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ORIGINAL CONTRIBUTIONS

# The Magnitude of Antral Resection in Laparoscopic Sleeve Gastrectomy and its Relationship to Excess Weight Loss

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**Abstract**
*Background* The objective of this study was to evaluate the effect of antral resection on weight loss and complications after laparoscopic sleeve gastrectomy (LSG).
*Methods* This was a retrospective study of the prospectively collected data of patients who underwent LSG at Jordan University Hospital from February 2011 to February 2012. Patients were divided into two groups based on antral resection: group A underwent a 6-cm antral resection, and group B underwent a 2-cm antral resection. The percentage of excess weight loss (%EWL) was calculated at 3, 6, 12, and 24 months postoperatively.
*Results* One hundred and ten patients were included in the study, all of whom completed at least 24 months of follow-up (mean follow-up, 33 months). Their mean body mass index was 46.1±7.9 kg/m$^2$. In group A, the mean %EWL was 38.1±14.1, 54.9±19.9, 65.6±22.8, and 66.8±28.4 % at 3, 6, 12, and 24 months, respectively. However, in group B, the mean %EWL was 42.1±13.4, 63.8±19.8, 80.0±22.1, and 81.5±22.9 % at 3, 6, 12, and 24 months, respectively. Patients in group B experienced statistically significant greater weight loss than patients in group A. Statistically significant greater weight regain was seen in group A. Group A had a higher incidence of reflux symptoms (six patients; 11 %) than group B (four patients; 7.1 %).
*Conclusions* Radical antral resection in association with LSG safely potentiates the restrictive effect achieved and may result in greater and better maintained weight loss.

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## Introduction

Laparoscopic sleeve gastrectomy (LSG) was first described as the initial step of a two-staged bariatric procedure for high-risk patients [1, 2]. In subsequent years, LSG has been described as a stand-alone bariatric procedure, and it is currently one of the bariatric procedures most rapidly growing in popularity. This is because of promising results in terms of excess weight loss and the resolution of comorbidities [3, 4]. The procedure's low long-term risk profile and simplicity make it even more appealing. However, LSG is not as straightforward as one might think, and the technique has not yet been standardized. Reported variations include the size of the bougie used for calibration, the length of antrum left behind, involvement of the gastroesophageal junction (GEJ), and whether stapler line reinforcement is used [5, 6]. These matters are debated among the most experienced surgeons.

There is an overall tendency toward more restriction of the final sleeve by using a smaller bougie and leaving a shorter antrum [5]. The conclusions of the 2012 summit [7] on sleeve gastrectomy support more capacity restriction by using a smaller bougie, with 36 Fr being the most common size used, and by leaving a shorter segment of the pyloric antrum, with 59.5 % of surgeons leaving less than a 5-cm antral pouch. In this study, we aimed to reveal the effects of changing the extent of antral resection on weight loss, complications, and reflux symptoms at 1 and 2 years after LSG.

## Materials and Methods

This was a single-center, single-surgeon, retrospective study of the prospectively collected data of patients who underwent LSG at Jordan University Hospital from February 2011 to February 2012. Informed consent was obtained from all patients enrolled in the study. The study was approved by the local ethical committee.

### Patients

Patients included in the study were accepted for LSG according to the 1991 NIH consensus criteria for bariatric surgery [8]: all had a body mass index (BMI) of either >40 or 35–40 kg/m$^2$ with a major comorbidity.

During the first period of our study, we performed 6-cm antral resection (the length of the antral remnant measured from the pylorus); subsequently, we adopted 2-cm antral resection (second period of the study). This allowed us to compare the two sets of patients based on the length of the remaining antrum. Group A consisted of 54 patients who were left with a 6-cm antral pouch, and group B comprised 56 patients who were left with a 2-cm antral pouch.

### Surgical Technique

All operations were performed in the French position with the surgeon standing between the patient's legs. Four ports were used: a 10-mm trocar was placed in the midline above the umbilicus, a 15-mm trocar was placed in the right subcostal area, a 12-mm trocar was placed in the left subcostal area, and a 5-mm trocar was placed in the subxiphoid for the liver retractor. An additional 5-mm trocar was placed on the left side, lateral to the rectus sheath, to aid in retraction of the omentum when necessary.

The stomach was completely mobilized by dividing the greater omentum from the stomach using LigaSure™ (Covidien, USA), starting 1–2 cm from the pylorus and extending up to the angle of His. A 38-Fr calibration bougie was inserted by the anesthesiologist along the lesser curvature of the stomach. The length of the antral remnant was measured from the pylorus (6 cm for group A and 2 cm for group B). From this point, resection began with the use of a 4.8-mm green Endo GIA stapler (Covidien), followed by several firings of a 60-mm blue stapler proximal to the angle of His; an approximately 5–10-mm cuff of stomach was preserved at the level of the angle of His to avoid including the esophagus in the staple line. The staple line was reinforced using seromuscular invaginating V-Loc™ sutures (Covidien).

### Postoperative Management

All patients received perioperative prophylactic anticoagulation. Patients were routinely started on a fluid diet on the second postoperative day and were discharged on the third postoperative day. They were seen in the outpatient clinic 1 week after discharge and at 1, 3, 6, 12, and 24 months postoperatively. Patient who developed reflux symptoms were evaluated for evidence of esophagitis by upper endoscopy.

### Statistical Analysis

SPSS version 21.0 was used for the statistical analysis. The paired Student's $t$ test was used for normally distributed variables. A $p$ value of $<0.05$ was considered to be statistically significant. Results are shown as mean±standard deviation (range) unless otherwise stated.

### Calculations

The percentage of excess weight loss (%EWL) was calculated as follows: %EWL=100 %×(weight lost)÷(preoperative weight−ideal body weight (IBW)). The IBW was calculated as that equivalent to a BMI of 25 kg/m$^2$. Weight regain was defined as an increase in body weight of more than 10 kg from the nadir.

## Results

One hundred and twenty-five consecutive patients underwent the LSG procedure in the period between February 2011 and February 2012; 15 patients were lost to follow-up and were excluded from the study. One hundred and ten patients were included in the study; all completed at least 24 months of follow-up, with a mean follow-up period of 33 months.

There were 27 male and 83 female patients aged 33.8±10.8 (16–58) years. The mean preoperative weight was 125.5±29.1 kg, and the mean preoperative BMI was 46.1±7.9 kg/m$^2$. The mean postoperative hospital stay was 3.1±2.2 days. The mean operative time was 83.2±34.6 min. The two groups were comparable in terms of preoperative weight, BMI, sex, and age. The mean operative time was shorter in group A, but the difference was not statistically significant (Table 1).

Overall, the %EWL was 39.9±13.9 % at 3 months, 58.8±20.2 % at 6 months, 72.9±23.5 % at 12 months, and 73.2±27.3 % at 24 months. In group A, the mean %EWL was 38.1±14.1, 54.9±19.9, 65.6±22.8, and 66.8±28.4 % at 3, 6, 12, and 24 months, respectively. In group B, the mean %EWL was 42.1±13.4, 63.8±19.8, 80.0±22.1, and 81.5±22.9 % at 3, 6, 12, and 24 months, respectively. Patients in group B had statistically significant greater weight loss than patients in group

**Table 1** Patient demographics and perioperative data in the two groups

| | Total ($n$=110) | Group A ($n$=54) | Group B ($n$=56) | $p$ value |
|---|---|---|---|---|
| Weight | 125.5±29.1 kg | 125.6±4.0 kg | 125.3±3.8 kg | 0.95 |
| BMI | 46.1±7.9 kg/m2 | 46.3±8.1 kg/m$^2$ | 45.8±7.9 kg/m$^2$ | 0.76 |
| Age | 33.8±10.8 years | 34.7±11.3 years | 32.8±10.3 years | 0.37 |
| Gender (female) | 75.5 % | 75.9 % | 75.0 % | 0.91 |
| Hospital stay | 3.1±2.2 days | 3.3±2.8 days | 2.9±1.2 days | 0.33 |
| Operative time | 83.2±34.6 min | 79.9±24.4 min | 86.4±42.1 min | 0.31 |

A (Table 2, Fig. 1). Statistically significant greater weight regain was seen in group A compared with group B.

One leak occurred, which was in group B. However, the difference in the leakage rate was not statistically significant. There were three cases of postoperative bleeding, which were all managed laparoscopically; one occurred in group A and two occurred in group B. There was no significant difference in the rate of postoperative bleeding between the two groups.

Overall, ten patients (9.1 %) developed reflux symptoms that were documented by upper endoscopy performed at the 1-year follow-up. These were divided between the two groups, with six patients (11.1 %) in group A and four patients (7.1 %) in group B being affected. Group A had a significantly higher incidence of reflux symptoms than group B.

## Discussion

The mechanisms of weight loss after LSG are multifactorial; a combination of gastric restriction, hormonal factors, and changes in gastric emptying and eating habits are involved. However, the degree of restriction performed plays the most important role [9].

Sleeve gastrectomy is primarily considered a restrictive type of bariatric surgery, where surgical technique plays a major role in the resulting and maintained weight loss. The ideal restriction creates a narrow gastric tube without a large antral pouch, leaving a gastric capacity of no more than 80 ml [10]. Multiple technical factors play a role in the restrictive effect of sleeve gastrectomy. The size of the bougie used for calibration varies among authors, and there is controversy surrounding proximal gastric resection and the use of reinforcement materials.

The degree of antral resection is another controversial issue in LSG. Some authors support antral preservation and start their resections 6 cm or more from the pylorus. They believe that doing so preserves contractile function, promoting gastric emptying and thus reducing intraluminal pressure and potentially decreasing leakage [5, 11, 12].

In contrast, Mognol et al. [13] and Baltasar et al. [3] began the division approximately 2 cm from the pylorus; they argue that since LSG is a purely restrictive procedure, the restriction should be more aggressive than when it is a part of another procedure such as a duodenal switch.

The most frequent argument against radical pyloric antrum resection is that it may predispose patients to developing a gastric evacuation disorder [5]. LSG is anticipated to have an impact on gastric motility patterns because it affects both the proximal and distal stomach in a significant way [14]. Theoretically, LSG may affect emptying via several mechanisms: removal of the fundus with its receptive and propulsive abilities, altered compliance and contractility of the resulting narrow and non-distensible sleeve, and removal of the gastric pacemaker area in the body of the stomach [15]. However, studies that have addressed the topic of gastric emptying following LSG have yielded conflicting results [5, 15–18]. Our

**Table 2** Surgical outcomes and %EWL among the two groups

| | Total ($n$=110) | Group A ($n$=54) | Group B ($n$=56) | $p$ value |
|---|---|---|---|---|
| Perioperative bleeding | 3 (2.7 %) | 1.9 % | 3.6 % | 0.32 |
| Leak | 1 (0.9 %) | 0 % | 1.9 % | 0.16 |
| GERD | 9.1 % | 11.1 % | 7.1 % | 0.04 |
| %EWL at 3 months | 39.9±13.9 | 38.1±14.1 | 42.1±13.4 | 0.17 |
| %EWL at 6 months | 58.8±20.2 | 54.9±19.9 | 63.8±19.8 | 0.05 |
| %EWL at 12 months | 72.9±23.5 | 65.6±22.8 | 80.0±22.1 | 0.001 |
| %EWL at 24 months | 73.2±27.3 | 66.8±28.4 | 81.5±22.9 | 0.03 |
| Weight regain | 14 (12.7 %) | 12 (22 %) | 2 (4 %) | 0.003 |

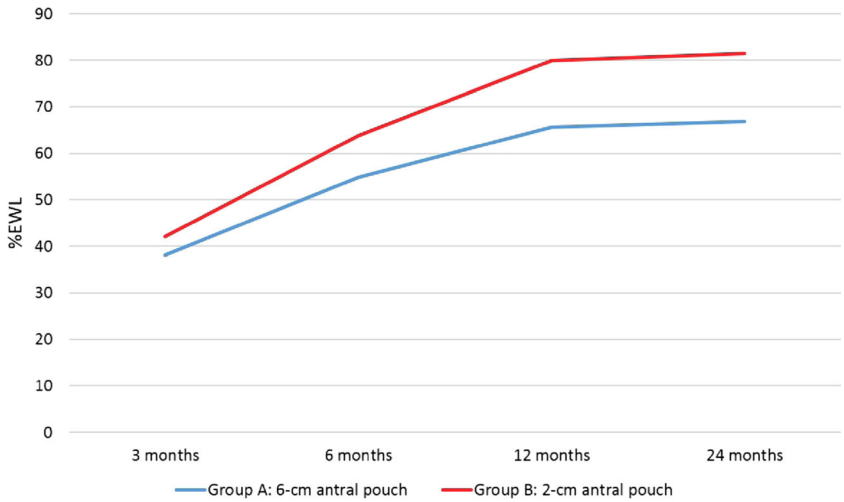


**Fig. 1** Comparison of %EWL between the two groups

study did not address the impact of antral resection on gastric motility, which is one of its limitations.

Studies that have looked at the effect of pyloric antral resection on weight loss have shown conflicting results. Jacobs et al. showed no statistically significant difference in the %EWL following creation of a 4- versus 7-cm antral pouch [19]. In contrast, analysis of data from the Spanish national registry revealed that resection closer to the pylorus resulted in better weight loss during the first and second postoperative years [20]. Our study showed that a more radical antral resection resulted in significantly better weight loss in the first two postoperative years.

The other concern regarding radical antral resection is its effect on reflux symptoms. LSG's effect on gastroesophageal reflux (GERD) is controversial. LSG may lessen reflux by reducing intra-abdominal pressure (by way of decreasing intra-abdominal fat) and reducing acid production by decreasing gastric tissue [21, 22]. Postoperative reflux may be attributed to technical issues; for example, partial resection of the sling fibers of the LES, which can produce a hypotensive LES, has been suggested to result in GERD [21]. A lack of gastric compliance, severely restricted gastric capacity with an intact pylorus, and impaired gastric emptying have also been suggested to predispose patients to reflux during the first postoperative period [23–25]. Whether antral resection is associated with the development of GERD is still controversial. Nocca et al. [26] performed resection at 10 cm from the pylorus and suggested that preservation of the antrum reduces the symptoms of reflux. However, Daes et al. [27] reported a very low incidence of postoperative GERD despite 3-cm antral resection. Our study showed a significantly lower incidence of GERD symptoms in the 2-cm antral pouch group. This can be explained by the faster emptying mechanism previously suggested by some authors. However, further studies comparing gastric emptying are needed.

The success of LSG when performed as a sole bariatric procedure may be limited by weight regain or insufficient weight loss, which occurs in 1.3–15 % of cases [28]. Failure is usually multifactorial, involving poor adherence to prescribed lifestyle modifications, procedural failure, and operator error [29, 30]. Potential explanations for LSG failure include eventual dilation of the gastric tube with consequent increases in gastric capacity, incomplete removal of the gastric fundus, and creation of a large gastric tube calibrated over a large bougie [31]. The hypothesis that the gastric tube may undergo dilation over time has been a constant source of debate [31, 32]. Bragetto [33] found that gastric volume increased over a 2-year period, but he did not report any weight regain. Whether the creation of a narrower tube with a higher pressure and less distensibility may prevent gastric dilatation and weight regain requires further study.

## Conclusion

LSG is a safe and effective bariatric procedure. The performance of radical antral resection safely potentiates the restrictive effect achieved by LSG and may result in greater and better maintained weight loss without increasing the complication rate.

**Conflict of Interest** Firas Obeidat, Hiba Shanti, Ayman Mismar, Nader Albsoul, and Mohammad Al-Qudah declare that they have no conflicts of interest.

**Statement of Human and Animal Rights** 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.

**Statement of Informed Consent** Informed consent was obtained from all individual participants included in the study.

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