Does Gastric Expansibility Affect Weight Loss Success After Laparoscopic Sleeve Gastrectomy?

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Abstract: Reduced excess weight loss (EWL) or regain is a worrying problem after metabolic surgery. Factors attainable from the resected specimen that can predict this outcome are investigated. We retrospectively analyzed 64 patients who had undergone laparoscopic sleeve gastrectomy. We collected demographic data, preoperative gastric emptying measurements, volume, expansion capacity, and 6-dimensional measurements of sleeve gastrectomy specimens. Correlations between EWL, body mass index levels, and gastric specimen measurements related to gastric remnant dimensions were also scrutinized. We found a significant correlation between the gastric specimen and remnant gastric volume, the resection line length in the gastric specimen, and 12th-month EWL%. Antrum expansibility was significantly increased in patients with weight regain. There was also a negative correlation between weight loss and age at postoperative first and third years. Sleeve resection line measurement and resected antrum diameter measurements can be used to predict weight loss, especially in the first year postoperatively.

Key Words: sleeve gastrectomy, gastric emptying, gastric specimen measurement, expansibility

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Morbid obesity is a preventable cause of death, but its prevalence is increasing daily in both adult and child populations. Bariatric surgery is the most effective treatment for morbid obesity and accompanying comorbid diseases. In recent years, laparoscopic sleeve gastrectomy (LSG) has become one of the most frequently performed bariatric surgeries globally in recent years, and it is the most performed bariatric surgery in the United States, with 51.4%.[1,2]

Notwithstanding, 14% of patients need revisional surgery due to insufficient weight loss.[3] Gastric resection line expansibility is the elongation of the staple line of the resected gastric specimen in response to increased gastric volume. A positive correlation has been shown between increased excess weight loss (EWL) and gastric resection line expansibility and gastric volume.[4,5] The potential relationship between the remaining gastric volume and excessive weight loss has also been noted.[5] Some studies have evaluated the volume of resected gastric specimen's volume and the capacity of these specimens to predict treatment failure or early weight gain.[6–8] As the preoperative stomach size varies significantly between patients, the resected volume is also a variable.[9] The gastric emptying rate is delayed in patients with obesity; however, after LSG, the gastric emptying rate increases considerably. In previous studies, gastric emptying in the sleeve gastrectomy groups was found to be significantly faster than in the average population.[10,11]

This study aimed to investigate the relationship between gastric emptying, gastric specimen measurements, and weight loss, which may be an early predictor of how much weight will be lost after LSG.

METHOD

Sixty-four patients who underwent LSG at Marmara University Hospital due to morbid obesity between June 2017 and June 2019 were analyzed retrospectively. The patients' demographic information, preoperative and postoperative 12 months' and 3 years' height, weight, body mass index (BMI) data, preoperative gastric emptying scintigraphy results, and surgery data were recorded. After the first year of control, the patients with weight gain were considered to regain. The Institutional Review Board approved this study. All the data were collected prospectively and reviewed retrospectively.

Patients between 18 and 60 years of age with a BMI >40 kg/m^2 or between 35 and 39.9 kg/m^2 with comorbid diseases (ie, hypertension, diabetes mellitus, OSAS, hyperlipidemia) were included. Informed consent was obtained. Patients with a history of previous upper abdominal surgery or bariatric surgery, who were younger than 18 years or over 60 years, who had converted from laparoscopic surgery to open surgery, and who had dropped out during follow-up were excluded.

Gastric Emptying Study

All patients fasted for at least 6 hours before the gastric emptying scan and were instructed to drink 200 to 300 mL of orange juice mixed with 99mTc-diethylene triamine penta acetic acid. To clear the residual activity in the esophagus after the ingestion of radiolabeled orange juice, a small amount of unlabeled water was given.

Immediately after ingestion, the dynamic images were recorded in the supine position at a framing rate of 60 seconds for 60 minutes in anterior and posterior projections. The oral cavity, proximal esophagus, thorax, and abdominal cavity were obtained in the field of view. Scintigraphy images were acquired with a γ camera that was equipped with low-energy high-resolution collimator, with photopeak settings of 20% at 140 keV in a 128×128-pixel matrix.

The region of interest was manually drawn over the entire stomach in the first frame image and applied to all dynamic images. The time-activity curve was generated by computer analysis from the counts displayed in the region of interest. The data were corrected for radioactive decay. The

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This retrospective review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.
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rate of gastric emptying and retention were calculated at the end of the scanning. The time required for the maximum measured count to decrease to its half value "gastric emptying halftime" ($t_{1/2}$) was automatically calculated by a data processing unit. In cases in which half gastric emptying did not occur during 60 minutes of dynamic scintigraphy imaging, the "gastric emptying halftime" was exponentially calculated by a "time-activity curve."

The ideal weight of each patient was calculated as a BMI of 25. The data from the patient's follow-up were obtained from the outpatient clinic registry. The EWL percentage was obtained by proportioning the EWL to the excess weight calculated according to the preoperative weight as EWL%: (EWL/EW×100).

Operation Technique

A standard LSG procedure was performed without leaving the antrum and fundus. The placements of the 4 trocars were a supraumbilical 10-mm camera trocar, two 10-mm trocars for a surgeon in the right and left upper quadrants, one 5-mm trocar for the assistant in the left lateral quadrant, and a Nathanson retractor for the liver. Resection began with a green stapler at over the pyloric sphincter and was completed at the left lateral surface of the gastroesophageal junction with the blue stapler. No reinforcement techniques were applied on the resection line, as there were no obvious technical complications or suspicions. A 38 Fr orogastric tube was inserted to determine the size of the sleeve tube.

Specimen Measurements

Each specimen was extracted from the left-sided 10-mm trocar site within the endobag. Attention was given not to avoid injuring the specimen. After extraction, the specimen was taken to the back table for measurements without providing time for shrinkage. In the distal edge, a hole was opened, and after draining the gastric fluid, a 5-mm trocar was placed in the hole. Specimen was insufflated with Olympus Laparoscopic System insufflator to a pressure of 10 mm Hg pressure with CO_2. All the parameters were measured twice, before and after insufflation. These measurement parameters were the lengths of the resection site line, greater curvature, the width of the fundus and antrum, and double-wall thicknesses of the fundus and antrum. The expansion rate was calculated, as previously described by Gunal and colleagues. The difference between pre- and postinsufflation measurement values was divided into the preinsufflation measurement value of each gastric dimension. This ratio and specimen volume were considered the expansibility indicators.[4]

The remnant gastric volume was also evaluated. The calculation was made according to the following formula, as the remaining stomach was close to the cylindrical shape. It was found by taking the diameter of the 38 Fr tube used, which was applied in all patients.

$$\text{Cylinder Volume} = h \cdot \pi \cdot r^2$$

where h = stapler line length, r = radius of the orogastric tube.

Statistical Analysis

For the analysis, SPSS 23.0 package program was used. Patient data were defined as percentages, mean ± SD, and median (minimum-maximum). Student t test (paired samples) was used for the normally distributed continuous data for the difference (P-value) between the preoperative and postoperative values of the patients, and the Mann-Whitney U test was used for non-normally distributed data. The χ^2 test was used for ordinal or nominal data. Correlations were calculated using the correlation coefficient of the spectrum. The results were evaluated at a 95% confidence interval and a significance level of $P < 0.05$.

RESULTS

Sixty-four consecutive patients undergoing sleeve gastrectomy were enrolled. Forty-nine (77%) of the patients were women and 15 (%23) were men. The mean age of 64 patients was 41 (21 to 65). Mean preoperative BMI was 50.5 (39.9 to 73.1). There were no staple line leaks or mortality in this series. Two patients were excluded because of the data loss. Fifty-seven patients were followed up to 12 months postoperatively. Fifty-four patients were followed further for up to 3 years. The flowchart of the study is shown in Figure 1. The median follow-up time was 25.9 months (11 to 38 mo). Twelve months and 3 years of excess body weight loss (EWL%) were 80% and 76%, respectively. The demographic data of the patients are presented in Table 1.

Gastric Emptying

The mean gastric emptying time $t_{1/2}$ and percentage of emptying at 1 hour before the operation was 37.6 ± 30.5 minutes and 74.7% ± 23.9%, respectively. There was no correlation between third-year EWL% and preoperative gastric emptying parameters (Tables 2 and 3).

Measurements of Stomach

The resected gastric mean volume was 802 ± 284 mL (300–1700). No significant correlation was found between the gastric measurements and the third-year EWL%. However, resection line length and age significantly negatively correlated with 12th-month EWL% ($P = 0.017$, $P = 0.02$, respectively).

The study showed a negative correlation between the 3-year EWL% and age ($P = 0.10$). When the factors affecting the third-year EWL% were examined in the regression analysis, a significant negative relationship was found with age. As age increased, it was observed that the third-year EWL% decreased ($P = 0.04$). The mean remnant gastric volume was 118.3 (with a range of 75.3 to 170.8) mm^3. Remnant gastric volume was significantly negatively correlated with 12-month EWL% ($P = 0.017$) but not with the third-year EWL% (Table 3).

The patients were divided into 2 groups based on whether they had weight regain (WR) between 12 months and 3 years after surgery. The antrum diameter variation and ratios were found to be different between the 2 groups. The antrum diameter ratio was significantly higher in patients with WR ($P = 0.023$) (Table 4).

DISCUSSION

Research has indicated that a WR rate of 20% to 25% was reported after surgery.[12] WR is the most important factor that determines the success of bariatric surgery. Therefore, detecting patients with probable WR as early as possible is crucial for achieving a positive outcome after the weight loss surgery. Many factors were investigated to predict WR after surgery.[13] Significant weight loss was detected after LSG in the overall study group. However, especially after 2 years, the periods of weight gain or weight loss deceleration occurred. Rubino[14] suggested using EWL% as the main determinant of weight loss surgery success. Rubino

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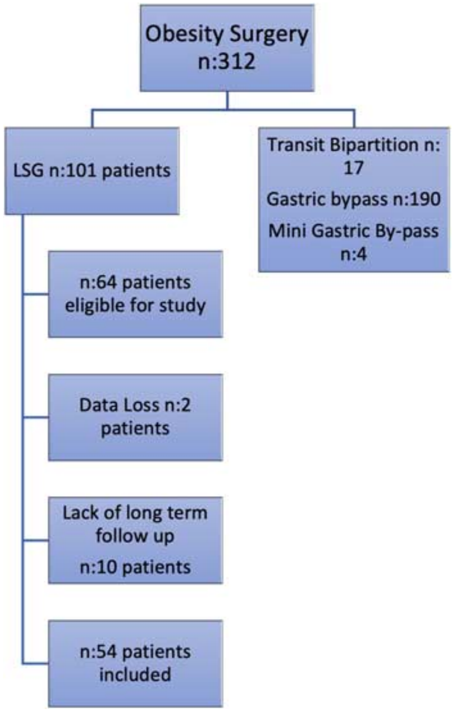

FIGURE 1. Flowchart of the study.

also proposed that the weight loss effect of bariatric surgery resulted not only from the restrictive function but also from the malabsorptive and humoral functions of the surgery. Despite these propositions, surgical anatomical nuances such as varying organ distances during bariatric surgery may alter the outcomes of surgery. These factors might be the indicators of surgical outcomes. Gastric specimen measurements after sleeve gastrectomy can easily be performed in the operating room. Our study examined the methods that may predict weight loss or WR cessation during the postoperative period.

Our study investigated the relationship among gastric emptying, gastric specimen measurements, and weight loss. The resection line length, remnant gastric volume, and age negatively correlated with the 12-month EWL%. A significant negative correlation was found between antrum enlargement and WR between 12 months and 3 years.

It was observed that the 12-month weight loss was less in patients with a large remaining gastric volume and in those older age (Table 3). However, this relationship remained only with age at the third postoperative year. Several previous studies have confirmed the positive effect of young age on weight loss after bariatric surgery. Our study also showed that advanced age also has a negative impact

TABLE 1. Demographic Features of Patients

N	62
Age (y), mean ± SD	41.3 ± 11.2
Sex	
Male, n (%)	15 (23)
Female, n (%)	47 (77)
BMI, mean ± SD	50.5 ± 8.4

BMI indicates body mass index.

TABLE 2. Gastric Measurements and Gastric Emptying Variables

Gastric Measurements and Gastric Emptying Variables	N = 62
Specimen insufflation volume (mL)	
Mean ± SD	814 ± 291
Median (range)	800 (300–2000)
Preoperative gastric emptying halving time ($t_{1/2}$, min)	
Mean ± SD	37.6 ± 30.5
Median (range)	27 (1–143)
Preoperative gastric emptying percent, mean ± SD	74.7 ± 23.9
Median (range)	79 (9–100)
Resection line length (cm)	
Mean ± SD	23.7 ± 4
Long curvature length ratio, mean ± SD	1.3 ± 0.1
Fundus diameter (cm), mean ± SD	5.8 ± 1
Fundus diameter ratio, mean ± SD	2.11 ± 0.55
Antrum diameter (cm), mean ± SD	4.78 ± 0.75
Antrum diameter ratio, mean ± SD	1.82 ± 0.3
Long curvature length (cm), mean ± SD	38 ± 5.3
Long curvature length ratio, mean ± SD	1.37 ± 0.16

TABLE 3. Correlation Between Measurements With 12th Month and Third-year EWL%

	12th Month EWL%	Third Year EWL%
Age		
r	−0.406	−0.381
P	0.002	0.004
Preoperative gastric emptying halving time		
r	0.092	0.064
P	0.506	0.646
Preoperative gastric emptying percent		
r	−0.203	−0.194
P	0.137	0.160
Resection line length		
r	−0.321	−0.178
P	0.017	0.197
Fundus diameter		
r	−0.149	−0.009
P	0.279	0.949
Antrum diameter		
r	−0.057	0.055
P	0.678	0.690
Long curvature length		
r	−0.181	−0.033
P	0.186	0.848
Resected gastric (specimen) insufflation volume		
r	−0.061	0.111
P	0.659	0.424
Resection line length ratio		
r	0.245	0.109
P	0.072	0.431
Fundus diameter ratio		
r	0.050	0.082
P	0.719	0.556
Antrum diameter ratio		
r	−0.057	0.055
P	0.678	0.690
Long curvature length ratio		
r	−0.159	0.001
P	0.247	0.996
Remnant gastric volume		
r	−0.321	−0.178
P	0.017	0.197

EWL indicates excess weight loss.

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TABLE 4. Comparison of Regain and No Regain Groups

	No Regain, N = 27	Regain, N = 27	*P*
Age (mean)	41.7	41.5	0.940
Sex	—	—	0.2
Female	18	23	—
Male	9	4	—
Preoperative gastric emptying halving time (min)	39.4	37.5	0.83
Preoperative gastric emptying percent in 1 h (%)	72.3	75	0.69
Resection line length (cm)	23.6	23.5	0.88
Fundus diameter (cm)	5.5	6	0.14
Antrum diameter (cm)	4.7	4.8	0.55
Long curvature length (cm)	38.5	37.3	0.40
Resected gastric (specimen) insufflation volume	748.1	885.1	0.09
Resection line length expansion ratio (%)	18.3	16.04	0.458
Fundus diameter expansion ratio (%)	115.0	109.9	0.742
Antrum diameter expansion ratio (%)	73.4	91.2	0.023
Long curvature length expansion ratio (%)	1.35	1.36	0.83
Remnant gastric volume (mm^3)	944.5	937.8	0.88

on postoperative weight loss. The significant relationship among weight loss and the remnant gastric volume and resection line length no longer existed 3 years postoperatively. This may presumably be related to the disruption of first-year gastric restrictive activity due to gastric expansibility developed by the third year.

Obeidat and colleagues filled the specimens with saline to measure the gastric volume. They found that gastric volume was an independent factor that affected weight loss. They suggested a cutoff value of 1100 mL gastric volume as determining weight gain or loss at the 12-month follow-up.[5] Weiner et al[6] prospectively evaluated 120 patients; the 5-year follow-up showed that failure in weight loss occurred when the gastric specimen volume was <500 mL. In this study, we observed that the resected gastric volume was greater in the group with regain; however, the difference was not statistically significant (Table 4). Although we could not find a relationship between gastric volume and WR, stapler line length resection line length correlated with weight loss. If gastric resection starts just from the pyloric sphincter and extends to the esophagus, as in our surgical technique, resection line length may be considered to be an indicator of gastric volume. Because of the constant values in the calculation formula of the cylinder volume of the remnant stomach (such as π and radius of the calibration tube 1.61), the height of the cylinder, as measured by stapler line length (resection line length), gives us the approximate remnant stomach volume. This suggests a correlation between the actual volume of the stomach and weight loss. Resection line length seems to be the most quantifiable measure of the remnant gastric volume in vivo.

In a prospective study, Yehoshua et al demonstrated that resected gastric volume could not be the single parameter that affecting the weight loss. They measured the whole gastric volume intraoperatively, contrary to our study. The resected part's volume and pressure were also calculated. The authors found that the addition of the volume of the sleeve tube and the removed part was not equal to the total gastric volume. This study concluded that extensibility is different in each part of the gastric wall and that the parameters that affect the weight loss are multifactorial. However, the study did not evaluate the relationship between gastric wall expansibility and weight loss.[15] Another study showed that resected gastric volume was related to the total gastric volume and preoperative BMI; however, it could not establish a relationship with weight loss.[8]

In this study, remnant gastric volume was negatively correlated with the 12-month EWL%. The resection line length was the parameter that directly determined the remnant gastric volume, as the orogastric tube used is 38F, and the standard surgery method was applied to all patients. This determined the volume of food that can be taken at a meal. The negative correlation with the 12th-month EWL% can be explained in this regard. In the long term, weight loss and remnant gastric volume correlation disappeared in the third year. The expansive adaptation of the remnant stomach may eliminate this relationship of weight loss and remnant gastric volume. The antrum extensibility rate was higher in the regain group. This information also shows that the gastric extensibility rate might predict the long-term weight gain. Gastric specimen measurements are essential tools for planning a postoperative follow-up. The small number of patients and retrospective analysis were the limitations of this study. Although the data were collected prospectively, some patient data were lost during the follow-up. Studies can be planned with a larger number of patients and long-term follow-ups.

CONCLUSIONS

Resection line measurement and antrum diameter measurements can predict postoperative weight loss, especially in the first year. Different resected gastric specimen measurement methods can be developed to predict successful weight loss in the long term.

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