



## Cohort Study

## Relationship between residual gastric area and weight loss after sleeve gastrectomy: A Cohort study



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## ABSTRACT

**Background:** The aim of this study is to evaluate the impact of the actual size and area of the remnant stomach, as measured by Upper gastrointestinal tract radiography, on weight loss after sleeve gastrectomy.

**Materials and methods:** From May 2017 to December 2019, 56 patients with morbid obesity were admitted to the Department of Medical and Surgical Sciences, University of Foggia and underwent laparoscopic sleeve gastrectomy.

**Results:** 56 patients underwent sleeve gastrectomy with a mean age of  $43,5 \pm 11$  years of which 40 were female. The mean Excess Weight Loss (EWL) at 1 month was  $24,09 \pm 15,04\%$ , at 6 months was  $27,07 \pm 19,55\%$  and at 12 months was  $69,9 \pm 23,7\%$ . The mean Excess Body Mass Index Loss (EBMIL) at 1 month was  $23,1 \pm 12,5\%$ , at 6 months was  $56,6 \pm 19,7\%$  and at 12 months was  $69,7 \pm 23,7\%$ .

The EWL % was correlated with the residual stomach area (RSA) at 1 month ( $r = -0,242$   $p = 0,072$ ), at 6 months ( $r = -0,249$   $p = 0,064$ ) and at 12 months ( $r = -0,451$   $p = 0,0005$ ).

The EBMIL % was correlated with the RSA at 1 month ( $r = -0,270$ ;  $p = 0,043$ ), at 6 months ( $r = -0,270$ ;  $p = 0,043$ ) and at 12 months ( $r = -0,46$ ;  $p = 0,0004$ ).

**Conclusion:** A greater postoperative EWL % was correlated with a smaller RSA and this resulted in a statistically significant change at 12 months after surgery.

## 1. Introduction

Obesity is a rising global epidemic that places significant strain on healthcare services worldwide. Morbid obesity is associated to complications affecting nearly every organ, resulting in a decrease in life expectancy [1–3].

In the last few years, various international guidelines and systematic reviews have confirmed laparoscopic sleeve gastrectomy (LSG) as a definitive and stand-alone procedure for morbid obesity [4–7].

LSG is perceived as one of the safest bariatric operations. The main advantages of LSG include: a relatively simple surgical technique with no need of anastomosis creation, short learning curve and low rate of metabolic complications [8].

Within bariatric surgery, it is common that radiologists must deal with the interpretation of images of patients after LSG. There are differences in peri and postoperative care protocols and likewise with the

approach to the imaging algorithm.

Upper Gastrointestinal (UGI) tract radiography with water-soluble contrast medium is the most basic study after LSG. This minimally invasive technique has a long history of being used for the detection of both early and late postoperative complications [9,10].

A normal postoperative UGI series will show free flow of contrast into the gastric remnant, which is tubular with no spillage of contrast beyond the staple line, which is located on the caudal aspect of the gastric remnant. Stenosis or obstruction of the stomach may occur if the stomach remnant is too tight or with torsion of the stomach [11].

In the literature most of the authors studied the correlation between postoperative gastric volume and percent excess weight loss (EWL) [12, 13]. The size of the remnant stomach with respect to weight loss after LSG remains controversial.

The aim of this study is to evaluate the impact of the actual size and area of the remnant stomach, as measured by Upper gastrointestinal

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tract radiography, on weight loss after LSG.

## 2. Materials and methods

### 2.1. Study design and setting

From May 2017 to December 2019, 56 patients with morbid obesity were admitted to the Department of Medical and Surgical Sciences, University of Foggia and underwent laparoscopic sleeve gastrectomy. UGI tract radiography with water-soluble contrast medium was performed on the second day after the operation to rule out leakage. The radiographic images were collected through a software program called “PACS” which combined with a viewer for image processing, allows for the calculation of the residual stomach area (RSA). RSA was correlated with postoperative weight (EWL) at 1, 6, and 12 months (Fig. 1a – 1b). The UIN for [ClinicalTrial.gov](https://clinicaltrials.gov/ct2/show/study/NCT05151107) Protocol Registration and Results System is: NCT05151107 for the Organization UFoggia.

### 2.2. Eligibility criteria

Adult patients of both genders with morbid obesity defined as BMI > 40 kg/m<sup>2</sup> or BMI > 35 kg/m<sup>2</sup> with at least one associated major comorbidity were included. We excluded patients with secondary obesity due to endocrine and psychological disorders, patients with previous bariatric procedures and patients unwilling to comply with postoperative diet and exercise program.

### 2.3. Statistical analysis

Continuous data were expressed as mean and standard deviation (SD) and they were analyzed using Student’s T test. The correlation between gastric volume before and after LSG and BMI and weight loss was measured using Pearson correlation coefficient test. Correlation coefficients were classified as strong (–1.0 to –0.5 or 0.5 to 1.0), moderate (–0.5 to –0.3 or 0.3 to 0.5), and weak (–0.3 to –0.1 or 0.1 to 0.3). P < 0.05 was considered statistically significant. This work is fully compliant with the STROCSS criteria [14].

## 3. Results

56 patients underwent sleeve gastrectomy with a mean age of 43,5 ± 11 years of which 40 were female. The mean preoperative weight was 127,5 ± 19,8 kg and the preoperative mean Body Mass Index (BMI) was 45,5 ± 5,57 kg/m<sup>2</sup>. The mean residual stomach area (RSA) was 64,8 ±

16,5 cm<sup>2</sup> (Table 1).

The mean Excess Weight Loss (EWL) at 1 month was 24,09 ± 15,04%, at 6 months was 27,07 ± 19,55%, at 12 months was 69,9 ± 23,7%. The mean Excess Body Mass Index Loss (EBMIL) at 1 month was 23,1 ± 12,5%, at 6 months was 56,6 ± 19,7%, at 12 months was 69,7 ± 23,7% (Table 2).

The EWL % was correlated with the RSA at 1 month (r = –0,242 p = 0,072), at 6 months (r = –0,249 p = 0,064) and at 12 months (r = –0,451 p = 0,0005) (Graphic 1, 2, 3).

The EBMIL % was correlated with the RSA at 1 month (r = –0,270; p = 0,043), at 6 months (r = –0,270; p = 0,043) and at 12 months (r = –0,46; p = 0,0004) (Graphic 4, 5, 6).

## 4. Discussion

LSG has become a popular technique in the treatment of morbid obesity owing to the satisfactory outcome as recently demonstrated in the SM-BOSS randomized trial which concluded that LSG and Roux-Y-gastric bypass are equally effective regarding short and mid-term weight loss, improvement in comorbidities, and complications [15]. Nevertheless, LSG can still be associated with failure to achieve significant EWL or failure to sustain weight loss with eventual weight regain at long-term follow-up [16].

LSG is a volume-restrictive procedure, the volume of remaining gastric pouch after LSG and the volume of the resected stomach were studied as possible causes of inappropriate weight loss or weight regain after the procedure [17–21] (Fig. 2).

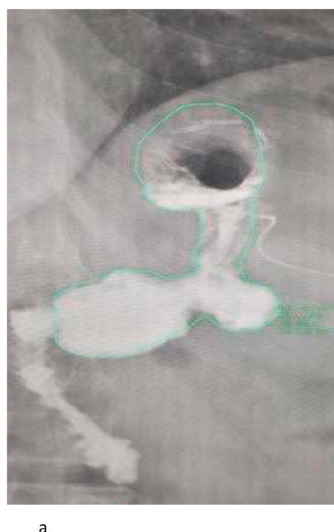
Elbanna et al. used CT volumetry for measuring the gastric volume before and immediately after LSG to assess the correlation of gastric volumes pre- and postoperatively and weight loss at 6 months after the procedure. They concluded that the size of the remaining gastric pouch and the percentage of the resected stomach had significant impact on % EWL after LSG [22].

**Table 1**

Demographic and operative characteristics of the study groups.

Age (years) mean ± (SD)	43,5 ± 11
Sex: n male/female	16/40
Height (cm) mean ± (SD)	167 ± 9,3
Preoperative weight (Kg) mean ± (SD)	127,5 ± 19,8
Preoperative BMI (kg/m <sup>2</sup> ) mean ± (SD)	45,5 ± 5,57
Residual Stomach Area (cm <sup>2</sup> ) mean ± (SD)	64,8 ± 16,5

SD: Standard Deviation.



a



b

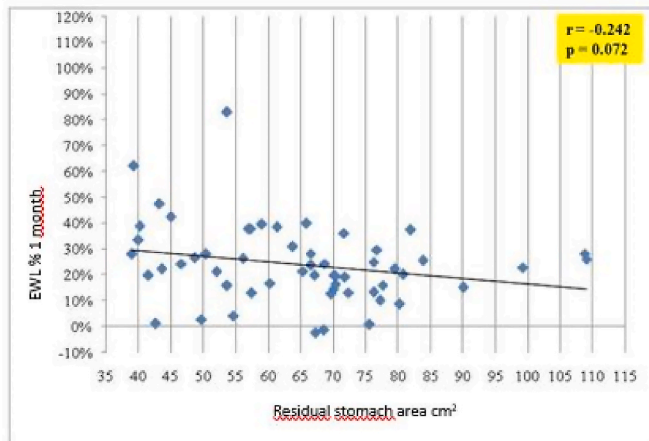
**Fig. 1.** a–1b: UGI tract radiography collected through a software called “PACS”.

**Table 2**

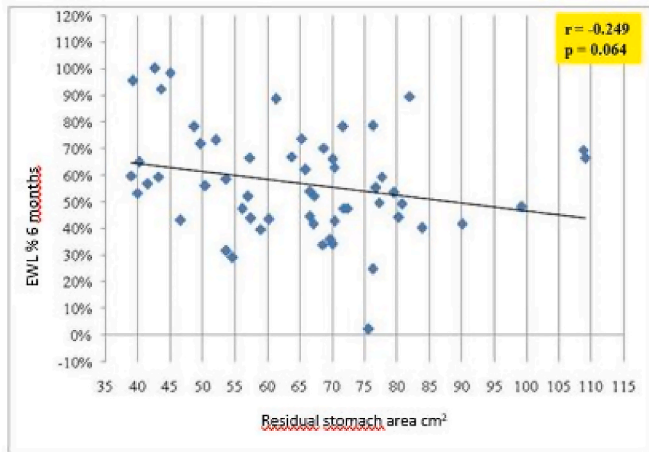
% EWL mean - % EBMIL mean.

% EWL mean - % EBMIL mean	
% EWL 1 month (mean) ±(SD)	24,09 ± 15,04
% EWL 6 months (mean) ±(SD)	27,07 ± 19,55
% EWL 12 months (mean) ±(SD)	69,9 ± 23,7
% EBMIL 1 month (mean) ±(SD)	23,1 ± 12,5
% EBMIL 6 months (mean) ±(SD)	56,6 ± 19,7
% EBMIL 12 months (mean) ±(SD)	69,7 ± 23,7

SD: Standard Deviation EWL: Excess Weight Loss EBMIL: Excess Body Mass Index Loss.



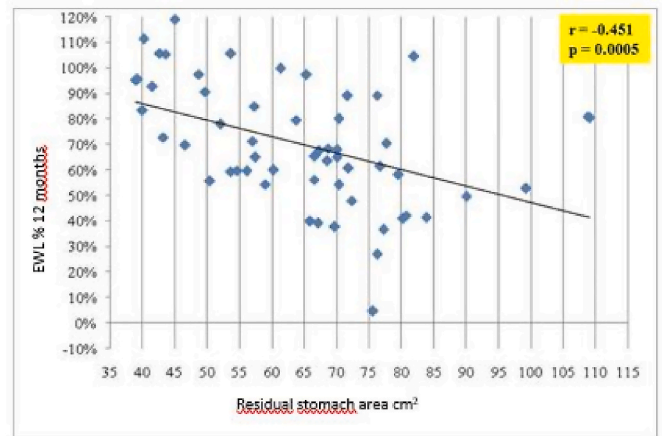
**Graphic 1.** % EWL 1 month – Pearson correlation – p value.



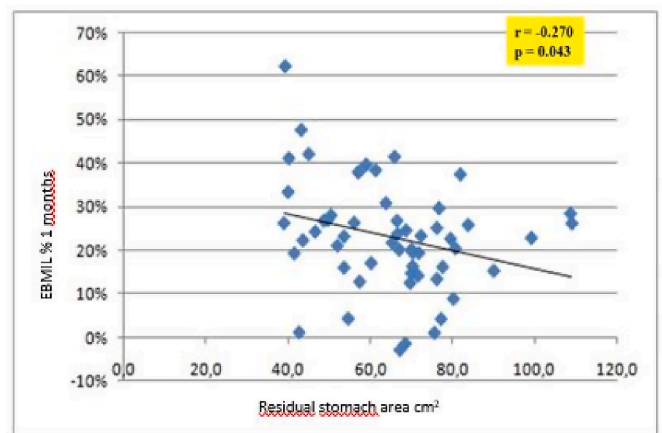
**Graphic 2.** % EWL 6 months – Pearson correlation – p value.

Salman MAA et al. used multidetector computed tomography (MDCT) to measure preoperative stomach volume and cuff volume. The actual resected gastric volume was measured after surgery. The primary outcome was the relationship between residual gastric volume and percentage of excess body weight loss (% EBWL) after 3 and 6 months. The secondary outcome was early postoperative complications. They concluded that gastric volume removed during LSG was significantly correlated with weight reduction after 3 and 6 months of surgery. Sleeve volume was not correlated with early weight reduction. MDCT is a reliable method of measuring gastric volume before and after surgery [23].

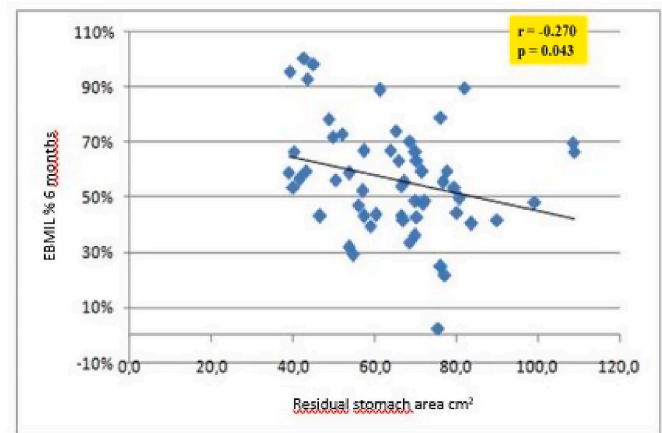
Hanssen et al. analyzed thirty patients who underwent LSG and were followed prospectively and evaluated at 6 months after the surgical



**Graphic 3.** % EWL 12 months – Pearson correlation – p value.



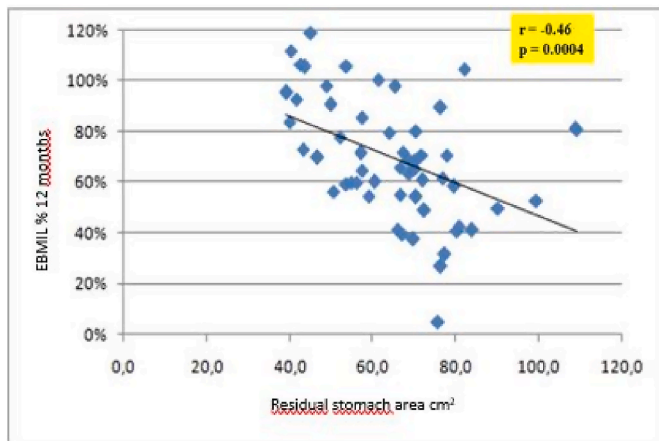
**Graphic 4.** % EBMIL 1 month – Pearson correlation – p value.



**Graphic 5.** % EBMIL 6 months – Pearson correlation – p value.

procedure, performing 3D CT reconstruction and gastric volumetry, to establish its relationship with EWL. A significant relationship between gastric volume (GV) and EWL 6 months after LSG was established, demonstrating that  $GV \geq 100$  ml at 6 months of LSG is associated with poor EWL [24].

In recent years, CT has been increasingly used as a primary post-operative examination after bariatric procedures for the detection of



Graphic 6. % EBML 12 months – Pearson correlation – p value.



Fig. 2. Excised stomach.

complications. There are many studies in the literature that analyze the potential relationship of residual gastric volume with excess weight loss in patients with sleeve gastrectomy. The main concern associated with the use of CT is its high radiation dose.

The advantages of UGI radiography compared to CT include the

speed of the procedure, the reduced associated costs, shorter waiting times for the patient and lower dose of radiation to which the patient is exposed. There is a significant difference in terms of absorption of radiation between the 3DCT and the direct abdomen, 7.8 mSV vs 1 mSV (Fig. 3).

The present study has some limitations that include a small sample size, the single-center nature of the study and the short follow-up duration.

### 5. Conclusion

A greater postoperative EWL % was correlated with a smaller RSA and this is statistically significant at 12 months after surgery ( $p < 0,05$ ). Although in the literature the standard for the relationship with post LSG weight loss is a volumetric measurement through 3DCT, the study of the RSA by UGI radiography could provide an important alternative, with an advantage demonstrated in terms of reduction of radiation absorbed by the patient, speed of procedure and reduction of costs to the NHS. Larger studies over a longer period of time are needed to confirm these findings.

### Ethics approval and consent to participate

The ethics committee of our institution approved the study.

### Funding

No funding.

### Authors' contributions

The Guarantors of this study are NICOLA TARTAGLIA and ANTONIO AMBROSI.

NICOLA TARTAGLIA and GIOVANNA PAVONE performed the study conception and design.

MARIO PIO GERMANO and GIOVANNI RUSSO analyzed and interpreted the data.

MARIO PACILLI contributed to acquisition of the data.

ANTONIO AMBROSI revised the manuscript.

### Conflicts of interest

NICOLA TARTAGLIA, GIOVANNA PAVONE, MARIO PIO GERMANO, GIOVANNI RUSSO, MARIO PACILLI, ANTONIO AMBROSI declare no conflict of interests.

### Registration of research studies

1. Name of the registry: [ClinicalTrials.gov](https://clinicaltrials.gov).
2. Unique Identifying number or registration ID: NCT05151107.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://register.clinicaltrials.gov/prs/app/action/>

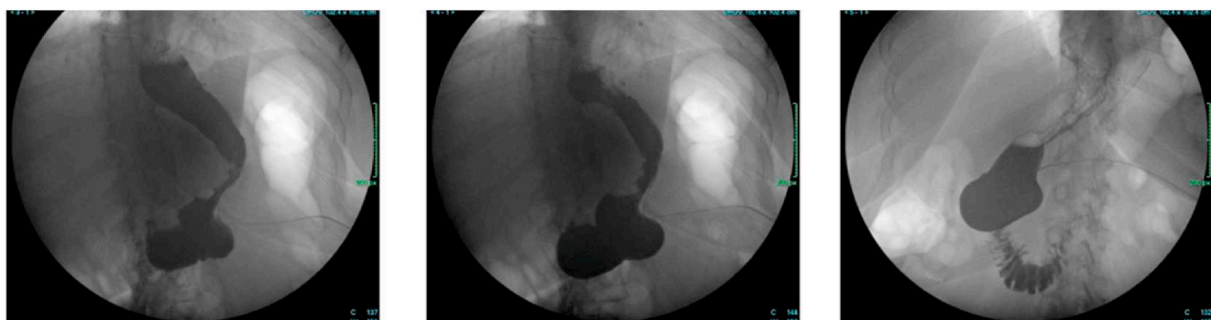


Fig. 3. UGI tract after LSG.

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## Guarantor

The Guarantors are Professor Nicola Tartaglia and Professor Antonio Ambrosi.

## Consent for publication

Informed consent was obtained from all individual participants included in the study.

## Provenance and peer review

Not commissioned, externally peer-reviewed.

## Declaration of competing interest

The authors declare no competing interests.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2021.103177>.

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