Original Article

Evaluation of Postprandial Symptoms in Two Different Laparoscopic Sleeve Gastrectomy Techniques Using Gastric Emptying Scintigraphy

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Abstract

Background: Laparoscopic sleeve gastrectomy (LSG) is a frequently used procedure in the surgical treatment of obesity in recent years. However, surgeons have different opinions regarding the distance from the antrum to the pylorus. In addition, postprandial symptoms significantly affect the overall quality of life. **Aim:** Therefore, this study aimed to understand the relationship between postprandial symptoms with gastric emptying time and surgical procedures. **Patients and Methods:** Sixty patients who underwent LSG surgery were analyzed retrospectively and divided into two groups: antrum preserved (AP) and antrum resected (AR). The antral resection margin was 2 cm from the pylorus in 35 patients (AR group) and 6 cm in 25 patients (AP group). Semisolid gastric emptying scintigraphy (GES) was performed prospectively in both groups. Postprandial symptoms were standardized with a questionnaire. The relationship of symptoms with a half time of gastric emptying (GE T½), retention percentage at 30 and 60 minutes, lag phase, body mass index (BMI), and a decline in excess weight (% EWL), and antrum resection were investigated. The obtained results were compared between the two groups and with the control group. **Results:** The study group comprised 60 patients (49 F/11 M, mean age: 40.3 ± 20.1 years, BMI 31.6 ± 8.1 kg/m2). The half-time of gastric emptying in the AR and AP groups (28.00 min ± 9.58, 28.24 min ± 11.90, respectively), percentage gastric retention at 30 and 60 minutes in the AR and AP groups (30 minutes: %44.37 ± 17.88, %40.52 ± 14.56 and 60 minutes: 17 ± 8.9, 19 ± 3.1) was significantly different compared with the control group, but no significant difference was observed between the study groups. In addition, there was no statistically significant difference between the AR and AP groups in postprandial symptom scores >9 (68.6%, 60%, *P* = 0.681), GER (77.1%, 64%, *P* = 0.253), and postoperative BMI (p = .397), % EWL (p = .975), and T lag phase (p = .332). **Conclusions:** In our study, the postprandial symptoms were not affected between two different surgical procedures in LSG.

Keywords: *Gastric emptying scintigraphy, laparoscopic sleeve gastrectomy, postprandial symptoms*

Received: 06-May-2022;
Revision: 15-Jun-2022;
Accepted: 29-Jun-2022;
Published: 18-Nov-2022

Introduction

The increase in morbid obesity worldwide has led to the rise in bariatric surgical procedures.[1] Bariatric techniques cause different obesity-related comorbidities and weight loss.[2] Laparoscopic sleeve gastrectomy (LSG) is the most popular technique in bariatric surgery.[3] This results in low postoperative morbidity and mortality rates, an average of 60% weight loss in body weight, and is relatively simple to learn and implement.[4,5] However, the ideal distance between the dissection line and the pylorus for resection or

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_315_22

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How to cite this article: Yilmaz F, Gedik GK, Yilmaz H. Evaluation of postprandial symptoms in two different laparoscopic sleeve gastrectomy techniques using gastric emptying scintigraphy. Niger J Clin Pract 2022;25:1875-82.

preservation of the antrum has not been fully clarified. It is suggested that in cases where the antrum is preserved, surgical complications such as proximal leakage will be more minor because the motor function of the stomach continues.[6] There are also publications showing that almost complete removal of the antrum is more effective in lowering body mass index (BMI) without increasing postoperative surgical complications.[7,8]

Postprandial symptoms can be seen in both procedures, impairing the patients' quality of life and shadowing the importance of LSG.[9] It is difficult to make a differential diagnosis since these symptoms may accelerate and decelerate gastric emptying.[10] Lack of the adaptive relaxation mechanism of the fundus, decreased motor function of the antrum, increased peristalsis, high residual intragastric pressure, lack of neurohormonal means, gastroesophageal dysmotility, etc., may cause postprandial symptoms.

Gastric emptying scintigraphy (GES) is the standard method for assessing gastric motility.[11] This study is based on non-invasive physiological ingestion of food (liquid or solid) and quantitative analysis. Therefore, we aimed to investigate the relationship between gastric emptying scintigraphy, a non-invasive method, and postprandial symptoms observed after surgery with two different LSG procedures.

Methods

Patients

A total of 60 patients (BMI >40 or >35 kg/m²) who underwent LSG surgery between January 2018 and December 2019 were retrospectively included. The mean age of the patients was 40.3 (range, 20-65) years. Given that patients digest solid foods with more difficulty in the first three months after LSG surgery, only patients who were 3-12 months post-surgery were included in the study. The mean time between LSG surgery and GES was 10.3 ± 4.03 (range, 3-12) months. In addition, patients who had undergone another bariatric surgery, those with a history of diabetes (fasting blood glucose >126 mg/dL, HbA1C >6%, 2nd hour postprandial blood glucose >200 mg/dL, and those using drugs that might affect gastric motility (e.g., prokinetics, theophylline, calcium blocking agents, opioids), patients with heart, liver, and kidney disease, and pregnant or breastfeeding women were not included in the study. The surgical information of the patients was determined using the surgical compact discs in the hospital information system. The distance from the pylorus to the surgical dissection margin was divided as 6 cm (antrum protected: AP group) and 2 cm (antrum resected: AR group). The control group included 20 patients without diabetes who underwent scintigraphic evaluation for other reasons, and half-time gastric emptying results and percent gastric retention results were compared between groups and with the control group. The local ethics committee approved our study of our institution (no: 44824), and consent forms were obtained from the patients who participated in the study.

Questionnaire: Postprandial symptoms occurring daily after LGS consisted of nausea, vomiting, reflux, epigastric discomfort, fullness, and early satiety. Symptoms were scored from 0 to 6, and the maximum score was 36. Based on this questionnaire, the study population was considered to have low postprandial symptoms with scores of ≤9 and high postprandial symptoms with scores of >9.

Surgical procedure

The bariatric surgery protocol in our institution includes a multidisciplinary preoperative program. Before the surgery, the patients' hemogram and biochemical blood controls and esophagogastroduodenoscopy, psychological, nutritional, endocrine, and cardiac evaluations were performed. LSG was performed on all patients in this study in a single institution and with the same surgeon. The first LSG was performed in our institution in 2010, and the antrum preservation approach was preferred more in the first years. Therefore, the distance between the dissection site and the pylorus in the first patients of the study was 6 cm. After 2010, the tendency to restrict stomach capacity more and use smaller orogastric tubes.

After deep vein thrombosis, the operations were performed under general anesthesia (enoxaparin sodium 6000 IU anti-Xa activity: equivalent to 60 mg) and chemoprophylaxis (cefazolin 2 g). An intermittent pneumatic compression device was used to prevent thromboembolism in both legs. The patient was placed in a semi-lithotomy and reversed Trendelenburg position. The pneumoperitoneum was created by inserting the first supraumbilical 10 mm vane trocar. Two additional working 15 mm bladed trocars were placed on the camera port's right and upper left sides. A port was placed in the subxiphoid area for liver retraction. The stomach vessels were separated using a vessel occlusion device (Covidien, USA). Gastric transection was performed using a 60 mm linear stapler (EndoGIA, Covidien, USA) guided by a 36 French bougie from the pylorus to the angle of his 2 or 6 cm. Reinforcement was performed with continuous absorbable barbed sutures (Covidien, VLoc, USA) over the stapler line, and then a drain was placed. An upper gastrointestinal contrast study was performed on all patients on the third postoperative day.

Gastric emptying scintigraphy

Gastric emptying scintigraphy was done in the morning after an overnight fast. All patients were given a combined semisolid food containing: 150 cc milk, half-thin toast bread, and one mCi ^{99m}Tc diethylenetriaminepentacetic acid labeled scrambled egg (200 kcal). At least 50% of the food was consumed within 10 minutes. No patient vomited after a meal. Images were taken and collected using a gamma camera (Siemens E-Cam Signature, Germany) equipped with a low-energy high-resolution collimator when the patient was supine. After the patient's meal, 1-minute dynamic images were taken for 60 minutes. Anterior and posterior images were acquired using a 128 × 128 matrix for dynamic acquisition with an energy peak of 140 keV ± 10%. An area of interest was drawn around the stomach and esophagus. A gastric region of interest (ROI) was drawn for anterior and posterior views at 30 and 60 minutes. A geometric mean was obtained with the counts found, and an attenuation correction was made. A time-activity curve (TAC) of the geometric mean of gastric counts at all time points was constructed, and the half-time of gastric emptying (T½) was calculated. Gastric retention calculations of the patients were made by taking the geometric mean of anterior and posterior images at 30 and 60' minutes. The lag phase is the time it takes for food to pass through the pylorus and break down into smaller pieces (5-25 minutes). The lag time of both groups was calculated using the TAC curve.

Detection of a retrograde peak at any intensity and time in the esophageal region in the images obtained from the anterior view for visual analysis used in the evaluation of GER, or at least one peak observed in TACs was considered as GER.

Statistical analysis

All statistical analysis was performed using the *R* software, version 3.6.0 (The *R* Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org). The Shapiro-Wilk normality test and Q-Q plots were used to assess the normality of the data, and also Levene's test was used to check the homogeneity of the variances. Numerical variables are presented as mean ± standard deviation or median (range: minimum-maximum), and categorical variables are defined as numbers (n) and percent (%). Independent samples t-test and Mann-Whitney U tests were used to examine whether there was a statistically significant difference between group AP and group AR regarding patients› age, postoperative BMI difference, and gastric emptying time. In addition, Fisher›s exact test or Yates's continuity correction Chi-square tests were performed to determine whether there was a statistically significant relationship between group AP and group AR in terms of sex and postprandial symptoms. Cohen d value t-test for independent samples, rank binary serial correlation coefficients (rrb) for the Mann-Whitney U tests, and phi coefficient (ϕ) for Chi-square tests were used to determine the effect size. A *P* value of less than. 05 was considered statistically significant.

Results

The mean age of the patients in the AR group was 41.40 ± 11.24 years, and there were 28 (80%) female and seven (20%) male patients. The mean age of the patients in the AP group was 38.76 ± 8.82 years, and there were 21 (84%) female and four (16%) male patients. The groups' mean age and sex distributions were similar, as shown in Table 1.

There was no statistically significant difference between the two groups in terms of postprandial symptom score >9 and GER (p = 0.681 and *P* = 0.253) [Table 1, Figure 1a].

The postprandial symptom scores were found to be high in 19 (70.4%) of 27 GER (+) patients in the AR group and in 10 (62.5%) of 16 GER (+) patients in the AP group. However, it was not statistically significant (p = 0.685 and *P* = 0.442, respectively, Figure 1a).

The half time of gastric emptying (28.00 min ± 9.58, 28.24 min ± 11.90, respectively) and percentage

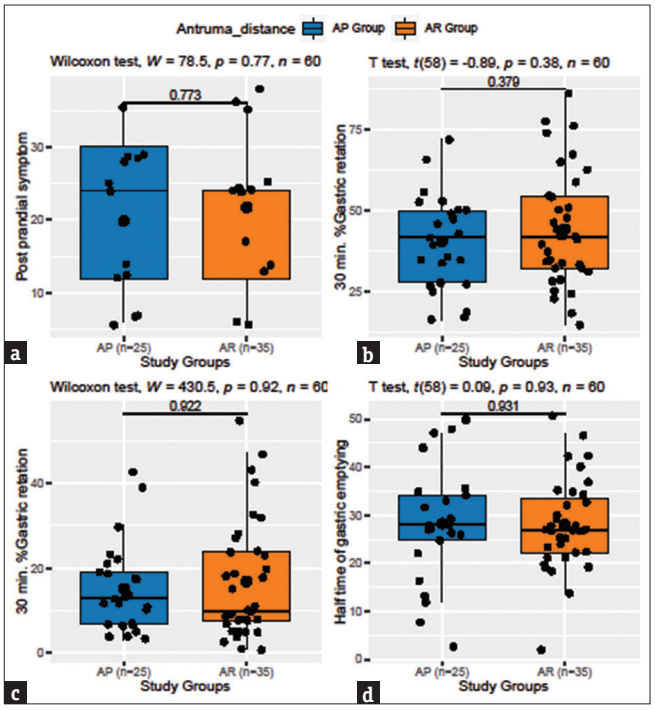

Figure 1: The box plots demonstrate the difference in postprandial symptoms (a), 30 min % gastric retention (b), 60 min % gastric retention (c), and half time of gastric emptying between the AR and AP groups (d)

Table 1: Comparison of gastric emptying (GE) results of antrum preserved (AP) and antrum resected (AR) groups with the control group (* Gastric Retention)

	GE halftime (min)	30 min % GR*	60 min % GR	T lag phase	*P*
AR group (*n*: 35)	28.00±9.58	44.37±17.88	17±8.9	5±2.1	<.05
AP group (*n*: 25)	28.24±11.90	40.52±14.56	19±3.1	7±2.6	<.05
Control group (*n*: 20)	54.35±24.31	74.8±7.1	62.3±11.5	18±6.9	<.05

Table 2: Comparisons of the variables according to the study groups

Variables	Group AR (*n*=35)	Group AP (*n*=25)	*P*
Age, mean±SD	41.40±11.24	38.76±8.82	0.332[1]
Sex (F/M), *n* (%)	28 (80)/7 (20)	21 (84)/4 (16)	0.748[2]
Preoperative BMI, median (range)	45 (37.6-67.6)	43.3 (37.8-58.4)	0.224[3]
Postoperative BMI, median (range)	30.1 (22.6-46.4)	29 (22.8-47.3)	0.397[3]
BMI difference (Preop.-Postop.), mean±SD	16.33±5.10	15.77±4.28	0.658[1]
Excess weight loss (%)	69.4±17.3	67.2±21.1	0.975[1]
Time from LSG to GES, mean±SD	10.09±3.97	10.72±4.13	0.551[1]
GER *n* (%)	27 (77.1)	16 (64)	0.253[4]
Postprandial symptom score (>9)	24 (68.6)	15 (60)	0.681[4]
Half time of gastric emptying, mean±SD	28.00±9.58	28.24±11.90	0.931[1]
30. min. % gastric retention, mean±SD	44.37±17.88	40.52±14.56	0.379[1]
60. min. % gastric retention, mean±SD	16.89±13.96	15.16±10.42	0.922[3]
T-lag (min), mean±SD	6.60±4.02	5.40±2.74	0.332[3]

Data were presented as mean±standard deviation, median (interquartile range: 25th percentile-75th percentile) or number (*n*) and percentage (%). [1]Independent samples *t*-test. [2]Fisher's exact test. [3]Mann-Whitney *U* test. [4]Yates continuity correction Chi-square test

gastric retention in the AR and AP groups at 30 and 60 minutes (30 minutes: %44.37 ± 17.88, 40.52 ± 14.56, and 60 minutes: %17 ± 8.9, 19 ± 3.1) were statistically significant compared to the control group, but no significant difference was observed between the two groups [Table 1, Figure 1b, 1c, 1d].

The median preoperative BMI of patients in AR was 45 (range, 37.6–67.6) kg/m^2 and 43.3 (range, 37.8–58.4) kg/m^2 in the AP group. The median postoperative BMI of patients in the AR group was 30.1 (range, 22.6–46.4) kg/m^2 and 29 (range, 22.8–47.3) kg/m^2 in the AP group. There was a statistically significant difference between the preoperative and postoperative BMI ($p < .05$). However, there was no statistically significant difference between the AR and AP groups regarding the mean BMI difference [Table 2].

Figures 2 and 3 show gastric emptying scintigraphies of two obese patients with LSGs 2 cm and 6 cm apart from the pylorus.

Discussion

LSG is the most effective method for ensuring and maintaining sufficient weight loss among bariatric surgery methods. The effect mechanisms of sleeve gastrectomy in weight loss can be summarized as a gastric restriction, neurohormonal effects, gastric motility, and changes in eating habits.[12] With the removal of the fundus, which stores and pushes the nutrients, the corpus part's wrinkles that provide stretching, and the antrum, which is the pumping mechanism, the remaining stomach residue volume is significantly reduced, and the stomach is restricted. The most important of these is the size of the stomach restriction. This is also important in the continuity of weight loss. The stomach size left behind in LSG has not been standardized in studies conducted so far. Moreover, conflicting results regarding gastric emptying continue in the publications on this subject.[13]

Michalsky *et al*.[13] examined 12 patients, including the resected antrum preserved (AP) groups. When they compared the results with the preop values, they found that T1/2 decreased statistically, similar to our results. However, they found no statistically significant differences between BMI, weight, and percentage EWL. Braghetto *et al*.[14] found similar results in 20 patients showing accelerated gastric emptying for both solids (T1/2:38.3 ± 18.77) and liquids (T1/2:13.6 ± 11.9) 3 months after 2-cm antral length LSG. Li *et al*.[15] examined gastric emptying times with solid gastric emptying scintigraphy 3 months after surgery in 21 patients who underwent LSG (6 cm from the pylors), and found that significant acceleration in gastric emptying time was significantly correlated with

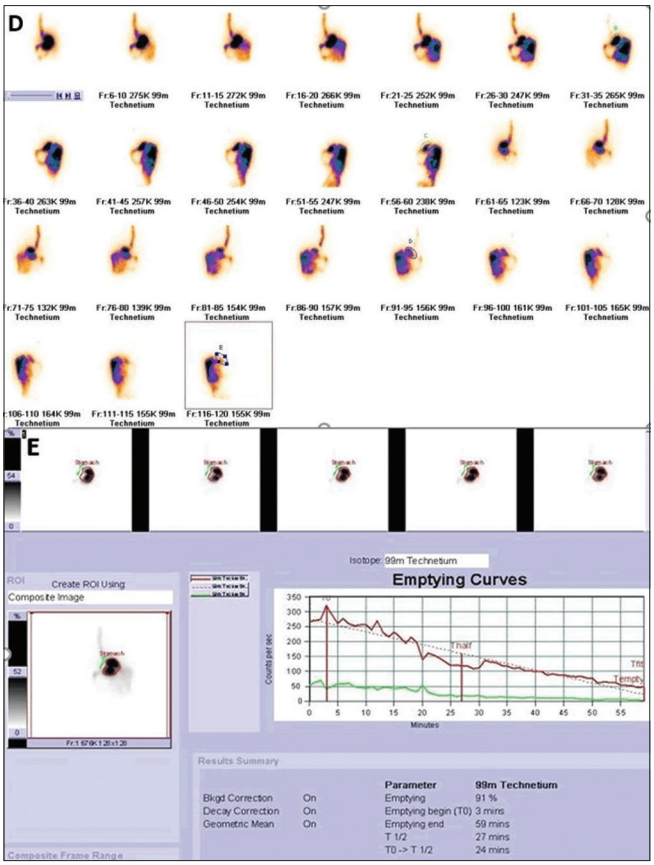

Figure 2: A 42-year-old female patient, who was 6 cm away from the antrum pylorus (AP group), the area of interest (ROI) was drawn around the sleeve in the anterior and posterior images (blue arrow: anterior, red arrow: posterior) at 30 and 60 minutes. The geometric mean of the activities in the count was calculated, 30 min: 34% gastric retention, 60 min: 11% gastric retention, postprandial symptom score: 30, no GER, e: Gastric emptying scintigraphy time-activity curve (TAC), half-time of gastric emptying: 25 min, T lag phase: 5 min

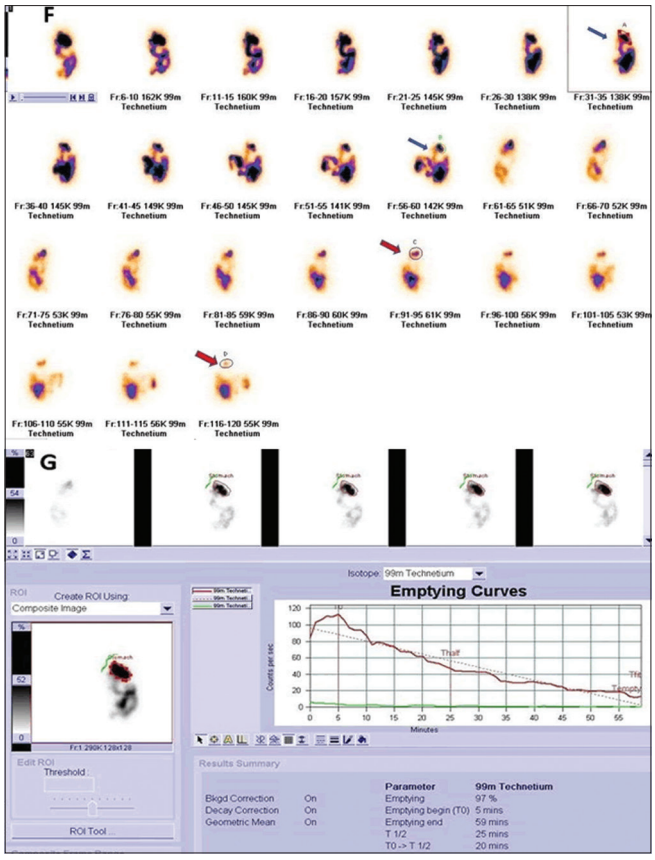

Figure 3: A 24-year-old female patient, LSG 2 cm distance from the pylorus (AR group), f: GER activity peaks from sleeve to the esophagus, postprandial symptom score: 24, 30 min: 41% gastric retention, 60 min: 18% gastric retention, g: Gastric emptying scintigraphy time-activity curve (TAC), half-time of gastric emptying: 27 min, T lag phase: 4.5 min

the decrease in postprandial glycemia. Pilone *et al*.[16] evaluated gastric emptying times of 45 patients who underwent LSG (5-6 cm from the pylors) with standard semisolid gastric emptying scintigraphy. They compared the gastric emptying times of the patients before surgery and the control group and showed that gastric emptying time was significantly reduced as in our study. Melissas *et al*.,[17] in 40 patients with LSG, 390 kcal solid meals, GE half-time (62.50 min at 6 months, 60.80 min at 24 months), and T lag phase (12.50 min at 6 months, 12.16 min at 24 months), it was found that there was a statistically significant decrease in the preoperative and postoperative period. After LSG, gastric emptying accelerates, satiety warnings increase, glucose metabolism improves, and weight loss begins. In addition, the release of ghrelin (known as the "hunger hormone" and released mainly from the fundus) decreases the desire to eat, and eating habits change.[18] Although there was a volume difference between the two groups in terms of the residual stomach in our study and studies with similar results, the lack of significant difference in BMI and %EWL indicates that the mechanism of weight loss is not only related to gastric restriction but also neurohormonal changes and the gut-brain axis. Burgerhart *et al*.[19] also divided the patients into two groups according to the severity of their symptoms. In both groups, GE half-time (276 kcal solid meal: 40.6 ± 10.0 and 34.4 ± 9.3) and T lag phase (6.4 ± 4.5 and 7.3 ± 6.3) were control groups found accelerated. In our study, the mean value of T lag phase AR and AP groups were (6.60 ± 4.02 and 5.40 ± 2.74), and the semisolid test meal was 200 kcal. These are less than in the other two studies and can be explained by our study's lower kcal amount of the semisolid test meal. On the other hand, Bernstine *et al*.[20] reported no statistically significant difference between GE half-time and percentage gastric retention in 21 patients with preserved antrum (6 cm from the pylorus and 48 french orogastric tubes) with LSG. We thought that they obtained different results from ours and other studies in the literature due to the larger residual stomach volume resulting from using a 48 french orogastric tube.

Kandeel *et al*.,[21] by giving solid and liquid meals to 40 patients undergoing LSG, reduced pre and postoperative GE half-times (solid meal GE T1/2: 28.4 ± 8.3, $P < 0.001$) and percentage gastric retention (30 and 60 min: 42.0 ± 11.1 and 20.8 ± 6.1, $P < 0.001$) and found that it decreased statistically significantly compared with preoperative values. Our study found that the percentage gastric retention rates at 30 minutes (44.37% ± 17.88 and 40.52% ± 14.56) and 60 minutes (17% ± 8.9 and 19% ± 3.1) decreased significantly compared to the control group, but there was no significant difference between the two groups. In addition, it has been suggested that the presence of <30% retention after 1 hour is more accurate than either the preoperative results of the cases or the gastric emptying half-time results of the normal control groups to evaluate the gastric emptying rate.[22] In our study, retention was <30% after 1 hour in both groups, and gastric emptying was accelerated.

Garay *et al*.[23] compared the GE half-time and % EWL between the AP (n: 13) and AR (n: 12) groups. They reported that although there was no significant difference between them in the first year, there was a significant GE acceleration in the AP group in the 2nd postoperative month. They argued that more or less surgical intervention in the antrum resulted in an acceleration in GE and that the leading cause of weight loss was the restrictive and hormonal effects of LSG. Vives *et al*.[24] examined 3 cm and 8 cm LSG in diabetic and non-diabetic subgroups. They reported that the gastric emptying half-time of the AR group (3 cm) was faster than in the other non-diabetic groups. They attributed this to the lack of a regulatory pump role of the antrum in this group. They also found that pylori distance did not affect gastric emptying time in diabetic patients. In the group whose antrum was preserved, diabetic patients had faster gastric emptying due to a worse metabolic control than nondiabetics. Similarly, Yang *et al*.[25] found that gastric emptying was significantly accelerated after LSG with 23 cases 4 cm away from the pylorus. They claimed that this was related to the glycemic profile in the preoperative period. However, the cases in our study were not diabetic in the preoperative period, and gastric emptying rates were increased.

Rubin *et al*.[26] evaluated 120 patients who underwent LSG with antrum preservation in terms of postoperative complications. The authors reported no symptoms and complications, including vomiting, developed except for early satiety. Our study scored the patients with a questionnaire for postprandial symptoms. Although symptoms and reflux events were more common in the AR group, we found no statistically significant difference between the AR and AP groups. Similarly, Burgerhart *et al*.[19] reported no significant relationship between gastric emptying half time and the severity of postprandial symptoms by performing liquid and solid gastric emptying scintigraphy on 20 patients with LSG with preserved antrums. Khiyani *et al*.[27] a retrospective study, investigated the hypothesis that preoperative gastric emptying abnormality is responsible for adverse postoperative outcomes. They concluded that abnormality in preoperative GES was not a strong predictor of clinical outcome in bariatric surgery. They also found that symptomatic patients at six months postoperatively were asymptomatic in long-term follow-up. Our study found that abnormal acceleration in GES in the postoperative period did not make a significant difference between the two groups in terms of clinical outcomes. Abdallah *et al*.[28] compared two groups who underwent LSG with preserved antrum (6 cm, n: 53) and AR (2 cm, n: 52) in terms of postoperative complications, comorbidity, and % EWL after two years. They found statistically significant weight loss in the AR group, but there was no significant difference between other findings. Our study was conducted 10 months on average after LSG, and there was no significant difference between BMI and % EWL between the two groups. Keidar *et al*.[29] investigated the presence of postoperative GER in a large series of patients with LSG 2-4 cm from the pylorus. They concluded that different surgical approaches, such as the size of antral resection and the size of the bougie, were ineffective in developing GER. In our study, no significant difference was demonstrated in postprandial symptoms and GER between patients with a 2 and 6 cm distance of surgical border to the pylorus. Sancho Moya *et al*.[30] evaluated the presence of GER in 52 patients who underwent LSG using pre- and postoperative 24-hour esophageal pH monitoring, esophageal manometry, gastric emptying scintigraphy, and GER questionnaires. The "de novo" GER disease rate was 76.4% in the first month and 41% in the 18th. They reported that the symptomatic patients did not improve. In a recent study examining the effect of LSG on the symptoms of GER, the authors said that LSG had no significant impact on patients with preoperative symptoms. However, they reported that new and prominent GER symptoms might develop in the postoperative period in patients without symptoms in the preoperative period.[31] On the other hand, Salman *et al*.[32] evaluated the gastric motor function of non-diabetic patients with obesity who underwent LSG (2-3 cm from the pylorus) by scintigraphy and also examined the presence of GER with a questionnaire. They attributed the significant improvement in

preoperative GERD patients to the acceleration of gastric emptying in the postoperative period. Although we detected a higher rate of scintigraphic GER in the AR group in our study (77.1% vs. 64%), there was no significant difference between the two groups. Also, there was no significant difference between postprandial symptoms in GER (+) patients of the two groups. Again, in a recent study, no significant difference was observed between the two groups in terms of GERD symptoms with AR (2 cm from pylors: 53 patients) and AP (6 cm from pylors: 56 patients).[33]

The limitations of our study are that gastric emptying was not evaluated scintigraphically in the preoperative period, and the number of patients included in the study was small. However, the use of gastric emptying scintigraphy, a non-invasive method, is crucial because it shows the motor function of the stomach and provides information about GER, one of the postprandial symptoms, in single imaging.

Conclusion

Our study results showed that shortening the antrum size accelerated gastric emptying and had no effect on postprandial symptoms. It was also revealed that the probability of GER disease after LSG, although not symptomatic, is high.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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