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ORIGINAL CONTRIBUTIONS

Midterm Clinical Outcomes of Antrum Resection Margin at Laparoscopic Sleeve Gastrectomy for Morbid Obesity

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Abstract
Background Laparoscopic sleeve gastrectomy (LSG) is one of the most frequently performed procedures in obesity surgery. The benefits of minimally invasive surgery include rapid recovery. We evaluated the clinical outcomes of different resection margin lengths from the pylorus in LSG.
Methods This retrospective study included 152 patients who underwent LSG from January 2011 to October 2014. The antrum was resected 2 cm from the pylorus in 84 patients (group A) and 6 cm from the pylorus in 68 patients (group B). The patients' demographics, staple line distance, complications, sex, age, body mass index loss, length of hospital stay, and comorbidities were retrospectively reviewed.
Results The patients comprised 104 women (68.4 %) and 48 men (32.6 %) with a mean age of 41.2 years (range, 28–53 years). The percent total and excess weight loss were statistically significant in both groups at 6 and 12 months postoperatively. Weight loss was significantly greater in group A than that in B at 6 and 12 months, but the difference at 24 months was not statistically significant. The results of pH monitoring showed significantly lower scores in group A than those in B at 6 and 12 months, but no difference at 24 months.
Conclusion LSG is an effective procedure with good short-term outcomes. Both procedures described herein are equally effective with respect to the patient's return to daily activities. Increasing the distance from the resection line to the pylorus is associated with better weight loss but slightly increased symptoms of gastroesophageal reflux disease without a significant difference in complications.

Keywords Obesity · Sleeve · Antrum · Gastrectomy · Margin

University of Selcuk at Konya is where the work was performed.

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Introduction

Laparoscopic sleeve gastrectomy (LSG) has become an established surgical treatment for morbid obesity during the past decade, and it is now one of the most frequently performed techniques because of its low complication rate [1]. LSG provides weight loss by the restrictive effect of a reduced stomach volume and resection of gastric ghrelin-secreting cells. Several studies have shown that LSG provides metabolic improvement and weight loss similar to that provided by laparoscopic Roux-en-Y gastric bypass [2]. The number of surgeons who perform LSG for treatment of morbid obesity is rapidly increasing. However, many aspects of the procedure are controversial, including the size of the bougie used as a calibrator and the distance from the pylorus to the first resection line. Many authors have proposed beginning the resection 6 to 7 cm from the pylorus to preserve the contractile function

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of the gastric antrum and promote gastric emptying [3]. Other authors have suggested a 2-cm resection margin from the pylorus because LSG is a purely restrictive technique and should be more aggressive than when part of another malabsorptive technique [4, 5].

The close association between obesity and gastroesophageal reflux disease (GERD) is well known. GERD is reported in about half of obese candidates for bariatric surgery, but it is not a contraindication for LSG [6, 7]. LSG may increase the risk of postprocedural GERD. Two systematic reviews by Chiu et al. [8] and Frezza et al. [9] demonstrated an unclear association of LSG with postoperative symptoms of GERD. Four of the studies in the review revealed an increased prevalence of GERD after SG, and seven studies showed a lower prevalence of GERD after sleeve gastrectomy. Technical considerations of LSG include how to decrease postoperative reflux, including determination of the optimal management technique for hiatal defects or herniation, and deciding on the appropriate shape of the final conduit [10]. Esophagogastroduodenoscopy facilitates the diagnosis of hiatal defects [3, 11, 12].

The aim of this study was to evaluate the effect of a 2- versus 6-cm resection margin from the pylorus in terms of weight loss and GERD symptoms.

Material and Methods

Patients

This retrospective study included 168 obese patients who underwent LSG from January 2011 to October 2013 at the Department of General Surgery, Selcuk University, Konya, Turkey. The study protocol was approved by the ethics committee and performed according to the principles of the Helsinki Declaration. Formal consent was not required due to the retrospective nature of the study.

All the patients were informed of the potential risks of surgery and follow-up period (control time about arrival to the hospital). The inclusion criterion, based on the Society of American Gastrointestinal and Endoscopic Surgeons, was a body mass index (BMI) of >40 or >35 kg/m^2 with at least one obesity-related comorbidity (e.g., hypertension, diabetes mellitus, dyslipidemia). All the patients underwent a complete blood count, biochemistry testing (including lipid, thyroid, and adrenal profiles), prothrombin time and partial thromboplastin time measurement, endocrine and psychiatric consultation, abdominal ultrasound to screen for pathology, and gastroscopy to screen for gastric pathology before applying the pH meter. The exclusion criteria were a history of thoracic, esophageal, or gastric surgery; a BMI of >60 kg/m^2; drug abuse; serious psychiatric disorders; and major gastrointestinal pathology or malignancy.

The collected data included demographic characteristics, distance from the staple line to the pylorus, complications, pH monitoring results, DeMeester score, sex, age, percent total weight loss (%TWL), percent excess weight loss (%EWL), length of stay, reinforcement technique, and comorbidities (Tables 1 and 2). Follow-up examinations were performed at 1 week and 1, 3, 6, 12, and 24 months after discharge.

pH Monitoring

A 24-h combined multichannel intraluminal impedance and pH (MII-pH) monitor (Medical Measurement Systems, Enschede, The Netherlands) was used preoperatively and at 6, 12, and 24 months postoperatively. After calibration, the MII-pH monitor was transnasally inserted into the esophagus until the lower tip reached the gastric cavity. The catheter was placed, allowing for monitoring of changes in the intraluminal pH above the lower esophageal sphincter. The patients were discharged and recommended to maintain their normal activities and sleep schedules, eat their usual meals at their normal times, and record all symptoms. The data were collected on a flash card for 24 h, downloaded onto a computer, and analyzed using a dedicated software program. The definitions of reflux episodes are shown in Table 3. The 24-h MII-pH monitoring results were defined as abnormal when the DeMeester score, number of long acid reflux episodes (>5 min), or percent time at a pH of <4 were above the upper limit of the reference range.

Table 1 Postoperative complications

	Group A (n = 84)	Group B (n = 68)	P
Complication, totally	8 (9.5)	5 (7.4)	0.634
Gastric leak	1 (1.2)	1 (1.4)	1
Staple line bleeding	2 (2.4)	1 (1.4)	0.688
İntraperitoneal infection	1 (1.2)	–	1
Wound infection	3 (3.6)	2 (2.8)	0.829
DVT	1 (1.2)	–	1
Pulmonary embolism	–	1 (1.4)	0.447
Clavien score			
0	69 (82.1)	61 (89.7)	0.188
1	10 (11.9)	2 (2.9)	0.042
2	4 (4.8)	3 (4.4)	0.918
3A	1 (1.2)	1 (1.5)	0.880
3B	–	–	–
4	–	1 (1.5)	0.447
5	–	–	–

Datas are expressed as n (%)

Table 2 Surgical outcomes

Variables	Group A (n = 84)	Group B (n = 68)	P value
TWL(%), 6 months	24.8 ± 2.3	22.3 ± 2.4	<0.05
TWL (%), 12 months	32.5 ± 2.4	24.0 ± 2.1	<0.05
TWL (%), 24 months	36.2 ± 3.5	32.2 ± 2.4	<0.05
EWL(%,), 6 months	49.8 ± 5.3	43.5 ± 2.3	<0.05
EWL (%), 12 months	60.9 ± 4.7	50.6 ± 2.6	<0.05
EWL (%), 24 months	68.7 ± 4.9	61.5 ± 2.3	<0.05

Datas are mean ± standard deviation

Means statistically significant ($P < 0.05$)

Operative Techniques

Low-molecular-weight heparin was subcutaneously injected 12 h before surgery, and an intermittent pneumatic compression device was applied to prevent thromboembolism. Cefuroxime axetil (2 g) was injected for chemoprophylaxis 15 min before induction.

All the patients underwent laparoscopic surgery under general anesthesia. The patients were situated in the supine position, and the operation was started by replacing the 15-mm bladed trocar. Carbon dioxide pneumoperitoneum at 12 mmHg was established, and four additional trocars were inserted. A Valleylab LigaSure (Covidien, Mansfield, MA, USA) was used to dissect the omental pieces of the great curvature and any adhesions of the pancreas and stomach. A 36-French orogastric tube was then placed in the stomach. Gastric transection was started at a distance of 2 cm (group A) or 6 cm (group B) from the pylorus using a stapler (EndoGIA; Covidien). All stapling was performed with purple cartridges, and the initial distance from the resection margin to the pylorus (approximately 2 cm) was measured using a tape measure. The staple line was reinforced with continuous barbed prolene sutures (V-Loc wound closure device; Covidien), and any sites of bleeding were closed with the LigaSure device. The portion of the stomach that had been transected from the pylorus was extracted through the 15-mm trocar site. No nasogastric tubes were placed in any patients.

Postoperative Management

All the patients were admitted to the intensive care unit for 8 h postoperatively. The abdominal drain output was recorded. An oral contrast examination was performed under fluoroscopy on postoperative day 2, and the patients were discharged on postoperative day 3. Six months of treatment with proton pump inhibitors and vitamin supplements was routinely recommended to all the patients, and these medications were given to all the patients in accordance with their biochemical test results.

Table 3 The incidence of resection distance on reflux parameters at LSG patients

	Group A (n = 84)				Group B (n = 68)			
	Preop	6 months	12 months	24 months	Preop	6 months	12 months	24 months
De Meester score	45.32 (8.59–75.89)	32.27 (6.17–61.2)*	14.42 (4.72–35.2)*	5.83 (1.74–23.6)	47.14 (9.63–78.4)	39.89 (8.21–67.3)*	19.69 (6.38–49.2)*	7.29 (2.37–25.1)
%time at pH < 4	15.41 (6.72–48.6)	9.45 (4.13–21.7)*	3.17 (1.34–13.44)*	2.31 (0.76–6.52)	14.32 (7.92–51.7)	11.65 (6.85–29.71)*	7.83 (4.73–19.01)*	3.57 (1.52–11.82)
Number of long acid reflux episode >5 min	11.74 (8.2–23.5)	6.47 (5.2–13.7)*	4.81 (3.1–9.7)*	3.32 (1.4–7.3)	12.23 (8.9–26.0)	9.65 (6.1–15.3)*	7.62 (4.5–11.4)*	4.27 (2.3–7.5)

Datas are median, (range)

Both of the groups are statistically significant in the 6th and 12th months ($P < 0.05$) (shown by (*)). This difference was synchronized, statistically insignificant in the 24th month

Follow-up

Surgical site healing, a complete blood count, and biochemical test results were evaluated at the first outpatient visit on postoperative day 7. Follow-up examinations were then performed at 6, 12, and 24 months postoperatively. Weight loss and pH monitoring data were recorded at 6, 12, and 24 months postoperatively.

Assessments

The patients' weight loss was evaluated using the BMI, %TWL, and %EWL. The %EWL was calculated as the amount of initial weight in excess of the upper limit of the normal weight range as estimated at a BMI of 25 kg/m^2 for a given patient's height, i.e., %EWL = ((preoperative weight − follow-up weight) / (preoperative weight − ideal weight)) × 100, and %TWL = postoperative EWL / preoperative weight × 100, with the ideal weight based on a BMI of 25 kg/m^2. The other assessed parameters were the distance from the staple line to the pylorus, perioperative and postoperative complications, gastroscopy results, age, length of hospital stay, duration of operation, reflux symptom index (RSI), 36-item short form survey quality of life questionnaire results, and comorbidities. Complications were evaluated using the Clavien–Dindo complication classification system [13–16].

Data Collection

All data were divided into three groups according to the surgical period. The first group of data included the demographic characteristics, preoperative BMI, comorbidities, and chronic diseases such as diabetes mellitus, hypertension, cardiovascular disease, and chronic obstructive pulmonary disease. The second group of data included the duration of surgical process and perioperative complications. The third group of data included the length of hospital stay and short-term gastric leakage.

Statistical Analysis

All statistical analyses were performed with PASW Statistics for Windows (version 18.0; IBM Corp., Armonk, NY, USA). Normalization of the data was evaluated with the Kolmogorov–Smirnov test. Differences between the groups were compared using the chi-squared test or Mann–Whitney *U* test, and Fisher's exact test was used as necessary. Student's *t* test was used to evaluate parametric data. Categorical variables were reported using percentages. Continuous variables and descriptive statistics were calculated and presented as mean ± standard deviation, and *P* values of <0.05 were considered statistically significant.

Results

Patient Characteristics

In total, 168 patients underwent LSG and were assessed for eligibility. Sixteen patients were excluded (5 because of a hiatal hernia, 5 because of refusal to perform postoperative pH monitoring, and 6 because of loss to follow-up). Thus, 152 patients were included in the study. Of these patients, 104 were women (68.4 %) and 48 were men (32.6 %). The mean age of the patients was 41.2 years (range, 26–65 years), and the mean BMI was 48.8 ± 5.3 kg/m^2. A total of 84 patients underwent resection 2 cm from the pylorus (group A), and 68 patients underwent resection 6 cm from the pylorus (group B). All other demographic characteristics were similar between the two groups (Table 4). Gastric scintigraphy was performed to diagnose delayed gastric emptying in one patient who had undergone gastroscopy for vomiting episodes in the short-term postoperative period.

Intraoperative Data

The mean operative duration was similar in both the groups (overall, 38.5 ± 7.48 min) (Table 4). Additional procedures were performed in nine patients (two in group A and one in group B were treated for cholelithiasis, and four in group A and two in group B were treated for umbilical hernias). All operations were performed laparoscopically. Bleeding occurred at the resection margin in five patients (three in group A and two in group B).

Postoperative Course

There was a significant difference in the antral resection margin and GERD symptoms at 6 and 12 months postoperatively ($P < 0.05$); however, the GERD symptoms were similar between the two groups at 24 months (Table 3).

Weight Loss

The mean %TWL at 6, 12, and 24 months postoperatively was 24.8 ± 2.3 %, 32.5 ± 2.4 %, and 36.2 ± 3.5 % in group A and 22.3 ± 2.4 %, 24.0 ± 2.1 %, and 32.2 ± 2.4 % in group B, respectively (Table 2). The patients in group A exhibited a significantly better %TWL and %EWL than those in group B without a significant increase in the complication rate.

Discussion

LSG is the most frequently performed operation for treatment of morbid obesity because of its low morbidity and rapid short-term return to work and social life. LSG is the first step in the

Table 4 Demographic, pre and perioperative datas in both the groups

	Group A (n = 84)	Group B (n = 68)	P
Age (years)	40.7 ± 12.4	43.1 ± 10.1	0.378
BMI (kg/m$^{2)}$	46.6 ± 5.4	47.1 ± 6.7	0.442
Gender (M/F)	26/58 (30.9/69.1)	22/46 (32.4/67.6)	0.592
ASA classification			0.381
I	20 (23.8)	17 (25)	
II	60 (71.4)	48 (70.5)	
III	4 (4.7)	3 (4.4)	
Duration of operation (min)	40.0 ± 6.7	37.4 ± 8.1	0.246
Length of stay in hospital (h)	74.0 ± 11.6	71.1 ± 13.6	0.154

Datas are expressed as mean ± SD, n, (%)

surgical treatment of obesity. However, LSG is not a fully integrated and standardized technique, and many surgical societies have outlined contradictions regarding the antrum resection border. The main finding in this study is that a shorter distance from the resection margin to the pylorus is associated with improved weight loss and fewer symptoms of GERD.

Different authors have applied various antrum resection techniques. Some have performed the resection close to the pylorus, nearly 2 cm; however, others have created a margin of nearly 6 cm. All authors reported that their method was the most effective according to their obtained outcomes. We separated our patients into two groups: those with a resection distance of 2 cm (group A) and 6 cm (group B) from the pylorus. Authors in favor of a shorter distance have stated that when they started 2 cm from the pylorus, the restriction size is the most decisive factor for weight loss, which is better than that achieved with a longer distance; additionally, the risk of short-term morbidities is lower. Abdallah et al. [17] found that an antral resection margin of 2 cm from the pylorus in LSG resulted in significantly better weight loss and earlier recovery from comorbidities than did a longer margin. Although some authors in favor of a longer resection margin have claimed that the restriction size plays an important role, the antrum has the capacity to expand with consumption of foods and liquids. ElGeidie et al. [18] reported that weight loss was better in patients with a 2-cm resection margin than that in patient with 6-cm resection margin at 6 months postoperatively; however, this difference disappeared at 12 months, and the authors associated this weight loss result with short-term vomiting episodes. Our results are similar to these authors' results in that the weight loss rate was higher in the first 12 months postoperatively; however, this rate equalized at 24 months [17, 18].

Three patients in group B regained weight postoperatively and required a second-step bariatric surgery (laparoscopic Roux-En-Y gastric bypass) after the study. According to these results, we believe that a 2-cm distance from the resection line to the pylorus is more effective than a 6-cm distance at 6 and 12 months, but not at 24 months. We considered that the patients who regained their lost weight or who had a lower %EWL and %TWL at the midterm were not compliant with our recommendations regarding food consumption (i.e., consume snacks instead of meals and multi-calorie liquid chocolate with short breaks). We also found slight pouch dilatation at gastroscopy in these patients, but we could not correlate their clinical outcomes to the dilatation.

We found similar results when we investigated the literature regarding complication rates. Complications in descending frequency were GERD, staple line bleeding, trocar site infection, hematoma formation, gastric leakage, pulmonary embolism, and deep vein thrombosis.

Diminishment of the stomach volume gave rise to some complications in the midterm period. One of these complications was GERD, which is the most frequent complication of LSG due to disruption of the angle of His. Although LSG can also reduce the incidence of GERD through the loss of total and excess weight, the stomach tube can worsen reflux if the fundal site is unsuccessfully removed. Gagner [19] found that LSG was not a contradiction in patients with GERD without Barrett's pathology. Additionally, Rebecchi et al. [20] found that LSG should be considered an effective option for the surgical treatment of morbid obesity in patients with GERD [19, 20] (Tables 3 and 5).

In this study, the percent time at a pH of <4, number of reflux episodes, DeMeester score, and RSI were significantly

Table 5 The comparison of health survey scoring demonstration and reflux symptom index questionnaire results

	Group A (n = 84)	Group B (n = 68)	P
Sf 36			
6 months	60.9 ± 3.9	53.6 ± 4.2	<0.05
12 months	71.6 ± 3.9	64.9 ± 4.7	<0.05
24 months	81.3 ± 4.1	74.0 ± 4.3	<0.05
RSI			
6 months	15.8 ± 2.7	11.8 ± 2.4	<0.05
12 months	21.9 ± 2.6	24.3 ± 2.7	<0.05
24 months	25.0 ± 2.2	26.4 ± 2.1	<0.05

different between the groups (group A < B) at 6 and 12 months. However, these differences were substantially equalized at 24 months. We considered that this may have been caused by gastric pouch dilatation in the midterm period (Tables 3 and 5).

Nian et al. [21] reported similar results with the exception of the RSI and acid reflux when they researched these parameters with respect to sex and patient position relative to gravity. We believe that the differences between our results and those of Nian et al. [21] resulted from lower BMIs and different eating habits. On the other hand, Farre et al. [22] found that weak acid reflux provoked dilation of the intercellular spaces, impairing the mucosal integrity. We identified a decrease in this type of damage from 12 to 24 months postoperatively by endoscopic examination [21, 22].

Group A had significantly less severe GERD than group B at 6 to 12 months postoperatively. However, the difference was not statistically significant, and the difference between the two groups diminished at 24 months. Cottam et al. [23] detected similar results at 12 months; however, Soricelli et al. [24] detected similar results at 24 months.

Conclusion

Although LSG has become a conventional surgical procedure in morbidly obese patients, GERD is a common and undesirable postoperative complication. Resection of the antrum could decrease the incidence of postoperative GERD. A smaller distance from the resection line to the pylorus provided better %TWL and %EWL and decreased the symptoms of GERD. Because there is no worldwide consensus regarding the resection line in LSG, more randomized prospective studies are needed on this topic.

Compliance with Ethical Standards

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study, formal consent was not required; this was a retrospective study.

Conflict of Interest The authors declare that they have no competing interests.

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