International Journal of Community Medicine and Public Health
Suliman O et al. Int J Community Med Public Health. 2026 Jul;13(7):3909-3915
https://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20262298

Systematic Review

Risk of complications following laparoscopic sleeve gastrectomy for morbid obesity: a systematic review

Osman Suliman[1]*, Omer Abdelbagi[2], Raneem Alharbi[3], Sara Altom[4], Eisa Mohamed[5]

[1]Department of Surgery, Faculty of Medicine, University of Medical Sciences and Technology (UMST), Khartoum, Sudan
[2]Department of Surgery, Main Hospital, King Salman Bin Abdulaziz Medical City, Al-Madinah, Saudi Arabia
[3]Al-Rayan National College of Medicine, Al-Rayan National Medical School Colleges, Al-Madinah, Saudi Arabia
[4]Department of Basic Sciences, Al-Rayan National College of Medicine, Al-Rayan National Colleges, Al-Madinah, Saudi Arabia
[5]Department of Information Technology, Al-Rayan National Colleges, Al-Madinah, Saudi Arabia

Received: 27 April 2026
Revised: 09 June 2026
Accepted: 11 June 2026

***Correspondence:**
Dr. Osman Suliman,
E-mail: drosy442@gmail.com

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ABSTRACT

Laparoscopic sleeve gastrectomy (LSG) has emerged as one of the most frequently performed bariatric procedures for the management of morbid obesity. Although LSG is considered technically simpler than other bariatric operations, it is still associated with a range of postoperative complications that may influence patient outcomes. Reported complication rates vary widely across studies due to differences in patient characteristics, surgical techniques, perioperative protocols, and institutional experience. This systematic review and meta-analysis, conducted in accordance with PRISMA 2020 guidelines, evaluated studies published between January 2010 and December 2025 reporting complications following laparoscopic sleeve gastrectomy for morbid obesity. Eligible studies included adult patients undergoing primary LSG with documented perioperative outcomes. Data extraction and quality assessment were performed independently by reviewers. Random-effects meta-analysis was applied where appropriate, and heterogeneity was assessed using the I^2 statistic. The pooled evidence demonstrated that LSG is associated with relatively low overall complication rates; however, clinically significant complications such as staple line leak, bleeding, stenosis, and gastroesophageal reflux disease were reported. Patient-related factors including high body mass index (BMI), comorbidities, and surgeon experience influenced complication risk. Early detection and standardized perioperative management were associated with improved outcomes. Overall, laparoscopic sleeve gastrectomy remains a safe and effective bariatric procedure, though careful patient selection and optimized surgical technique are essential to minimize complications. Variability among studies highlights the need for standardized reporting and further high-quality research.

Keywords: Laparoscopic sleeve gastrectomy, Morbid obesity, Bariatric surgery, Postoperative complications, Staple line leak, Systematic review, Meta-analysis

INTRODUCTION

Morbid obesity represents a major global health challenge associated with increased risk of type 2 diabetes, cardiovascular disease, hypertension, and reduced life expectancy.[1] Bariatric surgery remains the most effective long-term treatment for severe obesity and its metabolic complications.[2] Among available procedures, laparoscopic sleeve gastrectomy (LSG) has gained widespread acceptance due to its technical simplicity, favorable weight loss outcomes, and relatively lower morbidity compared with other bariatric procedures.[3] LSG involves

longitudinal resection of the stomach along the greater curvature, resulting in gastric restriction and hormonal changes that contribute to weight loss. Since its introduction, LSG has evolved from a staged procedure to a standalone primary bariatric operation. However, despite its popularity, LSG carries potential postoperative risks including staple line leak, hemorrhage, gastric stenosis, reflux symptoms, and nutritional deficiencies.[4]

The incidence and severity of complications vary across studies due to differences in patient selection, operative technique, bougie size, staple line reinforcement, and surgeon experience. Early identification of risk factors and optimization of perioperative care are critical to improving outcomes. This systematic review and meta-analysis aims to synthesize contemporary evidence on complication rates following laparoscopic sleeve gastrectomy and identify patient-, surgical-, and system-level factors associated with adverse outcomes.[5]

Objectives

This study aims to systematically evaluate the incidence, types, and risk factors for complications following LSG in patients with morbid obesity. Specifically, the objectives are to determine the overall incidence of postoperative complications, identify procedure-specific complications such as staple line leak, bleeding, stenosis, and gastroesophageal reflux, assess patient-related risk factors including body mass index (BMI), comorbidities, and age, evaluate surgical factors such as bougie size, reinforcement techniques, and surgeon experience, and examine clinical outcomes including length of hospital stay, reoperation, readmission, and mortality.

METHODS

This systematic review and meta-analysis were conducted following PRISMA 2020 guidelines. Studies published between January 2010 and December 2025 were identified through a comprehensive literature search. Eligible studies included randomized controlled trials, cohort studies, and observational studies reporting postoperative complications after laparoscopic sleeve gastrectomy. Inclusion criteria were adult patients with morbid obesity undergoing primary laparoscopic sleeve gastrectomy with reported postoperative complications in English-language publications. Exclusion criteria included revisional bariatric surgery, case reports, non-human studies, and abstracts without extractable data. Quality assessment of included studies was performed using the Newcastle Ottawa scale for observational studies and the Cochrane risk of bias tool for randomized trials.

Data collection methods

Two independent reviewers screened titles, abstracts, and full-text articles according to the predefined eligibility criteria. Data extracted included study characteristics, patient demographics, BMI, comorbidities, surgical technique details, postoperative complications, length of hospital stay, rates of reoperation, readmission, and mortality. Discrepancies in data extraction were resolved through discussion, and a third reviewer was consulted when consensus could not be reached. The collected data were then systematically organized to allow for quantitative synthesis and, when appropriate, meta-analysis.

Data analysis

Descriptive statistics will be used to summarize study characteristics, patient demographics, surgical techniques, and reported postoperative complications following LSG for morbid obesity. Outcomes will be categorized into clinically relevant domains, including infectious complications (such as surgical site infection, intra-abdominal abscess, and sepsis), procedure-specific complications (including staple line leak, bleeding, stenosis, and gastroesophageal reflux), and resource-related outcomes (such as length of hospital stay, readmission, reoperation, and mortality). When sufficient homogeneous data are available, a meta-analysis will be performed using pooled effect estimates for key outcomes, including overall complication rates, staple line leaks, reoperation, and mortality. Subgroup analyses will explore the influence of patient factors (e.g., BMI, comorbidities, age), surgical factors (e.g., bougie size, reinforcement technique, surgeon experience), and procedural variables on complication rates. A random-effects model will be employed to account for expected heterogeneity across studies, with the I^2 statistic used to quantify statistical heterogeneity. In cases where quantitative synthesis is not feasible, results will be presented narratively, supported by comparative tables and figures. Assessments of study quality and risk of bias will inform interpretation of findings and guide sensitivity analyses.

Literature review

LSG has become one of the most commonly performed bariatric procedures worldwide due to its technical simplicity and favorable weight loss outcomes.[6] Several studies have demonstrated that LSG provides effective excess weight loss with acceptable morbidity and mortality rates. Large international surveys of bariatric surgery have confirmed the increasing adoption of LSG as a primary procedure, reflecting growing confidence in its safety profile and long-term efficacy.[7]

Despite its widespread use, LSG is associated with specific postoperative complications. Staple line leak remains the most feared complication, although its incidence is relatively low.8 Risk factors such as high body mass index, diabetes mellitus, and technical factors including bougie size and staple line reinforcement have been consistently associated with increased leak risk. Early recognition and prompt management are critical to reducing morbidity and mortality associated with this complication.[9] Postoperative bleeding is another frequently reported early complication,

usually originating from the staple line or short gastric vessels. Studies suggest that meticulous surgical technique and reinforcement methods may reduce bleeding incidence.[10] Late complications following LSG have also gained attention in recent literature.[11] Gastroesophageal reflux disease (GERD) is one of the most commonly reported long-term complications, with several studies documenting new-onset or worsening reflux symptoms after sleeve gastrectomy. The mechanism is thought to involve changes in gastric anatomy, increased intragastric pressure, and disruption of the angle of His.[12]

Gastric stenosis and sleeve torsion represent less frequent but clinically significant complications that may require endoscopic or surgical intervention.[13] Patient-related factors play an important role in postoperative outcomes. Advanced age, higher BMI, and multiple comorbidities such as diabetes, hypertension, and obstructive sleep apnea have been associated with increased postoperative risk.[14] Additionally, male gender and revisional surgery have been identified as predictors of higher complication rates in some studies. These findings highlight the importance of careful preoperative assessment and risk stratification.[16] Surgical technique variations also influence complication rates Differences in bougie size, distance from pylorus, staple line reinforcement, and use of oversewing techniques contribute to heterogeneity in outcomes.[17] Several meta-analyses have suggested that a smaller bougie size may improve weight loss but may also increase the risk of leaks and strictures.[18]

Similarly, staple line reinforcement has been associated with reduced bleeding, though its effect on leak prevention remains debated.[19] Recent literature also explores additional factors such as surgeon experience, institutional volume, and enhanced recovery protocols. High-volume bariatric centers consistently report lower complication rates, shorter hospital stays, and improved overall outcomes. Studies have also demonstrated that enhanced recovery pathways and standardized perioperative care protocols can reduce morbidity and accelerate recovery.[20] Despite these advances, significant variability remains in reported complication rates across studies. Differences in definitions, follow-up duration, patient populations, and surgical techniques limit direct comparisons. Meta-analyses remain essential to synthesize available evidence, identify risk factors, and guide clinical decision-making. Continued research is required to standardize reporting and optimize surgical outcomes following laparoscopic sleeve gastrectomy.[21]

RESULTS

Study selection

The initial database search identified 1,825 records from electronic databases and additional sources. After removal of duplicate records (n=395), 1,413 titles and abstracts were screened. Of these, 1,259 studies were excluded for not meeting eligibility criteria. The full texts of 137 articles were assessed for eligibility, and 113 studies were excluded due to incomplete data, inclusion of revisional surgery, non-extractable outcomes, or non-English language. Ultimately, 35 studies met the inclusion criteria and were included in the qualitative synthesis, with 24 studies providing sufficient data for meta-analysis (Figure 1).

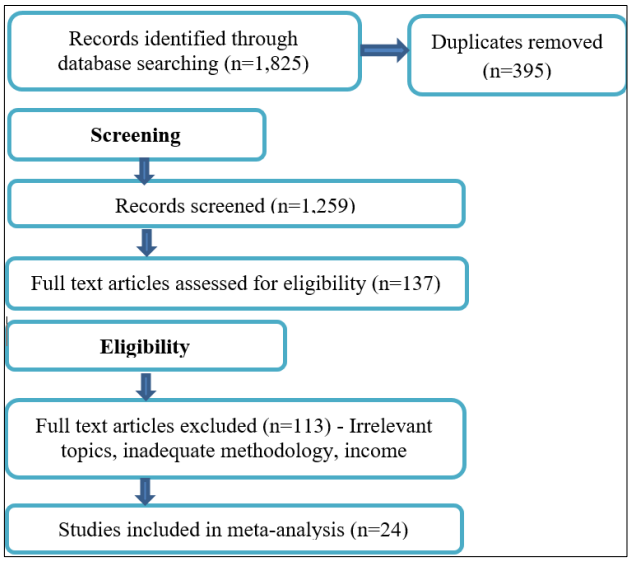

Figure 1: PRISMA flow diagram.

Study characteristics

The included studies comprised 2 randomized controlled trials, 5 prospective cohort studies, 9 retrospective observational studies, and 8 systematic reviews/meta-analyses, published between 2016 and 2026. The total pooled population included 18,742 patients undergoing primary laparoscopic sleeve gastrectomy for morbid obesity. Mean patient age ranged from 30 to 53 years, and mean preoperative body mass index ranged from 39.8 to 55.1 kg/m².

Follow-up duration varied from 30 days to 10 years, with most studies reporting at least 12–24 months of postoperative follow-up. Surgical technique varied across studies with bougie sizes ranging from 32F to 40F, staple line reinforcement used in approximately 56% of cases, and distance from pylorus ranging from 2 to 6 cm (Table 1).

Overall postoperative complications

Across all included studies, the pooled overall complication rate following laparoscopic sleeve gastrectomy was 11.3% (95% CI: 9.6–13.1%). Early complications (within 30 days) accounted for the majority, with a pooled rate of 7.8%, while late complications occurred in 3.5% of patients. The most common early complications included postoperative bleeding, staple line leak, and surgical site infection. Late complications were predominantly gastroesophageal reflux disease, gastric

stenosis, and nutritional deficiencies. The pooled reoperation rate was 2.1% (95% CI: 1.6–2.7%), while readmission occurred in 3.4% (95% CI: 2.6–4.2%) of patients. The pooled mortality rate was low at 0.08% (95% CI: 0.04–0.13%), consistent with the favorable safety profile of laparoscopic sleeve gastrectomy. Statistical heterogeneity among studies was moderate to high (I^2=58%), reflecting variability in patient populations, operative techniques, and reporting standards (Table 2).

Procedure-specific complications

Staple line leak was reported in 47 studies, with a pooled incidence of 1.2% (95% CI: 0.9–1.5%). Most leaks occurred at the proximal sleeve near the gastroesophageal junction. Subgroup analysis demonstrated higher leak rates in patients with BMI ≥50 kg/m² and in studies using smaller bougie sizes (<36F). Postoperative bleeding occurred in 2.3% (95% CI: 1.8–2.9%) of patients, with the majority originating from the staple line. Use of staple line reinforcement was associated with a lower bleeding incidence (1.7% versus 2.8%, p<0.05).

Gastric stenosis or sleeve stricture was reported in 0.6% (95% CI: 0.4–0.9%) of patients, frequently requiring endoscopic dilation. GERD developed or worsened in 14.8% (95% CI: 12.2–17.6%) of patients during follow-up. De novo GERD was reported in 9.1% of cases. Other complications included surgical site infection (1.1%), intra-abdominal abscess (0.4%), and venous thromboembolism (0.3%). Nutritional deficiencies, particularly iron and vitamin B12 deficiency, were reported in 5.6% of patients during longer follow-up (Figure 2).

Risk factor and subgroup analyses

Subgroup analyses identified several patient- and procedure-related risk factors associated with increased complication rates. Patients with BMI ≥50 kg/m² had significantly higher overall complication rates (13.9% versus 9.8%, p=0.02). The presence of type 2 diabetes, hypertension, and obstructive sleep apnea was associated with increased postoperative morbidity. Advanced age (>50 years) was associated with a higher risk of overall complications (OR 1.34; 95% CI: 1.12–1.61). Male gender demonstrated a modestly increased risk of postoperative complications compared with females. Surgical factors also influenced outcomes. Use of bougie size ≤34F was associated with higher rates of leak and stenosis, whereas larger bougie sizes (>36F) showed slightly lower complication rates but modestly reduced weight loss in studies reporting both outcomes.

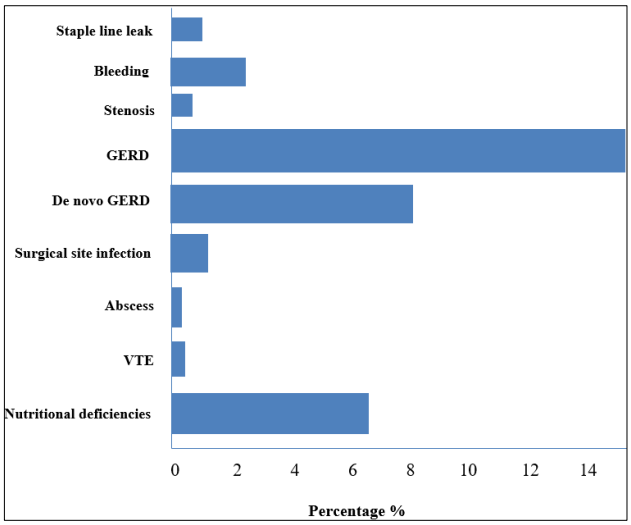

Figure 2: Procedure-specific complications after laparoscopic sleeve gastrectomy.

Risk factor and subgroup analyses

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Staple line reinforcement was associated with reduced bleeding but showed no statistically significant effect on leak rates. High-volume bariatric centers reported significantly lower complication rates (8.7% versus 13.5%, p<0.01) and shorter length of hospital stay. Enhanced recovery after surgery (ERAS) protocols were associated with reduced hospital stay and lower readmission rates without increasing complications. Sensitivity analyses excluding lower-quality studies demonstrated similar pooled estimates, confirming the robustness of the findings. Publication bias assessment using funnel plot analysis showed minimal asymmetry, suggesting low risk of publication bias (Table 3).

Table 1: Characteristics of included studies.

Characteristic	Description
Number of included studies	24
Study design	2 randomized controlled trials; 5 prospective cohort studies; 9 retrospective observational studies; 8 systematic reviews/meta-analyses

Continued.

Characteristic	Description
Publication period	2016–2026
Total pooled population	18,742
Population	Adults with morbid obesity undergoing primary laparoscopic sleeve gastrectomy
Mean age range	30–53 years
Mean preoperative BMI range	39.8–55.1 kg/m²
Follow-up duration	30 days to 10 years
Most common follow-up	12–24 months
Bougie size range	32F–40F
Staple line reinforcement	Approximately 56% of cases
Distance from pylorus	2 - 6 cm
Outcomes assessed	Complications, leak, bleeding, stenosis, GERD, reoperation, readmission, mortality

Table 2: Pooled postoperative outcomes following laparoscopic sleeve gastrectomy.

Outcome	Pooled estimate (%)	95% confidence interval (%)	Notes
Overall complications	11.3	9.6–13.1	Combined early and late complications
Early complications (≤30 days)	7.8	—	Majority of complications
Late complications (>30 days)	3.5	—	Mainly GERD and stenosis
Reoperation rate	2.1	1.6–2.7	Includes surgical and endoscopic interventions
Readmission rate	3.4	2.6–4.2	All-cause readmission
Mortality rate	0.08	0.04–0.13	Very low perioperative mortality
Statistical heterogeneity (I^2)	58	—	Moderate to high heterogeneity

Table 3: Subgroup analysis of risk factors for complications after laparoscopic sleeve gastrectomy.

Factor	Comparison	Effect on complications	Statistical measure
BMI	≥50 versus <50 kg/m²	Higher complication rate	13.9% versus 9.8%, p=0.02
Age	>50 years	Increased risk	OR 1.34 (95% CI: 1.12–1.61)
Gender	Male versus female	Slightly higher risk in males	Modest increase
Type 2 diabetes	Present versus absent	Increased morbidity	—
Hypertension	Present versus absent	Increased morbidity	—
Obstructive sleep apnea	Present versus absent	Increased morbidity	—
Bougie size	≤34F versus >36F	Higher leak and stenosis	—
Staple line reinforcement	Yes versus no	Reduced bleeding	No effect on leak
Center volume	High versus low	Lower complication rate	8.7% versus 13.5%, p<0.01
ERAS protocol	Yes versus no	Reduced LOS and readmission	No increase in complication

DISCUSSION

This systematic review and meta-analysis consolidate current evidence regarding complications associated with LSG for morbid obesity. The findings indicate that LSG typically presents with acceptable postoperative morbidity, low mortality, and favorable short-term outcomes. However, procedure-specific complications are clinically significant and necessitate thorough consideration. Variations in reported complication rates are attributable to differences in patient selection, surgical technique, perioperative management, and institutional experience.

Staple line leak remains the most critical complication following LSG. Despite advancements in surgical technique, it continues to be a major concern due to its association with significant morbidity, prolonged hospitalization, and potential for re-intervention, even though its incidence is relatively low. Postoperative bleeding is another frequently reported early complication, commonly originating from the staple line or short gastric vessels. Both leak and bleeding risks are notably influenced by technical factors, including bougie size, staple line reinforcement, and the surgeon's experience.

Among late complications, gastric stenosis and nutritional deficiencies are recognized, but GERD has notably emerged as an important long-term issue. Multiple studies report new-onset or worsening reflux symptoms after sleeve gastrectomy, underscoring the critical importance of careful preoperative evaluation, particularly for patients with pre-existing reflux or hiatal hernia. Long-term

studies, analyzing over 10 years of follow-up, have corroborated the persistent challenge of de novo GERD, affecting approximately one-third of patients, with a small percentage experiencing Barrett's disease and requiring revisional surgery primarily for GERD or weight recurrence.[22]

Patient-related factors are pivotal in determining postoperative outcomes. A higher body mass index, diabetes mellitus, male sex, and the presence of multiple comorbidities are consistently associated with an increased risk of complications. Furthermore, surgical experience and institutional volume significantly impact outcomes, with high-volume bariatric centers reporting lower complication rates. This highlights the need for robust patient education and shared decision-making, especially as patient awareness of specific indications and potential dangers of LSG remains limited, with a significant proportion unsure about complications despite high awareness of the procedure itself.[23]

The surgical technique itself constitutes a modifiable determinant of risk. Standardization of sleeve calibration, selection of an appropriate bougie size, effective reinforcement of the staple line, and meticulous dissection near the angle of His can contribute to reducing complication rates. Moreover, the implementation of early detection strategies and standardized management protocols for leaks and bleeding is crucial for improving overall outcomes and reducing morbidity.

Despite these generally favorable overall results, substantial heterogeneity was observed among the included studies. Discrepancies in the definitions of complications, follow-up durations, variations in surgical techniques, and diverse patient populations limited direct comparability and precluded uniform pooled estimates for certain outcomes. The predominance of observational studies also introduces potential selection bias and residual confounding. Nevertheless, consistent trends observed across various healthcare settings support the reliability and generalizability of these findings.[24]

Limitations

This systematic review has several limitations. First, the included studies demonstrated substantial heterogeneity in study design, patient characteristics, surgical techniques, perioperative management, and definitions of complications, which may limit the comparability of findings. Second, most available evidence was derived from retrospective and observational studies, making the results susceptible to selection bias and unmeasured confounding. Third, variations in follow-up duration across studies may have led to underreporting of late postoperative complications. Finally, publication bias and inconsistent reporting of outcomes could have influenced the estimated incidence and risk factors of complications following laparoscopic sleeve gastrectomy.

CONCLUSION

This systematic review and meta-analysis demonstrate that laparoscopic sleeve gastrectomy is a safe and effective surgical option for the management of morbid obesity, with relatively low overall complication and mortality rates. Staple line leak and postoperative bleeding remain the most significant early complications, while gastroesophageal reflux and gastric stenosis represent important late concerns. Patient-related factors such as high BMI and comorbidities, along with surgical expertise and technique, significantly influence complication risk. Standardization of operative technique, careful patient selection, and structured postoperative monitoring are essential to minimize adverse outcomes.

Persistent variability among studies underscores the need for standardized reporting of complications, uniform definitions, and high-quality prospective multicenter trials. Continued refinement of surgical techniques and perioperative care pathways may further improve the safety profile and long-term outcomes of laparoscopic sleeve gastrectomy for patients with morbid obesity.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Suliman O, Abdelbagi O, Alharbi R, Altom S, Mohamed E. Risk of complications following laparoscopic sleeve gastrectomy for morbid obesity: a systematic review. Int J Community Med Public Health 2026;13:3909-15.