Surg Endosc (2011) 25:88–97
DOI 10.1007/s00464-010-1136-5

Impact of surgeon experience and buttress material on postoperative complications after laparoscopic sleeve gastrectomy

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Received: 22 September 2009 / Accepted: 20 April 2010 / Published online: 5 June 2010

Abstract

Background Sleeve gastrectomy is gaining popularity whether as a primary, staged or revisional operation. The aim of this study is to evaluate the perioperative safety and the learning curve for laparoscopic sleeve gastrectomy (LSG).

Methods We performed a retrospective review of the prospectively collected data for all patients who underwent LSG for the treatment of morbid obesity at our institution from January 2003 to December 2008.

Results Data from 230 consecutive patients [male 47%, female 53%; mean age 44.0 ± 10.0 years, mean preoperative body mass index (BMI) 56.7 ± 11.5 kg/m^2], who were operated upon by three surgeons with different degrees of bariatric experience, were analyzed. There was no 30-day mortality, but there were two cases of late mortality (0.87%). Early complications were noted in 23 cases (10.0%), including 10 cases of leak (4.3%) and 10 cases of hemorrhage (4.3%). In 17 cases (7.4%) reoperations were performed. The rates of overall and major complications did not differ among surgeons or between early and late period of experience for the three surgeons; this trend held true individually and in subgroups. Overall, over the course of the learning curve, a significant decrease in operative time was noted. The only factor that was independently associated with complications was use of buttress material; the likelihood of complications was found to be 72% lower in patients in whom buttress material was used.

Conclusions LSG constitutes a potentially safe anti-obesity procedure with acceptable morbidity. Experience at the beginning can be discouraging, even for surgeons with advanced laparoscopic skills. LSG can be performed safely, with proper mentoring and in appropriate settings, even by less experienced bariatric surgeons. The use of staple-line reinforcement was associated with improved perioperative outcomes, and it should be considered in an attempt to decrease leaks.

Keywords Bariatric surgery · Sleeve gastrectomy · Complications · Learning curve · Staple-line reinforcement · Buttress material

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Laparoscopic sleeve gastrectomy (LSG) has been indicated as a definitive treatment in patients with BMI >40 kg/m^2 or BMI >35 kg/m^2 associated with comorbidities, and it has also been proposed for patients with moderate obesity BMI <35 kg/m^2 and metabolic syndrome [1–3]. Although classified as a restrictive procedure, sleeve gastrectomy (SG) appears to be more than just a gastric restrictive operation, because with the removal of the gastric fundus the number of orexigenic cells that produce the hormone ghrelin is significantly reduced [4]. Thus, SG is not only a multipurpose operation but also a multifactorial one, with a restrictive aspect and a complex neurohormonal aspect, not yet fully elucidated [5–7].

Patients experience excellent weight loss after SG alone, and multiple recent reports have documented SG as a single therapy for the treatment of morbid obesity [8, 9].

SG appears to be a technically easier and faster laparoscopic procedure than Roux-en-Y gastric bypass or malabsorptive procedures, in that there is no gastrointestinal anastomosis. However, LSG is not a "simple" procedure. Mortality of approximately 1% has been reported, which in a high-volume center for LSG, was increased to 3.2% among high-risk patients [5, 10]. Additionally, a median complication rate of 4.5% was recently demonstrated after a collective analysis of 17 cohorts of patients undergoing SG [10].

The aim of the present study is to audit and analyze our perioperative outcomes. Furthermore we tried to determine whether, despite previous experience with other kinds of laparoscopic surgery, there is a learning curve specific to LSG. We looked specifically at the impact of different surgeons and training backgrounds, and we further investigated the extent of the learning curve for LSG for a surgeon with advanced laparoscopic and bariatric skills in a newly established bariatric operation. Moreover we attempted to explore whether certain patient characteristics or surgical technical factors may be associated with adverse outcomes.

Materials and methods

The data of all patients, who underwent LSG for the treatment of morbid obesity at our institution from January 2003 to December 2008, were retrospectively reviewed from our prospectively collected database. The patients were offered LSG if their BMI was $\geq$60 kg/m^2. Additionally, LSG was performed in patients with contraindications for gastric bypass or malabsorptive operations (e.g., increased surgical risk due to severe comorbidities, multiple dense adhesions due to previous abdominal operations, anticoagulant or anti-inflammatory medication use, liver cirrhosis, inflammatory bowel disease, severe osteoporosis) and BMI $\geq$35 kg/m^2 in the presence of significant comorbidities that could be improved by weight loss or patients with BMI >40 kg/m^2. All patients were evaluated preoperatively by a multidisciplinary team consisting of a bariatric surgeon, an internist, an anesthesiologist, and a dietician. A thorough discussion of feasible surgical options, in conjunction with the individual characteristics of every patient, postoperative quality of life, expected weight loss, and possible complications, was carried out in every case. All patients gave their written informed consent prior to clinical and surgical procedures, with the understanding that LSG is a novel operation without enough long-term (>5 years) data on sustained weight loss and resolution of obesity-related comorbidities. A complete preoperative assessment was undertaken in all patients, including upper endoscopy and abdominal ultrasound.

All LSG were performed by one of three surgeons (A, B, C). Surgeon A is a dedicated bariatric surgeon with wide experience in advanced laparoscopic surgery. Surgeons B and C had experience in laparoscopic surgery including appendectomy, hernia repair, and cholecystectomy but no previous experience in bariatric operations; both assisted surgeon A in several LSG and other bariatric operations such as laparoscopic gastric bypass before their bariatric start-up. There was no variation in surgical technique among the surgeons.

Analyzed variables included BMI at operation, gender, age, type of previous abdominal operations, comorbidities, medication in use, operative time, use of buttress material, volume of resected stomach, in-hospital stay, early postoperative complications, and early readmissions. Operative time was recorded as time between initial skin incision and final skin suture. The early postoperative period was defined as within 30 days of surgery. The volume of the resected part of the stomach was measured by filling it, in the hanging position, with saline just after its removal [6].

Surgical procedure

The patient is placed in the lithotomy position with the surgeon positioned between the legs. Our technique involves establishing pneumoperitoneum to 15 mmHg pressure by using the Veress needle technique in the left upper quadrant. Pneumoperitoneum is maintained by a high-flow insufflator with warm gas flow up to a maximum of 45 L/min. The reverse Trendelenburg position is utilized, and five bladeless 12-mm trocars (three working ports, one port for the liver retractor, and one port for the camera) are typically placed. Dissection begins at the angle of His, defining the left crus of the diaphragm so as to facilitate total resection of the fundus (Fig. 1). Thereafter, the pylorus is identified and the division of the vascular supply of the greater curvature of the stomach follows, with ligation of the gastrocolic and gastrosplenic ligaments close to the stomach, avoiding the gastroepiploic vessels. Any posterior gastric attachments are also divided. The third step of the procedure is longitudinal transection of the stomach, starting 5–6 cm proximal to the pylorus, alongside a calibration tube through sequential firings of two green (4.8 mm) and three to five blue (3.5 mm) cartridges with a linear stapler. We apply the green cartridges to the thicker gastric wall near the pylorus and the blue ones to the thinner proximal gastric wall. A 42-French bougie is currently used. Initially in our experience, the staple line was reinforced with a running suture that later on was modified, due to the use of blue cartridges armed with a bioabsorbable buttress material (Peri-Strips Dry; Synovis, St. Paul, MN, USA), to a single inverted suture at the distal end of the staple line. Additional suture ligatures are used

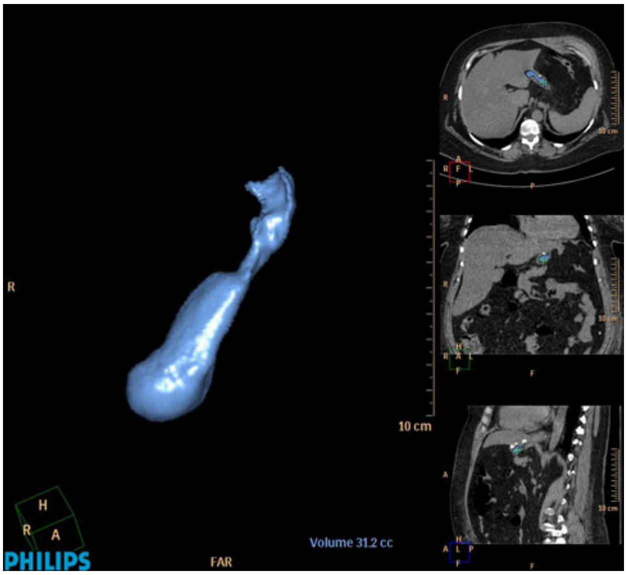

Fig. 1 Gastric sleeve volume measurement after LSG, 4 days after surgery, using a 64-channel multidetector computed tomography (CT) scanner. The total resection of the fundus can be noted

in case of staple-line bleeding. After completion of the gastric transaction, the integrity of the staple line is tested through instillation of methylene blue-stained saline. Finally, a silicon drain is placed at the left subdiaphragmatic space, and the resected stomach is removed in a specimen bag.

Perioperative care

The perioperative standardized antithromboembolic protocol of our department involves subcutaneous administration of enoxaparin sodium (4,000 anti-Xa IU/0.4 ml), once preoperatively (the evening before surgery) and once postoperatively (on a daily basis until day of discharge), in combination with graded elastic compression stockings and early ambulation, which is initiated on the evening of the operation. A single prophylactic dose of antibiotics is administered immediately before skin incision. Nasogastric tubes are not routinely used. Postoperatively, after successful extubation, patients are transferred to the Intensive Care Unit for overnight monitoring. On the second postoperative day, patients begin to receive limited amount of clear fluids by mouth. The amount of fluids consumed is increased the following day, and oral feeding (liquid diet) is resumed. The patients are advised to observe a fully liquid diet for the first 3 postoperative weeks, progress to half-solid food during the fourth week, and then continue with regular meals under specific dietary instructions. Proton pump inhibitor therapy is given to all patients for 6 weeks after the operation, while in those with positive preoperative tests for *Helicobacter pylori* infection, eradication treatment is recommended. Complete follow-up at the outpatient department is performed at 1, 6, and 12 months postoperatively, and annually thereafter.

Statistical analysis

Normal variables are presented as mean and standard deviation, while skewed variables are presented as median and interquartile range. Quantitative variables are presented as absolute and relative frequencies. For comparisons of proportions, chi-squared and Fisher's exact tests were used. To control for multiple testing in comparisons among the three surgeons a significance level of ≤ 0.016 was set. Student's *t*-test was computed for comparison of mean values for normal variables. The nonparametric Mann–Whitney test was used for comparison of median values. Spearman's correlation coefficients were used to explore the association of two continuous variables. Multiple logistic regression analysis was used to identify factors that were independently associated with outcome. Adjusted odds ratios with 95% confidence intervals were computed from the results of the logistic regression analysis. All *p*-values reported are two-tailed. Statistical significance was set at 0.05, and analyses were conducted using SPSS statistical software version 13.0 (SPSS Inc., Chicago, IL, USA). The patients were divided equally into two consecutive chronological groups (early and late period of experience) to accurately assess the surgeon-dependent learning curve. Comparisons were also carried out between surgeon A (mentor) and surgeons B + C.

Results

A total of 230 consecutive patients were enrolled in our study. Mean age of the study cohort was 44.0 ± 10.0 years, while mean preoperative BMI was 56.7 ± 11.5 kg/m^2. Median operative time was 58 min (44–82 min), and median resected stomach volume was 950 ml (750–1,200 ml). All operations were completed laparoscopically. Median in-hospital stay was 5 days (5–6 days). There was no 30-day mortality, but there were two cases of late mortality (0.87%) due to surgery-related reasons. Both patients were super-superobese and were reoperated upon due to leakage and bleeding, respectively. Multiple reoperations were necessary for the first patient, who died after a long hospitalization in the ICU due to multiple organ failure. After the second operation, the second patient developed severe rhabdomyolysis, which resulted in renal failure. He died several months later due to complications during treatment for renal failure. Both patients were operated upon at the beginning of our experience with LSG.

Twenty-four patients had undergone a previous failed laparoscopic gastric banding procedure for the treatment of obesity. More than half of the patients had undergone at least one previous abdominal surgery (62.2%). Thirty-seven patients (16.1%) had received one operation in the upper abdomen, while 20 patients (8.7%) had received at least two operations in the upper abdomen. Surgeon A performed 109 LSG (47.4%), surgeon B performed 45 LSG (19.6%), and surgeon C performed 76 cases (33.0%).

Patient characteristics and preoperative comorbidities are presented in Table 1. Our series included a considerable number of patients with obesity-related comorbidities. Sixty percent of them (138 patients) presented with a medical history of at least three comorbidities. Most patient parameters were nonsignificant between the two subgroups (A versus B + C), with the exception of a higher mean age (42.0 ± 11.0 versus 46.0 ± 10.0 years, $p = 0.006$) and higher incidence of hyperlipidemia, psychiatric disorders, and use of nonsteroidal anti-inflammatory drugs (NSAIDs) for the B + C subgroup. Surgeon A operated on significant more patients with liver disease.

Early complications were noted in 23 cases (10.0%) (Table 2). Blood transfusions were given to eight patients (3.5%). In 17 cases (7.4%) reoperations were performed and, of those, 13 cases (76.5%) were carried out laparoscopically. The most common leak location was proximal to the gastroesophageal junction (seven cases). In two cases the leak was detected at the distal end of the staple line. Hemorrhage incidence included two cases of liver injury, one case of spleen injury (splenectomy was required), three cases of trocar-site bleeding, four cases of staple-line bleeding, and one case of gastrocolic ligament bleeding. The rates of overall and major complications did not differ between subgroup A and subgroup B + C (Table 3). Moreover, no differences in complication rates were observed among the three surgeons (Table 4).

Table 1 Patients' demographic characteristics, incidence of comorbidities, and use of medication

	N	%
Gender		
Male	108	47
Female	122	53
Preoperative BMI (kg/m^2)		
<60	140	60.7
≥60	90	39.1
Hypertension	155	67.4
Diabetes	87	37.8
Sleep apnea	60	26.1
Musculoskeletal disorders	76	33
Hyperlipidemia	35	15.2
Liver disease	60	26.1
Heart disease	34	14.8
Psychiatric disorders	36	15.7
Hypothyroidism	29	12.6
Hyperuricemia	24	10.4
Inflammatory bowel disease	6	2.6
GERD	22	9.6
DVT	12	5.2
NSAIDs	34	14.8
Aspirin	30	13
Anticoagulants	24	10.4

DVT deep venous thrombosis, *GERD* gastroesophageal reflux disease, *NSAIDs* nonsteroidal anti-inflammatory drugs

Specifically, in the subgroup of patients who underwent laparoscopic conversion to SG after failed laparoscopic gastric banding (LAGB), a one-step revision procedure was performed in 7 patients (29.2%), while a two-step procedure was performed in 17 patients (70.8%). Two early postoperative complications were recorded (8.3%): one case of leak that required laparoscopic exploration for repair and drainage on the first postoperative day, and one case of bleeding in which immediate conversion to LSG was utilized and that was successfully treated with transfusion.

Over the course of the learning curve, a significant decrease in operative time was noted (Table 5). Comparison of the early period of experience with the late period of experience (first-half cases versus second-half cases) for surgeon A, B, and C individually demonstrated no significant reductions in the rates of complications, reoperations, or readmissions; however, length of surgery was shorter for all surgeons in the second phase of experience (Fig. 2). When complications, reoperations, readmissions, and operative characteristics were compared between the two subgroups (A versus B + C), for the early and the late stage of experience, only a significantly increased median operative time was noticed in the early period [57 min (45–79 min) versus 75 min (55–91 min), $p = 0.034$] for the newly trained bariatric surgeons. In the entire cohort, a significantly negative correlation was found between the

Table 2 Early postoperative complications

	N	%
Early complications	23	10.0
Leak	10	4.3
Bleeding	10	4.3
Other early complications (ischemic stroke, urinary tract infection, trocar-site abscess)	3	1.3
Reoperations	17	7.4
Blood transfusion	8	3.5
Early readmissions	4	1.7

Table 3 Comparison of complication rates and resected stomach volume between surgeon A and surgeons B + C

	Operator				*p* Fisher's exact test
	A		B + C		
	N	%	*N*	%	
Early complications					
No	99	90.8	108	89.3	0.553[a]
Yes	10	9.2	13	10.7	
Early readmissions					
No	107	98.2	119	98.3	>0.999
Yes	2	1.8	2	1.7	
Reoperations					
No	101	92.7	112	92.6	>0.999
Yes	8	7.3	9	7.4	
Leak					
No	105	96.3	115	95	0.752
Yes	4	3.7	6	5	
Bleeding					
No	104	95.4	116	95.9	>0.999
Yes	5	4.6	5	4.1	
Other early complications					
No	109	100	118	97.5	0.249
Yes	0	0	3	2.5	
Blood transfusion					
No	104	95.4	118	97.5	0.482
Yes	5	4.6	3	2.5	
Resected stomach volume (ml), median (range)	950 (750–1,125)		1,000 (750–1,200)		0.611[b]

[a] Chi-square test

[b] Mann–Whitney test

operative time and the number of cases ($r = -0.24$, $p < 0.001$) (Fig. 3) unrelated to patient's preoperative BMI for both subgroups ($r = 0.16$, $p = 0.107$ for A and $r = -0.01$, $p = 0.998$ for B + C).

A thorough assessment of the complications was carried out, and multiple logistic regression analysis was conducted with early complications as a dependent variable and the following as independent variables: gender, age at operation, preoperative BMI, length of surgery, surgeon, number of previous upper abdominal operations, and use of buttress material (Table 6). The only factor that was independently associated with complications was use of buttress material. The likelihood for complications was 72% lower in patients in whom buttress material was used. Specifically, reinforcement with buttress material was found to significantly decrease the rate of complications, reoperations, and leak (Table 7). Buttress material was used in 144 cases (62.6%).

Discussion

Sleeve gastrectomy is gaining popularity whether as a primary, staged or revisional operation [11]. In the last 3 years, the number of reports and series using LSG as a single-stage operation has increased [12–14]. This has resulted in widespread use of this procedure and an ever-growing number of surgeons offering LSG. However, the introduction of LSG, as a single-stage procedure in the bariatric field, requires more data regarding potential postoperative complications as well as long-term results. We report one of the largest single-center series to date of LSG and thoroughly examine the procedure's short-term morbidity and mortality.

LSG represents a valuable surgical intervention to supplement bariatric procedures currently used in the treatment of morbid obesity. LSG has the disadvantage of not being reversible, but it appears to be a safe and effective procedure with low morbidity and mortality that can be carried out in a reasonable operative time and with greater ease than LRYGB or LBPD-DS [15, 16]. However, LSG in morbidly obese patients is major surgery. The staple line is long, with potential for leakage and bleeding. Leakage is one of the most frequently reported causes of death after laparoscopic weight-loss operations including LSG, so we emphasize the importance of timely diagnosis and treatment [10, 17]. When such a complication is recognized promptly, it can be treated with an appropriate relaparoscopic procedure, and the worst-case scenario can be

Table 4 Comparison of complication rates among surgeons

	Operator						A versus B	A versus C	B versus C
	A		B		C				
	N	%	*N*	%	*N*	%	p^{a} Fisher's exact test		
Early complications									
No	99	90.8	39	86.7	69	90.8	0.562[b]	0.993[b]	0.549[b]
Yes	10	9.2	6	13.3	7	9.2			
Early readmissions									
No	107	98.2	44	97.8	75	98.7	>0.999	>0.999	>0.999
Yes	2	1.8	1	2.2	1	1.3			
Reoperations									
No	101	92.7	39	86.7	73	96.1	0.236	0.529	0.076
Yes	8	7.3	6	13.3	3	3.9			
Leak									
No	105	96.3	40	88.9	75	98.7	0.123	0.650	0.026
Yes	4	3.7	5	11.1	1	1.3			
Bleeding									
No	104	95.4	44	97.8	72	94.7	0.672	>0.999	0.650
Yes	5	4.6	1	2.2	4	5.3			
Other early complications									
No	109	100	44	97.8	74	97.4	0.292	0.167	>0.999
Yes	0	0	1	2.2	2	2.6			
Blood transfusion									
No	104	95.4	45	100	73	96.1	0.322	>0.999	0.293
Yes	5	4.6	0	0	3	3.9			

[a] Significance level ≤0.016

[b] Chi-square test

avoided. We should never forget that we operate on patients who appear to be "healthy" but are not. Systemic disorders derived from postoperative complications are more difficult to control and can lead to fatal outcome in morbidly obese patients, as in our initial stage of experience with LSG. Early re-exploration for leaks has been our guiding principle in this high-risk population.

In our series, there were no conversions to laparotomy, even though 62.2% of the patients had undergone at least one previous abdominal surgery. LSG has recently been reported as a safe and effective alternative to gastric bypass for patients with multiple intra-abdominal adhesions [18]. Our results strongly support these findings. The reoperation rate of 7.4% is higher than presented in other series of LSG [10, 19, 20]. Still, we believe in an aggressive approach toward a relaparoscopy when in doubt of major complications. Our experience also demonstrates that reoperations may be managed laparoscopically in many cases.

Although our early morbidity rate (10.0%) appears high, these complications did not result in significant long-term morbidity in most cases. An average complication rate of 9% was reported in a review of the first 15 studies looking at outcomes of SG, with leak being the most frequently reported postoperative complication [21]. The incidence of gastric leak and bleeding in several reports concerning LSG is listed in Table 8. Our leak rate of 4.3% seems to be relatively high but is consistent with that reported by other studies (Table 8). In our cohort, leak presented in ten cases, and it occurred early (during the first 72 postoperative hours) in nine of these cases, implicating mechanical causes. Mechanical failures represent the vast majority of leaks following bariatric surgery [22]. Moreover, our data suggest that patients are at risk of leak or bleeding after LSG regardless of surgeon experience. In addition, a learning effect could not be shown for the rates of complications, readmissions or reoperations. However, outcomes clearly improved with additional experience. This may indicate that, in attempting to statistically define a learning curve that incorporates all these parameters, a large number of procedures would have to be included due to the relatively low frequency of these events. Nevertheless, as experience is accumulated, surgeons tend to increase the complexity of the operations by approaching more challenging patients, and this may be reflected in our results.

Interestingly, our data, although retrospective, showed that LSG is a feasible option as a revisional procedure for failed LAGB, though with a slightly higher complication

Table 5 Comparison of operative characteristics and complications between early and late period of experience

	First 115 cases		Second 115 cases		*p*
	N	%	*N*	%	
Early complications					
No	102	88.7	105	91.3	0.388[a]
Yes	13	11.3	10	8.7	
Early readmissions					
No	112	97.4	114	99.1	0.372[b]
Yes	3	2.6	1	0.9	
Reoperations					
No	104	90.4	109	94.8	0.208[a]
Yes	11	9.6	6	5.2	
Leak					
No	109	94.8	111	96.5	0.518[a]
Yes	6	5.2	4	3.5	
Bleeding					
No	109	94.8	111	96.5	0.518[a]
Yes	6	5.2	4	3.5	
Other early complications					
No	114	99.1	113	98.3	>0.999[b]
Yes	1	0.9	2	1.7	
Blood transfusion					
No	110	95.7	112	97.4	0.722[b]
Yes	5	4.3	3	2.6	
Preoperative BMI (kg/m^2), mean ± SD	56.0 ± 11.4		57.4 ± 11.6		0.346[c]
Resected stomach volume (ml), median (range)	980 (850–1,200)		900 (700–1,200)		0.144[d]
Operating time (min), median (range)	68 (47–95)		54 (40–69)		<0.001[d]
Postoperative in-hospital stay (days), median (range)	5 (5–6)		5 (5–5)		0.960[d]

[a] Chi-square test
[b] Fisher's exact test
[c] Student's *t*-test
[d] Mann–Whitney test

rate than the primary procedure. In agreement with our data, recent reports have demonstrated the safety and feasibility of the laparoscopic conversion of adjustable gastric banding to SG [23, 24].

During the later phase of our experience, significantly improved outcomes in terms of operative time were noted. Operative time has been shown, in multiple studies from the bariatric field, to decrease significantly with experience, and our data demonstrate this with a significantly lower operative time throughout the series [25–27]. Operating time did not level out after the first-half cases but continued to fall. This may reflect that learning and improvements in operating efficiency may continue beyond a particular learning curve point. The maximum times are attributed to multiple adhesions and/or large abdominal hernias in patients with previous open abdominal surgery. As with any surgical procedure, the first and foremost goal is to perform it with minimal morbidity; however, as experience is gained, it is reasonable to expect a general decrease in operative time. Prolonged operative time potentially carries more clinical significance, in association with the incremental risk involved in prolonged anesthesia, and the impact on efficiency and turnover rate in the operating room.

Bariatric training in the form of fellowship or extended mentoring has been shown to affect outcomes, especially for less experienced surgeons [28]. The learning curve was shorter for surgeons who initiated their experience at an institution with an established laparoscopic bariatric program [29, 30]. On the basis of our data, this is also true for LSG, given that patient selection criteria, equipment and instruments, operative technique, postoperative care, and staff education are standardized and established. Among surgeons of different training backgrounds, no differences were found concerning complications, reoperations but also resected stomach volume, with the latter being a predictor of failure in treatment or early weight regain when <500 ml [6]. Surgical times for the initial experience of the newly trained bariatric surgeons were significantly longer than for the initial cases performed by the experienced bariatric surgeon; however, this figure dropped rapidly.

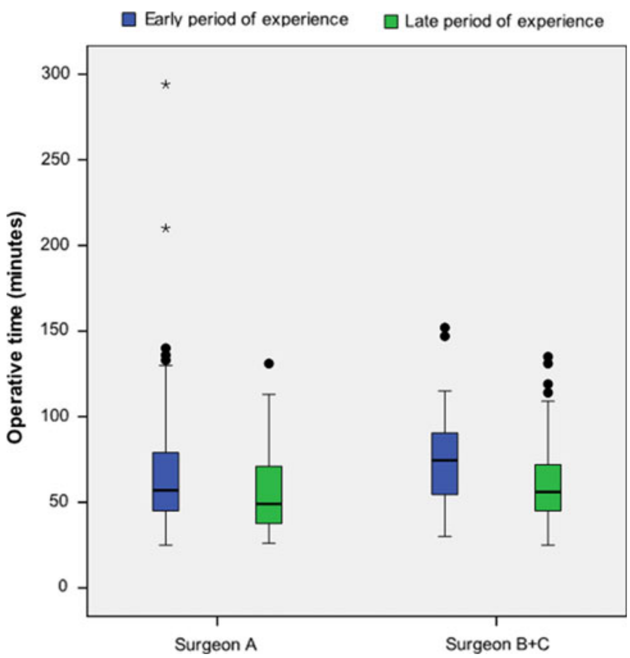

Fig. 2 Median values of operative time for early and late period of experience according to surgeon

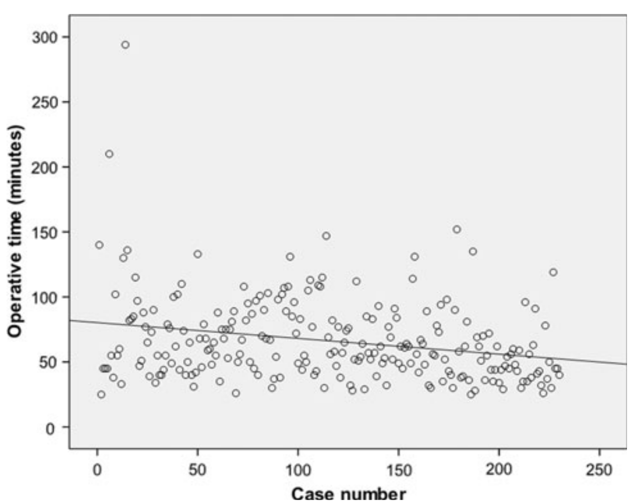

Fig. 3 Linear association of operative time with number of cases

Our complications were not associated with either preoperative BMI or experience of the operator. However, a significant decrease in complications, reoperations, and specifically leaks was related to the use of blue cartridges that incorporated buttress material. Staple-line buttressing has been shown to significantly increase staple-line strength [22]. Earlier reports have demonstrated the efficacy of staple-line reinforcement during laparoscopic gastric bypass [31, 32]. Moreover, Consten et al. have shown that use of buttress material in the staple line of sleeve gastrectomy may reduce staple-line hemorrhage and

Table 6 Multiple logistic regression analysis for early complications

	OR (95% CI)[a]	*p*
Gender		
Male	1.0[b]	
Female	1.75 (0.68–4.55)	0.248
Age at operation	1.01 (0.97–1.06)	0.582
Preoperative BMI	1.03 (0.99–1.07)	0.183
Operating time (30 min increase)	1.33 (0.89–1.99)	0.159
Operator		
A	1.0	
B + C	1.71 (0.63–4.67)	0.293
Previous upper abdominal operation		
None	1.0	
One	1.17 (0.37–3.69)	0.787
Two or more	0.22 (0.02–2.65)	0.231
Use of buttress material		
No	1.0	
Yes	0.28 (0.10–0.79)	0.016

[a] Odds ratios (OR) and 95% confidence intervals (CI)

[b] Reference category

Table 7 Association of staple-line reinforcement and complication rates

	Use of buttress material				*p* Fisher's exact test
	Yes		No		
	N	%	*N*	%	
Early complications					
No	135	93.8	72	83.7	0.013[a]
Yes	9	6.2	14	16.3	
Early readmissions					
No	141	97.9	85	98.8	>0.999
Yes	3	2.1	1	1.2	
Reoperations					
No	138	95.8	75	87.2	0.016[a]
Yes	6	4.2	11	12.8	
Leak					
No	141	97.9	79	91.9	0.043
Yes	3	2.1	7	8.1	
Bleeding					
No	140	97.2	80	93	0.181
Yes	4	2.8	6	7	
Other early complications					
No	142	98.6	85	98.8	>0.999
Yes	2	1.4	1	1.2	
Blood transfusion					
No	141	97.9	81	94.2	0.154
Yes	3	2.1	5	5.8	

[a] Chi-square test

Table 8 Incidence of gastric leak and bleeding after LSG in reported series

Author	No. of patients	BMI (kg/m^2)	Calibration bougie	Reinforcement	Leak rate (%)	Bleeding rate (%)
Nocca D et al. [8]	163	45.9 (mean)	36 F	Running suture or buttress material	5.5	1.2
Frezza E et al. [10]	53	53.5 (mean)	38 F	Buttress material	3.7	5.6
Jacobs M et al. [14]	157	44.3 (mean)	46–40–36 F	Buttress material ± sutures, fibrin sealant	1.3	NR
Cottam D et al. [16]	126	65.4 ± 9.0 (mean)	46–50 F	Fibrin glue	1.6	0
Lalor P et al. [19]	148	44.0 (mean)	52 or 44 F	Running suture	0.7	0.7
Lee C et al. [36]	216	49.0 ± 11.0 (mean)	32 F	Selectively buttress material	1.4	0.5
Fuks D et al. [37]	135	48.8 (mean)	34 F	Not systematically	4.5	0
Casella G et al. [38]	200	19 pts (9.5%) >60	48 F	Running suture	3.0	NR
Burgos AM et al. [39]	214	37.8 ± 5.0 (mean)	32 or 38 F	Suture	3.3	NR
Present series	230	56.7 ± 11.5 (mean)	42 F	Running suture or buttress material	4.3	4.3

NR not reported

leakage. The authors hypothesized that this may have contributed to shorter hospital stay, decreased costs, and lower morbidity [33]. Different techniques are implemented to reinforce the staple line, including buttressing and oversewing; however, the latter seems to be associated with higher incidence of sleeve stricture [9]. On the contrary, a recent report by Chen et al. argued against routine reinforcement of the staple line during SG [34]. Staple-line leak after LSG may still occur despite use of buttress material or oversewing the staple line [35]. However, in our series of very high-BMI patients, reinforcing the staple line with buttress material ultimately improved the early postoperative morbidity rate. Laparoscopic bariatric surgery is incredibly resource dependent because a multitude of instruments are required. Although buttress materials are not inexpensive and their use may add to the cost of SG, our results support the additional cost.

There were only a few differences in the patient profiles among the patients of the two subgroups; thus, we feel that the patient populations of the two subgroups were sufficiently similar for a fair comparison, especially because all analyses were done while controlling for potentially confounding variables. Therefore, despite the limitations of a retrospective study, the concurrent collection and analysis of data might help to minimize the occurrence of similar subsequent complications. Accurate recording of all patient outcomes and complications is essential to modern practice, as they will be scrutinized by patients, payers, and credentialing bodies. This is particularly important when developing a new procedure.

In conclusion, this study indicates that LSG constitutes a potentially safe anti-obesity procedure for high-risk patients with acceptable early postoperative morbidity. The experience can be discouraging at the beginning, even for surgeons with advanced laparoscopic skills, but this can be easily overcome. LSG can be performed safely, with proper mentoring and in appropriate settings, by less experienced bariatric surgeons. The use of staple-line reinforcement was associated with improved perioperative outcomes, and it should be considered in an attempt to decrease leaks.

Disclosures Authors M. Daskalakis, Y. Berdan, S. Theodoridou, G. Weigand, and R. Weiner have no conflicts of interest or financial ties to disclose.

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