Volumetric pouch study after laparoscopic sleeve gastrectomy

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Background
Laparoscopic sleeve gastrectomy (LSG) is frequently performed as a definitive bariatric procedure today. The aim of this study is to evaluate the volumetric changes of gastric reservoir 1 year after LSG using multislice spiral computed tomography (MSCT) and to analyze their relationship with weight loss.
Patients and methods
This is a prospective study of 50 morbidly obese patients submitted to LSG in the Upper Gastrointestinal Surgery Unit, Alexandria Main University Hospital. All patients were referred for abdominal MSCT with volumetric assessment of gastric pouch 1 month and 1 year after surgery.
Results
A significant increase in total gastric reservoir volume (111.90±41.56 and 144.14± 42.87 ml at 1 and 12 months, respectively) was observed. The percentage of excess weight loss was not significantly correlated with reservoir volume after 1 year of LSG.
Conclusion
MSCT allows for a comprehensive and quantitative evaluation of the gastric pouch volume. Gastric dilatation seems to be a normal behavior after LSG, yet it is not correlated with insufficient weight loss or weight regain after 1 year of LSG. A long-term follow-up is mandatory to confirm this conclusion.

Keywords:
bariatric surgery, gastric reservoir, multislice computed tomography, sleeve gastrectomy, volumetric assessment

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Introduction

Laparoscopic sleeve gastrectomy (LSG) was introduced for the management of obese patients as a first step before other techniques such as gastric bypass and duodenal switch. Yet in the last years after satisfactory results of LSG in weight reduction, it has been used as a single surgical technique for obese patients [1,2].

LSG is usually classified as a restrictive procedure, yet several hormonal changes have been described to account for the results of LSG. The gastric pouch volume is not the only key to success and so there is no specific volume that has been decided for the gastric reservoir; however, the suggested volumes range from 50 to 120 ml [1].

During the routine follow-up after LSG, usually there is dilatation of the gastric pouch; however, it is unclear whether there is a physiological process or a cause of weight regain and insufficient weight loss [3].

Radiology nowadays plays an important patients after LSG, either to measure the volume of gastric reservoir, and correlate it with the clinical outcome, or to diagnose the presence of complications [1,3,4].

Aim

The aim of this work was to study the relation between the gastric pouch volume after sleeve gastrectomy and weight loss using MDCT volumetry study.

Patients and methods

Patients

The study was carried out on 50 patients with morbid obesity admitted to the Upper Gastrointestinal Surgery Unit, Alexandria Main University Hospital. The inclusion criteria were: age ranging from 18 to 60 years, BMI of more than 40 or 35 kg/m^2 with comorbidities, obesity for more than 5 years, failure of supervised conservative management for obesity for at least 2 years, and willingness for prolonged follow-up with the surgeon and the nutritionist. The exclusion criteria were: BMI of more than 60 kg/m^2, endocrinal disorders, active peptic ulcer disease, general contraindication for laparoscopy, active alcohol abuse, major psychiatric disorders, and mental retardation.

Methods

Surgical technique

After establishing a capnoperitoneum, dissection began on the greater curvature ~5 cm from the pylorus. The greater curvature of the stomach was separated from the omentum and dissection continued until the left crus of the diaphragm was well visualized. A 36-Fr gastric tube was subsequently advanced into the stomach. Starting 5–6 cm lateral from the pylorus, a series of linear staples was applied toward the left of the lesser curvature vessels until reaching the gastric tube and then up to the angle of His. The resected stomach specimen was removed, and possible leakage was excluded by methylene blue testing.

All patients were scheduled for follow-up at 3, 6 months, and 1-year postoperatively. It included: weight loss data, laboratory investigations, amelioration of comorbidities, long-term complications, quality of life, and gastric volumetry using MDCT at 1 and 12 months after surgery.

Computed tomography technique

The patient was instructed to drink negative oral contrast immediately before scanning in order to distend the gastric pouch, directly afterward the patient laid down on the scanner table in the supine position. All examinations were performed on multislice spiral computed tomography (MSCT) scanners (64 slices) with dedicated workstation for postprocessing volumetric assessment of the gastric pouch. All acquisitions were performed during breath-hold. No intravenous contrast agent was administered.

Postprocessing volumetric study and image analysis

Thin-sliced images were reconstructed with a slice thickness of 1 mm with a soft tissue convolution kernel and were transferred to a dedicated workstation. Volume-rendering images were generated, and the total stomach volume was automatically calculated by the software. Furthermore, two curved planar reformats were manually generated with the image axis following the centerline of the stomach itself and the course of the staple lines.

Results

This was a prospective study which included 50 patients, 42 (84.0%) women and eight (16.0%) men. Their age ranged from 20 to 45 years with a mean age of 33.50±7.43 years (Table 1).

Preoperative anthropometric measures

Preoperative anthropometric measures are summarized in Table 2. Preoperative weight ranged from 110 to 175 kg with a mean of 134.40±18.27 kg. Height ranged from 150 to 175 cm with a mean of 162.65±6.47 cm. Preoperative BMI ranged from 42.20 to 57.0 kg/m^2 with a mean of 49.89±5.08 kg/m^2.

Early postoperative morbidity

Early (<30 days) postoperative surgical complications are summarized in Table 3. It was divided into major and minor complications. The major complications include leakage, wound dehiscence, incisional hernia, and deep vein thrombosis (DVT). No major complications happened in the studied patients.

Minor complications include wound infection and persistent vomiting. Two patients had trocar site infection which was treated by antibiotics and dressing. One patient suffered from persistent vomiting after resuming soft diet. The patient stopped soft diet, returned to fluids for a while, and treated by proton-pump inhibitors and prokinetic drugs until vomiting stopped.

Mortality rate

There was no mortality in the studied patients.

Follow-up

The patients were scheduled for follow-up at 3, 6 months, and 1 year postoperatively. This was done for all patients through regular visits at the outpatient clinic.

Table 1 Demographic profile of patients

Sex	*n* (%)
Female	42 (84.0)
Male	8 (16.0)
Age (years)	
<30	13 (26.0)
30 to <40	27 (54.0)
40	10 (20.0)
Minimum–maximum	20.0–45.0
Mean±SD	33.50±7.43
Median	33.50

Table 2 Preoperative anthropometric measures

	Minimum–maximum	Mean±SD	Median
Weight (kg)	110.0–175.0	134.40±18.27	131.0
Height (cm)	150.0–175.0	162.65±6.47	162.50
BMI (kg/m^2)	42.20–57.0	49.89±5.08	50.0

Table 3 Early postoperative complications

Early complications	*n* (%)
Major	0 (0.0)
Minor	3 (6.0)
Persistent vomiting	1 (2.0)
Trocar site infection	2 (4.0)

Table 4 Preoperative and postoperative patients' weight

Weight (kg)	Preoperative	3 months postoperatively	6 months postoperatively	1 year postoperatively	*F*	*P*
Minimum–maximum	110.0–175.0	96.20–152.70	82.50–126.80	70.70–104.60		
Mean±SD	134.40±18.27	115.63±15.59	98.60±12.04	83.95±9.19	1297.166*	<0.001*
Median	131.0	114.75	98.45	83.70		
P_1		>0.001*	>0.001*	>0.001*		

F: *F* test (analysis of variance) with repeated measures. P_1: *P* value for adjusted Bonferroni for comparing between pre and each other period. **P*=0.05, statistically significant.

Table 5 Percentage of excess weight loss in the follow-up period

Percentage of excess weight loss	3 months	6 months	1 year	*F*	*P*
Minimum–maximum	20.0–30.50	40.0–55.0	54.80–73.60	754.898*	<0.001*
Mean±SD	24.79±3.16	47.0±4.90	66.14±5.64		
Median	24.85	46.20	67.50		
P_1		<0.001*	<0.001*		

F: *F* test (analysis of variance) with repeated measures. P_1: *P* value for adjusted Bonferroni for comparing between pre and each other period. **P*=0.05, statistically significant.

Table 6 Long-term complications

Long-term complications	*n* (%)
Gastroesophageal reflux disease	1 (2.0)
Peripheral neuropathy	1 (2.0)

Table 7 Comparison between gastric reservoir volume at 1 and 12 months after laparoscopic sleeve gastrectomy

Gastric volume (ml)	After 1 month (*n*=50)	After 12 months (*n*=50)	*t*	*P*
Minimum–maximum	60.0–211.0	91.0–250.0	17.051*	<0.001*
Mean±SD	110.6 ±40.52	142.1 ±39.63		
Median	103.50	136.0		
Percentage of change	32.64			

P: *P* value for paired *t*-test for comparing between early and late gastric volume. **P*=0.05, statistically significant.

Weight loss data

Table 4 summarizes the patients' weight throughout the follow-up period. Starting from 3 months postoperatively, there was a statistically significant decrease of weight than initial weight and this significance increased with time during the follow-up period (*P*=0.05).

Table 5 summarizes the patients' percentage of excess weight loss (PEWL) throughout the follow-up period. The mean PEWL after 3 months was 24.79±3.16%, at 6 months it was 47.0±4.90%, and finally at 1 year it was 66.14±5.64.

Long-term complications

Symptoms of gastroesophageal reflux disease occurred in one patient. The patient was treated by proton-pump inhibitors until the end of the follow-up period (Table 6).

One patient developed peripheral neuropathy due to folic acid and vitamin B_{12} deficiency. The patient was treated by vitamin B_{12} injection.

Gastric computed tomography volumetry

All patients were referred for abdominal MSCT with volumetric assessment of gastric pouch within 1 month of surgery and 1 year postoperatively. Gastric volume within 1 month of surgery ranged from 60.0 to 210.0 ml with a mean of 110.6±40.52 ml, while the gastric volume 1 year postoperatively ranged from 91.0 to 250.0 ml with a mean of 142.1±39.63 ml. There was a statistically significant increase of gastric volume after 1 year (*P*=0.05) (Table 7 and Figs 1 and 2).

There was a nonstatistically significant weak negative correlation (*r*=-0.267, *P*=0.255) between PEWL and increase of gastric reservoir volume after 1 year of surgery (Table 8).

Discussion

It is essential to measure the gastric pouch volume and correlate it with our aim which is weight reduction. Recently, newly developed imaging techniques have been used to assess the volume of gastric pouch; MDCT with postprocessing volumetry study is considered an accurate method to measure the gastric pouch volume [4–6].

In our study, there was a statistically significant increase of gastric volume after 1 year of surgery which is consistent with other studies [3,7].

Braghetto *et al.* [3] reported a significant increase in residual gastric capacity after 2 years of surgery. They found that the early (3 days) postoperative gastric

volume was 116.2±78.24 ml assessed with MSCT and it was increased to 254±56.8 ml after 2 years of surgery.

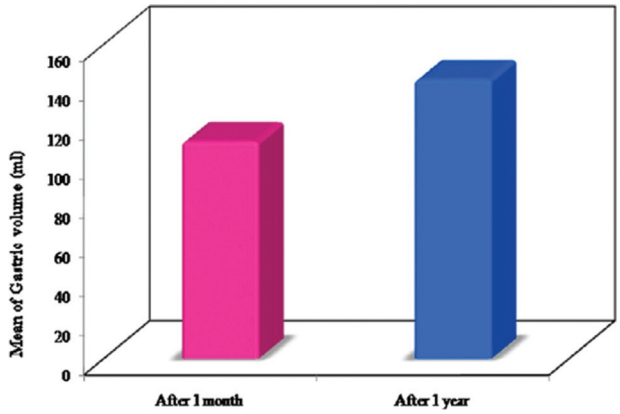
Baumann *et al.* [7] also observed a significant correlation between time after surgery and gastric volume with results similar to our study. In their study, MSCT was conducted early after surgery (1–2 months) and a mean gastric volume of 105.3±30.2 ml was found. A mean gastric volume of 196.8±84.3 ml was found in follow-up examinations after surgery (6–18 months) which represented a significant gastric dilatation.

Several factors affect the gastric pouch volume such as the bougie size used during surgery, eating habits of the patient, the distance from the pylorus to the LSG suture line, and complete fundus resection [1].

In the current study, we found that there is a nonstatistically significant weak negative correlation (r=–0.267, P=0.255) between the EWL and the increase of gastric reservoir volume after 1 year of surgery.

Braghetto *et al.* [3] reported that the increase in residual gastric volume after 2 years of LSG assessed with MSCT did not mean regain of weight until the end of their study.

Figure 1



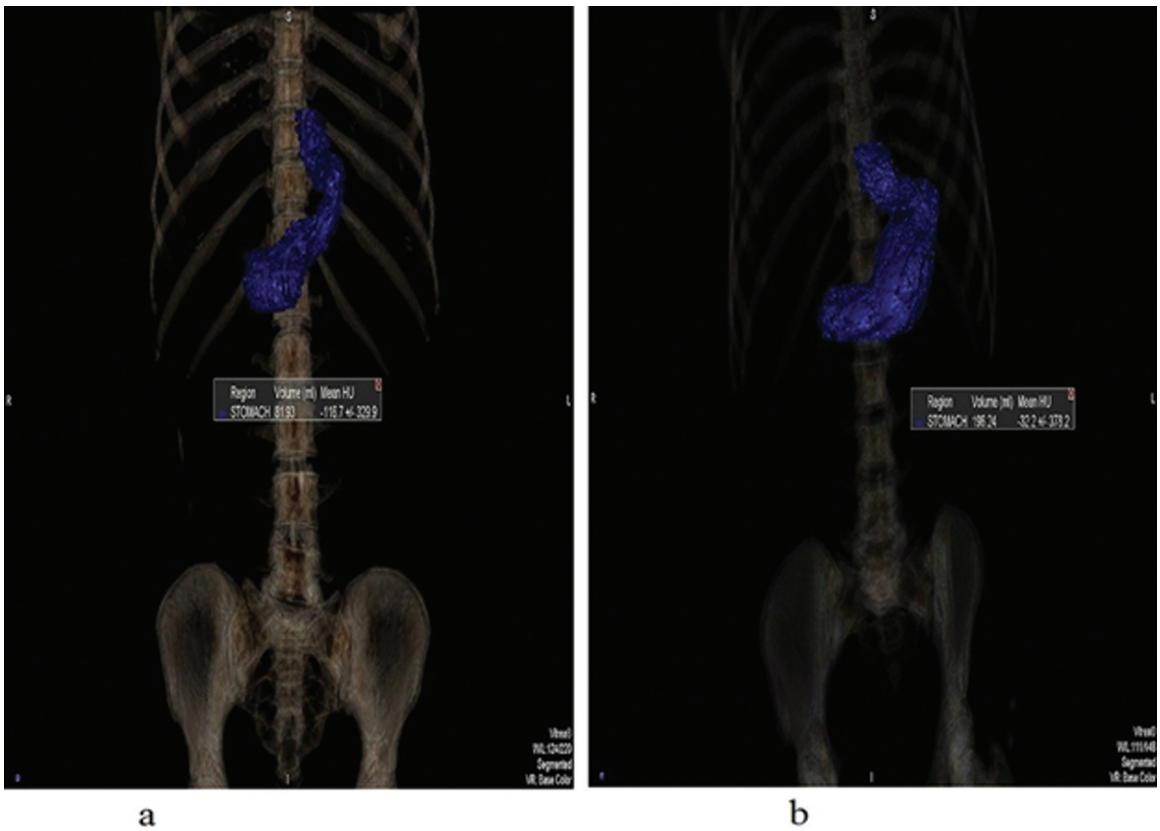
Comparison between gastric reservoir volume at 1 and 12 months after laparoscopic sleeve gastrectomy (Alexandria, Egypt). Copyright Alexandria, Egypt. All permission requests for this image should be made to the copyright holder.

Table 8 Correlation between percentage of excess weight loss and gastric volume after 1 year percentage of excess weight loss after 1 year

	r	*P*
Gastric volume after 1 year	–0.267	0.255

r, Pearson's coefficient.

Figure 2



a b

Three-dimensional multislice computed tomography image of gastric reservoir: (a) 1 month after laparoscopic sleeve gastrectomy (volume=81.9 ml) and (b) 1 year after laparoscopic sleeve gastrectomy (volume=196.2 ml).

Baumann *et al.* [7] concluded that gastric dilatation appears to be a normal finding after LSG and with no correlation with inadequate weight loss or weight regain. They found that PEWL 12 months after surgery showed no significant correlation with gastric volume measured by MSCT. However, if the initial size of the sleeve was already large at the operative time, mild weight regain has been found after 3 years of follow-up. We should consider that data from longer follow-up are necessary before a correlation between secondary dilatation of the pouch and weight regain can be excluded.

On the other hand, Vidal *et al.* [1] found that there was a 50% increase in gastric reservoir volume 1 year after LSG and a direct relationship between the increase in gastric sleeve volume and a lower weight loss 1 year postoperatively. However, they used a new radiological volumetric method to measure the residual gastric pouch volume. Gastric pouch volume was measured based on a simple defragmentation of the radiological image (obtained after an upper gastrointestinal series) into two well-known geometrical shapes: a cylinder (gastric body) and a truncated cone (antrum). Adding these two partial volumes, the total gastric sleeve volume can be measured. Therefore, we cannot compare our results with this publication.

Weight loss after LSG is not only determined by residual gastric volume, but also other factors are involved, such as postoperative neurohormonal mechanisms associated with ghrelin, PYY, GLP-1, and rapid gastric emptying [1].

Conclusion

LSG has proven more early weight loss during the first 2 years regardless of the sleeve volume, but it was associated with a weight gain after several years depending on the initial gastric pouch volume and postoperative neurohormonal mechanisms. The diameter of the residual gastric sleeve is important for later dilatation; a sleeve with a wide diameter will dilate earlier than a tighter one. Gastric dilatation seems to be the normal behavior after LSG.

Gastric dilatation was not correlated with insufficient weight loss or weight regain after 1 year after LSG. A long-term follow-up is mandatory to confirm this conclusion.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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