

Estimation of Gastric Volume after Laparoscopic Sleeve Gastrectomy by Multidetector Computed Tomography and Correlation with Weight Reduction

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Abstract:

Background: bariatric surgeries especially laparoscopic sleeve gastrectomy (LSG) has achieved excellent results in treatment of morbid obesity. Using Multi detector computed tomography to evaluate gastric volume are more accurate and feasible when compared to the other methods. **Aim:** The study aims at correlation between the postoperative residual gastric volume and body weight reduction percentage. **Methods** This is a prospective observational study of twenty sleeve patients with morbid obesity who underwent LSG; they were investigated by MDCT after oral administration of Gastrographin solution mixed with bicarbonate sodium to distend the stomach with gas. The examination was done three months after operation. The remaining gastric volumes were estimated via 3D volume reconstruction. **Results:** The relation between the body weight reduction percentage and gastric volume estimated 3 months after the operation in the selected patients was negatively correlated, which means that the smaller the residual gastric pouch volume we have, the larger the weight loss will happen. **Conclusion:** MDCT allows important anatomical and accurate measurements about the relation between residual gastric volume and body weight reduction in sleeve gastrectomy-candidate obese patients. So, with smaller residual gastric volume, we have more weight loss, but further studies are needed for longer period of time like 1 year period to confirm what we reached in this study.

Key words: Laparoscopic sleeve gastrectomy(LSG) , Multidetector CT(MDCT), residual gastric volume (RGV), weight reduction percentage

Introduction:

Obesity continues to be a major public health problem, as defined by a body mass index (BMI) ≥ 30 kg/m² (1).

The World Health Organization (WHO) defines obesity as a condition of excessive fat accumulation in the body to the extent that health and well-being are adversely affected. If the amount of body fat exceeds normal physiological values, a person is obese (1).

It has been shown that the more a disease is perceived as under volitional control, the more stigmatizing it is—with obesity generally being perceived as highly volitional. Numerous studies have documented harmful weight-based stereotypes that overweight and obese individuals are lazy, weak-willed, unsuccessful, and unintelligent, lack self-discipline, have poor willpower, and are noncompliant with weight loss treatment (2). Metabolic and bariatric surgery is a proven therapy for the treatment of obesity and obesity-related comorbidities (3).

The mechanism of action of the sleeve gastrectomy is believed to involve a combination of gastric restriction, hormonal

effects, and changes in gastric motility and eating habits (3).

MULTIDETECTOR COMPUTED TOMOGRAPHY of stomach (fig.1) can help in detection of postoperative complications (fig. 2), and has usefulness in estimation of residual gastric volume after surgery. It gives accurate data concerning gastric volumes (fig. 3) and diameters of anastomoses (4).

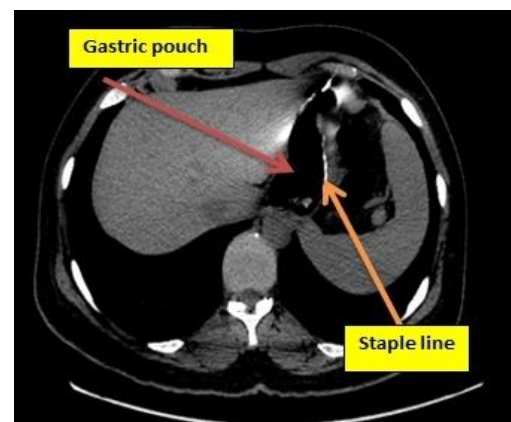


Fig (1) normal appearance of gastric sleeve by MDCT

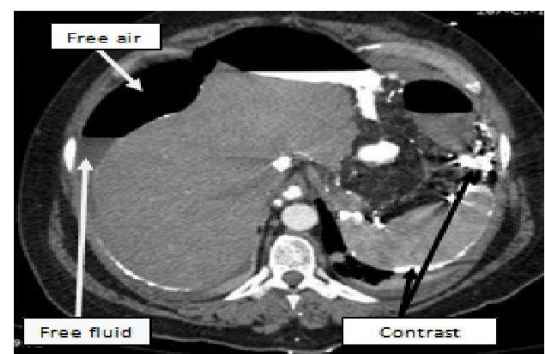


Fig (2) : Axial cut CT showing contrast leak and collection post gastric sleeve

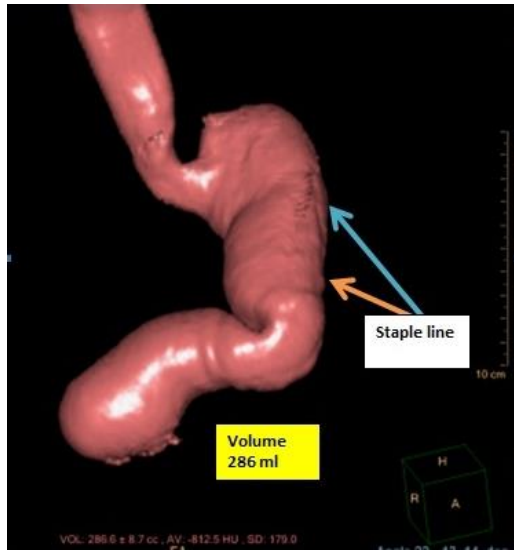
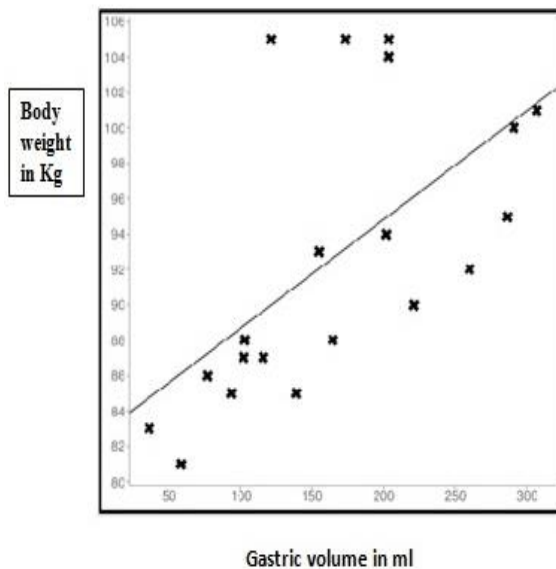


Fig (3) Axial volume and 3D reconstruction images of the stomach after sleeve gastrectomy showing volume 286 ml



Fig(4) Relation between body weight and gastric volume estimated three months after operation in the selected patients ($r= 0.611$; $p= 0.0042$)

Table 1 : Classification of overweight and obesity by BMI, waist circumference, and associated disease risks

	BMI (kg/m ²)	Obesity Class	Disease Risk Relative to Normal Weight and Waist Circumference	
			Men 102 cm (40 inch) or less Women 88 cm (35 in) or less	Men > 102 cm (40 in) Women > 88 cm (35 in)
Underweight	< 18.5		-	-
Normal	18.5–24.9		-	-
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very High
	35.0–39.9	II	Very High	Very High
Extreme Obesity	40.0	III	Extremely High	Extremely High

Patients and Methods:

This is a prospective observational study started from 13/10/2019 to 13/3/2020

Patients:

The study included 20 cases of pathological obesity. No age limits were considered. The study was conducted at Benha University Hospital

Inclusion criteria:

All patients either males or females who are candidates for gastric sleeve surgery for the first time.

Exclusion criteria

Patients who are candidates for gastric reduction surgery other than sleeve gastrectomy. Patients with secondary obesity due to endocrine disorders, or with psychologic disorders, or who had previous bariatric procedures.

All patients were submitted to the following:

Demographic and clinical data collection: including patient's name, age, (pre and post-operative weight, height, BMI), and past history of related significance, informed consent about procedure description and benefits.

Imaging procedure

- All patients were told to be fasting six hours prior to the examination, in order to have an empty stomach during the study to minimize imaging pitfalls as filling defects
- The study is performed by ingestion of the oral contrast agent according to a special protocol: (Gastrografin® diluted 3%) mixed up with bicarbonate sodium to distend the stomach with gas The patient drink solution gently in 5 minutes prior to the start of scanning Distending the stomach before volume measurement was deemed necessary since measuring the size

of the flaccid stomach may give inaccurate and underestimated measurements of the maximum residual gastric capacity.

- The patient then lies supine on the CT table (feet first) and CT abdomen is performed with a scanning time of about 10 seconds.
- Thin-slice images were reconstructed with a slice thickness of 1.5 mm. The inner gastric volume, the maximum cross-sectional area of the sleeve, the length of the whole stomach from the hiatus to the pylorus, the length of the staple line. The length of the stomach was manually separated into the length of the sleeve and the length of the antrum at the point of the most prominent and persistent diameter change of the stomach.
- All patients underwent CT abdomen after the operation by about three months with the same examination items mentioned.
- Using 3D reconstruction from which the estimated gastric volume is calculated on dedicated workstations.

Equipment:

- CT images were taken by a Philips Ingenuity 128 slices scanner and reconstructed in a Philips workstation.

- For statistical data analysis, we used descriptive and inferential statistic techniques employing the IBM SPSS Statistics software, version 19. The gastric volume was expressed in ml, and the pre and post-operative weight in Kg and we calculate the weight reduction percentage.
- To assess the relationship between postoperative weight reduction percentage and residual gastric volume, the Pearson's coefficient was used.
- Results are expressed as mean \pm standard deviation (SD), minimum, maximum and number (%).

Our study included 20 cases; all cases were obese individuals. There were 13 females and 7 males, with body mass index (BMI) above 30 kg/m^2 . The mean preoperative body weight 110.25 kg.

All patients were re-examined 3 months after the operation. The mean postoperative body weight was 92.7 kg. The average estimated volume of the remnant stomach using CT scan with 3D reconstruction was 166.85 ml.

The average excess weight loss (reduction percentage) was 16 % with a standard deviation of 4.56% (16 ± 4.56), a minimum excess weight loss of 9% and a maximum of 25%.

So, from these statistical analysis we found a statistical positive correlation between the body weight and residual gastric volume estimated after operation as in fig.4 and a statistical negative correlation between postoperative body weight reduction percentage and residual gastric volume (fig. 5).

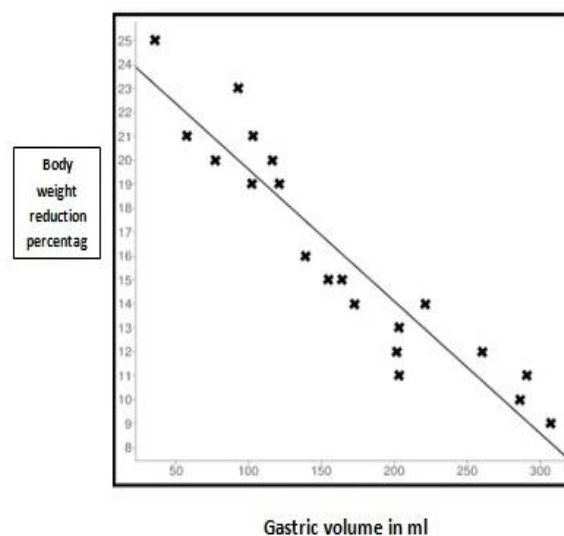


Fig (5) : Relation between body weight reduction percentage and gastric volume in the selected patients ($r = -0.940$; $p = 0.00001$).

Table 2: Descriptive statistics of the study

Number (20)	Minimum	Maximum	Mean	Std. Deviation	Median
Age	18.00	58.00	37.25	11.43	36.5
Preoperative body weight	101	130	110.25	7.16	109
After operation body weight (3 months)	81	105	92.7	7.81	91
Postoperative gastric volume (3 months)	36	307	166.85	76.15	159.5
Weight reduction (%)	9	25	16	4.56	15

Table 3: Relation between body weight reduction percentage and gastric volume size postoperative in the selected patients

Weight reduction percentage		
	<i>Pearson Relation</i>	<i>P value</i>
gastric volume size	-0.940	0.00001

$p > 0.05 =$ not significant.

Discussion:

It is well known that the prevalence of obesity and the associated comorbidities has increased over the last decades. There are no effective pharmaceutical agents to treat morbid obesity and conservative therapy is not very efficient (5).

Obesity increases the risk of several physical and mental conditions. The co-morbidities are most commonly shown in metabolic syndrome, which includes: diabetes mellitus (type 2), high blood pressure, high blood cholesterol, and high triglyceride levels (6).

Health consequences fall into two broad categories: those attributable to the effects of increased fat mass (such as osteoarthritis, obstructive sleep apnea, social stigmatization) and those due to the increased number of fat cells (diabetes, cancer, cardiovascular disease, non-alcoholic fatty liver disease) (7).

Bariatric surgery has proved effective in treatment of morbid obesity and its associated comorbidities. Laparoscopic sleeve gastrectomy (LSG) has become one of the most popular bariatric procedures for treatment of morbid obesity with growing evidence on its efficacy and safety (8).

Since LSG is basically a restrictive bariatric procedure, the impact of the residual volume of the stomach after LSG on weight loss and possible weight regain has been investigated (8).

The reduction of gastric volume, which decreases food intake, is one of the most important mechanisms of action of LSG (9). Thus, RGV is essential to achieve optimal weight loss results.

In the present study, we used MDCT for measuring the gastric volume after LSG as the preoperative gastric size varies widely among patients, therefore these values are

useless for correlation with preoperative weight, and perhaps the volume of the residual stomach is more important regarding . It is worth noting that other methods for assessment of gastric volume exist including biplanar barium or water soluble iodine contrasted images and gastric scintigraphy (8).

Yet we preferred to use CT with 3D reconstruction as it appeared more accurate and feasible when compared to the other methods and help with detection of postoperative complications.

Computed tomography also evaluate the shape of the remaining gastric pouch and exclude the presence of retained gastric fundus or any stenosis along the gastric sleeve and providing clinical information about stomach size, shape, removal of the fundus, absence of gastric leakage (13).

Our study included 20 obese cases with body mass index (BMI) above 30 kg/m². All patients underwent MDCT abdomen with oral contrast, 3 months postoperative.

The preoperative body weight ranged between 101 kg and 130 kg with mean value of about 110.25 kg.

All patients were re-examined 3 months after the operation. The postoperative body weight was between 81 kg and 105 kg with mean value of about 92.7 kg. The average estimated volume of the remnant stomach using CT scan with 3D reconstruction was 166.85 ml, with a standard deviation of 76.15ml (166.85 ± 76.15), with a minimum volume of 36 ml and a maximum of 307 ml.

The average weight reduction percentage was 16 % with a standard deviation of 4.56% (16 ± 4.56), a minimum excess weight loss of 9% and a maximum of 25%.

The primary outcome of our study was to correlate between postoperative residual gastric pouch volume and reduction in body weight in percentage three months after surgery, however actually more body weight loss will take place in the next month's especially in the first year, however in this short period of time, other factors than gastric pouch volume (i.e. dietary habits) will not have much impact on weight loss.

Pearson Relation coefficient: The correlation coefficient can range in value from -1 to +1. The larger the absolute value of the coefficient, the stronger the relationship between the variables.

For the Pearson correlation, an absolute value of 1 indicates a perfect linear

relationship. A correlation close to 0 indicates no linear relationship between the variables.

The relation between the body weight and remaining gastric volume estimated after operation in the selected patients (*Pearson Relation coefficient: 0.611*) was found to be statistically significant and positively correlated which means that the remaining stomach volume have positive relationship on body weight.

Also the relationship between body weight reduction percentage and remaining gastric volume in the selected patients after the operation (Pearson Relation coefficient:-0.940) has strong relationship and has clinical significance and was strongly negatively correlated which means that weight loss statistically strongly increases with smaller gastric volumes ,which means that the size of the resected gastric pouch have strong role on the postoperative weight loss over a three months period.

The present study has some limitations relatively small number of patients studied, and short duration of follow-up which allows the evaluation of short-term excess weight loss but not weight regain which warrants longer follow-up .

In the study done by Vidal and co-researchers which studied the correlation between an increase in gastric reservoir volume and a lower weight loss after surgery in 1 and 12 month period postoperatively, showed a direct positive relationship. This goes with our results and showed the importance of gastric volume postoperatively in achieving weight loss and that affect can be reduced by increase in the reservoir volume (9).

At the opposite side, in the study by Márquez and co-workers which was done on a longer time scale than our study, the volume of the gastric remnant increased significantly during the first year after LSG. However, this increment seems not to affect weight loss. Which highlights that the postoperative RGV is not the only factor responsible for weight loss and maybe there are another factors which help with reduction in gastric volume to achieve weight loss (10).

Factors influencing weight loss after sleeve gastrectomy include the serum ghrelin levels which contribute to satiety, lower appetite stimulation, and consequently, weight loss. The resection of the pyloric antrum might also be associated with an increase in gastric emptying without increasing gastro-

oesophageal reflux or the risk of leaks. It has also been suggested that accelerated gastric emptying associated with enhanced postprandial cholecystokinin and glucagon-like peptide-1 concentration could contribute to improved weight loss and glucose metabolism (11).

The study by Hanssen and colleagues which was done on thirty-two patients 6 month postoperatively, concluded that, there is a significant relationship between gastric volume and estimated weight loss 6 months after sleeve gastrectomy was established, seeming that $RGV \geq 100$ ml at 6 months of sleeve gastrectomy is associated with poor estimated weight loss, which goes with our result in 3 month postoperative period. However in our study, other factors than gastric pouch volume (i.e. dietary habits) will not have much impact on weight loss (12).

In the study of by Elbanna and others concluded that the preoperative volume of the stomach was positively correlated with baseline BMI, but not correlated with estimated weight loss (EWL%). The size of the remaining gastric pouch and the percentage of the resected stomach had significant impact on %EWL after LSG, which confirms with our result, that the volume of the residual stomach is a more

important factor in achieving weight loss after laparoscopic sleeve gastrectomy, as the most important mechanism of this technique is the reduction of gastric volume to limit the caloric intake (13).

Conclusion:

MDCT allows important anatomical and accurate measurements about the relation between residual gastric volume and body weight reduction in sleeve gastrectomy-candidate obese patients so with smaller residual gastric volume, we have more weight loss which will affect the surgeon decision of how much stomach size need to be resected during laparoscopic sleeve Gastrectomy, but further studies are needed for longer period of time like 1 year period to confirm what we reached in this study.

Conflict of interest

The authors declare that they have no conflict of interest.

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