

Correlation Between Preoperative Gastric Volume and Weight Loss After Laparoscopic Sleeve Gastrectomy

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Purpose: Long-term studies reported inadequate weight loss or weight regain after laparoscopic sleeve gastrectomy (LSG). This study investigated a possible relationship between preoperative gastric volume (GV) measured by CT volumetry and weight loss one year after LSG.

Methods: This prospective study included 120 patients scheduled for LSG. 3D CT gastric volumetry was done before surgery. The weight loss in the first year was serially recorded. The primary outcome measure was the correlation between preoperative GV and postoperative weight loss after one year. The secondary outcomes were the correlation between preoperative GV and other patients' characteristics as age and body mass index (BMI).

Results: Weight and BMI decreased significantly up to 12 months. The percentage of excess weight loss (%EWL) at 6 and 12 months was significantly higher than at three months. Preoperative GV was 1021 ± 253 , ranging from 397 to 1543 mL. GV was not related to sex, age, weight, height, postoperative weight, and BMI.

Conclusion: Preoperative gastric volume cannot predict weight loss one year after LSG. It is not correlated with age, sex, or preoperative weight, and BMI.

Keywords: correlation, gastric volume, weight loss, sleeve

Introduction

Currently, laparoscopic sleeve gastrectomy (LSG) is the most frequently performed bariatric surgery worldwide. In 2016, it represented 53.6% of all procedures, according to the International Federation for the Surgery of Obesity and Metabolic Diseases.¹ Its popularity is attributed to feasibility and satisfactory weight loss outcomes.² From the restrictive perspective, gastric volume (GV) before and after surgery may influence its outcome. The excision of nearly 80% of the stomach induces early satiety due to the low compliance of the narrow gastric lumen with high intraluminal pressure.³ Accordingly, some studies found that postoperative weight regain can be predicted from the resected volume of the stomach during SG.⁶⁻⁸ In a prospective study, a resected GV of <500 cubic centimeters predicted early weight regain or treatment failure.⁴ Hanssen et al found an inverse correlation between postoperative GV and weight loss six months after LSG.⁵ Toro et al⁶ proposed a resected gastric size of 1200–1600 mL to achieve a satisfactory weight loss. However, the authors did not find a correlation of variability in specimen volume and compliance with excess body weight loss.⁶

Nevertheless, the role of GV in obesity and response to bariatric procedures is not adequately studied. Gastric volume and emptying modify food intake and consequently may influence body weight. It has been shown that in obese persons, fasting GV was larger, and gastric emptying of solids was faster.^{7,8} Delgado-Aros et al reported an association between higher body mass, larger GV, and decreased satiation.^{9,10}

However, we found few studies exploring the preoperative gastric volume before LSG as a possible factor that could affect postoperative weight loss. Therefore, this study was designed to investigate a possible relationship between preoperative gastric volume detected by CT volumetry with weight loss one year after laparoscopic sleeve gastrectomy.

Patients and Methods

This prospective study was conducted during the period between November 2017 and July 2019. The study included 120 patients scheduled for laparoscopic sleeve gastrectomy (LSG). The study was conducted in accordance with the principles of the Helsinki Declaration and Good Clinical Practice. It was approved by the ethics committee of the Cairo University Hospitals. Written informed consent was obtained from all patients participating in this study.

The study included patients 17 to 65 years old, with a body mass index (BMI) > 40 kg/m² or BMI > 35 kg/m² associated with comorbidity. Patients with a history of stomach cancer, previous gastric surgery, chronic liver disease, previous abdominal exploration, or psychogenic disorders were excluded from the study.

All patients were subjected to thorough history taking and clinical examination. Preoperative laboratory investigations included complete blood count, coagulation profile, liver function tests, kidney function tests, fasting blood sugar, and hepatitis B and C markers. ECG, chest X-ray, and pulmonary function tests were done to assess the chest condition and airways before surgery.

3D CT Gastric Volumetry

3D CT gastric volumetry was done before sleeve gastrectomy. All patients were given oral effervescent granules before the study to ensure gastric distension crucial for acquiring volumetric data. Pouch dimensions were calculated using 3D CT; a proper pouch volume could be calculated using the parameters of height, width, and depth. Pouch volume was expressed in cubic centimeters (cc). Pouch area was calculated as height (or length) times

the width, expressed in square centimeters. The method used to calculate pouch area was measured on an antero-posterior radiograph at maximum pouch distention.

Laparoscopic Sleeve Gastrectomy

Before surgery, enoxaparin 40 IU at the night of the operation and antibiotic prophylaxis with 2 gm of cefazolin within one hour were administered. Surgery was performed under general anesthesia. A crepe bandage was applied to prevent thromboembolism in both legs. The patient was put in a reverse Trendelenburg position. Pneumoperitoneum was established through the insertion of a veres needle. The first trocar 10 mL for the camera was introduced 18–20 cm inferior to the xiphoid and patient's left side to the midline then insertion of camera 30° scope. The second trocar 5–10 mL for liver retractor was inserted just below the xiphoid from the patient's left side. The third and fourth trocars, 12–15 mL for the surgeon's working hands, were inserted from the patient's left and right midclavicular line 2 cm higher than the camera trocar. A fifth trocar for the assistant was inserted from the patient's left axillary line below the costal arch.

The pylorus was identified, and the greater curvature of the stomach was elevated. An advanced bipolar device was used to enter the greater sac via dividing the greater omentum. The greater curvature of the stomach was then dissected free from the omentum and the short gastric blood vessels using the bipolar device. An endoscopic linear cutting stapler was used to staple and transect the stomach serially. Stapling started 4–6 cm from the pylorus till the angle of His done over 36 Fr bougie (Figure 1). Hemostasis was secured, and a tube drain was inserted. Excised stomach was removed, then the ports' sites were closed.

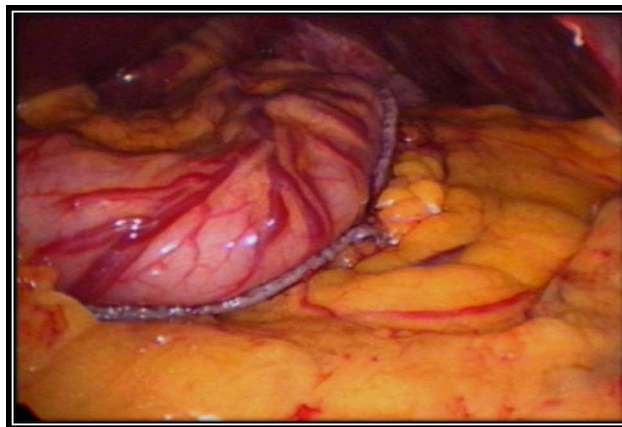


Figure 1 Sleeve pouch after stapling.

Postoperative Assessment

The postoperative complications were recorded after the first follow-up visit on day 7. Subsequent visits were scheduled at weeks 2, 3, and 4, then months 2, 3, 6, and 12. The body weight loss in the first year was recorded serially.

The primary outcome measure was the correlation between preoperative GV and postoperative weight loss after one year. The secondary outcomes were the correlation between preoperative GV and different patients' characteristics as age, sex, and preoperative BMI.

Statistical Analysis

Statistical analysis was done using IBM® SPSS® Statistics version 22 (IBM® Corp., Armonk, NY, USA). Numerical data were expressed as mean and standard deviation. Qualitative data were expressed as frequency and percentage. For quantitative data, comparison between two groups was made using independent sample *t*-test. Comparison of repeated measures was made using ANOVA for repeated measures followed by Bonferroni test as post-hoc test. Pearson product-moment was used to estimate the correlation between numerical variables. A *p*-value < 0.05 was considered significant.

Results

Table 1 shows the baseline characteristics of the studied group. Comorbidities were recorded in 47 patients (60.8%), the most common of diabetes mellitus (DM).

Table 1 Baseline Characteristics of the Whole Studied Group (n = 120)

	Value
Age (years)	34.0±9.7
Gender (Male/Female)	54/66
Body mass index (kg/m ²)	42.4±3.1
Comorbidities	
Diabetes Mellitus	24 (20.0%)
Hypertension	13 (10.8%)
Hyperlipidemia	4 (3.3%)
Spine problems	2 (1.7%)
Lumbar disc prolapse	1 (0.8%)
Obstructive sleep apnea	1 (0.8%)
Knee osteoarthritis	1 (0.8%)
Sleep apnea	1 (0.8%)
Ischemic heart disease	1 (0.8%)

Note: Data are presented as mean±SD or number (%).

Table 2 Change of Weight and Body Mass Index Throughout the Follow-Up Period (n = 119)

	Weight (kg)	Body Mass Index (kg/m ²)
Preoperative	119.2±12.5	42.5±3.1
3 Months	100.2±12.2	35.7±3.3
6 Months	83.1±8.8	29.6±1.9
12 Months	69.2±7.8	24.6±1.0

Note: Data are presented as mean±SD.

One patient suffered a severe postoperative leak and died in hospital. The follow-up data are presented for the remaining 119 patients. Table 2 shows that weight and BMI decreased significantly through the follow-up period up to 12 months (*p* < 0.001 for all comparisons). The percentage of excess weight loss (%EWL) during the follow-up period is shown in Table 3. %EWL at six months was significantly higher than that at three months. Also, the %EWL at 12 months was significantly higher than that at 3 and 6 months.

Preoperative GV was 1021 ± 253, ranging from 397 to 1543 mL. It was comparable in males (1012 ± 263 mL) and females (1030 ± 248, *p* = 0.703). Also, GV was not correlated with age, weight, height, postoperative weight, and BMI, or %EWL (Table 4).

One patient experienced staple line leakage one week postoperatively and was controlled by an endoscopic stent and intraabdominal drains after laparoscopic exploration and irrigation. But the patient died two weeks after re-exploration due to respiratory distress because of aspiration during a vomiting attack. Two patients suffered from bleeding and were managed by conservative measures and resuscitation by blood transfusion.

Discussion

The effectiveness of bariatric surgery has been emphasized over the past few decades. LSG has evolved into the most frequent bariatric procedure in many areas globally, with increasing evidence on its efficacy and safety.^{11,12} LSG achieves durable long-term weight loss with significant

Table 3 Percentage of Excess Weight Loss (%EWL) Throughout the Follow-Up Period (n = 119)

	%EWL	<i>p</i> -value*
3 Months	33.4±8.2	
6 Months	62.6±7.1	< 0.001
12 Months	86.2±5.1	< 0.001

Notes: Data are presented as mean±SD. *Compared to EWL at three months.

Table 4 Correlation of Preoperative Gastric Volume with Patients' Characteristics and Postoperative Weight Loss (n = 119)

	Correlation Coefficient	p-value
Age	0.095	0.302
Height	0.177	0.054
Preoperative Weight	0.170	0.064
Weight after 3 months	0.162	0.079
Weight after 6 months	0.149	0.106
Weight after 12 months	0.165	0.103
Body mass index	0.002	0.987
BMI after 3 months	0.024	0.796
BMI after 6 months	-0.026	0.780
BMI after 12 months	0.172	0.086
%EWL after 3 months	-0.046	0.620
%EWL after 6 months	0.051	0.582
%EWL after 12 months	-0.141	0.126

Abbreviations: BMI, body mass index; %EWL, percentage of excess weight loss.

comorbidities resolution, especially type-2 DM.¹³ However, multiple physiologic, anthropometric, and social factors affect the outcome of bariatric procedures. For example, a BMI above 50 kg/m² may be associated with a poor outcome than lower BMIs.¹⁴ Long-term studies reported an appreciable frequency of inadequate weight loss or even weight regain after LSG^{15,16} with an estimated failure rate of 10% to 30%.¹⁷ Therefore, many investigators tried to identify factors that might predict weight loss in a trial to improve bariatric surgery outcomes.¹⁸

Weight loss after LSG appears to be multifactorial, despite volume restriction being the key factor.^{19,20} The impact of residual sleeve volume after LSG on weight loss has been investigated. A high residual gastric volume (RGV) three years after LSG was a risk factor for failure.²¹ A recent meta-analysis of five studies showed that variations in RGV could explain up to 26.3% of the variability in weight loss following LSG.²² A meta-analysis of four studies demonstrated that a smaller bougie diameter was associated with a better weight loss than the larger diameter bougies.²³ Technically, LSG encompasses a longitudinal transection of most gastric fundus, body, and antrum directed by a bougie.²⁴ However, disparities have been reported in the bougie size and the distance from the pylorus as the point to start resection.^{10,11} But, the resected GV remains a non-standardized variable in all cases. So, many studies investigated the association between resected GV and weight loss after LSG,²⁵⁻³⁰ yet their findings were controversial.

Besides, stomach volume may vary widely among different patients. One study found that stomach size was affected by sex, BMI, and age. The greater curvature was significantly longer in patients with more severe obesity.³¹ Another study compared stomach size and volume in obese and non-obese individuals and found no significant difference. Moreover, patients with obesity had significantly smaller greater curvatures. The authors reported that BMI was negatively correlated with the length of greater curvature and positively correlated with that of the lesser curvature.³² Thus, the resected stomach volume can also vary and is not an appropriate predictor of the success of LSG.

Therefore, we investigated any possible correlation between the preoperative GV measured by CT volumetry before LSG and weight loss in the first postoperative year in this study. We found widely variable preoperative GV ranging from 397 to 1543 mL, which was not correlated with age, sex, weight, or height. However, it did not predict postoperative weight and BMI or %EWL.

In contrast to former beliefs, we did not find a correlation between GV and BMI. Previous studies reported that obese individuals tend to have a larger stomach capacity than non-obese,^{33,34} but the findings were based on subjective measures. They depend on the maximal tolerable volume with an intragastric balloon rather than the more objective intragastric pressure or compliance. A larger antral volume in fasting obese individuals was also demonstrated by Kim et al³⁵ in adults using single-photon emission computed tomography and in children by Chiloiro et al using ultrasonography.³⁶ More recently, Elbanna et al found a positive correlation between preoperative GV and BMI and body weight.¹⁴ These authors used three-dimensional (3D) CT. In the present study, we also used 3D CT, a feasible noninvasive method that provides a standardized GV with visualization of an easy-to-understand image by patients and surgeons.³⁷ Like the current study, Mohamed et al reported a non-significant correlation between preoperative GV and body weight.³⁸ The authors of the present study frequently observed a relatively small stomach in patients subjected to bariatric surgery.

No correlation between the preoperative GV and weight loss at 12 months postoperatively is the main finding of this study. This was concordant with the previous two studies investigating the relation between preoperative GV and weight loss after LSG. Elbanna et al found no correlation between preoperative GV and the %EWL six

months after LSG.¹⁴ Similarly, Mohamed et al did not show a direct impact of GV on weight reduction after LSG.³⁸

These findings support the notion of other non-restrictive mechanisms for weight loss in LSG, like postoperative hormonal and gastric emptying changes. Studies reported a postoperative reduction of ghrelin hormone levels, an appetite-stimulating hormone mainly produced by glands in the stomach fundus.³⁹ It is hypothesized that the increased gastric emptying rate increases secretion of some gut hormones like GLP-1 that induce more rapid satiety.^{40,41} Rapid gastric emptying causes faster intestinal transit, contributing to weight loss and improvement of type-2 DM.^{42,43}

We did not use preoperative screening and treatment for *Helicobacter pylori* as the findings of Gianluca Rossetti et al suggest that *Helicobacter pylori* infection seems not to influence postoperative outcome of patients operated of laparoscopic sleeve gastrectomy.⁴⁴

This study had some limitations; it missed the residual GV and pouch volume, but other studies evaluate them.⁴⁵ In conclusion, the preoperative GV cannot predict weight loss one year after LSG. Preoperative GV is not correlated with age, sex, or preoperative weight, and BMI. Long-term follow-up may reveal a predictive value of GV of the outcome of LSG and other bariatric surgery. 3D CT gastric volumetry appears to be an accurate tool for studying gastric size and structure before bariatric surgery. We advocate that LSG is not simply a restrictive procedure working through reducing stomach volume. Other mechanisms for weight loss operate more and need to be proved by more extensive research.

Disclosure

The authors report no conflicts of interest in this work.

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