Anastomotic Leak and Stricture in Colorectal Surgery: A Systematic Review and Meta-Analysis

Authors: Anna Lemańska[3] ORCID: 0009-0008-3207-1248, **Kornella Zieleń**[1] ORCID: 0009-0007-3440-909X**, Sandra Moska**[2] ORCID: 0009-0004-5475-3216, **Dagmara Kanar**[4] ORCID: 0009-0005-5577-5334**, Izabela Majchrzak**[1] ORCID: 0009-0009-0682-7184, **Joanna Cygan**[5] ORCID: 0009-0000-5512-8261**, Martyna Lenartowicz**[1] ORCID: 0009-0008-3452-6090, **Antonina Woźnicka**[1] ORCID: 0009-0001-3602-4819**, Julia Klincewicz**[1] ORCID: 0009-0002-2135-0117,

Authors' Affiliation:

[1]University Clinical Hospital in Poznań, Poland

[2]Regional Hospital in Poznań, Poland

[3]Central Clinical Hospital, Uniwersity Clinical Center of the Medical University of Warsaw, Poland

[4]Collegium Medicum, Cardinal Stefan Wyszyński University in Warsaw, Faculty of Medicine, Poland

[5]Independent Public Health Care Facility of the Ministry of Interior and Administration in Katowice, Poland

Corresponding Author: Anna Lemanska

Central Clinical Hospital, Uniwersity Clinical Center of the Medical University of Warsaw, Poland

Abstract

Background: Anastomotic leak (AL) and stricture (AS) are major complications of colorectal surgery. This systematic review synthesizes evidence on risk factors, prevention strategies, and management.

Methods: Comprehensive search of PubMed, Cochrane, Scopus, Embase, Web of Science (inception–July 2024). Meta-analysis using random-effects models with GRADE assessment. Study quality evaluated using MINORS and RoB 2 tools.

Results: 66 studies included (11,560 patients). Risk factors for AL: male sex (OR 1.53, 95% CI 1.23–1.91), low rectal location <7cm (77.8% of prediction models), neoadjuvant radiotherapy (OR 2.34, 95% CI 1.51–3.64), elevated BMI >30 kg/m². Intraoperative perfusion assessment significantly reduced AL rates (7.4% vs 12.4%, p<0.01). Indocyanine green fluorescence angiography (ICG-FA) demonstrated strongest evidence (OR 0.586, 95% CI 0.434–0.792,

NNT=21). Endoscopic salvage techniques proved effective: vacuum-assisted closure (88.8% success), over-the-scope clips (57–100%), self-expanding metal stents (50–100%) in hemodynamically stable patients. Anastomotic stricture incidence: 17% (95% CI 13–21%), with risk factors including protective stoma (OR 2.88), anastomotic leak (OR 3.72), radiotherapy (OR 2.43), and low location (WMD −3.11 cm). Mechanical anastomosis was protective (OR 0.39).

Conclusions: Intraoperative perfusion assessment with ICG-FA reduces leak rates (moderate-certainty evidence). Endoscopic salvage is safe and effective in selected patients. Multiple risk factors require individualized prevention strategies.

Keywords: anastomotic leak, anastomotic stricture, colorectal surgery, perfusion imaging, indocyanine green, meta-analysis, risk factors

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I. INTRODUCTION

Colorectal cancer remains a leading cause of malignancy worldwide. While surgical resection with primary anastomosis is standard treatment, anastomotic complications represent significant sources of morbidity and mortality [1]. Anastomotic leak occurs in approximately 5–15% of colorectal anastomoses and carries substantial morbidity (>50%) with mortality rates of 6–22% [2,3]. Anastomotic stricture affects 3–30% of patients and represents common late morbidity impacting quality of life [4,5].

Traditional assessment of bowel viability relied on visual and tactile evaluation. However, adoption of minimally invasive surgery and technical challenges of low anterior resection have driven development of objective perfusion assessment modalities including indocyanine green fluorescence angiography (ICG-FA), hyperspectral imaging (HSI), laser speckle contrast imaging (LSCI), and diffuse reflectance spectroscopy (DRS) [6,7].

Simultaneously, endoscopic salvage techniques have been developed for managing early anastomotic leaks in selected patients, offering alternatives to reoperation. Numerous risk stratification systems have been proposed, yet substantial heterogeneity exists in their methodology and predictive accuracy [8,9].

This systematic review synthesizes current evidence on: (1) risk factors for anastomotic complications; (2) effectiveness of intraoperative perfusion assessment; (3) endoscopic and surgical management strategies; (4) utility of existing risk stratification systems; and (5) gaps requiring future research.

II. METHODS

A. Search Strategy

Systematic review conducted per PRISMA 2020 guidelines [10]. Protocol registered with PROSPERO prior to initiation.

Literature search performed in PubMed, Cochrane Central Register, Scopus, Embase, Web of Science (inception–July 2024) using search terms: ("anastomotic leak" OR "anastomotic leakage" OR "anastomotic dehiscence" OR "anastomotic stricture") AND ("colorectal surgery" OR "rectal surgery" OR "anastomosis") AND ("risk factors" OR "perfusion" OR "fluorescence" OR "indocyanine green" OR "endoscopic management" OR "prediction").

B. Inclusion and Exclusion Criteria

Inclusion: Randomized controlled trials, prospective/retrospective cohort studies with ≥30 patients reporting anastomotic complications, risk factors, perfusion assessment, endoscopic management, or risk stratification systems.

Exclusion: Case reports, editorials, studies of non-colorectal anastomoses, publications lacking specific data, non-English articles without translation, duplicate cohorts.

C. Quality Assessment

Study quality assessed using MINORS for non-randomized studies and Cochrane RoB 2 for RCTs [11,12]. GRADE methodology applied for certainty of evidence assessment. Studies classified as high, medium, or low quality.

D. Statistical Analysis

Meta-analysis performed using random-effects models with DerSimonian-Laird variance estimation. Odds ratios (OR) and weighted mean differences (WMD) calculated with 95% confidence intervals. Heterogeneity quantified using Q statistic and I^2 index. Sensitivity analyses performed excluding high-risk-of-bias studies. Publication bias assessed using funnel plots and Egger regression (≥10 studies).

III. RESULTS

A. Study Selection and Characteristics

Search identified 2,307 references; 66 studies met inclusion criteria (6 RCTs, 4 prospective cohort, 28 retrospective cohort, 24 additional comparative studies). Total: 11,560 patients across 17 nations (Japan n=17, USA n=10, Italy n=10, Germany n=8, China n=3).

B. Risk Factors for Anastomotic Leak

Patient-Related Factors:

- Male sex: OR 1.53 (95% CI 1.23–1.91), representing 53% increased risk
- Age: Older age associated with increased risk (WMD 3.09 years, p=0.0002)
- BMI >30 kg/m²: Increased risk 1.2–1.8-fold across studies
- Smoking: OR 1.54 (95% CI 1.11–2.13), mechanism via vasoconstriction
- Diabetes: No significant association (OR 1.17, p=0.70)

Disease-Related Factors:

- Low rectal location (<7 cm): Strongest predictor (88.8% of risk models included this variable). Leak rates 14.4% vs 6.1% for higher locations
- Neoadjuvant radiotherapy: OR 2.34 (95% CI 1.51–3.64), mechanism via endarteritis obliterans

Intraoperative Factors:

- Prolonged operative time: Approximately 1.5-fold increased risk per 60 minutes
- Blood loss/transfusion: OR 1.3–1.8
- Surgical approach: No significant difference (laparoscopic vs open, OR 0.90, p=0.76)

C. Intraoperative Perfusion Assessment

Overall Effectiveness:

Perfusion assessment significantly reduced AL rates: 7.4% with assessment vs 12.4% without (OR 0.05, 95% CI 0.04–0.07, NNT=21).

ICG-FA (52 studies, 10,789 patients):

- Pooled AL rate: 5.0% (4.1% with ICG vs 9.3% control)
- Pooled OR: 0.05 (95% CI 0.04–0.06)
- RCT meta-analysis (6 RCTs, 1,949 patients): OR 0.586 (95% CI 0.434–0.792), absolute risk reduction 4.7%, NNT=21
- GRADE certainty: Moderate
- Operating time increase: median 5.4 minutes
- Margin relocation: 9–11% of cases
- Limitation: Lack of standardized protocol (variable uptake times, ICG doses)

HSI (5 studies, 265 patients):

- Pooled AL rate: 7.9% (intervention) vs 12.3% (control)
- Pooled OR: 0.08 (95% CI 0.04–0.16)
- Advantages: Objective StO_2 measurement, no dye required
- Disadvantages: Not laparoscopy-compatible, requires darkened field

LSCI (3 studies, 185 patients):

- Pooled AL rate: 4.3% vs 15.8%
- Pooled OR: 0.06 (95% CI 0.02–0.19)
- Advantages: Contrast-free, quantitative assessment
- Disadvantages: Not real-time, requires image superimposition

DRS (6 studies, 321 patients):

- Pooled AL rate: 13.4% vs 9.4%
- Pooled OR: 0.14 (95% CI 0.08–0.24)
- GRADE certainty: Very low
- Higher leak rates than other modalities; measurement of small tissue area may explain discrepancy

D. Endoscopic Management of Anastomotic Leak

Vacuum-Assisted Closure (14 studies, 197 patients):

- Salvage rate: 88.8% in patients without peritonitis
- Optimal timing: 75% success if <6 weeks post-diagnosis vs 38% if >6 weeks
- Mean sponge dwell time: 34.4±19.4 days
- Stoma reversal rate: 88%

- Mechanism: Promotes granulation, reduces edema, increases vascularity

Over-The-Scope Clips (7 studies, 62 patients):

- Technical success: 86–100%
- Long-term salvage: 57–100%
- Most effective for small defects (<2 cm)
- Endoscopic salvage rate: 92.9%

Self-Expanding Metal Stents (9 studies, 58 patients):

- Long-term salvage: 50–100% (typically 75–86%)
- Stent migration: 27.3% requiring restenting
- Mean stent dwell time: 24 days

Fibrin Glue (3 studies, 22 patients):

- Success rate: 75–100%
- Best suited as adjunctive therapy for small defects (<5 mm)
- Most effective combined with vacuum therapy

E. Anastomotic Stricture

Epidemiology: Incidence 17% (95% CI 13–21%) across 9 studies, 3,031 patients.

Risk Factors:

- Protective stoma: OR 2.88 (paradoxically increases risk via reduced mechanical stimulation)
- Anastomotic leak: OR 3.72 (mechanism: severe local inflammation and fibrosis)
- Radiotherapy: OR 2.34 (mechanism: endarteritis, transmural fibrosis)
- Low anatomic location: WMD −3.11 cm (each 3 cm closer to anus significantly increases risk)
- Mechanical anastomosis protective: OR 0.39 (61% risk reduction vs manual anastomosis)

Management: Endoscopic dilation first-line (70–90% initial success, 40–50% recurrence requiring repeat procedures); stents for refractory cases.

F. Risk Stratification Systems

Nine published scoring systems identified. Heterogeneity substantial:

- Predictive accuracy: AUC 0.597–0.973
- Variables in ≥2 scores: Distance from anal verge (88.8%), sex (77.8%), ASA score (66.6%), operative duration (66.6%)
- Limitations: Small derivation cohorts (some with only 12 AL cases), limited external validation (44.4% only), selection bias toward lower-risk patients

IV. DISCUSSION

A. Major Findings

This meta-analysis of 66 studies (11,560 patients) demonstrates: (1) Anastomotic leak remains significant (5–15% incidence, 25% for very low anastomoses) despite modern techniques; (2) Multiple modifiable perioperative risk factors exist; (3) ICG-FA is evidence-based with moderate-certainty RCT support (4.7% absolute risk reduction, NNT=21); (4) Endoscopic salvage safe and effective in hemodynamically stable patients (88.8% VAC success when <6 weeks); (5) Anastomotic stricture (17% incidence) has distinct risk factors and is potentially preventable via mechanical anastomosis; (6) Existing risk stratification systems are heterogeneous with limited validation.

B. Clinical Implications

Perfusion Assessment: ICG-FA recommended for high-risk anastomoses (location <7 cm, radiotherapy, male, BMI >30) given moderate evidence base. Lack of standardization remains limitation; future research should develop objective quantitative algorithms.

Endoscopic Salvage: For hemodynamically stable, non-peritonitic patients: small defects (<2 cm) → over-the-scope clips; medium defects (2–5 cm) → vacuum-assisted closure or stents; large defects (>5 cm) or high-risk locations → surgical diversion.

Stricture Prevention: Expedite protective stoma closure; use mechanical anastomosis when possible.

C. Limitations

Substantial heterogeneity in definitions, study designs, and populations. Publication bias potential despite inclusion of observational studies. Limited individual patient data; summary-level analysis only. Some outcomes restricted to small numbers of studies. Language restriction to English may exclude relevant literature.

D. Future Research Directions

1. Standardized protocols for perfusion assessment (objective quantitative measurements, standardized timing/doses)
2. Real-time, laparoscopy-compatible perfusion imaging systems
3. Comparative effectiveness trials of endoscopic salvage techniques
4. External validation of risk stratification systems with inclusion of surgeon experience
5. Patient-reported outcome measures and cost-effectiveness analyses
6. Investigation of stricture formation mechanisms after leak

V. CONCLUSIONS

Anastomotic leak and stricture remain important complications of colorectal surgery. This systematic review of 66 studies demonstrates that intraoperative perfusion assessment with ICG-FA (moderate-certainty evidence) reduces leak rates by 4.7% (NNT=21). Endoscopic salvage is safe and effective in appropriately selected hemodynamically stable patients. Anastomotic stricture (17% incidence) is common with distinct preventable risk factors. Current risk stratification systems lack standardization and external validation. Future research must prioritize objective quantitative perfusion assessment, standardized definitions, comparative effectiveness studies, and patient-reported outcomes.

REFERENCES

[1] Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71(3):209–249.

[2] Sciuto A, Merola G, Palma G, et al. Predictive factors for anastomotic leakage after laparoscopic colorectal surgery. *World J Gastroenterol*. 2018;24(21):2247–2260.

[3] Mirnezami A, Mirnezami R, Chandrakumaran K, et al. Increased local recurrence and reduced survival from colorectal cancer following anastomotic leak: systematic review and meta-analysis. *Ann Surg*. 2011;253(5):890–899.

[4] Luchtefeld MA, Milsom JW, Senagore A, et al. Colorectal anastomotic stenosis: results of a survey of the ASCRS membership. *Dis Colon Rectum*. 1989;32(9):733–736.

[5] Clifford RE, Fowler H, Govindarajah N, et al. Management of benign anastomotic strictures following rectal resection: a systematic review. *Colorectal Dis*. 2020;23(12):3090–3100.

[6] Kingham TP, Pachter HL. Colonic anastomotic leak: risk factors, diagnosis, and treatment. *J Am Coll Surg*. 2009;208(2):269–278.

[7] Renna MS, Grzeda MT, Bailey J, et al. Intraoperative bowel perfusion assessment methods and their effects on anastomotic leak rates: a meta-analysis. *Br J Surg*. 2023;110(9):1131–1142.

[8] Litchinko A, Buchs N, Balaphas A, et al. Score prediction of anastomotic leak in colorectal surgery: a systematic review. *Surg Endosc*. 2024;38(4):1723–1730.

[9] Rojas-Machado SA, Valdes-Hernandez J, Cintas-Catena J, et al. Prediction of anastomotic leak in colorectal cancer surgery based on a new prognostic index PROCOLE. *Int J Colorectal Dis*. 2016;31(2):197–210.

[10] Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.

[11] Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (MINORS): development and validation of a new instrument. *ANZ J Surg*. 2003;73(9):712–716.

[12] Higgins JPT, Altman DG, Sterne JAC. Chapter 8: Assessing risk of bias in included studies. In: *Cochrane Handbook for Systematic Reviews of Interventions*. Version 6.3. Cochrane; 2022.

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Conflict of Interest

The authors declare no conflicts of interest.

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