief within 15 min	
(0)	☐	Definite relief after 15 min	
(0)	☐	Not applicable (I don't take indigestion medicines	
5.	Which of the following BEST DESCRIBES the effect of lying flat, stooping, or bending on your main discomfort?		
(0)	☐	No effect	
(1)	☐	Brings it on or makes it worse	
(-1)	☐	Gives relief	
(0)	☐	Don't know	
6.	Which of the following BEST DESCRIBES the effect of lifting or straining (or any other activity that makes you breath heavily) on your main discomfort?		
(0)	☐	No effect	
(1)	☐	Brings it on or makes it worse	
(-1)	☐	Gives relief	
(0)	☐	Don't know or this does not apply to me	
7.	If food or acid-tasting liquid returns to your throat or mouth what effect does it have on your main discomfort?		
(0)	☐	No effect	
(2)	☐	Brings it on or makes it worse	
(0)	☐	Gives relief	
(0)	☐	Don't know or this does not apply to me	

Results

During the study period, 30 morbidly obese patients complaining of GERD who met inclusion criteria and signed informed consent were subjected to LSG and completed 3 months of follow-up. A total of 17 patients were excluded from the study, including nine patients with a history of previous weight loss procedures (seven intragastric balloons and two gastric bandings), four patients with chronic calcular cholecystitis, and three patients with concomitant hiatus hernia, and one patient with a history of psychological instability. Ultimately, 30 patients were evaluated, comprising 19 women and 11 men. Their mean BMI was 46.7 ± 6.3 kg/m^2, and they had a mean age of 37.7 ± 8.5 years. Preoperative anthropometric measures of selected patients were a mean weight of 131.70 ± 22.82 kg, mean height of 167.70 ± 10.11 cm, mean BMI of 46.76 ± 6.36 kg/m^2, mean waist circumference of 141.77 ± 8.32 cm, mean hip circumference of 172.73 ± 15.44 cm, and mean WHR of 0.82 ± 0.08. Preoperative laboratory results of the studied patients are presented in Table 1. The mean preoperative fasting blood glucose was 104.2 ± 48.4 mg/dl, and the mean glycated hemoglobin was 5.7 ± 1.2%. Overall, five patients required insulin and oral

hypoglycemic drugs to control diabetes. Hypertension was detected in 11 patients, who undertook preoperative strict antihypertensive medication to control their blood pressure, 21 patients complained of OSAS, seven had asthma, and osteoarthritis was detected in 14 patients (Fig. 1).

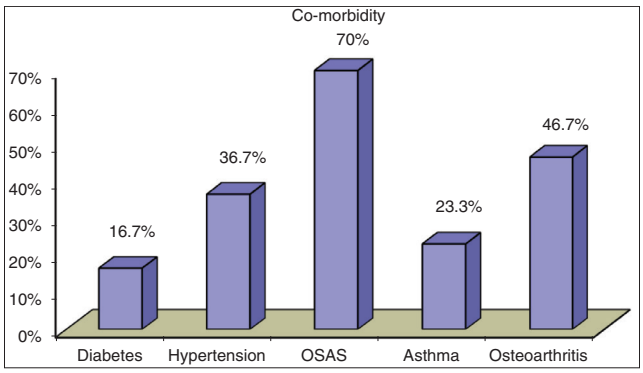
Statistical analysis of follow-up values of patients' weight and percentage of excess weight loss revealed highly significant differences at 1, 2, and 3 months postoperatively. The percentage of excess weight loss (calculated from an ideal BMI of 25 kg/m^2) has been excellent; it was 10.8% at 1 month, 18.8% at 2 months, and 25.5% at 3 months (Table 2 and Fig. 2). During the 3 months, postoperative weight loss was 14.20 ± 4.26, 24.57 ± 5.20, and 33.53 ± 8.01 kg, respectively (Table 3 and Fig. 3). Similarly, statistical analysis of follow-up values of patients' BMI revealed a highly significant difference at 1, 2, and 3 months postoperatively, where the percentage of BMI loss was 10.82 ± 2.87, 18.81 ± 3.60, and 25.54 ± 4.81, respectively (Table 4 and Fig. 4). Comparative statistical analysis of preoperative and postoperative CDQ scores showed a highly significant difference at different times of measurement, and its percentage of change values was −19.07 ± 33.61 at 1 month, −56.39 ± 44.13 at 2 months, and −70.60 ± 46.31 at 3 months (Table 5 and Fig. 5). Regarding sex, there was no significant difference between males and females with respect to weight, BMI, or CDQ score at 1, 2, or 3 months (Table 6). A correlation study done found no significant correlation between either weight change or BMI and other studied parameters at 1, 2, and 3 months of follow-up (Tables 7 and 8 and 8). In addition, there was no significant correlation comparing the CDQ score or CDQ score percent of change with weight and BMI change at 1, 2, and 3 months (Tables 9–11). However, a correlation study was done between CDQ scores at 1, 2, and 3 months with the other studied parameters, which declared the presence of a significant positive correlation between CDQ score % of change after 2 months and fasting blood sugar (P=0.020) and albumin (P=0.004) (Table 12, Fig. 6 and 7) Figs 7 (Table 8) (Table 9) (Table 10) (Table 11).

Table 1 Preoperative laboratory of the studied patients (total no.=30)

	Mean±SD	Range
Glucose (F)	104.27 ± 48.44	69–327
HbA1c	5.75 ± 1.26	4.6–11.3
Creatinine	1.11 ± 0.32	0.7–2.1
Cholesterol	183.77 ± 35.54	134–263
HDL	55.53 ± 11.86	33–81
LDL	99.77 ± 35.80	43–185
TGs	164.93 ± 98.51	73–513
Na	137.18 ± 2.63	132.8–142.2
K	3.81 ± 0.30	3.24–4.32
Albumin	3.76 ± 0.28	3.3–4.3

HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride.

Figure 1



Percentage of comorbidities among the studied patients.

Discussion

GERD is currently recognized as one of the commonest obesity-related comorbidities [10]. Consequently, treating the main source of the problem seems a reasonable approach to these patients. SG has rapidly gained wider acceptance as an effective bariatric procedure for patients with severe obesity. However, its effect on GERD is still unclear, with

Table 2 Follow-up for weight (kg) and percentage of excess weight loss at different measurement times

Weight (kg)	Pre	1 month	2 months	3 months	Test value	*P* value	Significance
Mean±SD	131.70 ± 22.82	117.50 ± 21.07	107.13 ± 20.46	98.17 ± 19.03	415.197•	<0.001	HS
Range	96–186	91–164	82–153	73–139			
% of weight loss							
Mean±SD	–	10.80 ± 2.87	18.80 ± 3.61	25.52 ± 4.84			
Range	–	4.58–16	10.46–26.89	15.69–34.29			
Post-hoc analysis by Bonferroni test							
Pre vs. 1 month	Pre vs. 2 months	Pre vs. 3 months	1 month vs. 2 months	1 month vs. 3 months		2 months vs. 3 months	
<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	

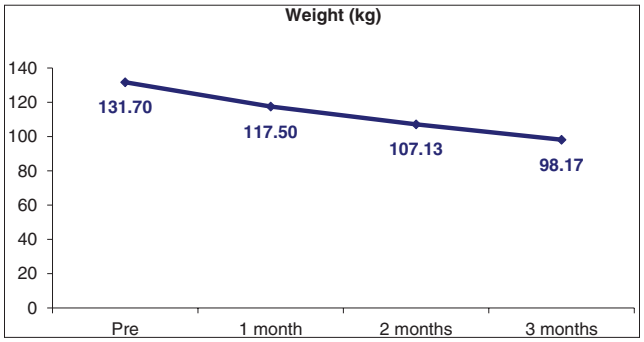
•Repeated measures analysis of variance test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

conflicting evidence about pre-existing reflux control after surgery. The present study was conducted with the objective to better clarify the effect of LSG on GERD. We recruited 30 morbidly obese patients seeking LSG surgery and having evident GERD symptoms in the absence of hiatal hernia or any upper GI pathology. Subjective evaluation of GERD was done using CDQ and was performed once preoperatively and at 1-month intervals for 3 months postoperatively. Statistical evaluation of our results demonstrated a highly significant decrease in weight, percent of weight loss, BMI, and percent of BMI decrease throughout the study at different times of patients' evaluation. There was also a highly significant improvement in CDQ score from the first-month postoperatively and consequently after the second and third months.

This reported improvement in GERD is consistent with the findings of DuPree and colleagues, who discovered a reduction in the prevalence of GERD symptoms following LSG. Over 4 years, they conducted a retrospective review of the Bariatric Outcomes Longitudinal Database, which included a total of 4832 patients who had LSG for morbid obesity and reported resolution of symptoms in 15.9%. Similarly, the published results of a prospective clinical study designed to evaluate the physiopathologic changes in morbidly obese patients after LSG revealed no significant differences between the two groups. The gastroesophageal functions of 71 patients were assessed using a clinically validated questionnaire: the Gastroesophageal Reflux Disease Symptom Assessment Scale (GSAS) questionnaire, upper endoscopy, esophageal manometry, and 24-h pH monitoring before and 24 months after LSG. They demonstrated a decrease in the GSAS score from 53.1 ± 10.5 to 13.1 ± 3.5 (P<0.001) together with a significant improvement in their symptoms. The DeMeester score (DMS) and total acid exposure (% pH<4) decreased from 39.5 ± 16.5 to 10.6 ± 5.8, P<0.001; % pH less than 4 from 10.2 ± 3.7 to 4.2 ± 2.6, P<0.001). Lower esophageal sphincter (LES) pressure and esophageal peristalsis amplitude did not change significantly. They concluded that LSG improves symptoms and controls reflux in most morbidly obese patients with GERD. In obese patients without preoperative evidence of GERD, the occurrence of 'de novo' reflux is uncommon, so LSG should be regarded as an effective surgical treatment option for obese patients with GERD [11].

Using esophageal manometry, 24-h pH monitoring, or 24-h MII-pH monitoring, only a handful of studies have specifically investigated changes in esophageal function after LSG. Regarding manometric changes, extremely controversial information has been published. A few studies have demonstrated a significant decrease in LES pressure, whereas others have demonstrated a significant increase. For instance, Braghetto and colleagues prospectively evaluated 20 morbidly obese patients undergoing LSG. They reported that the LES pressure of 85% of patients significantly decreased 6 months after surgery. Additionally, the high-pressure zone's total length and abdominal length were shortened. According to the authors, these findings were attributed to the partial section of the sling fibers of the cardias, according to the authors [12]. In contrast, Petersen and colleagues reported an increase in LES pressure irrespective of weight loss, indicating that this manometric change is related to the position of the stapler in relation to the angle of His. Specifically, the LES pressure is greater when the staple line is closer to the gastroesophageal junction. In a second prospective study involving 65 patients, researchers found no significant manometric changes in LES pressure or esophageal peristalsis amplitude [13]. At a median follow-up of 13 months,

Figure 2



Follow-up for weight (kg) and percentage of excess weight loss at different times of measurement.

Table 3 Postoperative weight loss (kg) at 1, 2, and 3 months

Postoperative weight loss	1 month	2 months	3 months	Test value	*P* value	Significance
Mean±SD	14.20 ± 4.26	24.57 ± 5.20	33.53 ± 8.01	238.520•	<0.001	HS
Range	5–22	13–33	17–48			
Post-hoc analysis by Bonferroni test						
1 month vs. 2 months		1 month vs. 3 months		2 months vs. 3 months		
<0.001		<0.001		<0.001		

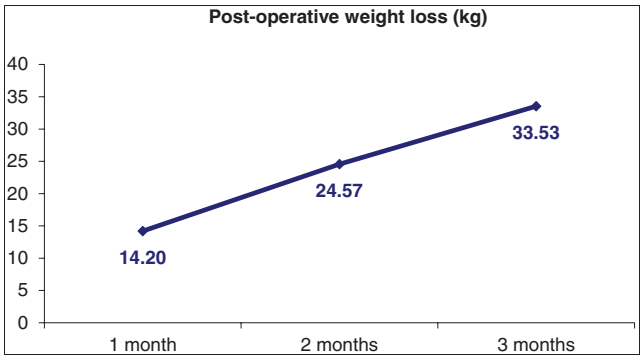
•Repeated measures analysis of variance test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

only Del Genio *et al.* [14] demonstrated an increase in ineffective peristalsis in a series of 25 obese patients with no change in LES function.

In addition, Rebecchi and colleagues found that 24-h pH monitoring performed 2 years after surgery in 28 patients with preoperative GERD revealed a significant reduction in the DMS and total percent pH 4. Despite its reduction, four (14.3%) patients still had pathologic esophageal acid exposure. Both the mean symptom index (SI) score and the proportion of patients with SI greater than 50% decreased significantly from 89.3% preoperatively to 14.3% postoperatively. Seven (18.9%) of patients with negative preoperative 24-h pH monitoring had pathologic DMS and total percent pH of 4. Two years after LSG, there were no significant changes in the mean SI score compared with the baseline. Overall, they observed a slight increase in the proportion of patients with SI greater than 50% from 8.1% before LSG to 18.9% 2 years after LSG (P=0.308). Nevertheless, real 'de novo' GERD was identified in 5.4% (2/37) of patients based on the correlation between symptoms and 24-h pH monitoring data [15].

In contrast, Georgia and colleagues studied prospectively 12 obese patients without preoperative reflux symptoms using 24-h multichannel intraluminal impedance-pHmetry before and 1 year after LSG. The mean DMS before surgery was 18.15. DMS was abnormal in five patients (42.7%). In 10 (83.3%) patients, abnormal DMS was detected postoperatively. One year after surgery, DMS levels were nearly 2.5 times higher than preoperative levels. Del Genio and colleagues reported the outcomes of a series of 25 obese patients without preoperative GERD who were evaluated with 24-h MII-pH monitoring preoperatively and 13 months after surgery. They detected a significant increase in the median DMS, the median percentage of patients with esophageal pH 4 in the supine position, the total number of nonacid reflux episodes in both the upright and recumbent positions, and the total number of reflux episodes in both positions [14].

Figure 3



Postoperative weight loss (kg) at 1, 2, and 3 months.

Gorodner *et al.* [16] evaluated the esophageal function of 14 obese patients before and 1 year after LSG. The DMS rose from 12.6 to 28.4 (P=0.05); specifically, the number of episodes longer than 5 min, the duration of the most extended episode, and the proportion of times the pH were below 4 (total) increased. Five (36%) patients developed 'de novo' GERD, whereas three (21%) patients with pre-existing GERD experienced a worsening of their symptoms. Balla and colleagues evaluated the changes in esophageal motility and acid exposure of the esophagus using esophageal manometry and 24-h pH-monitoring before and after LSG. Nine articles observed a worsening of the DMS and/or acid exposure time, and the de novo GERD rate ranged from 17.8 to 69% [17].

In addition, Chern and colleagues conducted a prospective cohort study on 31 patients undergoing SG with high-resolution impedance manometry, 24-h multichannel intraluminal impedance combined with pH testing (MII-pH), and GSAS questionnaire 1 month before and 6 months after SG. Their objective was to more precisely and objectively evaluate the effect of SG on esophagogastric physiology. In their findings, high-resolution impedance manometry was associated with significantly increased intragastric pressures (15.5–29.6 mmHg) and failed swallows (3.1–7.5%)

Table 4 Follow up for BMI (kg/m²) and percentage of BMI loss at different times of measurement

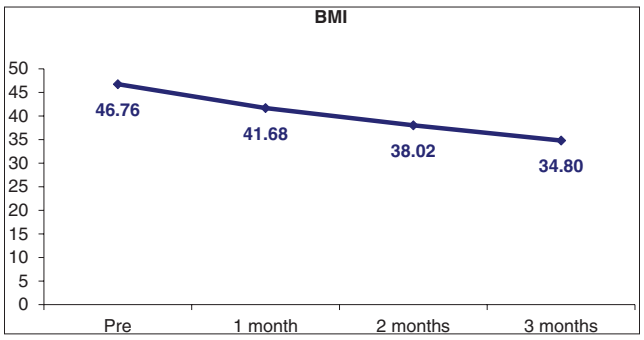
BMI	Pre	1 month	2 months	3 months	Test value	*P* value	Significance
Mean±SD	46.76±6.36	41.68±5.73	38.02±5.81	34.80±5.12	399.589	<0.001	HS
Range	36.1–62.2	30.96–54.67	26.81–49.33	25.85–45.71			
% of BMI loss							
Mean±SD	–	10.82±2.87	18.81±3.60	25.54±4.81			
Range	–	4.56–15.94	10.44–26.84	15.66–34.26			
Post-hoc analysis by Bonferroni test							
Pre vs. 1 month	Pre vs. 2 months	Pre vs. 3 months	1 month vs. 2 months	1 month vs. 3 months		2 months vs. 3 months	
<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	

but no change in esophageal motility. MII-pH did not demonstrate significant changes in acid exposure time (8.5–7.5%) or the number of reflux episodes; however, the numbers of long reflux episodes (2.3–4.7) and weak acid reflux episodes (15.4–55.2) increased significantly. The DeMeester and GSAS scores did not change significantly. There was no significant difference between patients who had reflux before treatment. However, acid exposure time increased significantly (1.3–6.7%) in patients without a history of reflux, as did DMSs (5.8–24.5), the number of long reflux episodes (0.1–4.4), and weakly acidic episodes (22.1–89.1). They concluded that SG was associated with increased intragastric pressures without changes in esophageal motility or acid exposure. There were increases in acid exposure time, long reflux episodes, weakly acidic reflux episodes, and the DMS among patients without a history of reflux [18].

A correlation study done in our thesis found no significant correlation between either CDQ score or CDQ score percent of change and decrease in weight and BMI at 1, 2, and 3 months. This may denote different effects of percent of weight loss on the degree of improvement of pressure gradient across LES in between patients. This variation could be linked to many other factors that could contribute to GERD, such as the percent of visceral to somatic fat lost, each patient's dietary intake habits, and any hidden underlying GI pathology. Kjellin and colleagues denoted that a proposed link between obesity, increased intra-abdominal pressure, and GERD symptoms has become widely accepted; however, questions remain as to why the weight loss does not necessarily lead to the same degree of improvement in GERD symptoms. Moreover, the long-term effect of sleeve gastrectomy on GERD and esophageal motility in patients with GERD still needs to be fully elucidated [19].

In addition, Quero and colleagues concluded that an objective correlation between structural gastric and EGJ changes has not yet been established. Their studies were conducted before and following a more than 50% reduction in excess body weight (6–12 months after LSG). MRI, high-resolution manometry, and ambulatory pH-impedance measurements were utilized to evaluate the structure and function of the EGJ and stomach before and after LSG. According to their findings, after 7.1 ± 1.7 months of follow-up, the average excess weight loss was 59 18%. After surgery, esophageal acid exposure [2.4 (1.5–3.2) to 5.1 (2.8–7.3), *P*=0.040 (normal 4.0%)] and reflux events [57 24–84 38; *P*=0.006 (normal 80/day)] increased. Esophageal motility was unaffected by surgery; nevertheless, intra-abdominal EGJ length and pressure were decreased (both *P*=0.001), whereas the esophagogastric insertion angle [35° 11° to 51° 16°; *P*=0.0004 (normal 60°)] and esophageal opening diameter (16.9 2.8–18.9 3.7 mm; *P*=changes in EGJ insertion angle) were correlated with an increase in reflux events (*P*=0.010). The researchers concluded that LSG has multiple effects on the EGJ and stomach, promoting reflux. They also noted that EGJ disruption, as indicated by an increased (more obtuse) esophagogastric insertion angle and small gastric capacity, was associated with an increased risk of GERD following LSG [20].

Figure 4



Follow-up for BMI (kg/m^2) and percentage of BMI loss at different times of measurement.

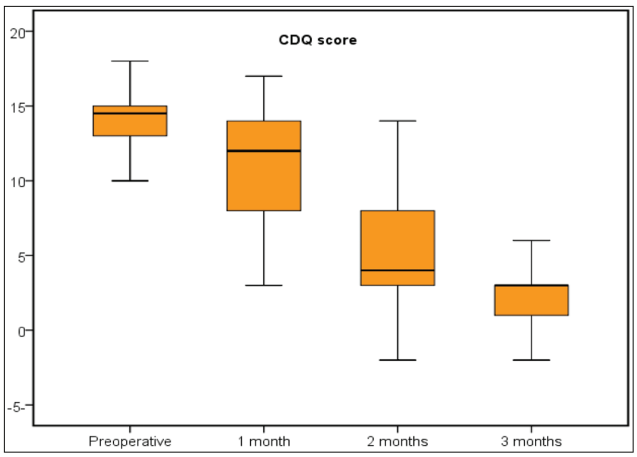
Table 5 Carlsson-Dent Questionnaire score at different times of measurement with % of change

CDQ score	Pre	1 month	2 months	3 months	Test value	*P* value	Significance
Median (IQR)	14.5 (13–15)	12 (8–14)	4 (3–8)	3 (1–3)	62.242*;	<0.001	HS
Range	8–18	3–17	–2–17	–2–17			
% of change							
Mean±SD	–	–19.07 ± 33.61	–56.39 ± 44.13	–70.60 ± 46.31			
Range	–	–78.57–87.5	–122.22–112.5	–122.22–112.5			
Post-hoc analysis							
Pre vs. 1 month	Pre vs. 2 months	Pre vs. 3 months	1 month vs. 2 months	1 month vs. 3 months		2 months vs. 3 months	
0.001	<0.001	<0.001	<0.001	<0.001		0.001	

CDQ, Carlsson-Dent Questionnaire; IQR, interquartile range. *;Friedman test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Nevertheless, in our study, the duration of postoperative follow-up of patients was restricted to 3 months. In other reports, extended postoperative follow-up durations were studied. Musella *et al.* [21] evaluated reflux following sleeve gastrectomy and one-anastomosis gastric bypass at 6 months and 1-year postoperatively, and Rebecchi and colleagues monitored their patients' 24-h pH at 2 years after surgery. Such extended follow-up durations would have surely been of better value in confirming or denying the continued positive effect of the procedure on GERD. Moreover, our established results needed to be re-evaluated after longer follow-up durations to elaborate on the long-term effect of the procedure on GERD and whether they are continuing as such or variation will develop after a while due to restoration of the altered upper GI dynamics of the patients as well as after adaptation of their dietary habits to the procedure [11].

Figure 5



CDQ score at different times of measurement with % of change. CDQ, Carlsson-Dent Questionnaire.

Another important point to be elicited is that we used a subjective method of evaluating GERD in our patients, the CDQ. Many controversies were noted

Table 6 Relation of gender of the studied patients with change of weight, BMI, and Carlsson-Dent Questionnaire score at 1, 2, and 3 months

	Female	Male	Test value	*P* value	Significance
	N=19	*N*=11			
Change after 1 month					
Weight					
Mean±SD	10.55±3.03	11.23±2.66	−0.617•	0.542	NS
Range	4.58–16	6.55–14.41			
BMI					
Mean±SD	10.58±3.02	11.22±2.68	−0.580•	0.567	NS
Range	4.56–15.94	6.58–14.52			
Change after 2 months					
Weight					
Mean±SD	18.02±3.26	20.14±3.95	−1.589•	0.123	NS
Range	10.46–23.73	15.48–26.89			
BMI					
Mean±SD	18.05±3.25	20.13±3.94	−1.563•	0.129	NS
Range	10.44–23.87	15.5–26.84			
Change after 3 months					
Weight					
Mean±SD	25.01±5.17	26.41±4.28	−0.755•	0.456	NS
Range	15.69–34.29	20–32.62			
BMI					
Mean±SD	25.04±5.15	26.4±4.25	−0.743•	0.464	NS
Range	15.66–34.26	20.08–32.47			
CDQ score					
Change after 1 month					
Mean±SD	−13.83±35.35	−28.12±29.73	1.127•	0.269	NS
Range	−78.57–87.5	−73.33–0			
Change after 2 months					
Mean±SD	−57.63±50.82	−54.26±31.48	−0.198•	0.844	NS
Range	−122.22 to 112.5	−80 to 21.43			
Change after 3 months					
Mean±SD	−72.75±50.97	−66.9±38.97	−0.328•	0.745	NS
Range	−122.22 to 112.5	−100 to 21.43			

CDQ, Carlsson-Dent Questionnaire. •Independent *t* test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 7 Correlation of weight change at 1 month, 2 months, and 3 months with the other studied parameters

	Weight change					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
Age	0.167	0.379	0.005	0.977	–0.028	0.885
Glucose (F)	0.102	0.593	0.186	0.325	0.142	0.455
HbA1c	0.226	0.231	0.195	0.301	0.095	0.619
Creatinine	0.114	0.549	0.262	0.162	0.191	0.312
Cholesterol	0.102	0.591	–0.013	0.946	–0.112	0.554
HDL	0.013	0.946	0.284	0.128	0.337	0.069
LDL	0.242	0.198	0.001	0.994	–0.094	0.622
TGs	0.099	0.601	–0.061	0.749	–0.121	0.525
Na	0.205	0.276	0.034	0.856	0.085	0.656
K	–0.025	0.894	0.019	0.920	0.110	0.563
Albumin	–0.206	0.276	–0.093	0.627	–0.039	0.839
CDQ score % of change after 1 m	0.010	0.956	–0.190	0.315	0.006	0.976
CDQ score % of change after 2 m	0.147	0.438	–0.135	0.477	–0.136	0.474
CDQ score % of change after 3 m	–0.100	0.600	–0.271	0.148	–0.220	0.242

CDQ, Carlsson-Dent Questionnaire; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 8 Correlation of BMI change at 1, 2, and 3 months with the other studied parameters

	BMI					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
Age	0.158	0.403	0.006	0.976	–0.031	0.870
Glucose (F)	0.089	0.642	0.192	0.309	0.154	0.415
HbA1c	0.211	0.264	0.198	0.295	0.101	0.594
Creatinine	0.102	0.591	0.276	0.139	0.206	0.275
Cholesterol	0.103	0.588	–0.017	0.927	–0.123	0.516
HDL	0.012	0.949	0.279	0.135	0.320	0.084
LDL	0.239	0.202	0.000	0.998	–0.105	0.580
TGs	0.085	0.654	–0.057	0.764	–0.111	0.560
Na	0.218	0.248	0.046	0.811	0.098	0.607
K	–0.042	0.825	0.008	0.967	0.113	0.553
Albumin	–0.215	0.254	–0.079	0.680	–0.028	0.881
CDQ score % of change after 1 m	0.014	0.943	–0.192	0.310	0.017	0.927
CDQ score % of change after 2 m	0.148	0.436	–0.137	0.471	–0.141	0.458
CDQ score % of change after 3 m	–0.104	0.584	–0.270	0.150	–0.217	0.250

CDQ, Carlsson-Dent Questionnaire; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 9 Correlation of Carlsson-Dent Questionnaire score at 1, 2, and 3 months with weight and BMI

	CDQ score					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
Change after 1 month						
Weight	0.010	0.956	0.147	0.438	–0.100	0.600
BMI	0.014	0.943	0.148	0.436	–0.104	0.584
Change after 2 months						
Weight	–0.190	0.315	–0.135	0.477	–0.271	0.148
BMI	–0.192	0.310	–0.137	0.471	–0.270	0.150
Change after 3 months						
Weight	0.006	0.976	–0.136	0.474	–0.220	0.242
BMI	0.017	0.927	–0.141	0.458	–0.217	0.250

CDQ, Carlsson-Dent Questionnaire. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 10 Correlation of Carlsson-Dent Questionnaire score % of change with weight change at 1, 2, and 3 months

	Weight change					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
CDQ score % of change after 1 month	0.010	0.956	–0.190	0.315	0.006	0.976
CDQ score % of change after 2 months	0.147	0.438	–0.135	0.477	–0.136	0.474
CDQ score % of change after 3 months	–0.100	0.600	–0.271	0.148	–0.220	0.242

CDQ, Carlsson-Dent Questionnaire. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 11 Correlation of Carlsson-Dent Questionnaire score % of change with BMI change at 1, 2, and 3 months

	BMI					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
CDQ score % of change after 1 month	0.014	0.943	–0.192	0.310	0.017	0.927
CDQ score % of change after 2 months	0.148	0.436	–0.137	0.471	–0.141	0.458
CDQ score % of change after 3 months	–0.104	0.584	–0.270	0.150	–0.217	0.250

CDQ, Carlsson-Dent Questionnaire. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 12 Correlation of Carlsson-Dent Questionnaire score at 1, 2, and 3 months with the other studied parameters

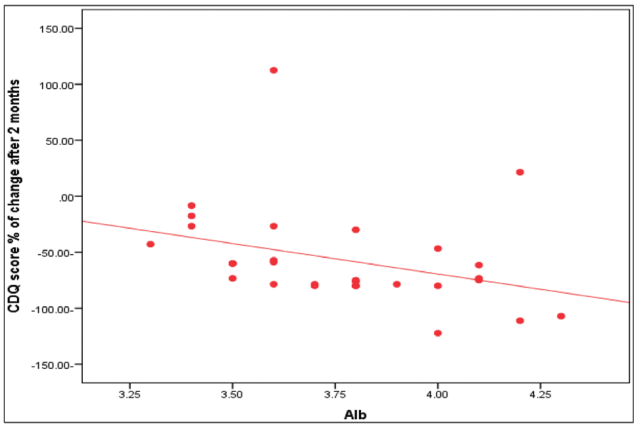
	CDQ score					
	Change after 1 month		Change after 2 months		Change after 3 months	
	r	*P* value	*r*	*P* value	*r*	*P* value
Age	0.119	0.531	0.120	0.526	0.176	0.354
Glucose (F)	–0.165	0.383	–0.422*	0.020	–0.342	0.065
HbA1c	–0.102	0.590	–0.252	0.179	–0.222	0.238
Creatinine	–0.269	0.151	–0.262	0.163	–0.186	0.325
Cholesterol	0.117	0.538	0.167	0.378	0.022	0.908
HDL	–0.172	0.364	–0.052	0.783	–0.054	0.776
LDL	0.125	0.512	0.220	0.242	0.019	0.920
TGs	0.059	0.756	0.111	0.558	0.067	0.727
Na	0.077	0.687	–0.079	0.677	–0.068	0.721
K	0.253	0.178	0.039	0.838	0.311	0.094
Albumin	0.031	0.872	–0.511**	0.004	–0.263	0.160
Change after 1 month						
Weight	0.010	0.956	0.147	0.438	–0.100	0.600
BMI	0.014	0.943	0.148	0.436	–0.104	0.584
Change after 2 months						
Weight	–0.190	0.315	–0.135	0.477	–0.271	0.148
BMI	–0.192	0.310	–0.137	0.471	–0.270	0.150
Change after 3 months						
Weight	0.006	0.976	–0.136	0.474	–0.220	0.242
BMI	0.017	0.927	–0.141	0.458	–0.217	0.250

CDQ, Carlsson-Dent Questionnaire; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride. Spearman correlation coefficient. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

about which questionnaire is validated to assess the degree of GERD as every questionnaire has different sensitivity and specificity on different cutoff levels. Moreover, objective evaluation using esophageal pH monitoring remains the current gold standard method for diagnosis of GERD as it provides direct measurement of acid in the esophagus and is the most objective method to document reflux disease, assess the severity of the disease, and monitor the response of the disease to medical or surgical treatment. Therefore, assessment of patients' GERD severity preoperatively and postoperatively using objective methods would have been of more accurate value, and we would recommend it for further studies.

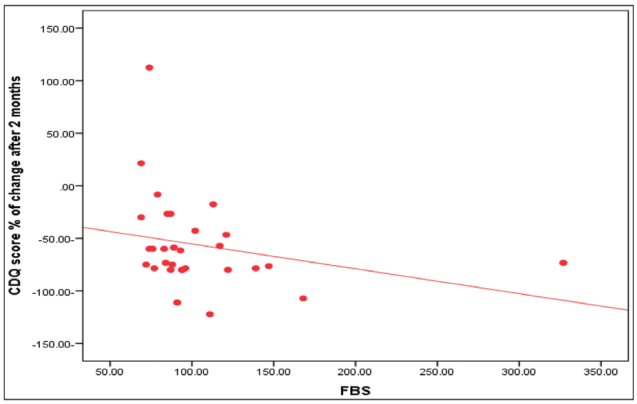
In conclusion, obesity and its associated comorbidities pose a significant threat to our health care system. With the advent of WLS, new therapeutic modalities have become available that have been demonstrated to be more effective than intensive medical treatment,

Figure 6



Correlation of CDQ score % of change after 2 months with fasting blood sugar. CDQ, Carlsson-Dent Questionnaire.

Figure 7



Correlation of CDQ score % of change after 2 months with albumin. CDQ, Carlsson-Dent Questionnaire.

dieting, and exercise alone in assisting patients to lose weight. As patients lose weight, a number of their obesity-related comorbidities significantly improve or even resolve. However, the effect of WLS on GERD has not been conclusively determined. In the scientific literature, the effect of LSG on GERD symptoms remains controversial. Although there is evidence that LSG can successfully improve postoperative GERD symptoms, the current consensus is that patients with severe erosive esophagitis and/or Barrett's esophagus should avoid LSG. After sleeve gastrectomy, it remains difficult to predict who will experience GERD improvement and who will experience worsening. As new bariatric procedures become available to clinicians, it will be necessary to conduct additional research to determine their effect on GERD severity and frequency.

Summary and conclusion

GERD has become one of the most prevalent complications of morbid obesity. The LSG has become an increasingly popular bariatric procedure over the past decade, as it is associated with significant weight loss and improvement or resolution of a number of comorbidities and is less technically demanding. However, its effect on GERD in morbidly obese individuals remains debatable. The objective of the present study was to prospectively determine the effect of the LSG procedure on pre-existing GERD in morbidly obese patients using a subjective questionnaire administered 3 months after surgery. The research included 30 morbidly obese patients with GERD who underwent LSG surgery. Patients' preoperative and postoperative data were compared statistically at all times of follow-up. Statistically significant improvement of GERD symptoms was observed over the course of the study period, as evidenced by the fact that the majority of patients had satisfactory postoperative reflux control, as demonstrated by our study and the majority of recent studies. As recently stated in publications on sleeve gastrectomy, these data are leading to a wider acceptance of LSG as a bariatric procedure in obese patients with GERD, provided that a tubular sleeve is created. Confirmation of these findings using objective instruments and more extended follow-up periods would strengthen the case for LSG as the most appropriate metabolic surgery procedure for morbidly obese patients with GERD [22,23].

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Nil.

Conflicts of interest

There is no conflict of interest.

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