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Original article

Oesophageal Dysmotility before and after Laparoscopic Sleeve Gastrectomy

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Abstract

Background: Despite the positive effect of sleeve gastrectomy regarding weight loss and improvement in obesity co-morbidities, there are concerns about its effect on esophageal motility especially the effect on lower esophageal sphincter function and the development of de novo GERD or worsening the existing GERD after this bariatric operation. **Aims of the study** is to compare preoperative with postoperative oesophageal manometric studies in patients undergoing sleeve gastrectomy; and study the consequences as well as the preoperative oesophageal motility disorders that might affect the outcome of sleeve gastrectomy in morbidly obese patients. **Methodology**: This is a prospective study for patients with morbid obesity treated by LSG from March 2017 to March 2018 in the Department of General Surgery Faculty of Medicine, Benha University Hospital. **Results**: As regard symptomatic assessment, five (25%) patients had preoperative heartburn and regurgitation. Two (10%) patients developed de novo heartburn and regurgitation postoperatively. As regard esophagogastroduodenoscopy and focusing on esophagus, four (20%) patients had reflux esophagitis before LSG. Two (10%) patients developed de novo reflux esophagitis six months after LSG. As regard esophageal manometry, LES resting pressure decreased from 15.4 (15.4±7) mmHg to 14.1mmHg (14.1±7). As regard 24 hours pH monitoring, four (20%) patients had abnormal DeMeester score preoperatively, which increased postoperatively to 7 (35%) patients. **Conclusion:** Our results demonstrate that LSG affects the antireflux mechanism and increases the postoperative GERD. So, bariatric surgeons should carefully evaluate any potential preoperative GERD-related complaints, and take this into account when choosing the proper bariatric surgical technique.

Keywords: esophageal dysmotility, sleeve gastrectomy, GERD

Abbreviations: GERD (gastroesophageal reflux disease), LSG(laparoscopic sleeve gastrectomy)

Introduction

Obesity is a worldwide epidemic with increasing prevalence in countries that have rising rates of sedentary lifestyles and Western diets [(1)].The accepted definition of obesity is based on the BMI and is defined as a BMI >30 kg/m2. An increased prevalence of metabolic syndrome, type 2 diabetes mellitus (T2DM), hypertension, acute myocardial infarction and chronic kidney disease is associated with an increasing BMI, resulting in substantially increased medical cost [(2)].

Treatment options for obesity are lifestyle changes (exercise and diet), pharmacological choices and bariatric surgery. However, lifestyle changes and pharmacological choices have not shown long-term benefits in weight reduction [(3)]. Bariatric operations are reserved for patients with a BMI > 40 kg/m^2 or a BMI > 35 kg/m^2 with comorbidities [(4)].

These operations have been the only modality proven to result in long-term, sustained weight loss, reduction in comorbidities and improvements in overall mortality [(5)].

Oesophageal disorders can range from GERD and disorders of the lower oesophageal sphincter (LES) to motility dysfunction. GERD, as defined by the Montreal Classification, is the reflux of stomach contents that leads to symptoms of heartburn and regurgitation [(6)].

GERD accounts for ~75% of oesophageal diseases among the general population and is believed to result from a disruption of the body's antireflux mechanism. This mechanism serves as a barrier and involves several components, such as the LES, the oesophageal hiatus of the diaphragm, which can serve as an extrinsic sphincter, phreno-oesophageal ligaments and the angle of His, which all protect the oesophageal mucosa from acidic contents of the stomach or reflux of bile [(7)]. A disruption, through either normal variation or surgical changes, can lead to the development of GERD.

Laparoscopic sleeve gastrectomy is a nonreversible procedure that involves removing ~80% of the body and the entire fundus of the stomach along the lesser curvature; the remaining portion of the stomach is formed into a narrow sleeve, which preserves the pylorus. With resection of the majority of the acid-producing part of the stomach (the corpus of the stomach), acid production in the gastric sleeve will be substantially reduced. LSG can lead to de novo GERD or the worsening of pre-existing GERD that was not clinically significant before the operation [(8)].

Mixed results have been obtained regarding the effects of LSG on oesophageal motility

and function. Some patients, when examined by symptom reporting and after receiving treatment, experienced deterioration in their GERD symptoms [(9)]. In other studies, which followed a similar evaluation of GERD, improvement of symptoms has been reported during varied follow-up periods (6–60 months) [(10)]. However, even in studies in which GERD showed an overall improvement in most patients, some individuals developed new GERD symptoms despite being asymptomatic pre-operatively. The question remains why some patients experience a subjective improvement in GERD after LSG, whereas others do not. Several different theories have been proposed: the sleeve leads to formation of a hiatal hernia; dissection of the phreno-oesophageal ligament during surgery; intrathoracic sleeve migration; a narrowing at the incisura; a disruption of the com-petency of the oesophagogastric junction and/or the development of high intrathoracic pressures. The size of the bougie, which is used to size the sleeve, is an ongoing area of debate with one study showing that a smaller-sized bougie (40 French compared with 60 French) led to an increased incidence of postoperative GERD [(11)]. Patients undergoing LSG, who have symptomatic GERD preoperatively due to a weak LES (as evident by oesophageal manometry) might continue to have symptoms, whereas patients who are asymptomatic, but also exhibit low LES pressures, are at a higher risk of subsequent GERD development [(12)].

Patients and methods

This study is a prospective study done for 20 patients with morbid obesity treated by LSG from March 2017 to March 2018 in the Department of General Surgery Faculty of Medicine, Benha University Hospital.

The patients had done LSG if BMI > 40 kg/m^2 or BMI > 35 kg/m^2 with co-morbidity, diabetes mellitus, hypertension, co-arthritis or obstructive sleep apnea syndrome.

Patients were excluded from the study if treated with bariatric procedure other than LSG, Patients with postoperative complications who failed to complete the study and patients with Redo sleeve gastrectomy.

The participants who agree to share in this clinical study gave informed consent after being fully informed about the technique and its circumstances. The study was conducted after approval of the Committee of Ethics in Faculty of Medicine, Benha University.

At our outpatient clinic, all patients were subjected to

-Thorough history and clinical

examination, assessment of dietary habit of patient and previous trials of weight loss by dieting, lifestyle modification or pharmacological therapy,

-Evaluation of associated co-morbidity and treatment medications used (DM, hypertension, co-arthritis and obstructive sleep apnea syndrome,

-Pre-operative assessment of patient symptoms done by questions assessing frequency, severity and duration of symptoms. Some of these questions assessing specifically GERD symptoms including typical symptoms as heartburn and regurgitation; atypical symptoms as epigastric pain and bloating; extra-esophageal manifestations as hoarse voice, cough and chest symptoms. Other questions assess dysphagia, nausea and vomiting.

A routine pre-operative screening upper endoscopy was done to rule presence of GERD and intrinsic lesions of the stomach or duodenum. Hiatus hernia was defined by the presence of diaphragmatic indentation at least 2 cm distal to the Z-line and proximal margins of gastric mucosal folds

Ph monitoring was done for patients before the procedure. Proton pump inhibitors should be withdrawn seven days before the study. Esophageal pH monitoring was performed for 24 hours and at the end of recording, patients tracing was analyzed and the results were expressed and a pH score called DeMeester Score was calculated, which is a global measure of esophageal acid exposure. GERD is defined when DeMeester score > 14.72.

Esophageal manometry was done for patients before the procedure. A catheter was inserted into the nose and was guided into the stomach. Once placed, the catheter was slowly withdrawn, allowing it to detect pressure changes and to record information for later review. The patient was asked at times to take a deep breath or to take some swallows of water. Patients were not sedated because sedatives would alter the functioning of the esophageal muscles. After the procedure is complete, patients can usually resume their normal daily activities.

Oesophageal manometry was performed using water-perfused catheters with lateral side holes attached to transducers outside the body. The water-perfused HRM assembly consisted of a 22-channel water-perfused catheter (Dentsleeve, Mississauga, ON, Canada). The luminal diameter of each perfusion capillary was 0.4 mm, and the total diameter of the catheter was 4.7 mm. The perfusion pressure during the entire manometric study was maintained at 0.15 ml/min.

Pressures were recorded with external pressure transducers (Argon Medical Devices, Plano, TX). The catheter was zeroed to atmospheric pressure before the catheter was introduced. The manometric signals were recorded with a frequency of 20 Hz and were stored on a personal computer. Water-perfused HRM data were analyzed with dedicated software [Medical Measurements Systems (MMS), Enschede, and The Netherlands].

Oesophageal motility was assessed with the Chicago criteria. Assessment of EGJ relaxation pressure, resting pressure, and upper esophageal sphincter (UES) resting pressure and relaxation pressure was automatically performed with dedicated software after manual inspection of the tracings and correct placement of analysis markers during a period of no swallowing directly following the 10 liquid swallows (QuickView Measurement and analysis software v. 8.23a; MMS).

EGJ pressure was referenced to gastric pressure, whereas the esophageal contraction parameters and UES pressures were referenced to atmospheric pressure. Breaks in the esophageal contraction wave were defined as segments within the esophageal contraction wave with amplitude below the 20-mmHg isobaric contour.

Average break length was defined as the mean break length during the 10 swallows. Contractile front velocity (CFV) was defined as the slope of the line connecting the points on the 30-mmHg isobaric contour at the proximal and distal margins of the distal esophageal segment [(15)]. Distal contractile latency (DL) was defined as the time between deglutitive UES relaxation and the contractile deceleration point (CDP: the inflection point along the 30-mmHg isobaric contour where propagation velocity slows, demarcating the tubular oesophagus from the phrenic ampulla).

The distal contractile integral (DCI) was calculated by multiplying the length of the smooth muscle oesophagus by the duration of propagation of the contractile wave front and the mean pressure in the manually placed frame excluding pressures below 20 mmHg.

Deglutitive relaxation of the EGJ was assessed with the integrated relaxation pressure (IRP), which measured the lowest 4-s cumulative pressure values that occurred during a 10-s post deglutition time window in the electronically generated e-sleeve signal through the anatomic zone defining the EGJ. Esophageal intrabolus pressure (IBP) was measured between the peristaltic wave front and the EGJ.

Operative details:

Laparoscopic sleeve gastrectomy was done according to the standard technique, using a 36 Fr bougie inserted trans-orally and advanced to the pylorus. The stomach is transected along the bougie with the use of 60-mm green endo-stapler (Ethicon, USA) two or six cm distance from the pylorus. The remaining staplers were 60-mm blue cartridges or with the use of Endo GIA™ Universal Straight 60-mm, blue cartridges. Number of used stapler is calculated and failure of stapler is recorded.

The bougie is removed, and the staple line is examined for leakage by the instillation of methylene blue through a nasogastric tube. In cases of intraoperative hemorrhage, the spurting vessel was controlled either with the application of intermittent 10 mm clips or with 3/0 absorbable suture and the leakage test is performed afterward. The resected specimen is then extracted. A drain was placed in the sub-hepatic space adjacent to the stomach tube and all trocar sites were closed.

Data collected intraoperative included, operative time, number of used staplers, blood loss and the need for blood transfusion and conversion to open surgery.

Post-operative evaluation was done by oral gastrograffin test in 1st post- operative day to assess the integrity of suture line.

Oral fluids were resumed immediately in the absence of fistula on this leak test. Then the clear output drain was removed usually in the 2nd day and the patient was discharged if haemodynamically stable, pain free and in the absence of post-operative complication with instructions to continue on oral fluids for the first week, liquid diet in the2nd week, then soft diet in the 3rd and 4th weeks. Subsequently, a long-term hypo-caloric, protein-enriched solid diet was maintained. Long-term oral daily supplements of vitamins and monthly administration of the intramuscular vitamin B12 were given to all patients.

Evaluation for post-operative complication such as gastric leak, peritonitis and abdominal bleeding was done.

The post-operative follow up of patients was done through out- patient visits 6 months after the procedure for:

1. Change in BMI, %EWL
2. Resolution or improvement in medical co-morbidities
3. Symptoms & signs of vitamin deficiency
4. Abdominal US to detect gall bladder stones development.
5. Any upper gastrointestinal symptoms

(Heart burn, regurgitation, dysphagia and vomiting. Re-assessment of symptoms done with the same questions used in assessment of preoperative symptoms.

6. Upper endoscopy to evaluate the gastric tube and to exclude presence of esophagitis or stricture.
7. Esophageal manometry and 24 hours pH metry were performed at 6 month post-operative to evaluate manometric and DeMeester Score changes.

The percentage of excess weight loss (% EWL) was defined as weight lost x 100/pre-operative weight – ideal body weight, with Ideal body weight usually captured through the Metropolitan Life Tables.

Statistical Methods

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United states).
Numerical data was summarized as means and standard deviations. Categorical data was summarized as numbers and percentages.
Categorical data was compared pre and post-operative using McNemar test.
Numerical data was compared pre and post-operative using Wilcoxon signed ranks test. Weight, BMI were compared pre-operative, at 3 months and at 6 months using Friedman's test. Post hoc analysis was done and all post hoc comparisons were Bonferroni adjusted.
All P values were two sided. P values less than 0.05 were considered significant.

Results

- **Demographic characteristics in the whole study population**
  - Mean age of the whole study population was 33 years with standard deviation of 7 years. As regard gender, 65.0% of study population was females while 35.0% were males. ***(Table1)***
- **Anthropometric measures in the whole study population**
  - Mean weight of the whole study population was 132 kg with standard deviation of 11 kg. Mean height was 165 cm with standard deviation of 6 cm. Mean BM was 48.6 with standard deviation of 5.4 ***(Table2)***
- **Pre and post-operative Symptoms**
  - There was no significant difference between pre and post-operative heart burn. P value was 0.480.
  - As regard vomiting. No patients complained vomiting pre-operative while 3 patients complained vomiting post-operative.***(Table3)***

❖ **pre and post-operative endoscopic findings**

- There were no significant differences between pre and post-operative esophagitis (P value = 0.754), gastritis (P value = 1.0) and duodenitis (P value = 1.0). **(*Table4)***

❖ **Pre and post-operative esophageal manometry**

- LES resting pressure significantly decreased from 15.4 mmHg pre-operative to 14.1 mmHg post-operative. P value was 0.001
- DCI significantly decreased from 842 pre-operative to 795 post-operative. P value was 0.001
- There were no significant difference between pre and post-operative LES total length and LES abdominal length. P values were 0.096 and 0.122 respectively. **(*Table5& Figure 1&2)***

❖ **Anthropometric measures pre and post-operative**

- Mean weight showed overall significance between different follow up times. P value was <0.001. Pairwise analysis revealed that :
  - Mean weight at 6 months was significantly lower (97 kg) compared to pre-operative weight (132 kg).
- Mean BMI showed overall significance between different follow up times. P value was <0.001. Pairwise analysis revealed that:
  - Mean BMI at 6 months was significantly lower (35.7) compared to pre-operative weight (48.6).
- EWL was significantly higher at 6 months (39%). **(*Table 6)***

❖ **24 h pH monitoring pre and post-operative**

- There was no significant difference between pre and post-operative DeMeester score. P value was 0.448 **(*Table7)***

❖ **Intra-operative details**

- Mean operative time was 2 hours with standard deviation of 0.5 h. 45.0% of patients showed fatty liver. Mean number of staplers was 6 with standard deviation of 1.0. Mean distance from pylorus was 5 cm with standard deviation of 1 cm. Mean amount of blood loss was 143 ml with standard deviation of 69 ml. 10% of patients needed blood transfusion. 38.9% showed staple

line bleeding. No conversion to open surgery occurred in all patients. **(*Table8)***

- **Post-operative details**
  - Mean duration of hospital stay was 3 days with standard deviation of 2 days
  - 20.0 % of patient showed reflux according to oral gastrograffin study.
  - The most frequent complication was port site infection (10.0%) followed by bleeding, chest infection and leak (5.0 for each)
  - Re-operation occurred in one patient only, presented with postoperative leak and managed by laparoscopic drainage together with endoscopic insertion of a stent. ***(Table9)***

Table (1) Demographic characteristics in the whole study population

Demographic characteristics			
Age (years)	Mean ±SD		33 ±7
Gender	Males	n (%)	7 (35.0)
	Females	n (%)	13 (65.0)

Table (2) Pre-operative anthropometric measures in the whole study population

	Mean ±SD
Weight (kg)	132 ±11
Height (cm)	165 ±6
BMI	48.6 ±5.4

BMI = Body mass index

Table (3) Distribution of symptoms pre and post-operative

		n (%)	**P value**
Heartburn	Pre	5 (25.0)	0.480
	Post	7 (35.0)	
Vomiting	Pre	0 (0.0)	NA
	Post	3 (15.0)	

McNemar test was used
NA = Not applicable

Table (4) Pre and post-operative endoscopic findings

		n (%)	P value
Esophagitis	Pre	4 (20.0)	0.754
	Post	6 (30.0)	
Gastritis	Pre	6 (30.0)	1.0
	Post	6 (30.0)	
Duodenitis	Pre	3 (15.0)	1.0
	Post	2 (10.0)	

McNemar test was used

Table (5) Pre and post-operative esophageal manometry findings

		Mean ±SD	P value
LES Resting pressure (mmHg)	Pre	15.4 ±7	0.001
	Post	14.1 ±7	
LES total length	Pre	4 ±0.4	0.096
	Post	3.9 ±0.5	
LES abdominal length	Pre	2.2 ±0.3	0.122
	Post	2.2 ±0.3	
DCI (mmhg.s.cm)	Pre	842 ±44	0.001
	Post	795 ±173	

Wilcoxon signed ranks test was used

LES = Lower esophageal sphincter

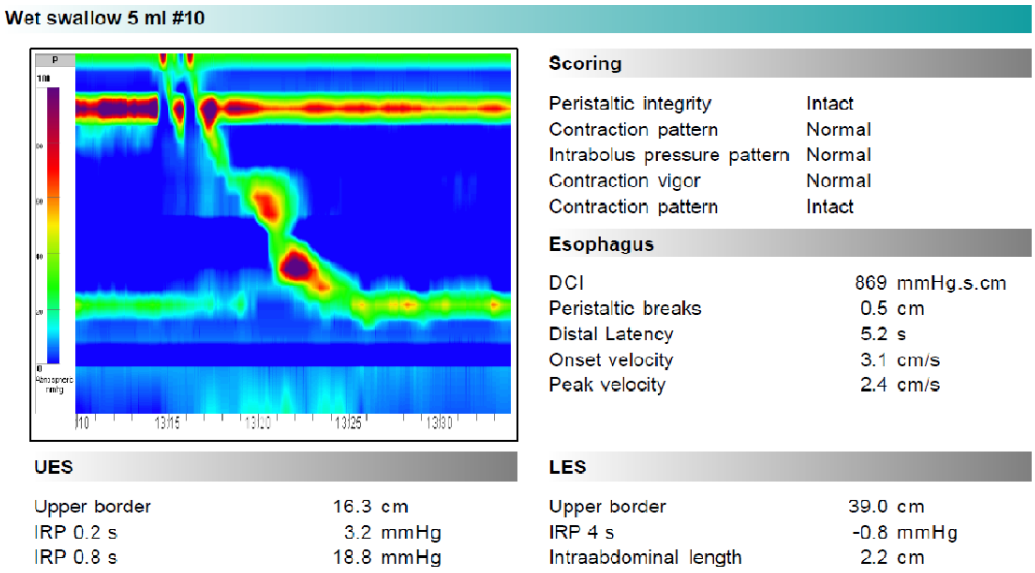

Fig. (1): Preoperative manometry

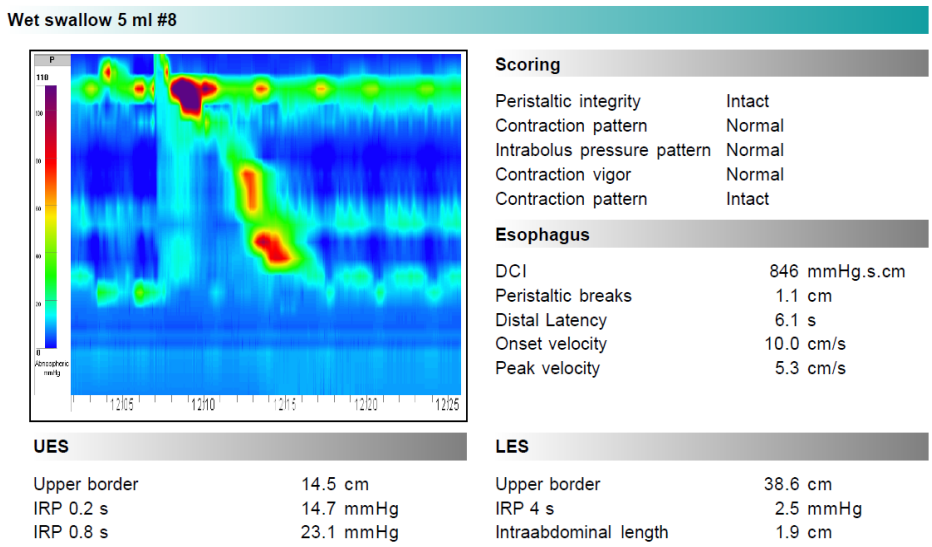

Fig. (2): Postoperative manometry

Table (6) Weight, height and BMI pre-operative, and at 6 months

		Mean ±SD	P value
Weight (kg)	Pre	132 ±11	<0.001
	At 6 months	97 ±7	
	At 6 months	35.7 ±3.5	
EWL (%)			
	At 6 months	39 ±5	

Friedman's test was used. Pairwise analysis was done and different letters indicate significant pair. All pairwise were Bonferroni adjusted

Table (7) Pre and post-operative DeMeester score

			n (%)	P value
DeMeester score	Pre	<14.1	16 (80.0)	0.448
		>14.7	4 (20.0)	
	Post	<14.1	13 (65.0)	
		>14.7	7 (35.0)	

McNemar test was used

Table (8) Intra-operative data in the whole study population

Intra-operative data		
Operative time (hours)	Mean ±SD	2 ±0.5
Liver status	Fatty n (%)	9 (45.0)
	Normal n (%)	11 (55.0)
Number of staplers	Mean ±SD	6 ±1
Distance from pylorus (cm)	Mean ±SD	5 ±1
Blood loss (ml)	Mean ±SD	142 ±69
Staple line bleeding	Yes n (%)	7 (38.9)
Conversion to open surgery	Yes n (%)	0 (0.0)

Table (9) Post-operative data in the whole study population

Post-operative data			
Duration of hospital stay (days)	Mean ±SD		3 ±2
Oral gastrograffin study	No reflux	n (%)	16 (80.0)
	Reflux	n (%)	4 (20.0)
Complications	Bleeding	n (%)	1 (5.0)
	Chest infection	n (%)	1 (5.0)
	Leak	n (%)	1 (5.0)
	port site infection	n (%)	2 (10.0)
	No complications	n (%)	15 (75.0)
Re-operation	Yes	n (%)	1 (5.0)

Discussion

Obese patients are at increased risk of GERD, esophagitis and esophageal adenocarcinoma [(13)]**.** Hampel et al., conducted a meta-analysis and described the effect of obesity and the risk for GERD and its associated complications. In 9 studies assessing the effect of obesity on GERD, 6 studies found significant associations between obesity and the prevalence of GERD. In 7 studies assessing association between obesity and erosive esophagitis, 6 studies found significant associations. In 7 studies assessing association between obesity and adenocarcinoma of the esophagus, 6 studies found significant associations ***(14)*****.**

In our study twenty patients underwent LSG at our general surgery department, Benha University during the study period. We found that 20% of patients had pathological 24 h pH results preoperatively. We found evidence of reflux esophagitis in 20% of patients in preoperative endoscopy. This was compared to Gorodner et al, who found pathological acid reflux in 29% of patients preoperatively and found evidence of preoperative reflux esophagitis in 29% of patients ***(15)*****.** Typical GERD symptoms were found in 25% of patients preoperatively. This was similar to Carter et al who found typical GERD symptoms in 34.6% of patients preoperatively ***(16)*****.**

Laparoscopic sleeve gastrectomy is considered one of the most popular bariatric procedures as it can achieve significant weight loss. In our study %EWL at 6 months was 39% and this is compared to Albeladi et al who reported %EWL of 46.6% at 6 months after LSG ***(17)*****.**

Despite the positive effect of sleeve gastrectomy regarding weight loss, there are concerns about its effect on esophageal motility especially the effect on lower esophageal sphincter function and the

development of de novo gastro-esophageal reflux disease (GERD) or worsening the existing GERD after this bariatric operation [18].

As regards **symptomatic assessment** in our study, five (25%) patients had preoperative heartburn and regurgitation. Two (10%) patients developed de novo heartburn and regurgitation postoperatively. Many studies reported the incidence of new- onset GERD symptoms, with an incidence ranging from 0% to 34.9% and follow-up varying between 1 and 60 months [19 and 20].

Diagnosis of GERD is usually based on symptoms in the regular clinical practice. We would like to emphasize how erroneous the diagnosis could be if it is supported merely on patient's symptoms. It has been previously documented by several authors that symptoms can be misleading at the time of identifying patients with GERD [21]. Investigators at the University of California San Francisco conducted a study over 124 patients reporting GERD-like symptoms after laparoscopic Nissen fundoplication. This study showed that only 48 (39 %) patients had abnormal DeMeester score [22]. Therefore, we considered that symptomatic assessment should not be used alone either in the preoperative or during the postoperative evaluation of GERD.

As regards **Esophagogastroduodenoscopy** in our study, four (20%) patients had reflux esophagitis before LSG. Two (10%) patients developed de novo reflux esophagitis six months after LSG. Four studies reported the incidence of new-onset esophagitis, ranging from 6.3% to 63.3% after LSG [23 and 24].

The absence of esophagitis on esophagogastroduodenoscopy does not exclude the diagnosis of GERD. It has been documented that mucosal changes are absent in about 50 % of patients with GERD [25]. Patti et al. found in their experience that esophagitis was absent in 54 % of the patients who had positive pH monitoring studies [26].

For that reason, we considered that esophagogastroduodenoscopy should not be used alone either in the preoperative or during the postoperative evaluation to confirm or exclude the presence of GERD.

As regards **oesophageal manometry** in our study, LES resting pressure decreased from 15.4 (15.4±7) mmHg to 14.1mmHg (14.1±7). A decrease in LES resting pressure from 14.2 mmHg preoperatively to 10.5 mmHg postoperatively [13], from 18.3 mmHg to 11 mmHg [19], and from 17.1 mmHg to 12.4 mmHg [15] was proved. This was in contrast to what was reported by some researchers who found an increase in LES resting pressure from 18.1 mmHg preoperatively to 21.1 mmHg postoperatively [27]. Table 10 shows the results of these studies.

In our study, four (5%) patients show hypotensive LES (incompetent LES) preoperatively and remained hypotensive LES after the procedure. This was unlike what was reported as a significant increase in the prevalence of LES incompetence after the procedure. They reported that all patients of their study was normotensive as regard the preoperative LES resting pressure but postoperative data show that hypotensive LES was present in 85% of patients. They correlated this finding with partial section of the sling fibers of the cardia [(13)]. A similar study also reported increase in the prevalence of LES incompetence from 7% preoperatively to 29% postoperatively [(15)].

Table (10): Studies reporting on manometric studies.

Studies	Number of patients	Preoperative LES resting pressure (mmHg)	Postoperative LES resting pressure (mmHg)	*P* value	Follow up (months)
Our study	20	15.4	14.1	.001	6
Braghetto et al [(13)]	20	14.2	10.5	0.01	6
Burgerhart et al[(19)]	20	18.3	11	0.02	3
Gorodner et al [(15)]	14	17.1	12.4	< 0.05	12
Kleidi et al[(27)]	23	18.1	21.1	0.01	1.5

As regard body motility, the percentage of normal peristalsis remained unchanged after LSG in our study. This is similar to what was reported before in 2001 [(26)]. In our study, the DCI decreased from 842(±44) preoperatively to 795(±173) postoperatively, but all these changes were not statistically significant.

As regards **24 h pH monitoring** in our study, four (20%) patients had abnormal DeMeester score preoperatively, which increased postoperatively to 7 (35%) patients. This was similar to others who reported increase in DeMeester from 12.6 to 28.4 after the procedure [(15)] and from 9 to 18.2 after the procedure [(28)]. **In a** study that included 28 patients with preoperative pathologic esophageal acid exposure and 37 patients with normal pH results, within the pathologic group, the DeMeester score show significant decrease from 39.5 to 10.6 while within the normal group the DeMeester score show non-significant increase from 11.9 to 12 [(24)]. Table (11) shows all these results.

Results concerning about the effect of laparoscopic sleeve gastrectomy on total acid exposure and DeMeester score are controversial. Researchers reported a significant increase in total acid exposure at 3- and 12-month follow-up respectively [(15 and 19)], while others found a significant decrease in total acid exposure within the group of patients with pathologic preoperative 24-hour pH results at 24-month

follow-up [24].

This paradox in the results and being not statistically significant was not surprising as the effect of sleeve gastrectomy on GERD is multifactorial. The absence of standardized technique for laparoscopic sleeve gastrectomy may also be responsible for this paradox. Another possible explanation is the wide variability in BMI among the patients who underwent laparoscopic SG, because this will not only influence the preoperative prevalence of GERD, but performing a laparoscopic sleeve gastrectomy in a patient with a BMI of 60 kg/ m^2 will be technically more challenging compared with a patient with a BMI of 40 kg/ m^2, thereby potentially affecting the performed technique.

Nevertheless, our study has some limitations. First, the number of patients who agreed to participate in a non- indicated examination was too small to allow us to reach significant conclusions regarding more manometric parameters. Second, the follow-up period in which the patients were reexamined can only indicate the reproducibility of our results. Even if many studies agree that postoperative reflux is aggravated in the first year, it can remit later on and might reappear after many years. Repeating manometry after a longer period could possibly reveal more changes on the LES, and this should be the purpose of future studies.

Table (11): Studies reporting on 24 hour pH results

Studies	Number of patients	Preoperative DeMeester score	Postoperative DeMeester score	*P* value	De novo pathologic pH result (%)	Excess weight loss (%)	Follow up (months)
Our study	20	>14.7: 20%	>14.7: 35%		15%	49.1	6
Gorodner et al [15]	14	12.6	28.4	< .05	36	74	12
Burgerhart et al [19]	20	Not answered	Not answered	-------	Not answered	19	3
Del Genio et al [28]	25	9	18.2	0.041	0	56	13
Rebecchi et al [24]	37/65	11.9	12	0.846	10.8	56	24
	28/65	39.5	10.6	< .001	No	54	24

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