

Management of Staple-Line Leaks after Laparoscopic Sleeve Gastrectomy: Efficacy of Double Pigtail Stenting and a Practical Algorithm for Early and Late Leaks

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Abstract

Background: Staple-line leak (SLL) remains one of the most severe complications following laparoscopic sleeve gastrectomy (LSG). Although endoscopic internal drainage using double pigtail stents (DPS) has emerged as an effective minimally invasive treatment, evidence comparing its efficacy according to leak timing remains limited. The aim of this study was to evaluate the clinical outcomes of DPS for the management of SLL after LSG and compare treatment success between early and late leaks.

Methods: This retrospective cohort study included consecutive patients referred to a tertiary bariatric referral center with confirmed SLL following LSG. Patients were categorized into early (<7 days) and late (≥ 7 days) leak groups. All patients underwent multidisciplinary management consisting of resuscitation, nutritional support, antibiotics, radiologic assessment, and endoscopic evaluation. DPS was used whenever technically feasible for internal drainage. Primary outcome was successful leak closure without the need for definitive reconstructive surgery. Secondary outcomes included additional interventions, hospital stay, intensive care unit (ICU) stay, and mortality.

Results: Fifty patients with SLL were included (26 early leaks and 24 late leaks). Baseline demographic and clinical characteristics were comparable between groups. DPS placement was attempted in 41 patients. Leak resolution following DPS was significantly higher in late leaks than early leaks (80.0% vs. 52.4%, $P=0.031$). Early leaks more frequently required radiologic drainage (84.6% vs. 54.2%, $P=0.030$) and surgical intervention (80.8% vs. 25.0%, $P=0.001$). The need for definitive reconstructive surgery was also significantly greater in early leaks (53.8% vs. 25.0%, $P=0.048$). Length of hospital stay, ICU stay, and mortality did not differ significantly between groups.

Conclusions: Double pigtail stenting is an effective minimally invasive treatment for staple-line leaks after LSG, particularly in patients with late leaks, where high rates of leak resolution can be achieved while avoiding major revisional surgery. Early leaks remain more challenging and frequently require multimodal management combining endoscopic, radiologic, and surgical approaches. Treatment strategies should therefore be individualized according to leak timing within a multidisciplinary bariatric program.

Key Points

- Double pigtail stenting achieved significantly higher leak closure rates in late staple-line leaks (SLL) than in early leaks after laparoscopic sleeve gastrectomy.
- Early SLLs required more frequent radiologic drainage, surgical intervention, and definitive reconstructive surgery.
- Leak timing using a 7-day cutoff could guide selection of endoscopic versus surgical treatment strategies.
- A practical multidisciplinary management algorithm is proposed to guide individualized treatment.

Introduction

Laparoscopic sleeve gastrectomy (LSG) has emerged as one of the most commonly performed metabolic bariatric surgery (MBS) worldwide due to its effectiveness in achieving significant and sustained weight loss, along with improvements in obesity-associated medical problems such as type 2 diabetes, hypertension, and obstructive sleep apnea (1–3). This minimally invasive technique involves the removal of a large portion of the stomach to create a tubular sleeve, which restricts food intake and alters gut hormone signaling (4). However, despite advancements in surgical techniques and perioperative care, staple line leak (SLL) remains a rare but serious complication, occurring in 0.7% to 5.3% of primary LSG cases and up to 10% in revisional surgeries (5–7). SLL can lead to severe sequelae, including sepsis, abscess formation, fistula development, prolonged hospitalization, and increased mortality, significantly impacting patient quality of life and healthcare costs (8, 9).

The pathophysiology of SLL is multifactorial, involving mechanical factors such as staple line tension, intraluminal pressure, and tissue thickness, as well as ischemic factors related to ligation of short gastric arteries (10, 11). Importantly, the timing of leak onset plays a critical role in its etiology and management. Early leaks (occurring within 7 days post-surgery) are often attributed to mechanical failures, such as improper stapling or excessive pressure, whereas late leaks (beyond 7 days) are more commonly associated with ischemia and impaired wound healing (12, 13). These distinctions necessitate tailored therapeutic approaches, as early leaks may require more aggressive interventions, while late leaks might respond better to conservative or endoscopic methods (14).

Current management strategies for SLL are multidisciplinary and staged, incorporating conservative measures (NPO, antibiotics, and TPN), endoscopic interventions (stents, clips, or Naso jejunal tubes), and surgical options (laparoscopic lavage, gastrojejunostomy, or total gastrectomy) (4, 15, 16). Among endoscopic techniques, the use of double pigtail stents (DPS) has gained attention for its ability to facilitate internal drainage, reduce pressure at the leak site, and promote healing without the need for invasive reoperation (14). DPS placement via esophagogastroduodenoscopy (EGD) creates a controlled pathway for fluid evacuation, potentially averting abscess formation and sepsis (17, 18). Preliminary studies suggest higher success rates with DPS in late leaks due to their ischemic nature, which may allow better tissue response to internal drainage compared to the acute inflammation in early leaks (18). However, evidence on the short-term (e.g., resolution rates, hospital stay) and long-term (mortality, need for definitive surgery) outcomes of DPS, stratified by leak timing, remains limited and inconsistent (14).

Despite these advances, there is a lack of consensus on optimal protocols, particularly regarding the role of DPS as first-line therapy versus adjunctive measures. Existing literature highlights gaps in comparative data between early and late leaks, with most studies being small-scale or non-stratified (19, 20). This retrospective study aims to address these gaps by evaluating the outcomes of DPS in managing SLL post-LSG in a cohort of patients referred to a tertiary center, stratified by early and late leaks. Specifically, we seek to compare success rates, complication profiles, and predictors of treatment

failure to inform evidence-based algorithms and improve patient selection for this minimally invasive approach.

Methods

This retrospective cohort study was conducted at a tertiary referral center in Iran, specializing in MBS complications. The study reviewed medical records of patients who developed staple line leak (SLL) following laparoscopic sleeve gastrectomy (LSG) from 2022 to 2025.

A total of 50 consecutive patients diagnosed with SLL post-LSG were included. Inclusion criteria encompassed all patients referred to the center with confirmed SLL, regardless of whether the initial LSG was performed at our institution or elsewhere. Patients were stratified into two groups based on the timing of leak onset: early leaks (occurring < 7 days post-LSG) and late leaks ($\geq$ 7 days post-LSG). Exclusion criteria included incomplete records, leaks from non-LSG procedures, or patients lost to follow-up before initial management.

Initial management followed a standardized multidisciplinary protocol involving metabolic bariatric surgeons, endoscopists, radiologists, and nutritionists. All patients were placed on NPO status, received broad-spectrum intravenous antibiotics, and were supported with total parenteral nutrition (TPN). Diagnostic confirmation and assessment of complications (abscess or collections) were achieved through computed tomography (CT) scans with contrast and/or upper gastrointestinal contrast studies.

For internal drainage, double pigtail stents (DPS) were placed endoscopically using esophagogastroduodenoscopy (EGD) under sedation or general anesthesia, as deemed appropriate. The DPS (typically 7–10 Fr, 7–10 cm length) was positioned to bridge the leak site, facilitating internal drainage from any perivisceral collections into the gastric lumen. Adjunctive interventions included percutaneous radiologic drainage for large collections, placement of a nasojejunal feeding tube (NJT) for enteral feeding if tolerated, and conservative monitoring. In cases of treatment failure (persistent leak, worsening sepsis, or hemodynamic instability), escalation to definitive surgical interventions occurred, such as laparoscopic lavage, gastrojejunostomy, or total gastrectomy with esophagojejunostomy (Fig. 1).

Follow-up involved serial EGD for stent assessment/repositioning (every 4–6 weeks or as clinically indicated), imaging (CT or contrast studies) to monitor leak resolution, and clinical evaluation until healing was confirmed (defined as absence of leak on imaging and resolution of symptoms).

Statistical Analysis

Using IBM SPSS statistics version 27, descriptive statistics were reported as means $\pm$ standard deviations for continuous variables and frequencies/percentages for categorical variables. Comparisons between early and late leak groups used independent t-tests for continuous data (e.g., age, BMI, hospital

stay) and chi-square or Fisher's exact tests for categorical data (e.g., success rates, surgical interventions). P-values < 0.05 were considered statistically significant.

Figure 1

Proposed definitive surgical strategies for persistent staple-line leaks after laparoscopic sleeve gastrectomy.

Schematic illustration of the principal reconstructive surgical procedures used for chronic or refractory staple-line leaks following laparoscopic sleeve gastrectomy after failure of conservative and endoscopic management. (A) Roux-en-Y gastrojejunostomy performed at the base of the fistula to divert gastric contents while preserving the gastric sleeve. (B) Esophagojejunostomy with completion gastrectomy for extensive proximal gastric destruction or non-salvageable sleeve. (C) Roux-en-Y fistulojejunostomy performed at the distal fistulous tract to preserve the remaining gastric sleeve while diverting the leak. Selection of the reconstructive procedure depends on fistula location, extent of tissue damage, residual sleeve viability, chronic inflammation, and the patient's overall clinical condition.

Result

A total of 50 patients with confirmed SLL post-laparoscopic sleeve gastrectomy were included in this retrospective analysis. Patients were stratified into two groups based on leak onset: 26 patients (53.1%) in the early leak group (< 7 days post-LSG) and 24 patients (46.9%) in the late leak group (≥ 7 days post-LSG). The mean age was 33.62 ± 9.68years, with no significant difference between early (33.69 ± 6.88 years) and late (33.54 ± 12.18 years) groups (p = 0.958). Similarly, mean body mass index (BMI) was 38.72 ± 4.33 kg/m², comparable between early (38.23 ± 4.028 kg/m²) and late (39.26 ± 4.661 kg/m²) groups (p = 0.405). Females predominated (71.4% overall), with 19 (73.1%) in the early group and 19 (79.2%) in the late group (p = 0.745). Obesity-associated medical problems, including type 2 diabetes and hypertension, were evenly distributed (p > 0.05 for all). Table 1 summarizes baseline characteristics.

Table 1

Table 1 Demographic and Clinical Characteristics of Patients in Early Leak and Late Leak Groups			
Variable	Early Leak (n = 26)	Late Leak (n = 24)	p-value
Age (years, mean ± SD)	33.69 ± 6.875	33.54 ± 12.183	0.958
BMI (kg/m², mean ± SD)	38.23 ± 4.028	39.26 ± 4.661	0.405
Gender (Female/Male)	19 (73.1%) / 7 (26.9%)	19 (79.2%) / 5 (20.8%)	0.745
Type 2 Diabetes (Yes/No)	3 (11.5%)	1 (4.2%)	0.348
Hypertension (Yes/No)	1 (3.8%)	3 (12.5%)	0.364

Initial diagnostic imaging confirmed SLL in all cases, with CT scans revealing perivisceral collections or abscesses in a majority of patients. Figure 2 illustrates a representative case from the early leak group, showing contrast extravasation and a perivisceral collection near the gastroesophageal junction.

Figure 2: Axial CT scan with contrast in a patient with early staple line leak post-LSG, demonstrating contrast extravasation and adjacent perivisceral collection formation near the gastroesophageal junction.

Treatment Interventions and Outcomes

TPN was administered in 19 patients (73.1%) in the Early group and 19 (79.2%) in the Late group. Sepsis control was required in 19 (73.1%) and 12 (50%) patients, respectively. NJ feeding was performed in 13 (50%) and 11 (45.8%) patients, and jejunostomy in 3 (11.5%) patients in the Early group only. All differences were non-significant ($p > 0.05$). DPS placement via esophagogastroduodenoscopy (EGD) was attempted in 41 cases (82%), including 21 patients (80.8%) in the Early group and 20 patients (83.3%) in the Late group, to facilitate internal drainage. Figure 3 depicts the endoscopic placement of a DPS, with the stent bridging the leak site to drain collections into the gastric lumen.

Figure 3

Endoscopic view demonstrating placement of a double pigtail stent (DPS). The stent is positioned across the leak site, with curls facilitating internal drainage from the perivisceral collection to the gastric lumen

Adjunctive interventions included radiologic drainage, which was more frequent in the early leak group (84.6% vs. 54.2%, $p = 0.030$). CT scans were performed a mean of 3.86 ± 2.7 times, with no group difference ($p = 0.373$). Hospital stays averaged 20.79 ± 22.4 days (early: 24.32 ± 25.3 days; late: 16.77 ± 18.44 days; $p = 0.281$), ICU stay was longer in the early group but not significant (14.75 ± 14.85 days vs. 8.36 ± 14.47 days; $p = 0.083$).

DPS success, defined as leak resolution without definitive surgery (Fistulojejunostomy, Gastrojejunostomy, Esophagojejunostomy, extra decompressive approach) needed, was significantly higher in the late leak group (80.4% vs. 47.6%; $p = 0.031$). Conversely, Surgical intervention (laparotomy, laparoscopy, or lavage) was more common in the early leak group (80.8% vs. 25%; $p = 0.001$). Follow-up imaging confirmed resolution in successful cases, as shown in Fig. 4, which demonstrates a healed staple line post-DPS placement.

Figure 4

Follow-up axial CT scan 2 weeks and 6 weeks post-DPS placement in a patient with early leak, showing resolution of the leak with no residual contrast extravasation or collection

Mortality rate was 8.2% overall, with no significant difference between groups (early: 7.7%; late: 8.3%; p = 1.000). Table 2 summarizes interventions and outcomes.

Table 2

Variable	Early Leak (n = 26)	Late Leak (n = 24)	p-value
TPN use	19 (73.1% staple-line leak)	19(79.2%)	0.745
Sepsis control	19(73.1%)	12(50%)	0.145
NJT use	13 (50%)	11 (45.8%)	0.785
Jejunostomy	3 (11.5%)	0	0.236
Leak Resolution after DPS	11/21 (52.4%)	16/20 (80.0%)	0.031
Radiologic Drain Use	22 (84.6%)	13 (54.2%)	0.030
Need for Definitive Surgery	14 (53.8%)	6 (25.0%)	0.048
Number of CT scans (mean ± SD)	4.19 ± 3.020	3.48 ± 2.466	0.373
Ward Stay (days, mean ± SD)	24.32 ± 25.337	16.77 ± 18.447	0.281
ICU Stay (days, mean ± SD)	14.75 ± 14.851	8.36 ± 14.477	0.083
Mortality	2 (7.7%)	2 (8.3%)	1.000

Discussion

Staple-line leak (SLL) remains one of the most feared complications following laparoscopic sleeve gastrectomy (LSG), despite continuous refinements in surgical techniques and perioperative care. Although its incidence is relatively low, SLL is associated with prolonged hospitalization, repeated interventions, substantial healthcare costs, and significant morbidity, making its optimal management a major challenge for bariatric surgeons. During the past decade, treatment paradigms have shifted from aggressive revisional surgery toward minimally invasive multidisciplinary strategies, with endoscopic internal drainage (EID) using double pigtail stents (DPS) emerging as one of the most promising approaches for clinically stable patients. In the present study, we demonstrated that DPS achieved significantly higher success in late leaks than in early leaks while reducing the need for definitive reconstructive surgery. Conversely, early leaks more frequently required radiologic drainage and operative intervention, underscoring the importance of tailoring management according to the timing and pathophysiology of leak presentation.

This retrospective study evaluated the short- and long-term outcomes of double pigtail stent placement in managing staple line leak following laparoscopic sleeve gastrectomy in 50 patients, stratified by early

(< 7 days) and late (≥ 7 days) leaks. Our findings demonstrate that DPS is an effective and safe endoscopic intervention, particularly for late leaks, achieving a significantly higher success rate (80.0% vs. 52.4%, $p = 0.031$) and reducing the need for definitive surgical interventions such as fistulojejunostomy, gastrojejunostomy, or esophagojejunostomy (25.0% vs. 53.8%, $p = 0.048$) compared to early leaks. Early leaks, likely driven by mechanical factors, necessitated more frequent radiologic drainage (84.6% vs. 54.2%, $p = 0.030$) and overall surgical interventions including laparotomy, laparoscopy, or lavage (80.8% vs. 25.0%, $p = 0.001$), reflecting their acute and complex nature. Although ICU stays were longer in the early leak group (14.75 ± 14.85 vs. 8.36 ± 14.47 days, $p = 0.083$), this difference was not statistically significant. Morbidity (e.g., sepsis requiring control in 73.1% of early vs. 50.0% of late leaks, $p = 0.145$) and mortality (8.2% overall) were comparable between groups (early: 7.7%; late: 8.3%; $p = 1.000$), indicating DPS as a low-risk approach across both cohorts.

These results align with existing literature but also highlight key differences. Donatelli reported a 74.6% leak closure rate with DPS in a single-center study of 21 patients, with a mean healing time of 57.5 days, higher than our late leak group but comparable to our early leak group(14). Their study included both acute and chronic leaks but did not stratify outcomes, limiting direct comparison. Similarly, another study conducted a meta-analysis of 385 patients, finding an 83–85% success rate for DPS in SLL, consistent with our late leak outcomes but higher than our early leak results. Their emphasis on patient selection and center expertise supports our observation that late leaks, with less acute inflammation, benefit more from DPS (17). Siddique focused on DPS as a salvage therapy post-failed self-expanding metal stent, achieving an 85% success rate in a smaller cohort ($n = 12$), reinforcing its efficacy in chronic leaks (21). However, their study excluded early leaks, unlike our broader inclusion. Another study analyzing 617 patients, reported an 85% success rate with endoscopic internal drainage, but only 15% required surgery, lower than our early leak group (16). This discrepancy may reflect their larger sample size or more standardized protocols.

Our study uniquely contributes by stratifying outcomes based on leak timing, revealing DPS as a preferred first-line therapy for late leaks, while early leaks often require adjunctive or surgical interventions. Masood et al. further advocate DPS with therapies like vacuum therapy for complex cases, a strategy our data supports for early leaks (22). Limitations include our retrospective design, small sample size, and single-center setting, which may limit generalizability. Future prospective, multicenter studies with larger cohorts are needed to validate these findings and develop evidence-based algorithms optimizing DPS use.

Our findings support the growing body of evidence favoring EID as a first-line endoscopic strategy for selected post-LSG leaks. Donatelli and colleagues were among the first to demonstrate that internal drainage with DPS could achieve durable fistula closure while avoiding repeated surgery in most patients. Their subsequent large prospective experience involving more than 600 patients established EID as a reproducible technique associated with high clinical success and relatively low morbidity. Likewise, Giuliani et al., in a systematic review, reported pooled success rates approaching 80–85%, particularly when DPS was performed in experienced tertiary referral centers. The success rate observed

in our late leak cohort is remarkably consistent with these reports, reinforcing the concept that internal drainage has become a mature and reliable endoscopic modality. In contrast, the lower success observed in our early leak cohort highlights that favorable outcomes reported in the literature frequently reflect heterogeneous populations in which chronic leaks predominate.

Our findings suggest that the success of endoscopic internal drainage with double pigtail stents depends not only on leak timing but also on the patient's clinical presentation. In our cohort, failure of DPS occurred more frequently in patients with early leaks who required emergency surgical interventions. In contrast, patients who remained clinically stable without generalized peritonitis—particularly those presenting with late leaks—were considerably more likely to achieve successful DPS placement. These observations underscore the importance of early referral to specialized bariatric centers with experts in advanced endoscopy, interventional radiology, and revisional bariatric surgery. Delayed referral or multiple attempts at local surgical management before transfer may increase the likelihood of requiring complex reconstructive procedures. Although this hypothesis cannot be definitively confirmed by the present retrospective study, it is consistent with our clinical experience.

Based on our findings and clinical experience, we propose that staple-line leaks after sleeve gastrectomy should be viewed similarly to bile duct injuries. Just as early referral of bile duct injuries to specialized hepatobiliary centers is the accepted standard of care, prompt referral of patients with sleeve gastrectomy leaks to experienced bariatric referral centers may maximize the success of minimally invasive therapies while reducing the need for major revisional surgery.

These results reinforce the importance of individualized, multidisciplinary care delivered within experienced bariatric referral centers and contribute additional evidence supporting endoscopic internal drainage as a cornerstone of contemporary leak management. Based on our experience and the current literature, we propose a practical management algorithm for patients presenting with staple-line leaks after laparoscopic sleeve gastrectomy (Fig. 5). The algorithm emphasizes early diagnosis, multidisciplinary management, patient stratification according to hemodynamic stability and leak timing, preferential use of endoscopic internal drainage in suitable patients, and timely escalation to definitive reconstructive surgery when necessary.

Figure 5

Conclusion

In conclusion, DPS offers a minimally invasive, effective approach for managing SLL post-LSG, particularly for late leaks, reducing the need for invasive surgery. Early leaks, however, often require a multimodal approach. These findings advocate for tailored management strategies based on leak timing and highlight the need for further research to standardize protocols and improve patient outcomes.

Declarations

Ethics Statement: The study received ethical approval from the Institutional Review Board of Iran University of Medical Sciences (Ethics Committee code: IR.IUMS.FMD.REC.1403.034).

Conflict of Interest

The authors declare no conflict of interests.

Informed Consent

Not applicable

Author Contribution

Safari S: Conceptualization. Shahabi Shahmiri S: Conceptualization and supervision. Safari S and Shahabi Shahmiri S: patient management, and data acquisition. Moradi M: data curation. Abdiaei E, Jazi K, and Vakili K: Methodology and formal analysis. Shahabi Shahmiri S, Nadjafi-Semnani A, Jazi K, and Vakili K: Writing – original draft preparation. All authors contributed to manuscript review and editing and approved the final version of the manuscript.

Data Availability

The datasets generated and analyzed during the current study are not publicly available because institutional restrictions apply, but are available from the corresponding author on reasonable request, subject to approval by the institutional ethics committee.

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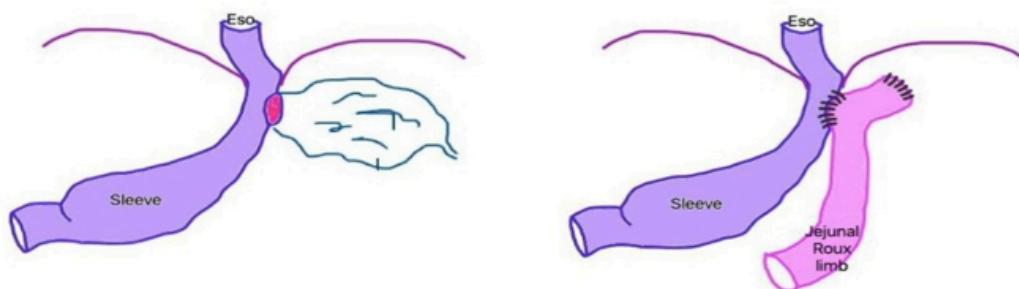
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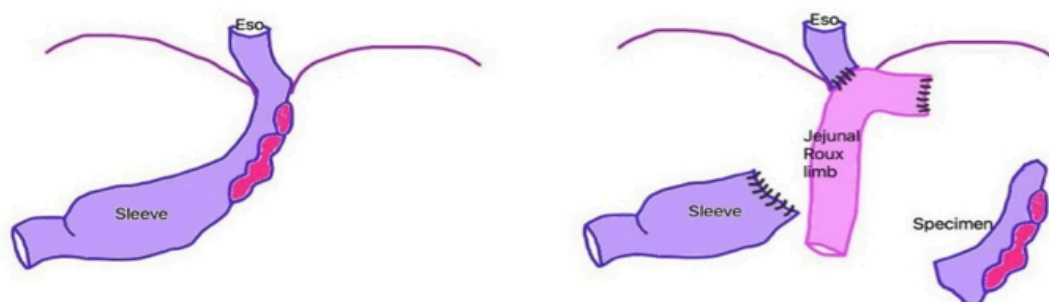
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Figures

(A) GastroJejunostomy at the base of fistula



(B) EsophagoJejunostomy



(C) FistulaJejunostomy at the tail of the fistula

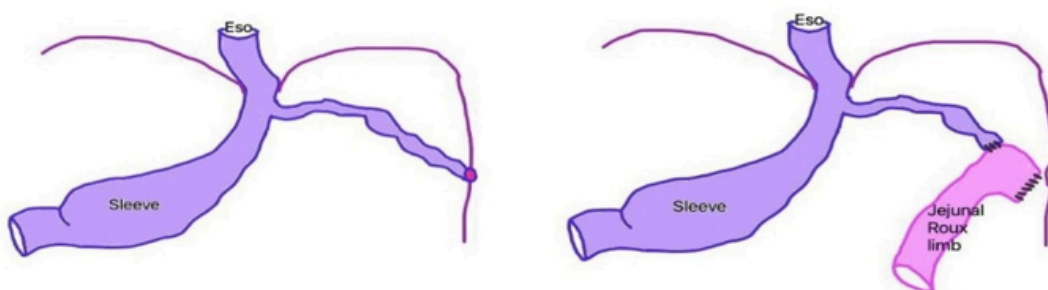


Figure 1

Figure 1

Proposed definitive surgical strategies for persistent staple-line leaks after laparoscopic sleeve gastrectomy.

Schematic illustration of reconstructive surgical options for chronic or refractory staple-line leaks after laparoscopic sleeve gastrectomy. (A) Roux-en-Y gastrojejunostomy performed at the base of the fistula to divert gastric contents while preserving the gastric sleeve. (B) Esophagojejunostomy with completion gastrectomy for extensive proximal gastric destruction or non-salvageable sleeve. (C) Roux-en-Y fistulojejunostomy performed at the distal fistulous tract to preserve the remaining gastric sleeve while diverting the leak.

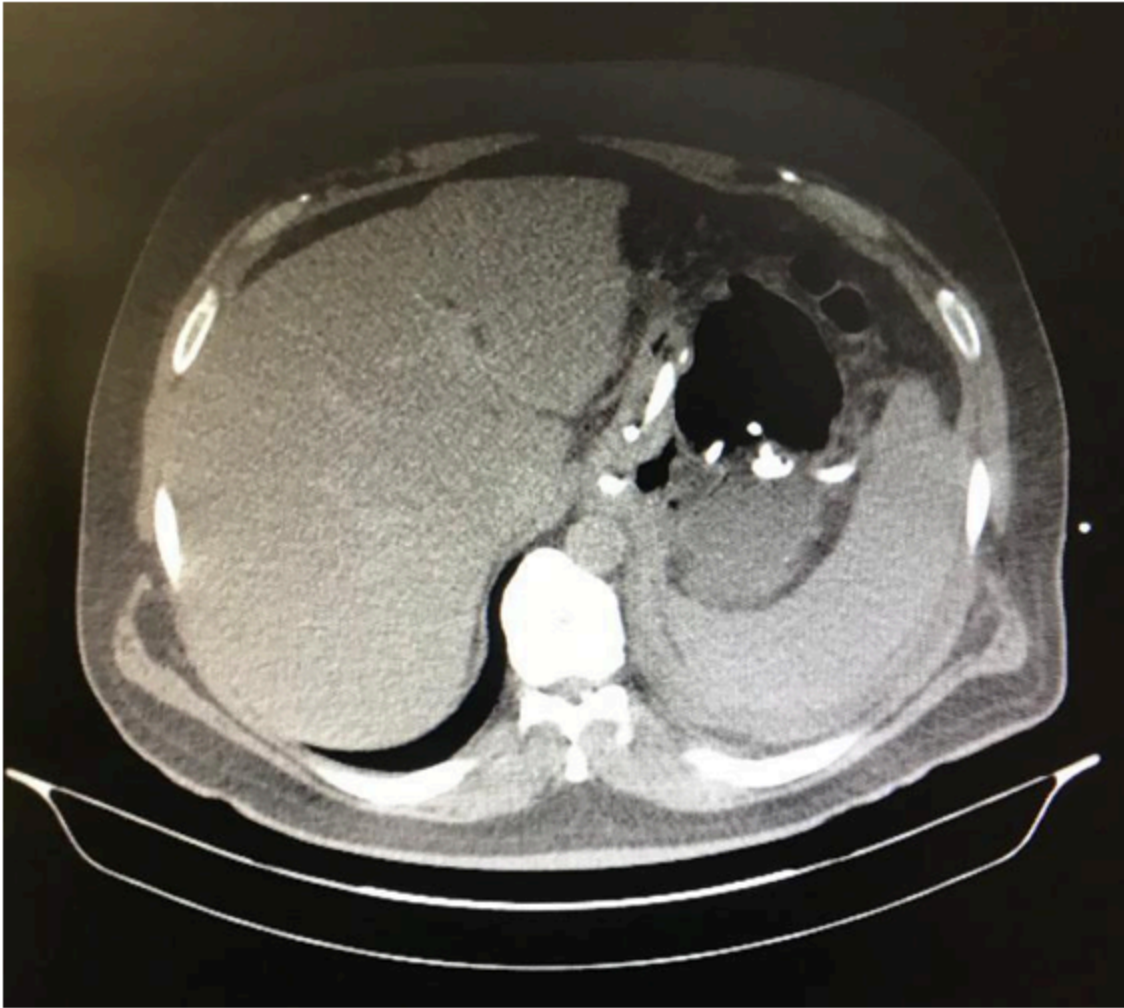


Figure 2

Figure 2

Axial CT scan with contrast in a patient with early staple line leak post-LSG, demonstrating contrast extravasation and adjacent perivisceral collection formation near the gastroesophageal junction.

Axial contrast-enhanced CT scan demonstrating early staple-line leak after sleeve gastrectomy, with oral contrast extravasation at the gastroesophageal junction and adjacent perivisceral collection.

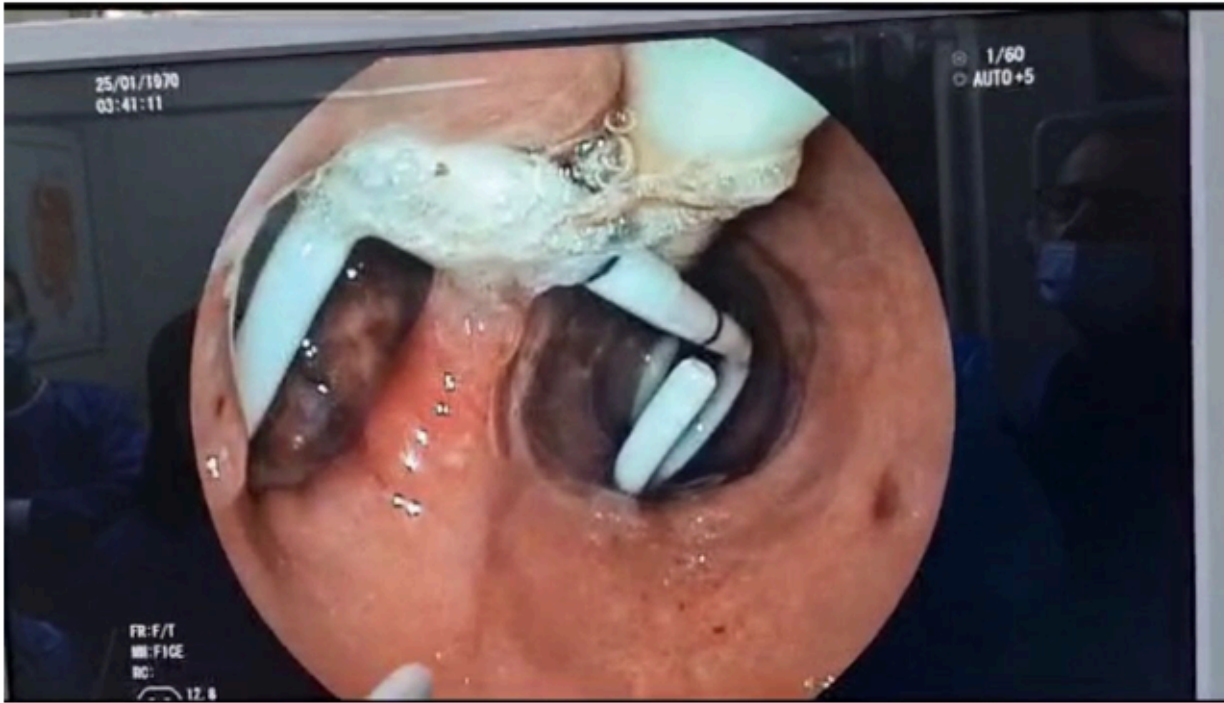


Figure 3

Figure 3

Endoscopic view demonstrating placement of a double pigtail stent (DPS). The stent is positioned across the leak site, with curls facilitating internal drainage from the perivisceral collection to the gastric lumen

Endoscopic view showing double pigtail stent placement across the leak or fistula tract, with stent curls facilitating internal drainage from the perivisceral collection into the gastric lumen.

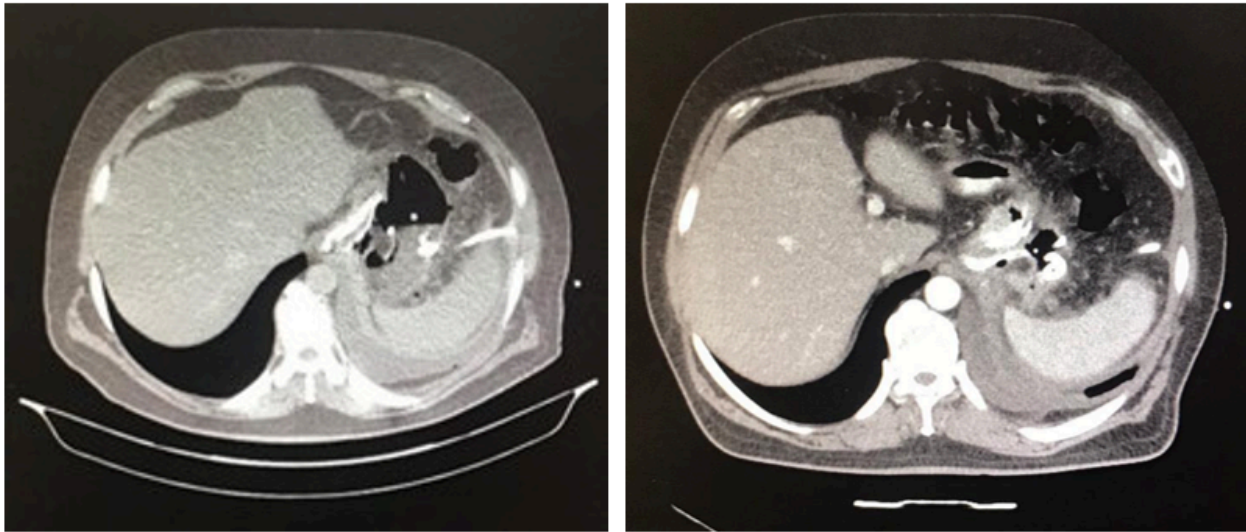


Figure4

Figure 4

Follow-up axial CT scan 2 weeks and 6 weeks post-DPS placement in a patient with early leak, showing resolution of the leak with no residual contrast extravasation or collection

Follow-up axial CT scans obtained 2 and 6 weeks after double pigtail stent placement, demonstrating resolution of the leak with absence of contrast extravasation and residual collection.

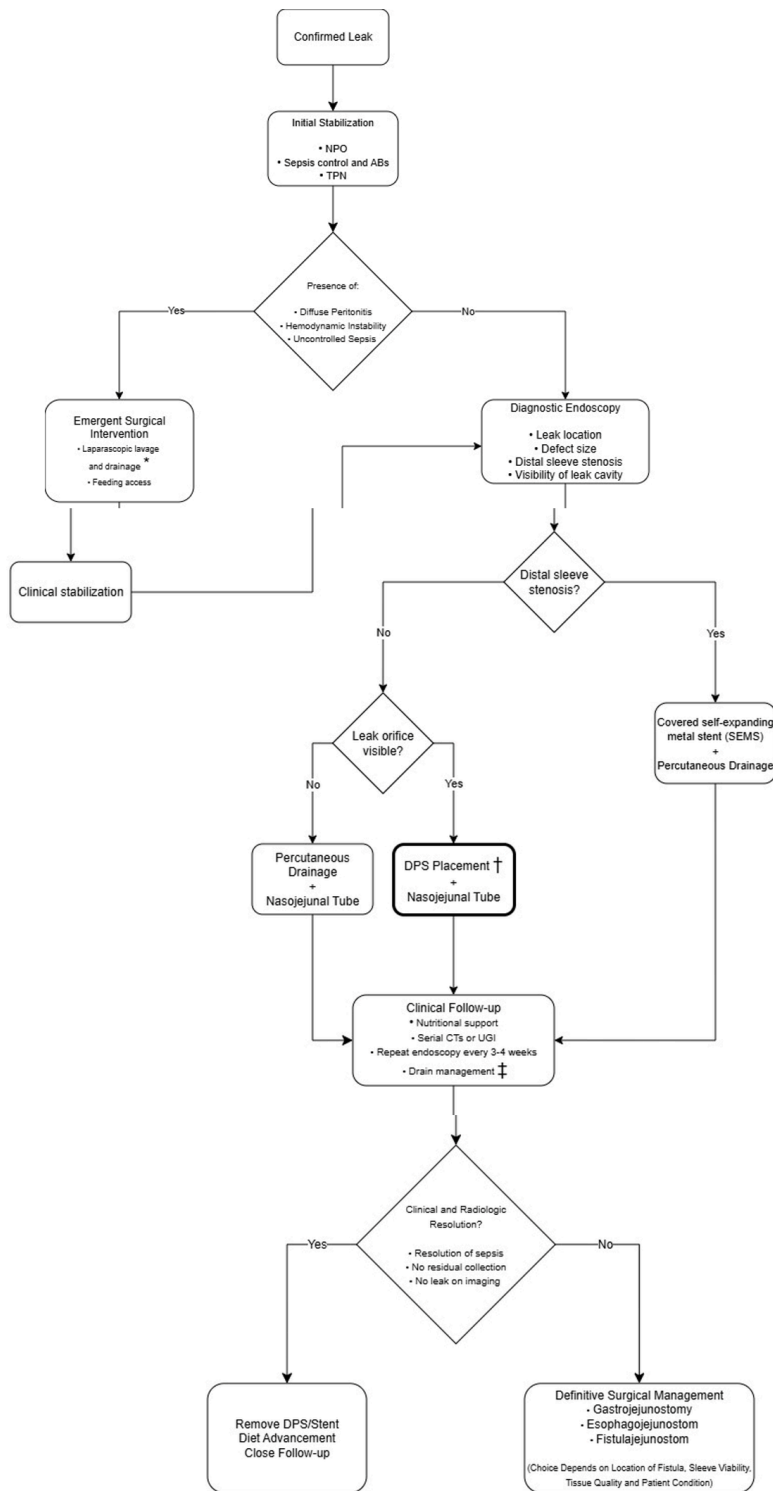


Figure 5

Figure 5

Proposed management algorithm for staple-line leaks after laparoscopic sleeve gastrectomy based on the authors' institutional experience and the findings of the present study.

* Consider conversion to Roux-en-Y gastric bypass when contamination is minimal and the patient's clinical condition permits.

† In the present study, clinically stable patients presenting with late leaks (≥ 7 days after sleeve gastrectomy) had a significantly higher likelihood of successful treatment with DPS than those presenting with early leaks (< 7 days).

‡ At our institution, external drains are gradually withdrawn approximately 2 cm every other day beginning 3–4 weeks after placement to reduce the risk of persistent external fistula formation

Proposed multidisciplinary management algorithm for staple-line leaks after laparoscopic sleeve gastrectomy, stratifying patients by hemodynamic stability and leak timing and outlining indications for double pigtail stenting, adjunctive drainage, and definitive reconstructive surgery.