Research Square

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Staple Line Reinforcement During Laparoscopic Sleeve Gastrectomy: Comparison of Through and Through vs. Lembert's Oversewing Methods: Single Center Experience

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Abstract

Backgrounds: The most serious stapler line complications (SLC) following laparoscopic sleeve gastrectomy (LSG) are bleeding and stapler line leakage (SLL). Various oversewing methods are used that reduce SLC by reinforcing the staple line (SLR): Through and Through (TaT) or Lembert suturing. In this retrospective study, we compared the effects of the Lemberts and TaT suturing on SLC incidence. Methods: A total of 586 patients were included in the study. These patients were divided into two groups: TaT (n=386) and Lemberts (n=200). The primary endpoints were SLL and bleeding. Secondary endpoints included postoperative complications, Clavien-Dindo Grade ≥3 complications, operative time, oversewing time, length of hospital stay, and mortality. Results: Operative time was longer in the TaT suturing method ($p<0.001$), while oversewing time was longer in the Lemberts suturing method ($p<0.001$). The incidence of bleeding and SLL was significantly lower with Lembert's suturing method ($p=0.01$, $p=0.04$; respectively). All postoperative complications, Clavien-Dindo Grade ≥3 complications and length of hospital stay were more seen in the TaT suturing method ($p=0.002$, $p=0.02$, $p<0.001$; respectively). The incidence of blood transfusions, intensive care unit stay, and readmission rates were similar between the two methods. Conclusion: Compared to the TaT suturing method, the Lemberts suturing method was associated with a reduction in postoperative bleeding, SLL, all postoperative complications, Clavien-Dindo Grade ≥3 complications, and length of hospital stay, without causing a major difference in oversewing and total operative time. No differences were found between the two methods in terms of blood transfusion, intensive care unit stay, or mortality.

1. Introduction

Laparoscopic Sleeve Gastrectomy (LSG) is now performed as a primary bariatric procedure due to its technical simplicity, excellent weight loss outcomes, absence of anastomosis, suitability as a bridge therapy for high-risk patients, and low rates of major morbidity (0.2–10%) and mortality (< 1%) [1–5]. LSG is not without complications, and can lead to significant complications due to the long stapler line. The most common stapler line complications (SLC) following LSG are stapler line leak (SLL) and bleeding [6]. Bleeding is the most common complication and occurs in approximately 1.1–4% of patients [7]. Bleeding is generally managed conservatively. SLL is the most dangerous complication and occurs in approximately 0.5–2.7% of patients [8, 9]. SLL is treated using one of several methods: medical, endoscopic, radiological, or surgical. SLL can also lead to mortality [10, 11].

Various methods to reinforce the stapler line (SLR) have been proposed to reduce SLL in the early period: suturing the stapler line, reinforcing the stapler line with various synthetic and biological materials, etc [12, 13]. At the International Sleeve Gastrectomy Surgery Consensus Meeting, it was reported that 100% of surgeons agreed that SLR reduces bleeding, 77% considered SLR acceptable, and 95% supported reinforcing the stapler line with sutures [14]. However, according to a report by the American Society for Metabolic and Bariatric Surgery (ASMBS), while the oversewing method is not recommended because it increases the risk of SLL due to impaired perfusion and/or ischaemia at the stapler line, it is noted that its application is understandable from a safety perspective [15]. Therefore, although SLR is not preferred

by some surgeons [14], a recent meta-analysis has shown that SLR significantly reduces the incidence of bleeding and SLL [7].

The use of oversewing as an SLR method is increasing [16, 17]. There are two commonly used oversewing techniques: seromuscular or seroseral imbrication suturing (Lembert's) and seroseral full-thickness suturing (over and over = through and through (TaT) [18]. Many randomized controlled trials (RCTs) and retrospective studies (RSs) have reported that the incidence of SLL and bleeding with the oversewing method is similar to that of non-SLR or other SLR methods [13, 19–23]. However, several RCTs and RSs have reported that the incidence of SLL [24–26] and bleeding [25, 27] is significantly lower with the Lembert's suturing method compared to the non-SLR method. One RS study also reported that the incidence of SLL is significantly lower with the TaT suturing method compared to the non-SLR method [28]. Despite numerous studies, there is still no consensus on which technique is best for reducing the incidence of SLL and bleeding [7, 16, 18, 19]. However, many authors today prefer the Lembert's suturing technique [24–27].

To the best of our knowledge, the Lembert's and TaT suturing methods have been compared in only three studies [19, 21, 29]. In their ex vivo studies measuring burst pressure, Rogula T et al. reported that the continuous Lembert's suturing method was associated with a lower incidence of SLL compared to the continuous TaT and non-SLR methods [29]. Carandina S. et al., however, reported no difference in the incidence of SLL or bleeding among the methods—non-SLR, Lembert's suturing, TaT suturing, and fibrin glue (FG)—in the patients they treated [19]. In the study by Bulbuller N et al., they reported that there was no difference in SLL and bleeding incidence among the methods—non-SLR vs. Lembert's suturing vs. TaT suturing vs. FG—in their patients; however, they noted that one patient experienced mortality with the Lembert's suturing method [21]. To the best of our knowledge, this study is the first to directly compare the Lembert's and TaT suturing methods, and includes the largest number of patients. With this study, we aimed to compare the SLL incidence rates between the two methods.

2. Methods

This study was conducted between February 2021 and February 2026, at the General Surgery Clinic of Trabzon University Kanuni Training and Research Hospital. The study was approved by the Local Ethical board number (2026/26059), and was conducted in accordance with the World Medical Association's ethical principles regarding human subjects (the Declaration of Helsinki). Informed consent forms were obtained from the patients. For the sample size (effect size: 0.5, alpha = 0.05, and power = 0.95), it was calculated that at least 105 patients were required for each group. All procedures were performed by an experienced bariatric surgeon. Patients with severe obesity aged 18–65 years were included in the study. The National Institutes of Health guidelines were used for the selection of patients with severe obesity: body mass index (BMI) ≥ 40 kg/m², or BMI ≥ 35 kg/m² with obesity associated medical problems. No funding was used for this study.

2.1. Surgical Technique:

The patient was positioned on the operating table in the supine position, with arms abducted, legs adducted, in a 10-degree reverse Trendelenburg position, and turned 10 degrees to the right. LSG was performed under general anaesthesia. Antibiotic prophylaxis was administered 30 minutes preoperatively (2 g Cefazolin), and at the 12th postoperative hour. Patients were fitted with compression stockings for intraoperative thrombosis prophylaxis. Pneumoperitoneum was created via a Veress needle in the left upper quadrant, and intra-abdominal pressure was set to 15 mmHg.

A 10-mm camera (30°) port was placed 18 cm below and 3 cm to the left of the xiphoid process. A 10-mm trocar in the left upper quadrant and a 12-mm trocar in the right upper quadrant were positioned to form a smile-like configuration. An additional 5 mm trocar was placed between the xiphoid process and the 12 mm trocar in the right upper quadrant. A Nathanson retractor was used to elevate the left hepatic lobe, and an access site was created 2 cm to the left of the xiphoid process using a 5 mm trocar. The greater omentum was dissected using a 5-mm laparoscopic LigaSure (Medtronic, Minneapolis, MN, USA) from 2–4 cm proximal to the pyloric ring to the angle of His and the left diaphragmatic crus. A 38-French gastric calibration tube was inserted through the mouth to the pylorus and secured against the lesser curvature. Under the guidance of the gastric calibration tube, an LSG was performed using a 60-mm purple laparoscopic stapler (Tri-Staple, Panther Healthcare, Beijing, China) from 2–4 cm proximal to the pylorus to the angle of His. A 30-second interval was observed between closing the stapler and firing it. The stapler line was examined for bleeding, and a cautery was used when necessary. A leak test was performed using methylene blue (100 mL) through the gastric calibration tube to test the LSG. The gastric specimen was removed by enlarging the trocar hole in the left upper quadrant. A drain was used if there was intraoperative bleeding. The fascia of the openings was not closed. The skin incisions were closed using absorbable 4/0 sutures, after removing the liver retractor and the trocars.

2.2. Reinforcement Techniques:

SLR was performed using a 6" (30 cm) 3/0 V-Loc™ (V-Loc, Medtronic, Minneapolis, MN, USA). SLR: In the TaT suturing method, continuous sutures were placed through the serosa of the anterior and posterior gastric walls, approximately 2–3 mm from the stapler line, and approximately 5 mm from the previous suture. In the Lembert's suturing technique, SLR was performed using continuous sutures that overlapped the stapler line, approximately 3–5 mm from the stapler line on both sides and approximately 5 mm from the previous suture. At the end of oversewing, the V-Loc suture was gently pulled over the stapler line. The tip of the V-Loc suture at the end of the stapler line near the pylorus was secured with a clip. In both oversewing methods, simultaneous omentopexy was performed from the incisura angularis to the pylorus.

2.3. Postoperative Management

Patients were monitored in the Postoperative Care Unit (PACU) during the postoperative period. Patient mobilisation began 6 hours postoperatively. Patients were transferred to the ward on the first postoperative day, and oral fluid intake was initiated. Postoperative thrombosis prophylaxis was provided for three days, using compression stockings and low-molecular-weight heparin (1–2 mg/kg).

Asymptomatic patients were discharged on the third postoperative day. Patients were prescribed daily multivitamins, iron, additional minerals, 28 days of low-molecular-weight heparin, three months of proton pump inhibitors, and 12 months of ursodeoxycholic acid. Patients were placed on a liquid diet for the first two postoperative weeks, a pureed/soft diet for weeks two through four, and subsequently, a low-calorie, high-protein diet. Patients were followed up on the 10th postoperative day and at 1 and 3 months, with physical examinations, weight measurements, and laboratory tests, including SLC. Postoperative complications were assessed according to the Clavien–Dindo classification [30].

2.4. Data Collection

Data were collected prospectively for statistical analysis. Preoperative demographic data, operative time, total operative time, postoperative complications, and length of hospital stay were recorded. Total operative time was recorded as the duration between the opening of the skin incision and its closure. The oversewing time was recorded as the duration during which the stapler line was sutured, from the pylorus to the angle of His.

The primary endpoint was bleeding from the stapler line and SLL. If there was suspicion of postoperative SLL (tachycardia, fever, or severe abdominal pain, presence of methylene blue in the drain), gastroscopy and/or abdominal CT were performed. SLL was defined as the presence of a defect in the stapler line on gastroscopic examination, or the presence of perigastric or left subphrenic abscess, or extragastric contrast material on abdominal CT. Bleeding was defined as clinical symptoms, such as hypotension, syncope, and hemorrhagic shock; the presence of melena or hematemesis; the presence of blood in the drain (≥ 500 mL); or a decrease in hemoglobin of ≥ 3 g/dL. Functional stenosis was defined as persistent nausea–vomiting and/or food intolerance and/or bloating. Secondary endpoints included other postoperative complications, total operative time, oversewing time, length of hospital stay, and mortality.

2.5. Statistical Analysis:

Categorical measures are presented as counts and percentages, while continuous measures are presented as mean ± standard deviation or median (range). The Kolmogorov–Smirnov normality test was performed to determine the appropriate statistical tests. Pearson's χ^2 test or Fisher's exact test was used for categorical data, and Student's t-test or the Mann–Whitney U test was used for continuous variables. All statistical analyses were performed using SPSS version 27 (IBM Corporation, Armonk, NY). A p-value < 0.05 was considered statistically significant.

3. Results

A total of 592 patients underwent LSG. Six patients—including five with a history of prior bariatric surgery and one patient who was converted from laparoscopic to open surgery—were excluded from the study, and 586 patients were included in the analysis. Patients were divided into two groups: the TaT suturing method was used for SLR in 386 consecutive patients who underwent LSG between February 2021 and January 2025. Due to a high incidence of SLL in these patients, the Lembert's suturing method was used for SLR in 200 consecutive patients who underwent LSG between January 2025 and February 2026.

Preoperative albumin levels were lower in the Lembert's suturing group (4.3 ± 0.3 vs. 4.4 ± 0.3, $p < 0.001$), and preoperative HbA1C levels were lower in the TaT suturing group (5.8% vs. 6.9%, $p < 0.001$). Preoperative haemoglobin and glucose levels were similar between the two groups ($p = 0.08$ and $p = 0.92$, respectively). The history of prior abdominal surgery was lower in the TaT suturing group (28.5% vs. 48.5%, $p = 0.002$). Other demographic characteristics were similar between the two groups. The patients' preoperative demographic characteristics are presented in Table 1.

Table 1
Preoperative demographic characteristics of patients

Parameters	All Patients (n = 586)	Oversewing type		p
		TaT (n = 386)	Lemberts (n = 200)	
Age (years)	34 (18–66)	33 (18–66)	36 (18–66)	0.11
Gender (n, %)	94 (16.0)	58 (15.0)	36 (18.0)	0.35
Male	492 (84)	328 (85.0)	164 (82.0)	
Female				
BMI (kg/m^2)	46.0 (35.0-75.2)	46.2 (35.0-73.4)	45.4 (38.0-75.2)	0.62
History (n, %)	174 (29.7)	111 (28.8)	63 (31.5)	0.50
Smoking	15 (2.6)	8 (2.1)	7 (3.5)	0.41
Alcohol comsuption	13 (2.2)	6 (1.6)	7 (3.5)	0.15
Use of anticoagulant drug	207 (35.3)	110 (28.5)	97 (48.5)	0.002
Abdomen surgery				
Comorbidity (n, %)	184 (31.4)	111 (28.8)	73 (36.5)	0.06
Hypertension	105 (17.9)	65 (16.8)	40 (20.0)	
Type II DM	85 (14.5)	55 (14.2)	30 (15.0)	
COPD	37 (6.3)	25 (6.5)	12 (6.0)	
OSAS	18 (3.1)	11 (2.8)	7 (3.5)	
CAD	9 (15.4)	8 (2.1)	1 (0.5)	
CHD	1 (0.2)	1 (0.3)	0 (0.0)	
AF	5 (0.9)	3 (0.8)	2 (1.0)	
CVE	1 (0.2)	1 (0.3)	0 (0.0)	
Hyperlipidemia	10 (1.7)	10 (3.0)	0 (0.0)	
Others	31 (5.3)	13 (3.4)	18 (9.0)	
Preoperative labs	4.4 ± 0.3	4.4 ± 0.3	4.3 ± 0.3	< 0.001
Albumin values (g/L)	13.4 ± 1.4	13.5 ± 1.5	13.3 ± 1.4	0.08

TaT: Through and through, **BMI**: Body mass index, **DM**: Diabetes Mellitus, **COPD**: Chronic obstructive pulmonary disease, **OSAS**: Obstructive sleep apnea syndrome, **CAD**: Coronary artery disesase, **CHD**: Congestive heart failure, **AF**: Atrial fibrillation, **CVE**: Cerebrovascular event

Parameters	All Patients (n = 586)	Oversewing type		p
		TaT (n = 386)	Lemberts (n = 200)	
Hemoglobin values (g/dL)	99 (69–439)	99 (73–439)	98 (69–368)	0.92
Glucose values (mg/dL)	6 (4.4–11.4)	5.8 (4.4–11.4)	6.9 (5.4–10.8)	< 0.001
HbA_1C values (%)				

TaT: Through and through, **BMI**: Body mass index, **DM**: Diabetes Mellitus, **COPD**: Chronic obstructive pulmonary disease, **OSAS**: Obstructive sleep apnea syndrome, **CAD**: Coronary artery disesase, **CHD**: Congestive heart failure, **AF**: Atrial fibrillation, **CVE**: Cerebrovascular event

Additional surgery was performed in two patients in the Lembert's suturing group (cholecystectomy [n = 2]) and in 11 patients in the TaT suturing group (crural repair [n = 5], cholecystectomy [n = 3], primary small bowel repair [n = 2], and primary colon repair [n = 1]). Total operative time was longer in the TaT suturing group (55 min vs 49 min, $p < 0.001$) and oversewing time was longer in the Lembert's suturing group (8 min vs 7 min, $p < 0.001$). Intraoperative blood loss was more in the TaT suturing group (10 ml vs 5 ml, $p < 0.001$). A drain was used in 39 patients (10.1%) in the TaT suturing group and in three patients (1.5%) in the Lembert's suturing group ($p < 0.001$). Intraoperative results are presented in Table 2.

Table 2
Comparison of results of stapler line reinforcing methods

Parameters	**Oversewing type**		**p**
	TaT (n = 386)	**Lemberts (n = 200)**	
Total operative time (min)	55 (25–190)	49 (30–110)	< 0.001
Oversewing time (min)	7 (5–12)	8 (5–16)	< 0.001
Intraoperative total bleeding (ml)	10 (0–80)	5 (0-700)	< 0.001
Blood transfusion (n, %)	7 (1.8)	3 (1.5)	1.00
Drain (n, %)	39 (10.1)	3 (1.5)	< 0.001
POC (n, %)	72 (18,7)	18 (9.0)	0.002
Staple line bleeding	54 (14.0)	14 (7.0)	0,01
Staple line leak	9 (2.3)	0 (0.0)	0,04
Omental artery bleeding	2 (0.5)	2 (0.5)	
Pulmonary embolism	1 (0.3)	0 (0.0)	
Functional stenosis (nausea and vomiting)	1 (0.3)	0 (0.0)	
Necrotizing pancreatitis	1 (0.3)	0 (0.0)	
Incarcerated incisional hernia	1 (0.3)	0 (0.0)	
Prerenal acute renal failure	0 (0.0)	1 (0.3)	
Portal vein thrombosis	0 (0.0)	1 (0.3)	
Malignant hypertension	0 (0.0)	1 (0.3)	
Clavien-Dindo Classification (Grade ≥ 3; n, %)	11 (2.8)	0 (0.0)	0.02
3a	8 (2.1)	0 (0.0)	
3b	1 (0.3)	0 (0.0)	
4a	1 (0.3)	0 (0.0)	
4b	1 (0.3)	0 (0.0)	
Re-admission (n, %)	8 (2.1)	4 (2.0)	1.00
Staple line leak	7 (1.8)	0 (0.0)	
Nutritional disorder	0 (0.0)	2 (1.0)	

TaT: Through and Through, **Min**: Minute, **Ml**: Milliter, **POC**: Postoperative Complication, **ICU**: Intensive Care Unit

Parameters	Oversewing type		p
	TaT (n = 386)	Lemberts (n = 200)	
Portal vein thrombosis	0 (0.0)	1 (0.5)	
Malignant hypertension	0 (0.0)	1 (1.0)	
Nausea and vomiting	1 (0.3)	0 (0.0)	
ICU duration (day)	5.5 (0–17)	1 (1–2)	0.12
Hospital stay (day)	4 (2-177)	3 (2–16)	< 0.001
Mortality (n, %)	0 (0.0)	0 (0.0)	1.00

TaT: Through and Through, **Min**: Minute, **Ml**: Milliter, **POC**: Postoperative Complication, **ICU**: Intensive Care Unit

Postoperative bleeding occurred in 72 patients. Bleeding originated from the stapler line in 68 patients, while, in four patients, it originated from the omentum majus. Bleeding from the stapler line was more common in the TaT suturing group (14.0% vs. 7.0%, p = 0.01). In the TaT suturing group, two patients with stapler line bleeding received blood transfusions. All four patients with omentum majus bleeding received blood transfusions; one patient underwent laparotomy and bleeding control (TaT suturing group). Blood transfusions were also administered to four additional patients: two patients with a preoperative hemoglobin level below 10 g/dL who experienced a hemoglobin drop of ≥ 3 g/dL, and two patients with a hemoglobin drop of more than ≥ 3 g/dL due to SLL.

Postoperative SLL developed in nine patients. SLL was observed only in the TaT suturing group (2.3% vs. 0.0%, p = 0.04). Detailed information on patients who developed SLL is provided in Table 3.

Table 3
Characteristics of patients who develop staple line leak

Patients no	Age (years)	Gender	BMI (kg/m^2)	Stapled line Leak time (day)	Gastric leak localization	İntervention	Discharge time (day)
1	30	Female	38,9	4	Fundus	OTSC	23
2	38	Male	42,1	3	Fundus	OTSC, ES, PD, Stapled line primary repair, RYGB, GJ revision.	177
3	35	Female	62,5	18	Fundus	ES	20
4	17	Female	42,2	30	Fundus	ES, PD	16
5	23	Female	46,7	4	Antrum	PD	28
6	48	Female	55,1	10	Fundus	ES, PD	26
7	18	Female	56	6	Fundus	ES, PD, Tube thoracostomy	26
8	33	Female	53,5	7	Fundus	OTSC, ES, PD	55
9	33	Male	41,1	8	Fundus	ES, PD	27

OTSC: Over-The-Scope Clip, ES: endoscopic stents, **PD**: Percutaneous pigtail drainage, **RYGB**: Roux-and-Y gastric bypass, **GJ**: Gastrojejunostomy

Postoperative all complications and Clavien–Dindo Grade ≥ 3 complications were more frequent in the TaT suturing group (respectively; 18.7% vs 9.0%, p = 0.002 and 2.8% vs 0.0%, p = 0.02). Re-admission rates and length of stay in the intensive care unit were similar between the two groups (respectively; p = 1.00 and p = 0.12). The length of hospital stay was longer in the TaT suturing group (4 days vs. 3 days, p < 0.001). No mortality was observed.

4. Discussion

Despite advances in stapler technology, SLL and bleeding remain the most dangerous SLCs [16]. SLCs increase postoperative morbidity, mortality, and hospital costs [1, 6, 7]. Even a small reduction in SLCs can prevent serious events such as reoperation, blood transfusions, peritonitis, and septic shock, and reduce mortality [31]. For this reason, many surgeons employ various SLR methods to reduce SLCs, and some meta-analysis studies support this approach [7, 12, 13, 31–33]. Studies have generally compared the oversewing method with other SLR methods. These studies have reported that the absorbable polymer membrane (APM) and the oversewing method are the two SLR methods with the lowest SLC rates. While APM is costly, the oversewing method—though it increases costs by prolonging surgery time

—is a more accessible and affordable option compared to other SLR methods [33]. Since there are very few studies directly comparing oversewing methods, there is no consensus on which oversewing methods to use [14, 19, 21, 29]. At our clinic, we have been preferring the oversewing method for SLR in LSG patients for the past 5 years. In the first 386 consecutive patients who underwent LSG, we preferred the TaT suturing method. However, due to high rates of SLL and bleeding with the TaT suturing method, we discontinued its use and opted for the Lembert's suturing method in the last 200 consecutive patients. In the last 200 patients where we used the Lembert's suturing method, no SLL developed, and bleeding decreased significantly. Additionally, we observed that all postoperative complications, Clavien–Dindo Grade ≥ 3 complications, and length of hospital stay also decreased significantly with the Lembert's suturing method.

SLL is caused by high intra-gastric pressure and typically occurs in the proximal portion of the stapler line immediately below the gastroesophageal junction [1]. The thinner gastric wall at the gastroesophageal junction and its consequently lower resistance to increased intraluminal pressure may be the cause of SLL [34].

SLLs are classified into two types based on etiology: mechanical and ischemic SLL. Mechanical SLLs occur within the first 48–72 hours postoperatively and are mostly caused by inappropriate staple size, surgical errors, or injuries. Ischemic SLLs, on the other hand, occur 5 days after surgery and are likely caused by distal obstruction [35]. SLL is observed in 0.5–2.7% of LSG patients [7–9]. According to RCT and RCS studies, the incidence of SLL has been reported to range from 0–2.6% with the TaT suturing technique [19, 20, 22, 28, 36] and from 0–2% with the Lembert's suturing technique [13, 19, 23–27]. In our study, the incidence of SLL was 2.3% (9/386) with the TaT suturing technique and 0% (0/200) with the Lembert's suturing technique. Our results are similar to those of Rogula T et al., but, unlike the studies by Carandina L et al. and Bulbuller N et al. [19, 21, 29] they demonstrate that the incidence of SLL is significantly lower with the Lembert's suturing technique compared to the TaT suturing technique ($p = 0.04$). Burgos AM et al. reported that most SLLs are ischemic in origin, resulting from thermal injury caused by the energy devices used for dissection [37]. The authors applied the continuous TaT suturing method in their patients. In our study, ischemic-type SLL developed in six patients (Table 3). Our results emphasize the importance of the Lembert's suturing method, even for ischemic SLL that may develop due to thermal injury.

As reported in the studies by Casella G et al., the decrease in SLL incidence may be attributed not only to the effectiveness of the oversewing suturing method, but also to increased experience [11]. The authors applied the continuous TaT suturing technique in their patients. In our first 386 patients treated with the continuous TaT suturing technique, SLL cases developed over similar time intervals up to the final 15 months of the study. Although our experience has increased, our results underscore the importance of the Lembert's suturing technique in reducing SLL.

Gastric wall thickness may be a risk factor for SLL, and as BMI increases, so does gastric wall thickness. Rawlins L et al. [38] reported an increased incidence of SLL in patients with a BMI > 52 kg/m², while

Aurora AR et al. [39] reported a non-statistically significant increase in SLL incidence in patients with a BMI > 50 kg/m². Rawlins L et al. [38] also reported that male gender is associated with an increased risk of SLL. In our study, no association was found between male gender and SLL (2.1% vs 1.4%, p = 0.64). Although the incidence of SLL did not increase statistically significantly in patients with a BMI ≥ 50 kg/m² in our study (2.6% vs. 1.1%, p = 0.25), the incidence of SLL increased significantly in patients with a BMI ≥ 52 kg/m² (4.0% vs. 1.0%, p < 0.05) (Table 4).

Table 4
Analysis of patients who developed staple line leak following LSG

Parameters	**Stapled line leak**		**P**
	Positive	**Negative**	
Gender n (%)			
Male	2 (2.1)	92 (97.9)	0.64
Female	7 (1.4)	485 (98.6)	
Body mass index n (%)			
<50.0	5 (1.1)	428 (98.9)	0.25
≥50.0	4 (2.6)	149 (97.4)	
Body mass index n (%)			
<52.0	5 (1.0)	482 (99.0)	< 0.05
≥52.0	4 (4.0)	95 (96.0)	

LSG: Laparoscopic Sleeve Gastrectomy

Bleeding after LSG typically originates from the stapler line. Other sites of post-LSG bleeding include the omentum, the short gastric artery, the spleen, the gastroepiploic artery, and the abdominal Wall [31]. Additionally, the surgeon's learning curve, patient associated medical problems (hypertension and chronic kidney disease), coagulation disorders, postoperative medication use (ketorolac and heparinoids), suture type (intermittent vs. continuous), and the thickness of laparoscopic staples are among the many factors that may influence this [31, 40]. In LSG, after the gastric wall is incised, the exposed incision edges and microvascular ends are prone to bleeding. The incidence of bleeding from the staple line after LSG has been reported to range from 1.1% to 4% [7]. The bleeding incidence can reach up to 10% in patients undergoing the TaT suturing method, and up to 5% in those undergoing the Lembert's suturing method [20, 25]. Our results differ from those of Carandina L et al. and Bulbuller N et al., who reported similar bleeding incidence rates for the TaT and Lembert's suturing methods [19, 21]. We observed a significant decrease in the bleeding incidence rate in patients treated with the Lembert's suturing method (14.0% vs. 7.0%, p = 0.01). Our findings may also be consistent with the studies by

Aggarwal S et al. and Sroka G et al., which reported that the bleeding incidence may decrease with experience [23, 41]. Although our rates of bleeding from the stapler line were higher than the general rates in the literature, the definition of bleeding and the follow-up period vary [35]. No patient was readmitted or underwent surgery due to bleeding. Bleeding in our patients was controlled with medical treatment, and blood transfusion was performed only in two patients who underwent the TaT suturing method.

The effect of oversewing methods on postoperative complications is controversial. In a meta-analysis by Wang Z et al., it was reported that SLR methods significantly reduced overall complications compared to non-SLR methods; however, in a subgroup analysis, the oversewing method did not affect the reduction in complications [42]. In a meta-analysis by Aiolfi A. et al., it was reported that the oversewing method reduced postoperative complications compared to the non-SLR method, but this effect was similar to that of other SLR methods [31]. In a study by Carandina L et al., the incidence of postoperative complications was reported as 4.7% for the TaT suturing method and 3.3% for the Lembert's suturing method [19]. Our results showed a significant reduction in postoperative complications and Clavien–Dindo grade ≥ 3 complications with the Lembert's suturing method (18.7% vs 9.0%, $p = 0.002$, and 2.8% vs 0.0%, $p = 0.02$, respectively). We attribute this finding to the reduction in postoperative bleeding and SLL incidence.

Postoperative stenosis occurs in 0.6–2.4% of LSG patients [19]. Many surgeons agree that there is a direct relationship between bougie size and stenosis [14, 19]. Another possible cause of stenosis may be the oversewing technique. When the Lembert's suturing technique is performed continuously, the gastric tube may narrow and create asymmetry in the sleeve, leading to functional stenosis [43]. Therefore, the upper sutures of the stapling line should be placed symmetrically to distribute pressure evenly along the suture line and prevent twisting of the gastric tube [27]. Our results contradict these theories. This is because we used a 38-Fr bougie in our patients and observed functional stenosis in only one patient in the T suturing method.

Many factors, such as the surgeon's experience, collaboration among the surgeon, assistants, and nurses, and SLR techniques, influence both the SLR duration and the total operative duration [6]. Oversewing increases the operative duration compared to other SLR and non-SLR methods [19, 23, 31]. However, it is a fact that, as experience increases, the operative time spent on oversewing decreases. In the study by Gentileschi P. et al., the oversewing time for the TaT method was 14 minutes; in the study by Carandina S. et al., the oversewing time for the Lembert's suturing method was 26 minutes and for the TaT suturing method 21 minutes [19, 44]. In our study, the oversewing time was 8 (5–16) minutes for the Lembert suturing method and 7 (5–12) minutes for the TaT suturing method, which is considerably shorter than those reported in the literature. We attribute this to our extensive experience in laparoscopic surgery and the V-Loc suture's ability to reduce oversewing time [19]. Our study demonstrated that the oversewing time was significantly lower with the TaT suturing method ($p < 0.001$). In studies comparing the Lembert's and TaT suturing methods, the operative time is longer with the Lembert's suturing method [19, 21]. Our results contradict these findings and show that the total operative time is shorter with the

Lembert's suturing method (49 min vs. 55 min, $p < 0.001$). We attribute this difference to increased experience, the use of the V-Loc suture in both techniques, and the surgical team's improved coordination.

Our results showed that the hospital stay was longer with the TaT suturing method ($p < 0.001$). The recovery period for complications related to bleeding, particularly SLL, averages 40 days [6]. This significantly prolongs patients' hospital stays [43]. Due to treatments administered for SLL in the TaT suturing method (Table 3), patients' hospital stays were longer (26 [16–177] days). In the TaT group, two patients received blood transfusions due to stapler line bleeding. In the Lembert's suturing method, there was no prolongation of the hospital stay because SLL, bleeding requiring treatment, and functional stenosis did not develop.

This study has some limitations: First, this study is a retrospective analysis of prospectively collected data, and is therefore susceptible to biases associated with retrospective analysis. Second, this study was conducted at a single, high-volume centre by a surgeon with extensive experience in laparoscopic surgery. Increased surgical experience is associated with a reduction in SLCs [11, 45]. Therefore, the results of surgeries performed by an experienced surgeon at high-volume centers may not be generalizable. Third, this study does not include revision surgery, cost analysis, or long-term follow-up, particularly for gastroesophageal reflux. Consequently, this study did not assess the long-term effects of the oversewing technique. Nevertheless, our findings require validation through randomized controlled trials (RCTs).

In conclusion; compared to the TaT suturing method, the Lembert's suturing method was associated with a reduction in postoperative bleeding, SLL, overall complications, Clavien-Dindo ≥ 3 complication incidence, and length of hospital stay, without creating a major difference in oversewing or total surgery time. No differences were observed between the two methods in terms of blood transfusion, intensive care unit stay, or mortality.

Declarations

Author Contribution

Aydin Aktas wrote the main manuscript text and prepared tables. Aydin Aktas reviewed the manuscript.

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