Impact of laparoscopic sleeve gastrectomy on esophageal physiology

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Introduction. Laparoscopic sleeve gastrectomy (LSG) is a popular weight loss surgery technique, but the impact on esophageal physiology and esophagogastric junction is still debatable. The aim of our study was to evaluate the manometric changes of the lower esophageal sphincter (LES) after LSG in order to indicate LES manometry pre- procedure.

Methods. In a prospective study we evaluated clinically, with upper gastrointestinal endoscopy, and high-resolution esophageal manometry 45 morbidly obese patients before, and 6–12 months after LSG.

Results. The BMI (body mass index) decreased from 46.28 ± 5.79 kg/m² to 32.28 ± 4.65 kg/m² postoperatively ($p < 0.01$), with a reduction of ~ 14 kg/m² of BMI, 39.9 (± 11.9) kg body weight and 29.9 (± 6.2)% of the TWL (Total Weight Loss index), in a median interval of 7.9 months. Gastroesophageal reflux disease (GERD) prevalence increased from 17.8% to 31.1% postoperatively, with new GERD onset in 22.2%, but mild symptomatology (the median GERD-HRQL score increased from 1.56 to 2.84 points). Postoperative reflux was associated with lower esophageal sphincter (LES) hypotonia, shortening of LES length and IIGP (increased intragastric pressure). Hiatal hernia repair rate was 17.8%, and proton pump inhibitor consumption 20%. After weight loss, the 10 cases of esophagitis discovered preoperatively cured, but 3 patients were diagnosed with de novo esophagitis. The prevalence of manometric dysmotility after LSG was 28.9%, lower than before surgery (44.4%).

Conclusion. Even if GERD remains the main limitation of LSG, the high-resolution esophageal manometry has proved useful and should be implemented in morbidly obese evaluation protocol, to better select the bariatric procedure.

Key words: obesity, sleeve gastrectomy, gastroesophageal reflux, esophageal dysmotility.

INTRODUCTION

Bariatric surgery is an effective method of weight loss, recommended for morbid obesity, defined by BMI (body mass index) above 40 kg/m², or > 35 kg/m² with obesity-associated comorbidities: type II diabetes, metabolic syndrome, sleep apnea syndrome, dyslipidemia, cardiovascular disease, hypertension [1].

The prevalence of obesity has tripled from 1975 because of sedentary lifestyle and eating behavior [2,3], but only 20% of the obese achieve weight loss with a long-term diet [4]. The benefits of anorexigenic drugs are not great and the risk of side effects high, especially pulmonary hypertension and valvulopathy [5,6].

Laparoscopic sleeve gastrectomy (LSG) is a popular bariatric procedure, the weight loss is obtained by lowering the stomach volume – restrictive mechanism, and by decreasing the level of ghrelin – an appetite stimulating hormone [7].

The effects of LSG on esophageal physiology and lower esophageal sphincter (LES) are still debatable, and for that purpose we evaluated all the patients with high-resolution esophageal manometry. 24-h esophageal pH monitoring and gastric emptying radiological studies were not available in our center or approved by the ethic committee.

MATERIALS AND METHODS

We performed a prospective before-after study on morbidly obese patients included in the “Dr. Carol Davila” Emergency University Central Military Hospital Bucharest bariatric surgery program (2016-2020), following them at 6–12 months after LSG. We focused on clinical aspects, resolution of comorbidities, GERD (gastro-esophageal reflux disease) and hiatal hernia prevalence, the esophageal motility pattern and

esophagogastric junction evaluation, modifications of the lower esophageal sphincter (LES). The aim was to include high-resolution esophageal manometry in the bariatric surgery evaluation protocol, in order to reduce the rate of post LSG complications.

The inclusion criteria for this study were: age > 18 years, BMI more than 40 kg/m² or 35 kg/m² with minimum one comorbidity, acceptable risk for the procedure, signed informed consent. The study has been approved by the ethics committee of the hospital.

The exclusion criteria were: age under 18 years, BMI < 35 kg / m², peptic ulcer or tumor, tuberculosis, HIV, increased risk of anesthesia (severe decompensated liver disease, kidney or cardiovascular disease), severe mental illness, alcohol and drug addiction, pregnancy or breastfeeding, inclusion in another recent study, other bariatric surgery performed previously or anti-reflux surgery, postpeptic or postcaustic esophageal stenosis with or without endoscopic dilation procedures.

All morbidly obese patients eligible according to the inclusion and exclusion criteria were evaluated preoperatively. Demographic and anthropometric data, medical history and associated comorbidities were collected for each patient. Then all patients completed the GERD-HRQL questionnaire “GERD-Health Related Quality of Life Questionnaire” to assess the severity of reflux symptoms and life quality, followed by upper digestive endoscopy and high-resolution esophageal manometry (HRM) performed by a single examiner with the Sierra-Scientific HRM-solid catheter, according to the protocol (a 30 seconds baseline LES resting pressure recording, then 10 unique – 5 ml water swallows separated by minimum 30 seconds of respiration in supine position), analyzed with v3.0 of Chicago classification. Then the patients underwent the LSG performed by the same surgical team in our bariatric center, without immediate post-procedural complications.

The post-therapeutic study phase consisted in clinical reexamination, recording of the weight loss, the follow-up rate, the resolution of obesity comorbidities, resumption of the GERD-HRQL questionnaire, upper digestive tract endoscopy and esophageal manometry after the bariatric procedure. HRM followed the same protocol as preoperative, the recording was done by the same examiner and catheter to exclude technical differences.

Postoperative control at 6 months could not be performed due to pandemics and to patients' lack of compliance, so the average interval of 6-12 months after bariatric surgery was accepted.

Statistical analysis was done by SPSS Statistics 25 (Armonk, NY, USA). Statistics included the paired t-student test to compare the averages of parameters before and after surgery. The threshold of statistical significance was chosen for a value $\alpha = 0.05$.

RESULTS

The characteristics of the obese study group (45 patients) are summarized in Table 1. The obesity comorbidities increased with age and BMI values, the most frequent was obstructive sleep apnea syndrome in 73.4%, hypertension in 62.0% and diabetes mellitus in 49.4%. Cardiovascular disease was also present in young patients (eg. a 31 years old male with myocardial infarction)

The preoperative manometric data focused on LES evaluation: hypertonic LES in 24.4%, hypotonic LES in 11.1%, LES length of 3.24 ± 0.87 cm, EGJ morphology and presence of hiatal hernia in 31.11%, and esophageal dysmotility in 44.4%: 22.2% (25) patients diagnosed with EGJ outflow obstruction (EGJO), 13.3% (6) IEM – ineffective esophageal motility, 4.4% (2) DES – distal esophageal spasm, 2.2% (1) Jackhammer esophagus and 2.2% (1) manometric aspect suggestive for achalasia type II but asymptomatic (the Eckardt score 0 points) – important data that were compared with post LSG manometry.

LSG proved to be a safe intervention, the reported postoperative mortality was zero, without any major complication. The postoperative follow-up rate at 6-12 months post LSG was 78.9% (57 operated patients, 45 patients with follow-up). The comorbidities' resolution after weight loss was 90% for the sleep apnea syndrome, 70.8% for diabetes mellitus, but also significant for dyslipidemia, nonalcoholic fatty liver, hypertension and osteoarticular pathology.

After the comparative analysis for the 45 patients that completed the study, the following results were found: the BMI value decreased from 46.3 ± 5.8 kg/m² preoperatively to 32.3 ± 4.6 kg/m² postoperatively ($p < 0.01$) in a median interval of 7.9 months, with a reduction of ~ 14 kg/ m² of BMI, 39.9 (± 11.9) kg body weight and 29.9 (± 6.2)% of the TWL (Total Weight Loss index).

Table 1
Characteristics of obese patients (n=45)

Age (years) Median ($\pm$ SD) Interval	47.89 ($\pm$ 10.03) 26–70
Sex % (n) Male Female	44.44 % (20) 55.56 % (25)
Origin % Urban Rural	86.67 % 13.33 %
BMI (kg/m ²) Median Maximum	<u>46.28</u> 61
Weight preoperatory (kg) Median Interval	132 85–177
Most frequent obesity comorbidities: • <u>obstructive sleep apnea syndrome</u> • <u>hypertension</u> • <u>diabetes mellitus</u> • <u>NAFLD (non-alcoholic fatty liver disease)</u>	<u>73.4 %</u> <u>62.02 %</u> <u>49.37 %</u> <u>29.1 %</u>

GERD increased postoperatively from 17.8% to 31.1% with mild symptoms, and de novo GERD appeared in 22.2%. The median GERD-HRQL score increased from 1.56 to 2.84 points. Hiatal hernia repair rate was 17.8%, from 31.1% incidence before, to only 13.3 % patients after LSG. All the esophagitis discovered preoperatively, 22.2 % (10), was cured, but 3 patients were diagnosed with de novo esophagitis at endoscopic control, the PPI consumption being similar, 20% vs. 22.2%. Shortening of LES length was seen in 55.5%, and IIGP (increased intragastric pressure) at 17.8%, these modifications being associated with LES hypotonia, favoring reflux. An important manometric change after LSG was lowering the LES tonus in those patients who previously had hypertensive esophagogastric junction (from 11 patients before, to 3 patients after the procedure).

80% of the patients with de novo reflux symptoms had LES length shortening, from a median value of 3.24 ± 0.87 cm before, to 3.1 ± 0.7 cm after LSG. Also, 37 patients asymptomatic

before surgery (GERD-HRQL score zero points) had a median GERD-HRQL score higher post intervention, 2.92 points, explaining new onset of reflux symptoms after bariatric surgery.

The comparative results pre- and postoperative for the followed group are illustrated in Table 2.

Table 3 presents the esophageal dysmotility before and after LSG based on Chicago classification version 3.0. The prevalence of manometric dysmotility after LSG was lower (28.9%) than before surgery (44.4%); from 20 patients with manometric modifications at baseline, only 10 had abnormal HRM diagnosed at control, and 3 patients had new esophageal dysmotility (IEM, fragmented peristalsis and DES). One patient with preoperative manometric diagnostic of DES, after LSG had IEM, considered a minor disorder of peristalsis according to Chicago classification. To correlate esophageal dysmotility with postoperative GERD, we need a larger cohort.

Table 2
Comparative results (n=45)

	Preoperative	Postoperative
BMI kg/m^2	46.28 ± 5.79	32.28 ± 4.65 (p value < 0.001)
GERD % (n)	17.78% (8)	31.11% (14) of which, new GERD 22.22% (10)
GERD-HRQL score (points)		
Median	1.56	2.84
Interval	0–17	0–21
Esophagitis % (n)	22.22 % (10)	6.67 % (3)– new cases p = 0.036
PPI consumption % (n)	22.22 % (10)	20 % (9)
Hiatal hernia % (n)	<u>31.11 % (14)</u>	<u>13.33 % (6), p = 0.043</u>
Manometric dysmotility % (n)	44.44 % (20)	<u>28.88 % (13)</u>
Manometric diagnosis % (n)		
Normal		71.11 % (32)
EGJOO (outflow obstruction)	55.56 % (25)	6.67 % (3)
IEM	22.22 % (10)	15.56 % (7)
DES	13.33 % (6)	2.22 % (1)
	4.44 % (2)	2.22 % (1)
	2.22 % (1)	0
Jackhammer esophagus	2.22 % (1)	2.22 % (1)
Achalasia type II	0	
Fragmented peristalsis		
LES tonus		
• hypertonia	24.44 % (11)	6.66 % (3) p = 0.020
• hypotonia	11.11 % (5)	11.11 % (5)
LES length (cm)	<u>3.238 $\pm$ 0.8669</u>	<u>3.108 $\pm$ 0.702</u>

BMI – body mass index; GERD-HRQL Health Related Quality of Life; DES – Distal esophageal spasm, IEM – Ineffective esophageal motility, PPI- proton pump inhibitor; LES- lower esophageal sphincter; EGJOO – Esophagogastric junction outflow obstruction

Table 3
Manometric diagnosis pre-and postoperative

No.	Preoperative	Postoperative
1	DES	IEM
2	DES	N
3	Achalasia type 2	N
4	EGJOO	N

Table 3 (continued)

5	EGJOO	N
6	EGJOO	N
7	EGJOO	N
8	EGJOO	N
9	EGJOO	N
10	EGJOO	N
11	IEM	N
12	EGJOO	EGJOO
13	EGJOO	EGJOO
14	EGJOO	EGJOO
15	IEM	IEM
16	IEM	IEM
17	IEM	IEM
18	IEM	IEM
19	IEM	IEM
20	Jackhammer esophagus	Jackhammer esophagus
21	N	IEM
22	N	Fragmented peristalsis
23	N	DES

N – normal, DES – Distal esophageal spasm, IEM – Ineffective esophageal motility,
EGJOO – Esophagogastric junction outflow obstruction

DISCUSSION

As expected, obesity was associated with high prevalence of GERD symptoms (17.8%), erosive esophagitis (22.2%), and proton pump inhibitor consumption (22.2%). Dupree C *et al.* reported 44.5% preoperative GERD prevalence [8]. Some studies showed that reflux symptoms are more common in individuals who gain weight, the BMI increase with 3.5 units being accompanied by a 3 times higher risk of developing GERD [9].

Esophageal manometry helped to determine LES basal pressure, esophago-gastric junction morphology, hiatal hernia (HH) and esophageal contractility, all contributing to reflux. Obesity was associated with hiatal hernia but without a linear relationship with BMI values.

The relationship between GERD and esophageal dysmotility in obese has gained interest, the mechanisms involved being: LES basal hypotonia, the short segment of intra-abdominal LES due to increased abdominal pressure in obese leading to LES relaxation and hiatal hernia [10], delayed gastric emptying, and esophageal dysmotility. Suter

M. *et al.* in 2004 described a prevalence of 25.6% for dysmotility [11].

LSG proved to be a safe intervention increasing the patients' quality life, optimization of body weight led to the high resolution of comorbidities (70.83% for diabetes mellitus, 90% for sleep apnea syndrome), data similar to Chopra A *et al.* who described 84% resolution of diabetes and 90.74% for sleep apnea syndrome and zero mortality [12].

The lowering of intra-abdominal pressure due to bariatric surgery and hiatal hernia repair influence the resolution of GERD symptoms [12]. This is probably the logic explanation for all esophagitis healing observed in our postoperative surveillance. But despite the weight loss achieved and hiatal hernia repair, GERD symptoms increased, with new GERD onset, and three new cases of esophagitis with mild symptoms, that didn't influence the proton pump inhibitor intake. So laparoscopic sleeve gastrectomy does not aggravate pre-existing reflux, but may cause de novo reflux. Dupree C *et al.* [106] described 8.6% de novo postoperator GERD.

The manometric data showed shortening of LES length post LSG, LES pressure changes – lowering the LES tonus in those patients who previously had

hypertensive esophago-gastric junction, and IIGP-increased intragastric pressure, all considered GERD risk factors. There are some studies that reported an increase of de novo reflux post LSG and worsening of the reflux symptoms [13–15], because the gastric volume is reduced and the intragastric pressure is high, and sectioning the esophagogastric junction muscle fibers might alterate the Hiss angle. Also, antral pump disfunction and esophageal dysmotility can promote GERD [16]. Highlighting these modifications, the high-resolution esophageal manometry has proved useful in morbidly obese evaluation before bariatric surgery, and should be implemented in the protocol, or at least in those with GERD symptoms or esophagitis.

CONCLUSION

In conclusion, LSG can lead to new GERD, but does not aggravate the symptoms of pre-existing reflux or esophagitis. Post LSG, the reflux symptoms proved to be minor, easy to treat without need for anti-reflux surgery.

The mechanisms of postgastrectomy reflux are related to the LES shortening, lowering LES pressure and intragastric pressure gradient and less to the esophageal peristalsis and clearance.

By lowering the abdominal pressure gradient after weight loss and treating hiatal hernia at the same operation time, LSG improved the esophagus acidic exposure and probably cured the pre-existing esophagitis.

Given the results, esophageal manometry should be implemented in the evaluation protocol of morbidly obese patients before bariatric surgery, or at least to those with reflux and esophagitis. The manometric LES hypotonia could be a limitation for LSG, because altering the Hiss angle post-surgery might perturb the antireflux mechanism. So GERD remains the main limitation of LSG, however its benefits outweigh the side effects. The lack of severe early or late postoperative complications, make this bariatric surgery a safe operation. Because there is a risk of Barrett's esophagus, especially in those with asymptomatic reflux, endoscopic surveillance post-sleeve gastric should be implemented.

As future research directions proposed, 24-h esophageal pH monitoring and gastric emptying radiological studies (C13 octanoic acid respiratory test – nondispersive infrared spectroscopy or scintigraphy) may bring additional information on this topic.

Introducere. Gastrectomia sleeve laparoscopică (LSG) este o procedură populară de chirurgie bariatrică, însă efectele ei asupra fiziologiei esofagiene sunt discutabile. Pentru a reduce complicațiile postoperatorii, propunem includerea manometriei esofagiene în protocolul de evaluare al obezității morbide.

Metode. În acest studiu prospectiv am evaluat clinic, endoscopic și manometric 45 de pacienți obezi la momentul inițial și la 6–12 luni după operație.

Rezultate. Valoarea IMC (indicei de masă corporală) a scăzut de la $46,28 \pm 5,79 \text{ kg/m}^2$ la $32,28 \pm 4,65 \text{ kg/m}^2$ postoperator ($p < 0,01$), cu o reducere de $\sim 14 \text{ kg/m}^2$ a IMC, $39,9 (\pm 11,9) \text{ kg}$ greutate corporală și $29,9 (\pm 6,2)\%$ indice total de pierdere în greutate (TWL), într-un interval mediu de 7,9 luni. Rezoluția comorbidităților postoperator a fost de 90% pentru sindromul de apnee în somn și 70,83% pentru diabetul zaharat. Prevalența bolii de reflux gastroesofagian (BRGE) a crescut postoperator de la 17,8% la 31,1%, cu BRGE de novo la 22,2%, dar cu simptomatologie ușoară. Refluxul a fost asociat cu hipotonia sfincterului esofagian inferior (SEI), scurtarea lungimii SEI și gradientul de presiune intragastrică crescut. Rata de reparare a herniei hiatale a fost 17,8%, iar consumul de inhibitori ai pompei de protoni 20%. După pierderea în greutate, esofagita descoperită preoperator la 22,2% (10) s-a vindecat, 3 pacienți fiind diagnosticați cu esofagită de novo. Prevalența dismotilității manometrice după LSG a fost de 28,9%, mai mică decât preoperator (44,4%).

Concluzii. BRGE rămâne principala limitare a LSG, manometria esofagiană aduce informații importante privind morfologia joncțiunii eso-gastrice și a dismotilității esofagiene și ar merita implementată în protocolul de chirurgie bariatrică.

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