Is there a role for upper gastrointestinal contrast study to predict the outcomes of sleeve gastrectomy? Lessons learnt from a prospective study

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Abstract

Context: The importance of upper gastrointestinal (UGI) contrast study following sleeve gastrectomy (SG) is equivocal. It can, however, yield anatomical and functional details, the significance of which mostly remains unknown.

Settings and Design: This prospective, single-center study included SG patients between January 2018 and January 2019.

Materials and Methods: UGI contrast study was done on post-operative day 1. The findings of the study namely gastroesophageal junction (GEJ) holdup time, presence of fundus, gastroduodenal emptying (GDE) time, and sleeve shape were compared with weight loss, improvement of glycosylated hemoglobin (HbA1c) and gastroesophageal reflux disease (GERD) symptoms at 3, 6, and 12 months follow-up.

Results: There were 138 patients with 100% follow-up. Radiological sleeve patterns observed were: tubular (62.3%), superior (16.0%), and inferior (21.7%) pouches. GEJ holdup time had no effect on percentage total weight loss (%TWL) \((P = 0.09)\) or HbA1c improvement \((P = 0.077)\). The absence of fundus led to greater %TWL at 6 months \((P = 0.048)\). GDE time <15 s led to higher %TWL \((P = 0.028)\) and lower HbA1c \((P = 0.010)\) at 12 months. Antrum size <2 cm was associated with higher %TWL \((P = 0.022)\) and lower HbA1c level \((P = 0.047)\) at 12 months. Vomiting and regurgitation were common with tubular sleeves.

Conclusion: UGI contrast study can predict weight loss, HbA1c improvement, and GERD symptoms. The absence of fundus, small antrum, and rapid GDE are associated with better weight loss. HbA1c improvement is better with small antrum and rapid GDE. Tubular sleeve predisposes to vomiting and regurgitation.

Keywords: Bariatric, diabetes, gastrograffin, gastroesophageal reflux disease, sleeve gastrectomy, weight loss
INTRODUCTION
Laparoscopic SG is the most common bariatric surgery performed worldwide and in India, constituting approximately 46% of all procedure.[1] The degree of weight loss and diabetic remission following SG varies considerably and efforts have been made during the recent years in this aspect, to identify various pre-operative predictive factors which may alter the degree of weight loss and diabetes remission in the post-operative period. The identification of these preoperative factors would thereby allow surgeons to identify those subset of patients who would most likely benefit from surgery, for optimum patient satisfaction and resource allocation. Variables that predict postoperative weight loss are preoperative weight loss, baseline body mass index (BMI), gender, ethnicity, outpatient attendance, educational status, marital status, preoperative physical activity, presence or absence of psychiatric illness and binge eating behaviour.[2] Similarly, preoperative predictors that affect diabetic remission are C-peptide, BMI, duration of type 2 diabetes mellitus (T2D), age of the patient, glycemic status, residual B-cell function and need for insulin therapy preoperatively.[3] Despite the high incidence of gastroesophageal reflux disease (GERD) post SG (20%–66%),[4,5] we have so far not been able to predict who will develop GERD following SG.

It is still common practice for many of the bariatric centers to do gastrograffin study following SG whenever complications are suspected, because of its simplicity and low cost compared to computed tomography.[8] Existing literature has shown equivocal results concerning upper gastrointestinal (UGI) contrast studies. Most of the studies to date have analysed the usefulness of UGI contrast in complications post-SG (e.g., leak rate, stricture).[7,8] There have been a few studies that assessed the impact of UGI contrast findings on weight-loss parameters and the association of GERD symptoms.[9,10] The studies yielded conflicting results, and most of the studies were retrospective in nature. We did a prospective study with the ability of upper GI contrast study (gastrograffin study) to predict the weight loss outcomes as the primary outcome and the prediction and resolution of T2D in terms of HbA1C and other GERD symptoms as the secondary outcomes following SG, and to understand the relationship of post-operative anatomy and its physiological effects on these outcomes.

MATERIALS AND METHODS
Study design and settings
We did a prospective study of patients who underwent SG for morbid obesity between January 2018 and January 2019. The study was performed in the Department of Obesity and Metabolic Surgery at a tertiary care teaching institute in India. Patients were subjected to oral UGI contrast study on post-operative day (POD) 1. The findings of the UGI contrast study were compared with trends in weight loss, glycosylated haemoglobin (HbA1C) and GERD symptoms at 3, 6 and 12 months follow-up. Apart from doing UGI contrast study, all patients were managed by the Enhanced Recovery After Surgery protocol. The Institutional Ethics Committee had approved the research study. Written informed consent was taken from all the participants of the study. The patients who consented for the study were evaluated by a multidisciplinary team of doctors dedicated to bariatric surgery, including surgeons, medical gastroenterologists, dieticians and psychologists. All patients were counseled before surgery regarding the indications, merits and demerits of the procedure. All the surgical procedures were performed by a team of only two bariatric surgeons.

Patient selection
Patients were selected for SG as per the recommendations of IFSO-APC guidelines.[11] All patients were subjected to pre-operative UGI endoscopy, and those with severe GERD symptoms (heartburn score ≥2, regurgitation score 3),[10] esophagitis (Los Angeles grade C and D), hiatus hernia of any size, stricture or Barrett’s changes were excluded from the study. Patients undergoing revisional surgery and those who did not consent for the study were excluded from the study.

Operative procedure
Preoperatively, all patients were subjected to a liquid (low-calorie) liver shrinkage diet for a minimum period of 2 weeks. SG was done in the standard five-port technique, with a 10 mm supraumbilical camera port, a 5 mm sub-xiphoid liver retraction port, two 5 mm right hand working ports and a 13 mm port (Multiport, Olympus Corp. PA, USA), directed towards the pylorus for firing the stapler. Greater omentum division was done cranially, about 0.5–1 cm from the gastroesophageal junction (GEJ), exposing the left crus completely, and caudally up-to 4–5 cm proximal to the pyloric ring. Posterior gastro-pancreatic attachments were released to free the stomach completely. After the mobilisation of the stomach, linear staplers were fired, and sleeve created using a standard gastric calibration tube of 37.6 Fr. Proximal one-third of the stomach was reinforced with surrounding omentum after imbrication of anterior and posterior wall of the stomach. Staple line bleeds were clipped. A titanium clip was put at the caudal end of the sleeve, to serve as a radiological marker for the UGI contrast study. Air leak test was done intra-operatively.
by inflating air through a Ryles tube with normal saline around the gastric sleeve to look for any potential site of leak. Any area of leak if identified was reinforced with additional sutures.

**Upper gastrointestinal contrast procedure**

All the patients were subjected to oral gastrograffin (water-soluble iodinated contrast medium) procedure on POD 1, after a minimum of 24 h from surgery. Patients swallowed the oral contrast medium, not exceeding a single bottle of the contrast medium (60 ml of diatrizoate meglumine). The solution was diluted using water (60 ml), making it a bit more palatable. The images were acquired via video-fluoroscopy observation. For standardising the findings, images were acquired in the standing position in anteroposterior view. All examinations were performed and interpreted by a single radiology expert. Parameters noted were the shape of the sleeve, presence or absence of fundus, GEJ hold up time, antrum size and gastroduodenal emptying (GDE) time. GEJ hold up time was estimated as the time taken for the contrast collected at GEJ to empty into the stomach. The shapes of the sleeve on contrast study was classified as described by Werquin et al. A homogenous opacification of the contrast media in a tubular fashion comprised the ‘tubular’ shape of the sleeve. The presence of wider opacification in the region of fundus was classified as a superior pouch. The size of the remnant antro-pyloric segment (considered as antrum size) was measured from the last radio-opaque clip placed at the caudal end of the sleeve to the point where emptying into the duodenum started. Based on the above observation, the antrum size was divided into small (<2 cm), medium (2–4 cm), and large (>4 cm). The shape of the sleeve was classified as an ‘inferior pouch’ when the size of the antrum was more than 4 cm. The time duration between the holdup of the contrast at the gastroduodenal junction and the time of start of inflow to the duodenum was calculated as the GDE time.

Alteration of each one of the reflux symptoms (heartburn, vomiting and regurgitation) were assessed in relation to the radiological pattern of the gastric sleeve. A questionnaire-based scoring system, as proposed by Lazoura et al., was utilised for scoring the reflux-related symptoms before surgery and 12 months following surgery and is shown in Table 1.

**Definitions**

**Weight loss**

Percent total weight loss (%TWL) was derived from the formula: (weight loss/initial weight) × 100.

**Follow-up**

All the patients were given ondansetron 4 mg Q12H on the day of surgery and the first POD. Proton-pump inhibitor (Pantoprazole 40 mg) was given once daily for 1 month after the surgery. No prokinetics were given for any of the patients.

Patients were followed up prospectively by the multidisciplinary team at 15 days, 45 days, 90 days, 180 days and 12 months following surgery. There was a 100% follow-up of the patients at the end of 1 year.

**Statistical analysis**

Statistical analysis was performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). Data were presented in the form of mean ± standard deviation (SD) for continuous variables and frequency percentages for categorical variables. We used paired t-test for continuous data to compare the pre-operative and post-operative parameters after SG. Correlations between GEJ hold up time, presence of the remaining gastric fundus, antrum size, gastric emptying time, weight loss parameters and HbA1C improvement were determined using Pearson’s correlation coefficient (R). Analysis of variance was done to determine the difference in GERD symptoms between the different sleeve patterns. All statistical analyses were tested at a 5% level of significance.

**RESULTS**

A total of 146 patients underwent SG during the study period, but eight patients were excluded as they did not consent for the study. The study finally comprised a total of 138 patients (74 males, 64 females). The mean age and BMI were 38.68 ± 12.08 years and 44.34 ± 7.69 kg/m², respectively. Number of patients belonging to the super-obese group (>50 kg/m²) was...
Upper gastrointestinal contrast study outcomes

The shape of the remnant sleeve was divided into tubular (62.3%), superior pouch with remnant fundus (16.0%) and inferior pouch (antrum size >4 cm) (21.7%) as depicted in Figure 1. UGI contrast study results are depicted in Table 3.

A significant change ($P < 0.001$) in terms of reduction in weight, BMI, HbA1C was seen, while %TWL at 1 year follow-up was 31.16 ± 5.34% [Table 4].

We observed improvement in the glycaemic index in 74.24% of our patients at the end of 1 year. There was no correlation found between GEJ holdup time and %TWL ($r = 0.433$, $P = 0.063$), HbA1C levels ($r = -0.398$, $P = 0.077$), regurgitation ($r = -0.230$, $P = 0.552$), heartburn ($r = -0.204$, $P = 0.598$) or vomiting ($r = 0.066$, $P = 0.866$) scores at 1-year follow-up.

Patients with remnant fundus were found to have higher weight and BMI, 92.07 ± 13.43 kg versus 80.95 ± 17.17 kg ($P = 0.046$) and 32.59 ± 3.78 versus 29.31 ± 4.52 ($P = 0.027$) at 1 year. We also observed a significantly lower %TWL, 24.38 ± 3.56 versus 26.44 ± 3.38 ($P = 0.048$) at 6 months and is depicted in Figure 2.

Patients with faster GDE time (<15 s) were associated with a lower BMI ($P = 0.045$), better %TWL ($P = 0.028$) and lower HbA1c ($P = 0.010$) at 1-year follow-up [Figures 3 and 4]. Furthermore, there was no correlation between GDE time and regurgitation ($r = 0.056$, $P = 0.056$), heartburn ($r = 0.626$, $P = 0.071$) or vomiting ($r = -0.15$, $P = 0.266$) scores.

Patients with small antrum size had a faster GDE time (10.87 ± 5.67 s) when compared to patients with a medium antrum size (28.76 ± 31.07 s) or large antrum size (38.50 ± 47.77 s) ($P = 0.048$), respectively. Patients with a small antrum size were observed to have lower mean HbA1C (4.13 ± 0.57 vs. 4.27 ± 0.70 vs. 4.69 ± 0.68; $P = 0.047$), compared to medium and large antrum size, at 1 year of follow-up. Smaller antrum size was also associated with better %TWL at the end of one year (32.56 ± 5.52 vs 30.78 ± 4.05 vs 28.34 ± 4.92; $P = 0.022$) [Figures 5 and 6].

Table 2: Demographic profile of the patients

| Parameter                      | $n$ (%) |
|--------------------------------|---------|
| Total number of patients (n)   | 138     |
| Males                          | 74 (53.6) |
| Age (years)*                   | 38.68±12.08 |
| Height (cm)*                   | 165.88±10.05 |
| Pre-operative weight (kg)*     | 123.57±29.16 |
| Pre-operative BMI (kg/m$^2$)*  | 44.34±7.69 |
| HbA1c (%) in diabetic cohort*  | 8.13±1.76 |
| HTN                            | 30 (21.7) |
| T2D                            | 66 (47.82) |
| Smoking                        | 23 (16.67) |
| Pre-operative OGD              |         |
| Normal                         | 72 (52.1) |
| Grade A esophagitis            | 50 (36.23) |
| Grade B esophagitis            | 16 (11.6) |

*Mean±SD. BMI: Body mass index, HbA1C: Glycosylated hemoglobin, HTN: Hypertension, T2D: Type 2 diabetes mellitus, SD: Standard deviation, OGD: Oesophago-gastro-duodenoscopy

Table 3: Upper gastrointestinal contrast dye study results

| Parameter                    | $n$ (%) |
|------------------------------|---------|
| Remnant fundus               | 22 (16.0) |
| Antrum size (cm)             |         |
| <2                           | 8 (5.8) |
| 2-4                          | 100 (72.5) |
| >4                           | 30 (21.7) |
| GDE time (s)                 |         |
| <15                          | 62 (44.9) |
| 15-60                        | 60 (43.5) |
| >60                          | 16 (11.6) |
| GEJ hold-up time (s)         | 6.02±4.84 |
| GDE: Gastroduodenal emptying, GEJ: Gastroesophageal junction

Table 4: Outcomes following sleeve gastrectomy

| Parameter                      | 3 months | 6 months | 12 months | $P$     |
|--------------------------------|----------|----------|-----------|---------|
| Weight                         | 101.67±22.98 | 92.56±20.21 | 82.73±17.05 | <0.001* |
| BMI                            | 36.68±6.13  | 33.41±5.35  | 29.41±4.30  | <0.001* |
| Percentage TWL                 | 17.72±2.80  | 24.45±3.39  | 31.16±5.34  | <0.001* |
| HbA1C                          | 5.57±0.86   | 5.07±0.75   | 4.35±0.69   | <0.001* |

*Statistically significant. BMI: Body mass index, TWL: Total weight loss, HbA1C: Glycosylated hemoglobin

Figure 1: Upper gastrointestinal contrast images showing different sleeve shapes: Tubular, superior pouch and inferior pouch
We observed a significant increase in the regurgitation scores during the first 3 months (0.58 ± 0.04 vs. 0.41 ± 0.03 vs. 0.11 ± 0.04), and 12 months (0.70 ± 0.16 vs. 0.41 ± 0.09 vs. 0.14 ± 0.02), in the tubular, superior pouch and inferior pouch categories, respectively. Still, scores were significantly higher at the end of 1 year, in the tubular shape as compared to the superior and inferior pouch. (*P = 0.002) [Table 5].

There was an alleviation of heart-burn scores, observed in all the three patterns of sleeve at 3 months (0.62 ± 0.04 vs. 0.35 ± 0.16 vs. 0.85 ± 0.12), and at 12 months (0.39 ± 0.17 vs. 0.25 ± 0.09 vs. 0.25 ± 0.08), respectively. However, at twelve months follow-up, none of the sleeve shapes had a significant difference with regard to heartburn. (*P = 0.345) [Table 5].

Similarly, the incidence of vomiting score was found to be increased during the first 3 months in the tubular (0.24 ± 0.12), and the superior pouch (0.15 ± 0.06) category and subsequently decreased at 12 months (0.11 ± 0.03 vs. 0.01 ± 0.02), respectively. The tubular shape of the sleeve was, however, associated with a significantly higher (*P < 0.001) incidence of vomiting, one year following SG. The inferior pouch category had no incidence of vomiting postoperatively [Table 5].

Two patients had staple line bleed, which was managed conservatively. There were no leaks, strictures, or any other complications observed in our study. No mortality was noted.

**DISCUSSION**

SG has emerged to be one of the most promising options for long term weight loss and resolution of T2D. The degree of weight loss, improvement of T2D, and the onset of GERD post-SG are considerably variable. Substantial
efforts have been made to identify predictive factors in these patients, which might influence the degree of the above outcomes.\textsuperscript{[2,3]} Studying the association of the anatomical and physiological changes post SG using UGI contrast findings and correlation with the outcomes of SG may help define an ideal sleeve.

It is well known that gastrointestinal motility is altered following SG. While studies so far have analysed the effect of gastric emptying on weight loss,\textsuperscript{[9]} the impact of GEJ holdup time on weight loss is not known.\textsuperscript{[14]} Assuming alterations in the esophageal motility and GEJ holdup time as part of a spectrum of post-bariatric motility changes, we hypothesised that alterations in GEJ holdup time could affect weight loss. However, no correlation between GEJ holdup time and weight loss was noted in our study. To the best of our knowledge, this is the first study to compare GEJ holdup time and weight loss.

The presence of remnant fundus influenced %TWL in our patients. The fall in weight and BMI were more in patients without retained fundus, reaching significance at the end of 12 months. %TWL was significantly lower in patients with retained fundus at 6 months ($P = 0.048$) It could be due to a decrease in the levels of the orexigenic hormone ghrelin following removal of the fundus that induces weight loss. The importance of ghrelin in relation to weight loss following SG has been shown in studies by Langer et al. and Karamanakos et al.\textsuperscript{[15,16]} Pomerri et al., however, found no correlation between residual fundus volume and percentage excess BMI loss.\textsuperscript{[9]} Salamat et al. also reported no significant difference in %EWL in patients with or without retained fundus in their study.\textsuperscript{[17]} This discrepancy, as explained by the authors of that study, could be due to a lack of a truly large fundus. It is also possible that the differences noted in different studies could be due to a lack of standardisation of gastric fundus volume estimation. To assess the impact of gastric fundus volume on weight loss, a universally applicable yet simple form of gastric fundus measurement should be devised.

Antrum size was estimated based on UGI contrast series performed on the first POD and sub-divided into three types: <2 cm, 2–4 cm, >4 cm. Errors in intra-operative measurements, inadequate posterior antral dissection, post-operative oedema while firing the staplers led to different sizes of antrum. Antrum size <2 cm was associated with a significantly higher %TWL at 12 months ($P = 0.022$). In a randomised controlled trial (RCT) of 105 patients, Abdallah et al. noted that %EWL was greater with antral resection compared to the group with preserved antrum.\textsuperscript{[18]} McGlone et al., in a meta-analysis involving six RCTs and two cohort studies, also found that antral resection was associated with a better weight loss than antral preservation, consistent with our findings.\textsuperscript{[19]}

GDE <15 s was associated with better weight loss. The %TWL was higher at 6 months ($P = 0.033$), and 12 months ($P = 0.028$) when the GDE was <15 s. Consistent with our findings, Pomerri et al. also noticed higher %BMI loss in patients with rapid GDE.\textsuperscript{[9]} On the other hand, Parikh et al., in their retrospective study, found no correlation between GDE and %EWL.\textsuperscript{[20]} It is interesting to note that 11.6% of our patients and 14.03% of patients in the study by Pomerri et al. had GDE of more than 60 s, while almost 99% of the patients in the study by Parikh et al. had a GDE of <60 s the reason for which remains to be elucidated. Pomerri et al. had chosen a cut-off of one minute while Parikh et al. had chosen a cut-off of 30 s to differentiate fast and slow GDE.

We studied the relationship between antrum size and GDE. GDE was faster in patients with a small antrum of size <2 cm ($P = 0.048$). Our findings were in line with the findings of Vives et al.\textsuperscript{[21]} This is, however, a subject of much controversy with varying results reported by different authors. Michalsky et al. found that gastric emptying time reduced following radical antral resection, while Garay et al., noticed a significantly reduced gastric emptying time only in patients with a retained antrum.\textsuperscript{[22,23]} Bernstine et al., on the other hand, reported no difference in gastric emptying rate with antrum preservation.\textsuperscript{[24]} Further research is needed to corroborate our findings.

SG is associated with alterations in gastrointestinal motility. GDE is accelerated following SG. In a systematic review, Sioka et al. found gastric emptying was accelerated following SG in 17 out of 18 studies. It appears to be due to aberrant ectopic pace-making following the removal of the gastric pacemaker.\textsuperscript{[21]} In our study, about 45% of patients had GDE <15 s, and it was less than a minute in almost 90% of patients. We analysed our data to study the effect of GDE on HbA1c improvement. GDE was
found to have an impact on the improvement of glycemic index, with GDE <15 s associated with better glycaemic control compared to GDE of 15–60 s and GDE of more than 60 s. The improved glycaemic control with rapid gastric emptying could probably be due to increased GLP-1 secretion, though we didn’t specifically measure GLP-1 levels. As mentioned above, we noticed rapid GDE in patients with antrum size <2 cm, than in patients with antrum of larger size. Vives et al., in their randomised study, found that gastric emptying was faster in the antral resection group. They also found that diabetic patients who underwent antral resection had significant improvements in HbA1C and HOMA-IR (Homeostatic model assessment-insulin resistance) index. HbA1c levels were similarly significantly lower in patients with small antrum in our study (4.13 ± 0.57, P = 0.047).

De-novo GERD following SG has a reported incidence ranging from 20% to 66%, Following SG, alterations that lead to increased GERD are hypotensive lower esophageal sphincters, alteration in the angle of His, partial resection of the sling fibers, reduced gastric capacity and lack of gastric compliance. Different sleeve patterns based on the radiological patterns have been described by Werquin et al. Different patterns noted are due to the technical alterations encountered during SG. Eighty-six patients (62.3%) had a tubular shaped sleeve in our study. Creation of long tubular sleeve results from resection of greater curvature using a standardised gastric calibration tube, from the pylorus to the angle of His. We noticed a fall in the scores of heartburn in all the patterns of the sleeve, at the end of 1 year [Table 5]. Reduced intra-abdominal pressure, decreased gastric acid production, reduced gastric volume and accelerated gastric emptying time could be a cause for heartburn relief. Tubular sleeve shape was found to have a significantly higher incidence of regurgitation and vomiting scores when compared to the superior and inferior pouches [Table 5]. SG creates a high intragastric pressure zone due to the loss of the fundus and body of the stomach and the impaired receptive relaxation mechanism. It might be one of the reasons that both vomiting and regurgitation are significantly increased in the tubular pattern post-surgery. Fundus and body of the stomach are the reason for the receptive relaxation mechanism and food accommodation. Failure to release the posterior gastric fundus leads to the superior pouch pattern. Sixteen percent (n = 22) of our patients had remnant fundus. Lesser gastric content is available for reflux in the presence of a superior pouch, because of the ability of the stomach to accommodate and distend with food. Less severe vomiting and regurgitation due to a reduction in regurgitant volume could be observed in such cases as compared to tubular gastric sleeves. The antrum is mainly responsible for trituration and emptying of the food. Thirty patients (21.7%) had an antrum size of more than 4 cm in our study. Misidentification of the pylorus and misplacement of the gastric calibration tube may lead to the use of the wrong landmarks for the commencement of the division, resulting in the preservation of antrum, and hence leading to inferior pouch pattern. Lower rates of reflux symptoms have been observed with the preservation of the antrum when dissection of the great curvature began 10 cm from the pylorus in a study by Nocca et al. A similar study by Ahmed and Anas had shown that patients undergoing SG with remnant antrum size 6 cm had a lower incidence of reflux symptoms and vomiting (7.1%) as compared to patients with remnant antrum size of 2 cm (11%).

To the best of our knowledge, this is the first research work from the Indian subcontinent to study the utility of routine UGI contrast study for predicting weight-loss parameters, HbA1c improvement, and GERD symptoms following SG. The strength of the study lies in the fact that it was a prospective study with a large sample size without any attrition.

The edema present at the GEJ, stomach, and the antrum on POD 01 might alter the GEJ junction hold up time and even the GDE time. The extent of edema could also be different in different patients. However, by performing the study uniformly on POD 1 in all our patients, we have tried to eliminate the influence of this factor. We did not do 24-hour pH study or esophageal manometry for the work-up of GERD, which is another limitation of our research. We have instead used a simple symptom-based GERD scoring system, which can give an objective score that is reproducible.

This study showed that tubular sleeve has highest %TWL as well as the highest incidence of GERD. So, further technical refinements are needed which can address the issue of higher incidence of GERD.

CONCLUSION

UGI contrast findings post-SG can be used as a predictor of weight loss and HbA1C improvement. The presence of remnant fundus and large antrum size predisposes to inadequate weight loss. Smaller antrum size correlates to a faster GDE time in this study. Patients with a smaller antrum size have better weight loss and better HbA1C improvement. Tubular shaped sleeve predisposes to a higher incidence of regurgitation and vomiting when compared to superior or inferior pouch postoperatively.
Although tubular pattern of sleeve with a small antrum seems ideal, further studies on augmentation techniques to reduce GERD is the need of the hour.

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Conflicts of interest
There are no conflicts of interest.

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