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ORIGINAL CONTRIBUTIONS

Remodifying Omentopexy Technique Used with Laparoscopic Sleeve Gastrectomy: Does It Change any Outcomes?

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Abstract

Background Gastric obstructions, leaks and staple line bleeding are reported after laparoscopic sleeve gastrectomy (LSG). There is no ideal method or technique to avoid these mishaps. We added modified omentopexy (OP) to LSG to determine if there is any effect on gastric leaks and some other complications.

Methods This single institution case control study included two groups of morbidly obese patients undergoing LSG. They were grouped as omentopexy (OP) or no omentopexy (NP). Patient characteristics such as age, sex, ASA (American Society of Anesthesiologists) risk, body mass index (BMI), nutritional status and comorbidities were comparable. Postoperative follow-up was scheduled at 1 week, 1 month, 3 months, 6 months and 12 months. All received standard postoperative clinical, nutritional evaluation and PPI therapy for at least 3 months.

Results Total 737 patients underwent LSG from January 2012 to December 2017. Out of these, 370 that had OP and 367 that had NP were analyzed. NP group was subdivided into Lemberted Staple line (LS) and bioabsorbable staple line reinforcement (BSLR) groups. Gastric leaks and perforations were clubbed together as gastric disruptions (GD). Patients with at least 15 months of postoperative follow-up were included. Those who failed to follow up were excluded. GD was reported in 7 out of 367 NP patients (1.9%), while no GD was seen in 370 OP patients ($P = 0.01$). Bleeding was seen in 1 OP versus 2 NP patients ($P = 0.6$). Venous thromboembolism was reported in 2 OP versus 1 NP patients ($P = 1$). Wound infection was seen in 1 OP versus 2 NP patients ($P = 0.6$). Readmissions were noted in 2 OP versus 6 NP patients ($P = 0.1$). Pneumonia was seen in 2 OP and 2 NP patients ($P = 1$). Postoperative dehydration was seen in zero OP versus 1 NP patients ($P = 0.4$). Gastric obstruction was not seen in any of the patients. Postoperative gastric reflux was present in 49/370(13.2%) OP versus 57/367(15.4%) NP patients ($P = 0.4$). Within NP group, LS (Lemberting of Staple line) patients (286/367) had 4 GD (1.39%) versus no GD in OP ($P = 0.03$). BSLR (Bioabsorbable Staple line re-enforcement) patients (81/367) had 3 GD (3.7%) versus no GD in OP ($P = 0.005$). None of the groups had any mortality.

Conclusions GD (gastric disruptions) were statistically significant, but the following bleeding, venous thromboembolism and gastroesophageal reflux did not reach statistical significance, which indicates that OP, if performed correctly with LSG, has favorable effects on gastric leaks.

Keywords Laparoscopic sleeve gastrectomy · Omentopexy · Bariatric surgery

Introduction

LSG is the preferred and most commonly performed bariatric operation in the USA. The fear of staple line leaks associated with LSG still remains high. This is eluded to the fact that LSG creates an elevated intraluminal pressure secondary to partial or complete closed-loop condition within the functional pyloric and lower esophageal sphincters.

LSG is performed in a fundamentally similar fashion across the USA. However, there have been variations in the use of

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sizes of bougies, staple line reinforcements (SLR) and omentopexy (OP). Postoperative dysphagia, obstruction secondary to strictures or twists and bleeding and leaks are some of the complications of LSG. Leaks are also less likely to close spontaneously because of the high intraluminal pressures. Proposed strategies to lower some of these complications range from wider division of stomach from the pylorus, using larger size bougies, choice of specific staplers, reenforcements and OP. There have been few published studies highlighting pros and cons of adding OP to LSG. We have attempted to analyze any benefits of adding OP to LSG.

Materials and Methods

This is a single institution–case control study performed at the Penn Medicine Princeton Medical Center, NJ. Data was collected using hospital database and MBSAQIP. The study was exempt from Institutional Review Board (IRB) due to the retrospective nature of the study. All patients who underwent LSG from January 2012 to December 2017 were included. Those who failed to follow up for 1 year were excluded. Patients referred to our center from weight management program, primary care and other specialties were enrolled. After their preliminary evaluation by our weight management program, patients undergo selection process that includes but is not limited to nutritional, psychological, medical and GI assessment. The patients provide appropriate prior written informed consents for all types of bariatric procedures. At this time, risks, benefits and complications of LSG are discussed. All patients undergo upper endoscopy as part of preoperative evaluation and initiated on a pre-operative 'liver shrinking' diet (600–800 Cal/day) for at least 2 weeks. Size 40 or 44 Fr bougies were used for calibrating the sleeve sizes in both groups. Proton pump inhibitor (PPI) therapy is routinely given postoperatively for first 90 days. This treatment is based on additional clinical indications of either symptomatic hiatal hernia or reflux esophagitis or history of peptic ulcer disease.

Operative Approach

Three surgeons A, B and C performed all the LSG at our institution during the year 2012 to 2017. Their technique is identical in performing LSG and is as follows:

Pneumoperitoneum is achieved, and left lobe of liver is retracted using liver retractor. The gastrocolic omentum is divided using hormonic scalpel in the laparoscopic approach. We use the following operative guidelines: (1) use a bougie size of40 Fr; (2) begin the gastric transection 5–6 cm from the pylorus with appropriate stapler cartridges for LSG; (4) reinforce the staple line with buttress material (BSLR) in LSG; (5) stay away from the angle of His at least 1 cm; (6) check hemostasis at the staple line; (7) perform an intraoperative blue dye test to check for leaks; (8) stomach specimen is removed, and neo-greater curve is tacked laterally and inferiorly with interrupted sutures to correct the sleeve configuration, this is called omentopexy; and, finally, (9) a closed suction drain is left in the sub hepatic location. Port placement is shown in Fig. 1. We use 40–44 Fr size bougies for the sleeve calibration. Surgeon A performs OP, while surgeons B and C do not perform OP. Surgeon A uses BSLR and performs OP. Surgeon B uses LS and fibrin sealant. Surgeon C prefers partial BSLR at proximal and distal gastric staple line.

In the OP group, pexy was performed using braided non absorbable interrupted sutures. The sutures were placed to tack the posterior wall of the sleeved stomach to the remnant greater omentum (Figs. 2 and 3). With this technique, it is ensured that the staple line remains accessible should there be any bleeders to be dealt with later. The layout of the sutures is based on the tension needed to achieve a smooth contour at the staple line interface, and therefore specific fixation sites are chosen (described in greater detail below). The result is a smooth anatomical configuration with reverse-C shape

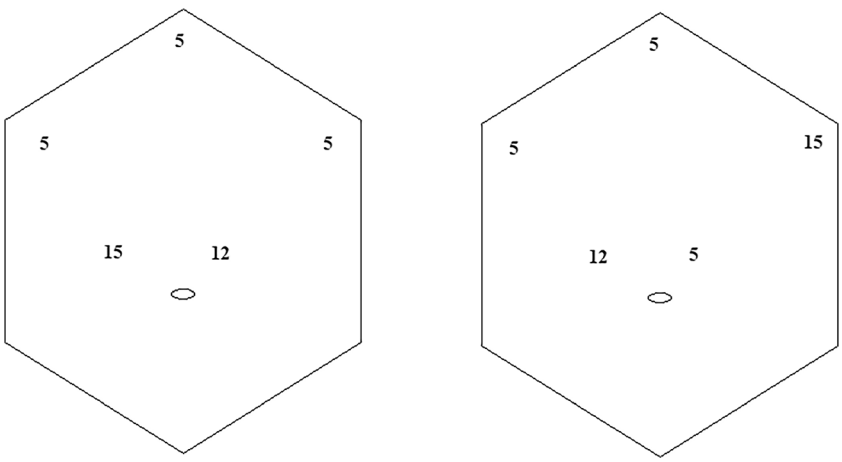

Fig. 1 Port placements with two LSG techniques at our institution

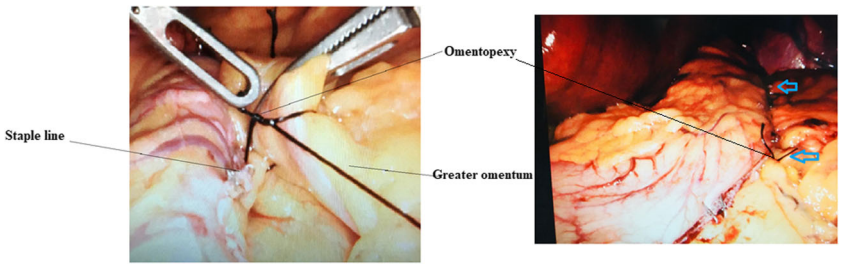

Fig. 2 Shows intraoperative pictures of OP

to prevent any windsock deformities or twisting of the gastric sleeve.

Within the NP group, LS group had continuous nonabsorbable, braided Lembert's sutures to cover the staple line with fibrin sealant sprayed over the area. BSLR group had proximal and distal portions of staple line covered with BSLR.

Postoperative Course

We follow enhanced recovery after surgery protocol (ERAS), except for preoperative carbohydrate treatment. The postoperative orders, pain management and discharge protocol are standard for our LSG patients. Patients are kept NPO (nil per os) during the day of surgery, and, following clinical evaluation, bariatric clear liquids are commenced on first postoperative day. Intravenous acetaminophen is started on the day of surgery. We usually do not start postoperative NSAIDs or enoxaparin if there is any clinical indication of bleeding. Patients are discharged after overnight observation and are sent home with 3 months of PPIs. Postoperatively, they are followed up at 1 week, 1 month, 3 months, 6 months and 12 months. Comorbidity assessment and nutritional status are evaluated routinely at each visit. Starting at third month follow-up routine, anemia labs are obtained, which includes complete blood count and measuring serum iron concentration, total iron binding capacity (TIBC), transferrin saturation. Patients are treated with iron supplements, multivitamins and vitamin B12.

We do not perform postoperative upper GI study in our patients, unless there is clinical indication based on the symptoms. Figures 4 and 5 demonstrate upper GI studies done during follow-up in some symptomatic patients in the two groups.

As seen in Figs. 4, 5 and 6, the lateral traction from the previously attached greater omentum is lost after LSG. This causes an imbalance in the forces on the sleeved stomach making the anatomical configuration as "L-shaped" without OP as opposed to a "reverse C-shaped" with OP. (Fig. 7). We notice that the angle at the incisura is narrower without omentopexy as compared to being more open with OP (Figs. 6 and 7).

Statistics

Statistical analysis and power analysis were performed to check for adequacy of the sample size. Standard univariate methods were used to express continuous variables with respect to mean, standard deviation and 95% confidence intervals. Discrete variables were expressed as proportions. Comparison was performed by using Fischer exact test. A two-sided p value of 0.05 was considered significant. The study was conducted with the understanding that there are multiple factors causing postoperative leaks and obstructions, including but not limited to operative technique, ischemia, hematoma and staple misfiring. Regression analysis was performed for all these factors.

Regression analysis was also performed to evaluate for factors that would affect postoperative outcomes such as age, ASA class, BMI, comorbidities, gender and anemia.

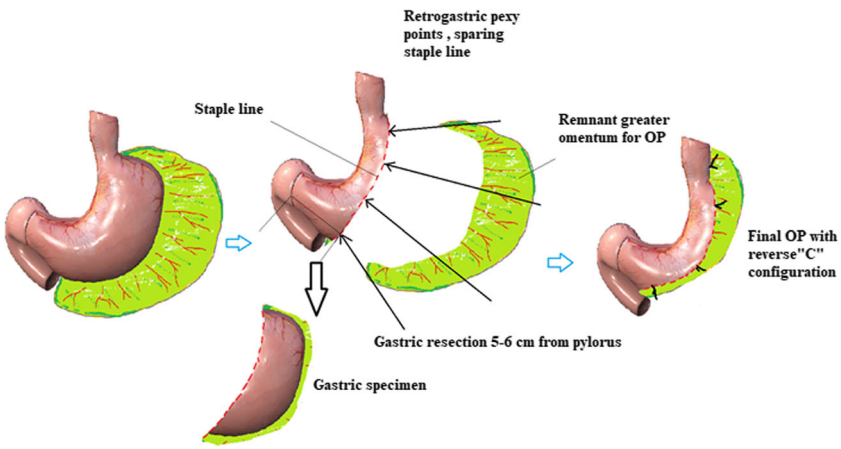

Fig. 3 Showing steps of p[erforming OP

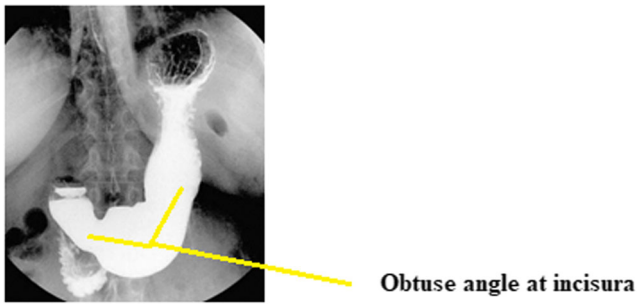

Fig. 4 UGI on a patient without LSG with normal gastric anatomy and obtuse angle at incisura

Results

We had total 737 patients undergoing LSG from 2012 to 2017. Out of those, 370 underwent LSG with OP and 367 underwent LSG without OP. The technique of performing LSG was similar in the two groups, including the choice of stapler device in accordance with the thickness of gastric wall. Patient demographics, BMI, ASA class and comorbidities were also comparable as shown in Table 1. All patients were explained the risks, benefits and complications of doing standard laparoscopic sleeve gastrectomy. Alternative bariatric operations were discussed, and informed consents were obtained. Choice of OP or NP was operating surgeon's preference, and this was discussed during preoperative session. It was noted that intraoperative time was 15–30 min longer in the OP group as compared with NOP group. Postoperatively, all patients were followed at 1 week, 1 month, 3 months, 6 months and 12 months intervals. Table 2 shows complications in the postoperative follow-up period of up to 15 months.

As shown in Table 2, a total of 7 out of 367 patients had GD in the NP group as compared with no GD seen in the OP group with significant *p* value. Other complications were comparable between the two groups. Interestingly, there was no significant difference in the postoperative reflux seen in the two groups**.** Four out of the seven GD were managed conservatively using observation, parenteral nutrition, antibiotics, endoscopic management and CT (computed tomography) guided drainage. The remaining three patients were treated using operative management and converted to Roux-en-Y procedure. There was no mortality in any of the two groups. GI obstructions were not seen in any of the groups. The incidence of gastric reflux was between 13 and 15% in the two groups, and this was statistically not significant. The finding of reflux was based on clinical findings and the need for acid reducing therapy in the two groups beyond 3 months after LSG.

Regression analysis was carried out for possible factors affecting leaks, reflux or bleeding. These were surgical approach, staple line reinforcement, use of fibrin glue, comorbidities, staple line over-sewing, size of bougies (40 versus 44 Fr), omentopexy and BMI. None of these, except the omentopexy, showed some correlation. All patients were followed postoperatively at 1 week, 1 month, 3 months, 6 months and 12 months and had nutritional evaluation with micronutrient supplementation as necessary.

Discussion

Laparoscopic sleeve gastrectomy (LSG) has outnumbered all bariatric procedures due to its growing popularity and comparable weight loss outcomes. As with any bariatric surgical intervention, LSG has its own set of complications. The most dreaded complication being staple line leaks. They can result in significant morbidity and an associated mortality rate of 0.1–0.2% [1, 2]. As outlined earlier, most of the leaks do not heal spontaneously due to high intragastric pressure seen in these patients.

The incidence of leaks after LSG ranges from 0.5% to 7% in different series [3]. Approximately 75–85% of the leaks after LSG occur at the proximal third of the staple line [4–8]. It is believed that ischemia, choice of bougie size, stapler size, reinforcements, inadvertent stapling of the esophageal wall and omentopexy are some of the contributory factors affecting leaks in LSG [9, 10]. There is enough evidence to support selective rather than routine contrast studies after bariatric surgery [11–15]; therefore, we selectively perform upper GI study in symptomatic patients. One can debate that surgical technique may affect leak rate. However, surgical technique may not affect leak rate, other than causing variability in operative times

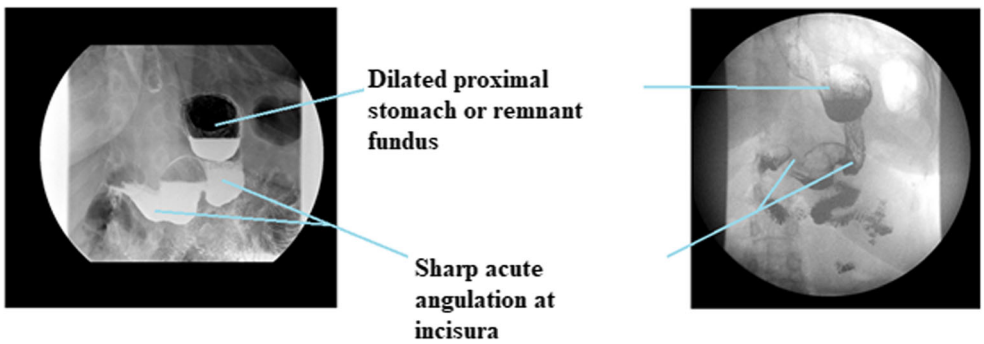

Fig. 5 Showing UGI in a patient 2 years following LSG without OP with acute angle at incisura and new onset hiatal hernia, likely due to increased intragastric pressures

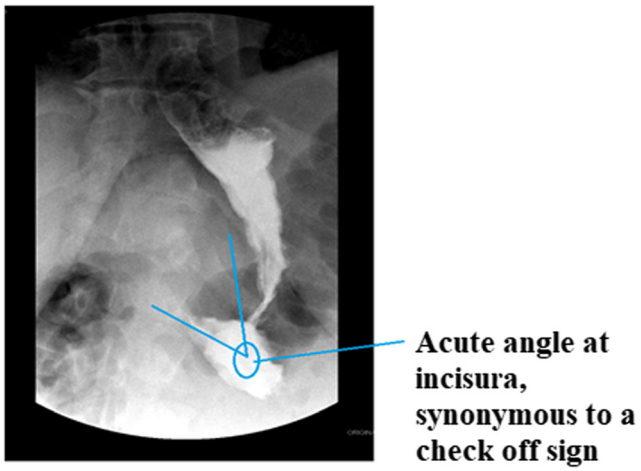

Fig. 6 Showing UGI in a patient without OP with compromised gastric angle at incisura

[16]. There are various methods suggested to prevent leaks; however, none of them are entirely successful. Some institutions have proposed staple line re-enforcements or buttressing, while others have suggested over-sewing the staple line only with controversial results. The use of fibrin glue and barbed continuous suture for staple line reinforcement during laparoscopic sleeve gastrectomy had no effect on post- or perioperative hemorrhage and leakage [17]. Another study showed that there were significantly lower staple line leak rates using absorbable staple-line reinforcement as compared with over-sewing, use of sealants, non-absorbable reinforcement or no reinforcement [18]. Whether tissue sealants or hemostatic agents play any role in reducing leak rate is controversial. Some studies have shown that buttressing or SLR (staple line re enforcement) results in better hemostasis, but clearly it does not affect the leak rate [19, 20] The conclusions from most studies show either no effect on bleeding or leak, some effect on leak based on the material used for buttressing or no effect on leak but

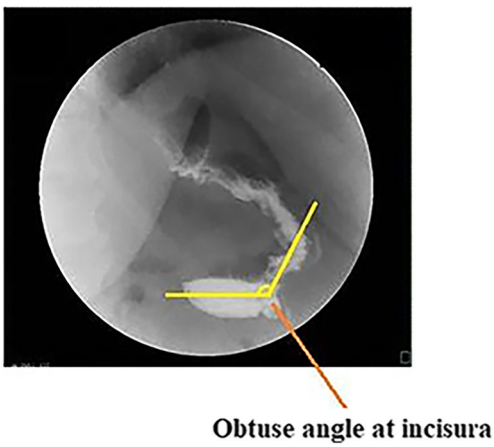

Fig. 7 UGI in a patient 2 years after LSG with OP, showing reverse "C" configuration and obtuse angle at incisura, synonymous to normal gastric anatomy

Table 1 Preoperative characteristics of all patients undergoing LSG

Variables	LSG with OP	LSG without OP	*P* value
Age (years)			
Mean ± SD Range	45.1 ± 12.58 19–70	45.5 ± 10.5 25–66	0.75
95% CI	42.2–47.9	41.6–49.4	
Sex			
Males	167	155	0.24
Females	203	212	0.45
BMI (kg/m^2)			
Mean ± SD Range	42.7 ± 7.58 31–66	45.1 ± 6.9 35–60	0.79
95% CI	40.95–44.36	42.6–47.7	
ASA class			
Mean ± SD Range	2.53 ± 0.5 2–3	2.59 ± 0.49 2–3	0.63
95% CI	2.42–2.65	2.4–2.78	
Type II diabetes	111	118	0.57
Hypertension	140	127	0.59
High cholesterol	129	136	0.31
Sleep apnea	222	204	0.18
GERD	39	44	0.5

SD standard deviation, *CI* confidence interval, *LSG* laparoscopic sleeve gastrectomy, *OP* omentopexy, *ASA* American Society of Anesthesiology Class, *BMI* body mass index, *kg* kilograms, *m^2* square meters

decreased staple line bleeding. Role of over-sewing in order to reduce the incidence of leak also has been controversial [21–23]. A large review of quality improvement data shows that SLR using over-sewing is associated with a 60% increased risk of gastric leak, compared with closures without staple line reinforcement [24]. In vitro, Lembert's suture reinforcement technique on stapled human stomach was associated with less

Table 2 Postoperative outcomes of all patients undergoing LSG

Events at 0 to 15 months	LSG with OP	LSG without OP	*P* value
GD	0	7	0.01
Bleeding	1	3	0.37
VTE	2	1	1
Infection	1	2	0.62
Readmission	2	6	0.17
Pneumonia	2	2	1
Dehydration	0	1	0.5
GI obstruction	0	0	1
GERD	49	57	0.4
Mortality	0	0	1

LSG laparoscopic sleeve gastrectomy, *OP* omentopexy, *VTE* venous thrombo-embolism, *GI* gastro-intestinal, *GERD* gastro-esophageal reflux disease, *GD* gastric disruptions

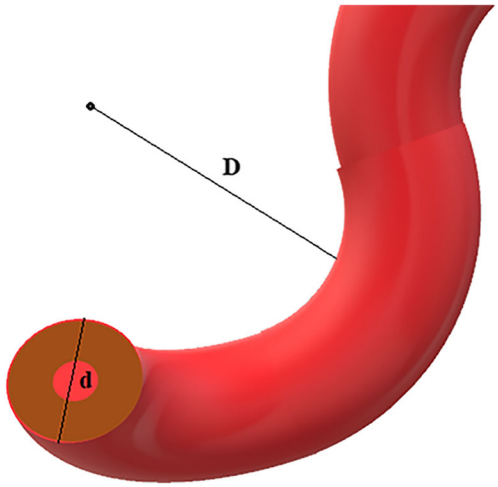

Fig. 8 Showing a curved line

leakage rate in comparison to over-sewing reinforcement and non-reinforced staple-line [25].

There has been much controversy in the choice of ideal bougie sizes for calibrating gastric sleeves. Most surgeons across the world have used between 32 and 44 Fr bougies and have concluded that sizes less than 32 Fr are less desirable, as they cause higher readmissions, complications and prolonged hospital stay [F]. Moreover, the use of 32 Fr bougie has higher complications and does not result in significant excess weight loss differences as compared with 40 Fr boogie [26]. Smaller sized bougie (less than 36) had greater impact on metabolic syndrome [27] The use of appropriate size linear stapler is equally crucial to the outcomes, to account for gradual decrease in gastric wall thickness from pylorus to angle of His. Our technology is short of identifying correct thickness of the stapler according to gastric wall thickness. At this time, precise recommendations on the selection of the appropriate stapler cartridge have not been established [28]. Insufficient data is available to analyze the pros and cons of adding omentopexy to LSG. There are fewer studies looking at the

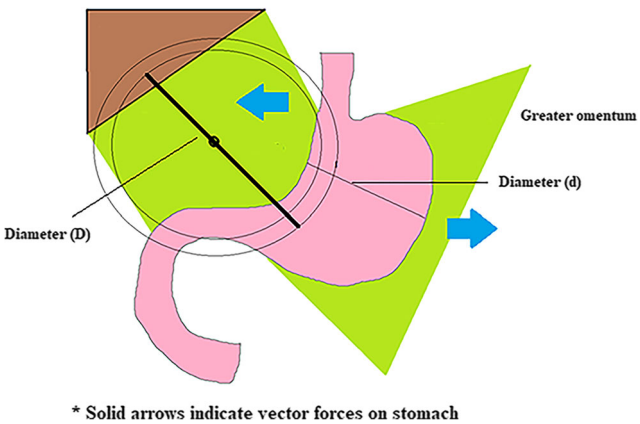

Fig. 9 Normal stomach with medial and lateral vector forces acting on stomach from hepatogastric ligaments and greater omentum, respectively

effect of OP on leak or any other major complications. Most of these studies have not precisely explained the exact technique of OP. Some studies have suggested that there is technically less twisting/kinking or obstructions, which, in turn, leads to decreased incidence of proximal leaks. According to one study, omentopexy could prevent gastric twist, which is a functional cause of gastric stenosis, by stabilizing the posterior stomach wall [29]. This study had only one leak and no obstruction in their follow-up.

There is lack of data on the impact of OP in decreasing gastro esophageal reflux (GERD) rate. One study has shown that LSG with OP improved the clinical score of GERD and that OP was indeed associated with decreased clinical reflux symptoms and strictures [30]. Another study showed that OP could reduce complications arising from improper positioning and gastric tube alterations in LSG, particularly symptoms related to food intolerance and GERD in the immediate postoperative period [31].

It is appropriate to highlight the anatomy and interplay of various physiological forces on the sleeved stomach. Some of the principles of pressure-fluid dynamics in a curved tube can be applied to the LSG. The Hagen-Poiseuille Law is a special case of the Navier-Stokes Equation that describes laminar flow in straight tubes. From the Hagen-Poiseuille Law, change in pressure through a length of tubing can be related to characteristics of the fluid and tube dimensions, with the equation [32]

$$\frac{\Delta P}{l} = \frac{32\mu U}{d^2}$$

where ΔP is the pressure differential, l is the length of tubing, μ is the kinematic fluid viscosity, U is the fluid velocity, and d is the tube diameter.

In curved tubes, resistance to flow is always greater, as the more rapidly flowing central portion of the fluid is forced outwards by centrifugal forces, while the slower portions of the fluid are forced inwards. Experiments by W.H. Dean quantify flow by the introduction of a new dimensionless number, the Dean Number. The Dean Number is a slight modification of the Reynolds Number and is defined as

$$De = \mathrm{Re}\sqrt{\frac{d}{D}} = \frac{Ud}{\nu}\sqrt{\frac{d}{D}}$$

Where d is the tube diameter, D is the diameter of curvature, U is the fluid velocity, and ν is the dynamic viscosity. (conceptualized in Fig. 8) Therefore, as the diameter of the curve of the sleeve gastrectomy increases, there should be proportional decrease in the intraluminal sleeve pressure differential. OP decreases the curvature diameter (D) of the sleeve as compared with no pexy. Along those lines, the intraluminal pressure should be higher in a routine sleeve without omentopexy (NP) as compared with sleeve gastrectomy with OP. After standard sleeve gastrectomy, the medial

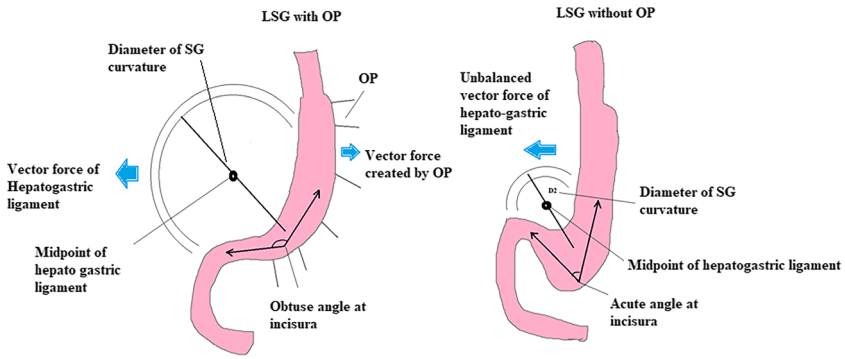

Fig. 10 Effects of OP in balancing vector forces on stomach

forces of the hepato-gastric ligament on the sleeved stomach are unchanged, while the lateral forces are lost as a result of detachment of the greater omentum. OP gives a smooth, reverse C-shaped configuration to the sleeved stomach, intern reducing the intragastric pressure and kinking. This resembles closely to the normal stomach anatomy (Fig. 9).

Of note, the greater intraluminal diameter of normal stomach than any SG would increase the intragastric pressure in LSG as explained by fluid physics earlier. In our study, we did not perform manometry or measure the actual intragastric pressures. We think that it would be clinically impractical to check these parameters in asymptomatic patients. Whether the anatomy after LSG with OP affects gastric emptying and intragastric pressures needs to be further investigated. This is important to understand in postoperative GERD as it is governed by multiple factors. These are the lower esophageal sphincter characteristics [33–36], anatomy of gastro-esophageal junction [37, 38], anatomy of diaphragmatic hiatus, impaired esophageal motility or hiatal hernias [39–41]. Therefore, it is more complicated to evaluate the direct effects of OP on gastro esophageal reflux after LSG.

Back to the principles of fluid dynamics in a curved tube, we think that the gastric angle at the level of incisura is more acute without OP and results into more resistance to flow and increased intragastric pressure. This may contribute to slightly higher proximal staple line leaks in patients without OP. As shown in Fig. 10, D1 and D2 are the diameters of the curves of the SG, with midpoint of hepato-gastric ligament as the fixed center. D1 is greater than D2, resulting into differences in the gastric angle at the level of incisura. Also, the vector of forces is more evenly balanced with the technique of OP as compared with no OP, in which case there is absent lateral traction on the stapled side. This is shown in Figs. 10 and 11.

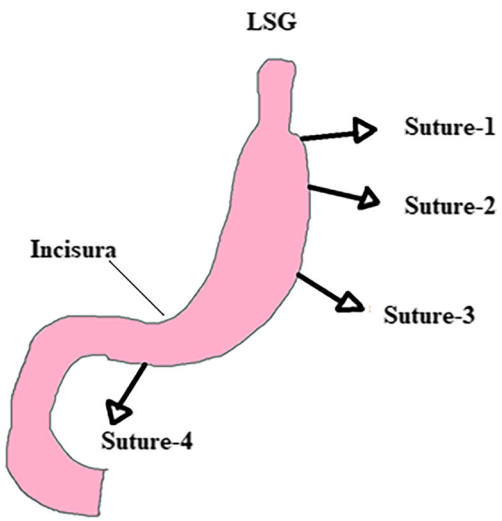

Fig. 11 Site of OP sutures

Studies addressing staple line re-enforcement (SLR), propose that SLR probably lowers postoperative bleeding but it does not have any effect on leak outcomes. In our study, we observed statistically significant lower leak rates with OP as compared with NP. However, NP group in our study mostly had patients with Lemberting of the staple line (LS), which has shown lower leak rates as discussed previously. Within NP group, we compared the leak rates in patients with Lemberting (LS) and BSLR (Bioabsorbable Staple line re-enforcement) and found no statistical difference in the findings. However, the comparison between LS group and BSLR group with OP group was statistically significant for leaks. This is shown in Tables 3 and 4. As discussed above, use of BSLR does not prevent leaks; therefore, the difference of outcomes is possibly due to OP, when comparing the two methods. Also, LS has lower leak rates in general, but, when compared to OP, the outcomes are less desirable.

There is one study in the literature that showed no benefits to adding OP [42], while all others as discussed above have shown variable outcomes. Most of the other studies on OP have not described their techniques in detail, especially

Table 3 Postoperative leak outcomes for all patients

Surgeon	Technique	GD	Total patients
A	Omentopexy (OP)	0	370
B	Lemberting and fibrin sealant	4	286
C	Partial BSLR	3	81

A, B and C represent surgeons

GD gastric disruption

Table 4 Comparison of postoperative leak outcomes by technique

Comparison of outcomes	Total LSG patients	GD	*P* value
A and B	656	0 versus 4	0.04
A and C	451	0 versus 3	0.006
B and C	367	4 versus 3	0.18

A, B and C represent surgeons

A Omentopexy (OP)

B Lemberting and fibrin sealant

C Partial BSLR

GD gastric disruption

lacking the information on the specifics of placement of fixation sutures. We believe that correct technique of performing OP is paramount, in that it will eventually affect the pressure physiology and clinical outcomes. In our technique, we typically place 2–4 sutures at the site proximal to incisura and one suture at the most distal end of staple line as shown in Fig. 11. We never put any suture at the level of incisura as this would compromise the gastric angle at the incisura negating the benefits of OP. This technique essentially makes the LSG more desirable giving it a smoother anatomical configuration and an obtuse angle at the gastric outlet as shown in Fig. 11.

We have continued to perform OP even in our robotic sleeve gastrostomies. There is no doubt that it adds additional 15–30 min to the operative time, on a case-by-case basis. We believe that it is worthwhile to add it to LSG as it takes a short time to perform OP.

Our study is limited due to its retrospective nature, lack of randomization, selection and surgeon bias. As it is true with other studies doing comparative analysis of surgical techniques, it is arduous to accurately control and replicate the steps and dimensions of performing the operative procedure in each subject or even the same subject. This fact will limit the outcomes of any surgical study, solely based on the techniques. Most of our data is clinical, and we think that objectively measuring gastric pH and pressures or performing gastric motility study in a sleeved stomach would add substantial evidence, but this may not be practical. As these tests cannot be routinely justified in practice without any clinical indications, there is always a possibility that the patients who lost follow-up may have had complications and were treated elsewhere or they simply changed their location. We suggest that a more well-designed and well-controlled studies are needed to uphold the validity of our study.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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