Association of Radiographic Morphology with Early Gastroesophageal Reflux Disease and Satiety Control after Sleeve Gastrectomy

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BACKGROUND: Variable gastric morphology has been identified on routine upper gastrointestinal series after laparoscopic sleeve gastrectomy. This test might give us useful information beyond the presence of leak and obstruction. The aim of this study is to standardize a morphologic classification of gastric sleeve based on water-soluble contrast upper gastrointestinal series, and to determine possible clinical implications.

STUDY DESIGN: One hundred morbidly obese patients underwent laparoscopic sleeve gastrectomy and had routine upper gastrointestinal on postoperative day 1 or 2. Images were reviewed by 4 radiologists who were blinded to outcomes, and sleeve shape was classified as upper pouch, lower pouch, tubular, or dumbbell. Inter-observer agreement was calculated. Clinical outcomes including weight loss, satiety control, and reflux symptoms were recorded. Comparisons were determined by 1-way ANOVA and t-test.

RESULTS: Mean age was 46 ± 12 years and mean BMI was 45.1 ± 6 kg/m². Overall inter-observer agreement level for the sleeve shape classification was 76.3%. Sleeve shapes were tubular in 37%, dumbbell in 32%, lower pouch in 22%, and upper pouch in 8%. Mean excess body weight loss at 1, 3, and 6 months was 16.8%, 29.9%, and 39.1%, respectively. Excess body weight loss was not associated with sleeve shape. Mean hunger score was 213 ± 97, and patients with dumbbell shape had higher hunger scores (p = 0.003). Mean reflux score was 5.7 ± 8. Upper pouch shape was associated with greater severity of reflux symptoms (p = 0.02).

CONCLUSIONS: This study suggests a standardized radiographic classification of gastric sleeve morphology. Although sleeve shape is not correlated with weight loss, gastric sleeves with retained fundus result in lower satiety control and higher severity of reflux symptoms. An adequate resection of the gastric fundus might avoid this potential complication. (J Am Coll Surg 2014;■:1−9. © 2014 by the American College of Surgeons)

Obesity has become an extremely common disease, with recent studies showing an overall prevalence of 35.7% in the United States.[1] In addition, obesity is associated with comorbidities including hypertension, diabetes, dyslipidemia, and sleep apnea, leading to decreased life expectancy.[2] Bariatric surgery is currently the most effective method to achieve sustainable weight loss and resolution of comorbidities.[3]

Diverse surgical procedures have been developed through the history of bariatric surgery and these have gained more popularity in the last 2 decades due to the availability of laparoscopic techniques. Currently, the most commonly performed procedures are Roux-en-Y gastric bypass, laparoscopic adjustable gastric band, laparoscopic sleeve gastrectomy (LSG), and biliopancreatic diversion with or without duodenal switch.[4] However, LSG is one of the more attractive options in the bariatric armamentarium because of the absence of anastomosis, the avoidance of foreign body use, and minimal

Abbreviations and Acronyms

EBWL = excess body weight loss
HRQL = Health-Related Quality of Life
LSG   = laparoscopic sleeve gastrectomy
POD   = postoperative day
UGI   = upper gastrointestinal series

morbidity and mortality. Although previously considered the first step of biliopancreatic diversion with or without duodenal switch, LSG has shown rapid growth as a primary procedure, with reported mean excess body weight loss (EBWL) of around 60%, and improvement rates of >90% for diabetes and sleep apnea and >70% for hypertension and dyslipidemia.[5]

As LSG is being increasingly performed, it is imperative that surgeons and radiologists understand the surgical technique, the normal postoperative anatomy, and the imaging findings of potential complications.[6,7] The rationale of the operation is to perform a vertical gastrectomy resulting in a narrow and tubular stomach. This is usually performed laparoscopically through 4 to 5 trocars in the upper part of the abdomen. The resulting effect is primarily restriction of oral intake, although some metabolic and hormonal effects have been described, such as ghrelin-level reduction due primarily to resection of the gastric fundus, where the majority of the ghrelin-producing cells are located.[8] Although it is a low morbidity procedure, potentially disastrous complications, such as leaks, can occur.

In many centers, a water-soluble contrast upper gastrointestinal series (UGI) is usually performed in the first 24 to 48 hours after the procedure. For some bariatric surgeons, this is a routine test included in the perioperative management protocol before restarting oral intake; others use it only in selected cases when there is clinical suspicion of leak or obstruction.[9,10] As the frequency of these complications is low, and most leaks occur after postoperative day 5, many surgeons have stopped performing UGI studies routinely on these patients.[11] Unnecessary radiation exposure and increased cost are 2 additional disadvantages. However, some reports highlight the potential advantages of performing this test, such as the assessment of contrast flow that can indicate the oral fluid tolerance[12] and the documentation of normal postoperative anatomy, which is especially important for the performance evaluation of surgeons in training.[11]

Although routine UGI to evaluate for leak might not be justified, it might be that the routine UGI series could provide useful information about sleeve shape. In fact, previous reports have identified different gastric sleeve shapes on UGI series[13] and have tried to determine the correlation between these shapes and the

clinical outcomes of the procedure.[14] The aims of this study were to standardize a morphologic classification of gastric sleeve based on UGI series and determine the possible implications of the radiographic sleeve shape in terms of weight loss, satiety control, and GERD symptoms.

METHODS

Patient population

We included 100 consecutive morbidly obese patients who underwent LSG between December 2011 and October 2013 in our group. Most (83%) of the patients were female and 17% were male. Mean age, preoperative weight, and preoperative BMI were 46 ± 12 years (range 20 to 71 years), 124 ± 23 kg (range 85 to 188 kg), and 45.1 ± 6 kg/m^2 (range 33.6 to 67.8 kg/m^2), respectively. All but 1 patient had at least 1 comorbidity. The main comorbidities, in decreasing order, were hypertension (75%), GERD (49%), joint disease (43%), diabetes (37%), obstructive sleep apnea (36%), hyperlipidemia (19%), psychiatric disorders (19%), and hypothyroidism (17%). Other perioperative clinical variables were collected from the electronic medical records. This study was approved by the Institutional Review Board of Emory University (IRB No. 45910).

Surgical technique

The same surgical technique and instruments were used in all patients. All cases were either laparoscopic or robot-assisted procedures and performed by 2 surgeons. We used a 4-trocar approach (two 12-mm and two 5-mm) and an epigastric 5-mm incision for the liver retractor. After trocar placement, the dissection begins 4 cm proximal to the pylorus toward the gastroesophageal junction, detaching the major omentum from the greater gastric curve. Special attention is paid to coagulate and divide the short gastric vessels when the fundus is fully mobilized. All the attachments between the gastric fundus and the left crus are released and the gastroesophageal junction is identified.

Next, a diagnostic gastroscope (approximately 32F in diameter) is passed through the stomach into the first portion of duodenum and is used as a calibration bougie. The first stapler firing is performed at the antrum, ensuring not to place the stapler too close to the incisura angularis to avoid any narrowing. Subsequent stapler firings are carried out proximally for the rest of the stomach. All staple loads are reinforced with bioabsorbable buttress material. The last firing is performed 1 cm lateral to the gastroesophageal junction to avoid any accidental stapling of the distal esophagus and potential leaks.

The staple line is then closely examined. We performed an intraoperative endoscopy for checking hemostasis and ruling out leaks. Next, a round Blake drain is placed
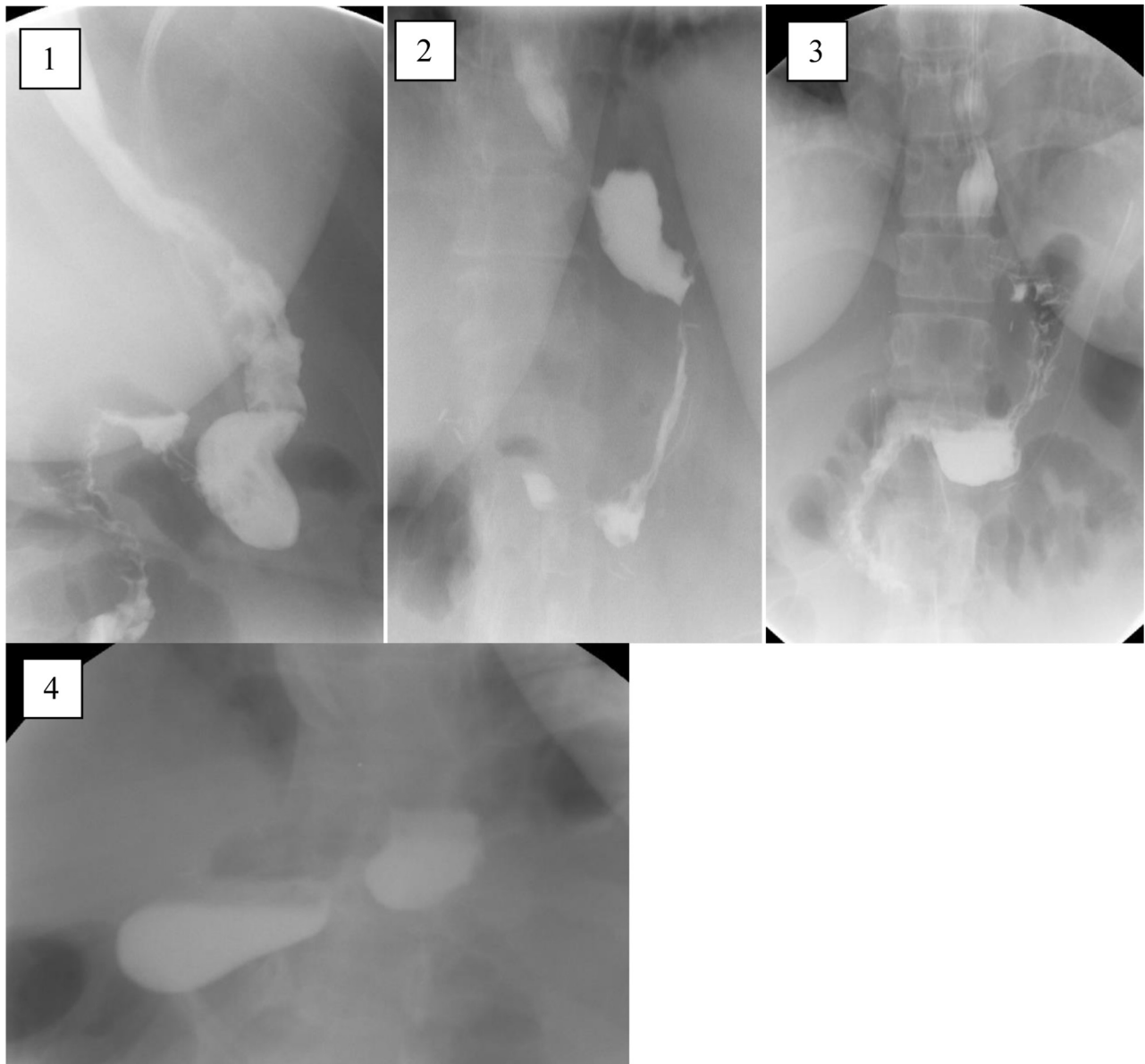
Figure 1. Radiographic sleeve morphology. Examples of the identified sleeve shapes. (1) Tubular, with near-uniform diameter on contrast distention. (2) Upper pouch, with a dilated proximal stomach, a narrowed distal gastric tube. (3) Lower pouch, with contrast pooling predominantly in the antrum, without uniform filling of the proximal aspects of the gastric tube. (4) Dumbbell shape, where contrast fills the upper and lower stomach, with a reproducible narrowing in the middle.

along the staple line according to surgeon preference and an omental patch is fashioned over the gastric sleeve with clips. The resected stomach is retrieved in a specimen bag. Finally, a standard fascia and skin closure is performed.

Upper gastrointestinal series

A water-soluble contrast (diatrizoate meglumine and diatrizoate sodium solution; Gastrografin) study was performed routinely in all patients on postoperative (POD)

day 1 or 2. All fluoroscopic studies were performed to evaluate for a postoperative leak. Patients ingested water-soluble contrast material. Fluoroscopic images were obtained in frontal and oblique projections with the patient in both semi-flat and upright positions. After confirming the study was negative for leaks or obstruction, the patients were started on clear oral fluids. Spot fluoroscopic images were saved and retrospectively reviewed.

Hunger Questionnaire

1. How hungry are you right now?

   0 10 20 30 40 50 60 70 80 90 100

2. How strong is your desire to eat right now?

   0 10 20 30 40 50 60 70 80 90 100

3. How much could you eat right now?

   0 10 20 30 40 50 60 70 80 90 100

4. How full are you right now?

   0 10 20 30 40 50 60 70 80 90 100

5. How strong is your desire to eat something savory right now?

   0 10 20 30 40 50 60 70 80 90 100

6. How strong is your desire to consume something sweet right now?

   0 10 20 30 40 50 60 70 80 90 100

7. How thirsty are you right now?
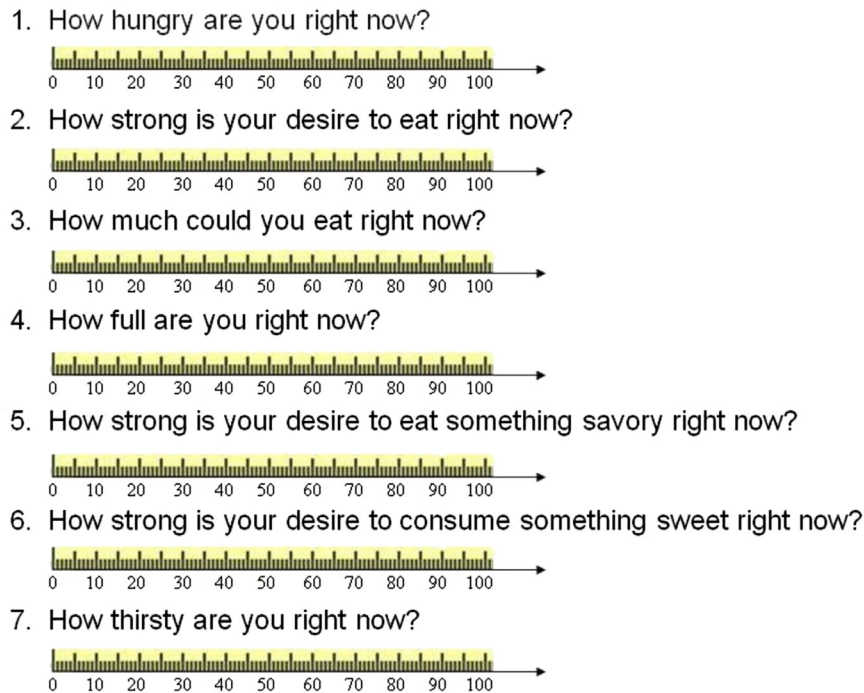
   0 10 20 30 40 50 60 70 80 90 100

Figure 2. Hunger score scale. Modified visual analog scale we used for satiety evaluation. 0 is the minimum score indicating complete satiety and 700 is the maximum indicating an extreme feeling of hunger.

Sleeve shape definition and method of standardization

Based on previous publications,[13,14] we identified the 4 most common sleeve shape subtypes: tubular, upper pouch, lower pouch, and dumbbell (a combination of upper pouch and lower pouch shapes). For this investigation, an upper pouch was defined as an area proximal to the tubular portion of the stomach, with a maximal luminal diameter of more than twice that of the tubular portion of the stomach. Lower pouch was defined as an area distal to the tubular portion of the stomach with a maximal luminal diameter of more than twice that of the tubular portion of the stomach. Dumbbell was defined as the presence of both upper and lower pouches. If neither an upper nor lower pouch was present, the shape was defined as tubular (Fig. 1).

The 100 postoperative UGI studies were reviewed independently by 4 board-certified radiologists with fellowship training in abdominal imaging (CM, WS, PM, AS). Radiologists recorded the presence or absence of an upper pouch and lower pouch for each study. Radiologists were blinded to clinical outcomes. We computed inter-observer variability, as detailed here. For those studies where agreement was not initially achieved, a second film review was performed and the images were placed into 1 of the 4 shape categories for the clinical variable analysis.

Clinical outcomes evaluation

Postoperative weight loss data were collected at 1, 3, 6, and 12 months and expressed as %EBWL, which is a universally understood metric for weight loss. These data were collected during the surgical and medical bariatric follow-up visits at the same time points. For satiety control, all patients were asked to complete the modified hunger score scale. This is a reliable and validated questionnaire for satiety evaluation in obese and lean individuals.[15] The scale contains 7 questions to assess the overall feeling of hunger or satiety for different kinds of foods. Each question has a scale from 0 to 100. According to the ratings, 0 is the minimum score, indicating complete satiety, and 700 is the maximum score, indicating an extreme feeling of hunger (Fig. 2). Patients were also asked to complete the GERD Health-Related Quality of Life scale, a well-known and validated instrument to measure the severity of GERD symptoms.

Statistical analysis

Results are reported as mean or median ± SD for continuous variables. For the inter-observer variability calculation, we used descriptive statistics (frequencies), and we also obtained a "light" κ coefficient (mean of agreement among 4 radiologists). A κ coefficient ≥0.6 was considered an ideal agreement level. Clinical differences among sleeve shape groups were determined by 1-way ANOVA and t-test. The comparisons of clinical scores are reported with 1-tailed p value. A p value <0.05 was considered significant. All statistical calculations were generated using Microsoft Excel 2007 (Microsoft) and SPSS software (version 20, IBM Corporation).

RESULTS

Perioperative results

All cases were completed either laparoscopically or robot-assisted without intraoperative complications or conversions to open technique. Mean operative time and estimated blood loss were 97 ± 34 minutes (range 49 to 247 minutes) and 40 ± 35 mL (range 5 to 200 mL), respectively. Patients had a mean length of stay of 2.3 ± 0.8 days (range 2 to 7 days). Only 1 patient was admitted to the ICU for 4 days due to a severe community-acquired pneumonia. Readmission rate in the first 30 days after the procedure was 8%.

We had 2 leaks in our series (2%) and both were classified as early leaks (POD 11 and POD 30). These 2 patients were successfully treated with nonoperative management. Both required antibiotics and CT-guided percutaneous drainage of the perigastric abscesses, and 1 of them required an endoscopic stent placement. The routine POD 1 UGI series for both patients were negative. One of these patients had a large paraesophageal hernia repair along with LSG, and presented with an esophageal leak and empyema in the right chest. This complication was treated with video-assisted thoracoscopic surgery and endoscopic esophageal stent placement. The leak was related to the paraesophageal hernia repair and not associated with the gastric staple line. The second leak was small and proximal, which resolved with CT-guided drainage and an internal stent placement for 2 weeks.

One patient (1%) presented with a mid-sleeve stricture on POD 16. Again, the previous POD 1 UGI study was normal, but the study was repeated, which subsequently confirmed the diagnosis. The patient was managed successfully with endoscopic dilations. One patient was found to have a grossly cirrhotic liver intraoperatively, but because the liver function tests were normal, the procedure proceeded. Acute anemia developed in this patient

Table 1. Laparoscopic Sleeve Gastrectomy Perioperative Outcomes (n = 100)

Outcomes	
Operative time, min	
Mean ± SD	97 ± 34
Range	49−247
Blood loss, mL	
Mean ± SD	40 ± 35
Range	5−200
Transfusion rate, %	1
Length of stay, d	
Mean ± SD	2.3 ± 0.8
Range	2−7
ICU admission rate, %	1
Major complications, %	5
Leaks	2
Strictures	1
Bleeding	1
Pneumonia	1
Minor complications, %	6
Dehydration	3
Persistent nausea	3
30-day readmission rate	8
Follow-up, mo	
Median	6
Range	1−15
Mortality	0

during the hospital course and required transfusion of 2 U RBC. Operative treatment was not required in this case. Other complications were minor. Ninety-six patients completed the follow-up. Median follow-up length was 6 months (range 1 to 15 months). There was no mortality in this series (Table 1).

Upper gastrointestinal series and inter-observer variability

Overall agreement level for sleeve shape determination was 76.3%. The calculated light κ coefficient was 0.5 (p < 0.001). On initial review, 72 patients were assigned a sleeve shape category based on agreement of at least 3 of 4 radiologists. The remaining 28 cases required a second film review and were subsequently placed into a shape category.

Sleeve shape classification

The main 4 categories identified previously were tubular, upper pouch, lower pouch, and dumbbell shapes. The tubular shape was the most common subtype and the upper pouch shape was the least common (Fig. 3). There
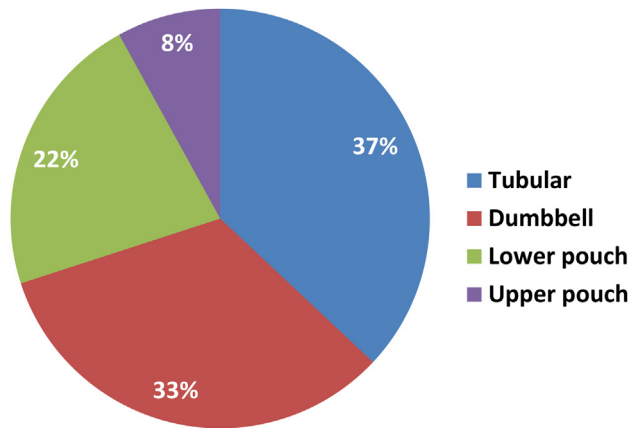
Figure 3. Sleeve shape distribution. Pie chart showing the different sleeve shape categories with their respective percentage.

were no significant differences in demographics, preoperative weight, and preoperative BMI among the groups (Table 2). Patients in the upper pouch group had higher preoperative weight and BMI, but this finding was not statistically significant.

Sleeve shape vs weight loss

The mean %EBWL at 1, 3, and 6 months for the whole group was 16.8%, 29.9%, and 39.1%, respectively. We found no statistically significant differences in weight loss among the 4 groups (Table 3). On subgroup analysis, tubular shape compared with nontubular shape (ie, upper pouch, lower pouch, and dumbbell) showed a trend of higher 3-month %EBWL (33% vs 28.8%; p = 0.08). However, weight loss was equivalent at 6 months for these groups (40.3% vs 38.6%; p = 0.69). Only a few patients reached the 12-month follow-up at the time we performed this analysis, therefore, this result was not compared.

Sleeve shape vs satiety control

Eighty-one percent of the patients completed the hunger score. Mean score was 213 ± 97 (range 30 to 560). Comparison among groups found no significant differences (Table 3). However, a comparison of the no retained

fundus group (ie, tubular and lower pouch) vs the retained fundus group (ie, upper pouch and dumbbell) demonstrated better satiety control in the first group, with a significantly lower hunger score (191 vs 240; p = 0.01) (Fig. 4). Dumbbell shape was associated with the highest hunger score when compared with other groups (252 vs 191; p = 0.003). Patients in the lower pouch group had the lowest mean score, although this finding did not reach statistical significance (p = 0.05).

Sleeve shape vs reflux symptoms

Seventy-six percent of the patients completed the GERD-HRQL score. The incidence of reflux symptoms in this series was relatively low. Forty-five patients (59.2%) reported any reflux symptoms, but only 6 (7.8%) had moderate to severe reflux symptoms with GERD-HRQL scores >20. Mean score was 5.7 ± 8 (range 0 to 35). The comparison of the 4 groups showed no significant differences (Table 3). Analysis between upper pouch shape vs the other groups revealed that upper pouch shape had the higher severity of reflux symptoms, and this finding was significant (12 vs 5; p = 0.02) (Fig. 5). Lower pouch shape was the subtype with least reflux symptoms and this finding also reached statistical significance (2.6 vs 6.5; p = 0.005).

DISCUSSION

Laparoscopic sleeve gastrectomy is now an accepted primary procedure for morbid obesity treatment. It has proven to be effective and safe for achieving remarkable weight loss and resolution of obesity-related comorbidities. Our study identified 4 sleeve shapes on the UGI (tubular 37%, dumbbell 33%, lower pouch 22%, and upper pouch 8%) and highlighted very interesting clinical implications. We found that the early EBWL at 1, 3, and 6 months was not related to sleeve shape. However, the satiety control measured by the hunger score was significantly better in the no retained fundus group (tubular and lower pouch) compared with the retained fundus group (upper pouch and dumbbell) (p = 0.01). In addition, the dumbbell shape was associated with highest hunger score (p = 0.003), possibly because it is the shape with

Table 2. Preoperative Characteristics of Shape Categories

Variable	Tubular	Dumbbell	Lower pouch	Upper pouch	p Value*
Patients, n	37	33	22	8	NA
Sex, female/male, n	31/6	27/6	18/4	7/1	NA
Age, y, mean ± SD	45 ± 12	44 ± 13	50 ± 10	45 ± 13	0.40
Weight, kg, mean ± SD	120 ± 22	125 ± 22	126 ± 23	135 ± 27	0.36
BMI, kg/m^2, mean ± SD	44.2 ± 6.8	45.1 ± 5.8	45.4 ± 6.8	48.1 ± 9.9	0.52

*p values indicate no significant differences among groups (1-way ANOVA).
NA, not applicable.

Table 3. Comparison of Clinical Outcomes among Groups

Outcomes	Tubular	Dumbbell	Lower pouch	Upper pouch	p Value*
%EBWL					
1 month	17.6 ± 6.6	16 ± 4.4	15.7 ± 3.9	18.8 ± 4.1	0.47
3 month	33 ± 9.1	28.9 ± 6.2	29.1 ± 7.8	27.1 ± 3.7	0.39
6 month	40.3 ± 9.7	37.9 ± 11.7	37.7 ± 13	42.2 ± 13	0.85
Hunger score	194 ± 92	252 ± 105	188 ± 60	190 ± 122	0.06
GERD-HRQL score	6.3 ± 9.4	5.4 ± 7	2.6 ± 3.5	12 ± 14	0.13

Results reported as mean ± SD.
*p Value indicates no significant differences among groups (1-way ANOVA).
EBWL, excess body weight loss; HRQL, Health-Related Quality of Life.

the largest gastric sleeve volume. We believe these findings could be explained by the fact that a gastric sleeve with a retained fundus has greater gastric capacity, which translates into an incomplete sensation of fullness and the need for larger meals to achieve gastric satiety.

In a similar study performed by Lazoura and colleagues,[14] the authors identified 3 different patterns of the gastric sleeve at UGI: tubular pattern in 65.9%,

Figure 4. Satiety evaluation. (A) Comparison of hunger scores among groups. The p value indicates a significant difference between dumbbell (DB) shape and other shapes (t-test). (B) Comparison of no retained fundus (tubular [T] and lower pouch [LP]) and retained fundus (upper pouch [UP] and DB) Hunger scores. The p value indicates a significant difference between groups (t-test).

superior pouch in 25.9%, and inferior pouch in 8.2%. They found that vomiting and regurgitation were greater in the tubular pattern group. The authors hypothesized that it could be due to a higher increase in intragastric pressure and impaired gastric relaxation mechanism in this group. These findings did not agree with the results of previous reports in which a proximal pouch sleeve shape was associated with a higher incidence of reflux.[16] Besides the shape, other factors have been implicated in the pathophysiology of GERD after LSG, such as alteration of the angle of His anatomy, partial resection of sling fibers at the lower esophageal sphincter, reduced gastric capacity with an intact pylorus, and impaired gastric emptying.[16-18] Fortunately, long-term follow-up LSG series demonstrate that reflux symptoms are usually temporary and improve after 1 year.[17] Our series showed an overall low incidence of reflux symptoms after the procedure. However, even though the upper pouch group consisted of only 8% of the cohort, the significantly higher GERD score compared with the others was an important finding (p = 0.02), which might help surgeons understand a possible cause when patients report such symptoms. Interestingly, we found the lower pouch shape to be significantly associated with fewer reflux symptoms (p = 0.005), which suggests that total or near-total antrum preservation might result in normal gastric emptying, eliminating the surgically induced antral pump dysfunction as a potential cause of reflux.

We also agree with previous publications suggesting that the various gastric sleeve shapes might reflect variations or limitations of the surgical technique.[13] We attempt to achieve a tubular shape every time and all procedures followed identical surgical principles, despite that, sleeve shapes can still be different. Several intraoperative factors, such as adhesions on the posterior gastric fundus, high intra-abdominal fat content complicating gastric mobilization, or surgeon decisions, might be responsible for the variability of sleeve shape. In fact, in this series, the upper pouch shape had the higher preoperative BMI (although not statistically significant), which might
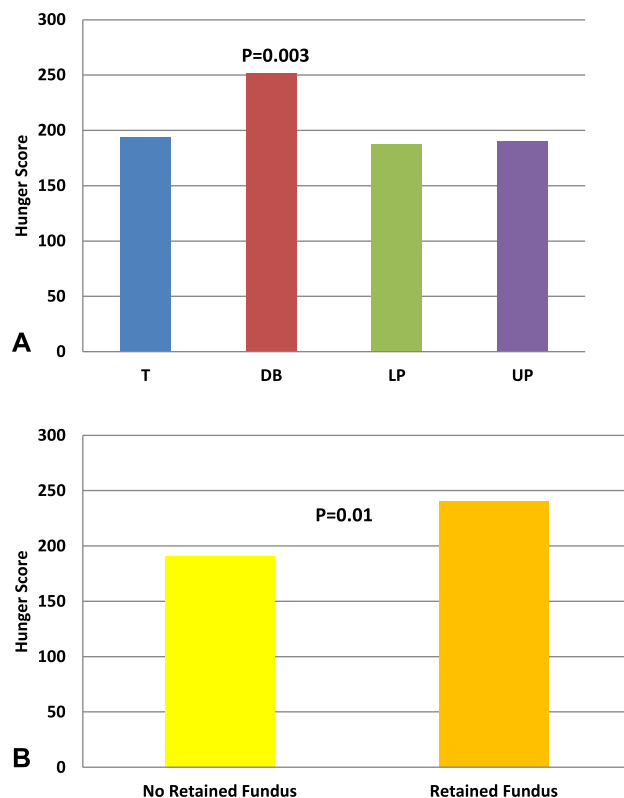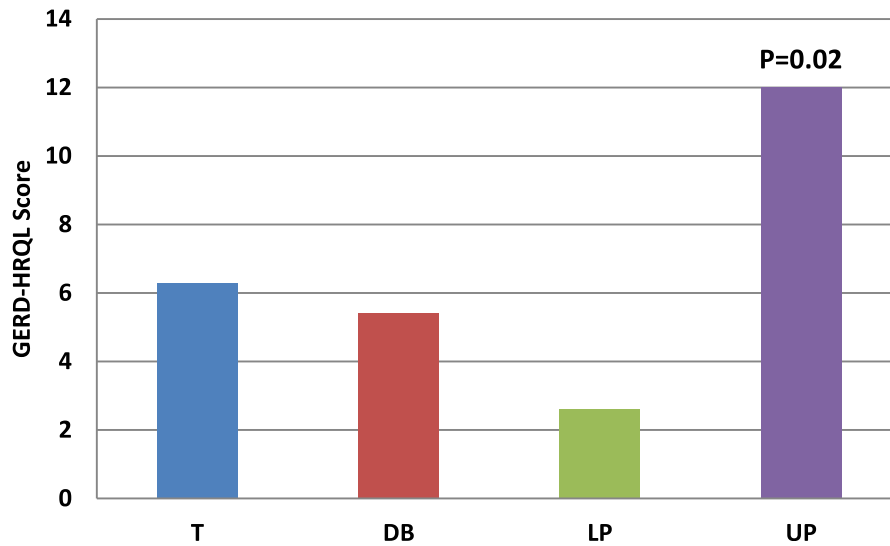
Figure 5. Reflux symptoms evaluation. Comparison of GERD scores among groups. A *t*-test was performed and the p value indicates a significant difference between upper pouch (UP) shape and other shapes. DB, dumbbell; LP, lower pouch; T, tubular; UP, upper pouch.

have contributed to the technical difficulty for complete fundus resection. As do many other bariatric surgeons, we assume that the straight tube morphology is the desired gastric shape and, for this reason, the surgeon's role is to perform a proper dissection and resection of the gastric fundus; it might avoid the potential complications of postoperative reflux symptoms and poor satiety control. However, sometimes even a perfectly fashioned tubular sleeve can result in the most unpredictable radiographic morphology. The surgeons in this study had performed >50 sleeve gastrectomies, and there were no differences in outcomes by surgeon or surgical approach (ie, laparoscopic or robotic). We tested the notion that a completely tubular stomach was more beneficial for weight loss than a nontubular stomach, but found no differences in weight loss at 6 months between the aesthetically pleasing tubular shape and the others.

Another potential indication of UGI series during the follow-up is to look for gastric sleeve dilation. This is not routinely performed but could be especially important in the setting of weight regain. Several authors have shown that even after creating a narrow gastric tube, the gastric capacity increases over time and considerable dilation is not an uncommon finding.[19,20] Braghetto and colleagues,[19] in an interesting study, followed 15 patients who underwent LSG and performed a UGI and a CT scan with volumetric assessment of the remaining sleeve within the first 3 days and then 2 to 3 years after the operation. They found sleeve dilation in all patients, however, the BMI remained stable and no weight regain was documented. In a certain way, these findings

coincide with ours in which the patients with greater sleeve volume (upper pouch, dumbbell) did not show any difference in weight loss, at least in the short term. In a similar study, 27 patients underwent 3-dimensional multislice CT scan with gastric volume evaluation after LSG. The authors found that sleeve dilation increased with time after surgery (longer follow-ups found greater dilation), but this finding was not related to weight regain.[20] Interestingly, they identified 10 patients with partial intrathoracic migration of the gastric staple line and, in this subgroup, persistent regurgitation developed in 40% of patients.

The current study has some limitations. We know the evaluation of gastric morphology with radiographs is somewhat subjective. We tried to overcome this potential problem by standardizing the reading criteria among the participating radiologists, and we were able to achieve an acceptable inter-observer variability with an agreement level >75%. This approach is a good example of minimizing subjectivity in radiology readings, and this method of standardization might be reproducible and applicable to many different radiographic classifications. Additionally, because the UGI studies were all performed to rule out leak, images might not have been optimized to demonstrate maximum distention of an upper pouch or lower pouch. On the other hand, we used a GERD-HRQL score to assess the severity of reflux symptoms. Surprisingly, the incidence of reflux symptoms in this series was very low. It is unknown if patients with leaks would result in a stricture within the tube, which can lead to later reflux. The gold standard test for reflux

evaluation is the 24-hour pH study, but we believe the expensive cost and invasive nature of the test is not warranted routinely for bariatric surgery patients and should be performed only if severe GERD is suspected. Patients completed a median 6-month follow-up. We did not evaluate any UGI series during the follow-up period to determine if sleeve shapes remained stable. However, it is important to note that it is not possible to perform serial studies, especially given the added radiation risks, if the patients have no symptoms.

Fortunately, there were only 4 patients (2 dumbbell shaped, 2 tubular shaped) in this cohort who reported early postoperative nausea and vomiting requiring readmission and intravenous hydration. One of these was found with a mid-sleeve stenosis requiring endoscopic dilations.

CONCLUSIONS

The current study found that gastric sleeve shape on the postoperative UGI series might predict clinical outcomes. Although the different shapes did not seem to change weight loss, gastric sleeves with retained fundus (dumbbell, upper pouch) resulted in lower satiety control and higher severity of reflux symptoms after the procedure. Special attention should be paid when dissecting and resecting the gastric fundus to avoid this potential complication. We also demonstrated that standardizing reading criteria among radiologists is a valuable strategy to validate an imaging-based classification and minimize the subjectivity of certain radiographic studies. In this way, a standard method of communicating sleeve gastrectomy shapes can be used for every professional caring for patients who have had sleeve gastrectomy.

Author Contributions

Study conception and design: Toro, Lin, Moreno

Acquisition of data: Toro, Lin, Patel, Davis, Sanni, Urrego, Sweeney, Srinivasan, Small, Mittal, Sekhar, Moreno

Analysis and interpretation of data: Toro, Lin, Davis, Moreno

Drafting of manuscript: Toro, Lin, Davis, Moreno

Critical revision: Toro, Lin, Patel, Davis, Sanni, Urrego, Sweeney, Srinivasan, Small, Mittal, Sekhar, Moreno

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