

ANASTOMOTIC TECHNIQUE, SUTURE CHARACTERISTICS AND CIRCULAR STAPLER DIAMETER IN RELATION TO ANASTOMOTIC LEAKAGE: IMPLICATIONS FOR SURGICAL QUALITY MANAGEMENT

Roland Sebastian HORVATH, MD^{1,2},
Ramona Amina POPOVICI, Prof.³,
Anamaria GOZMAN-POP, MD⁴, Teodor
Andrei MAGHIAR, PhD⁵, Octavian Adrian
MAGHIAR, PhD⁵, Paula Bianca MAGHIAR,
MD⁵, Ligia VAIDA, Prof.⁶ and Marius Adrian
MAGHIAR, Prof.⁵

¹ Doctoral School of Biomedical Sciences, University
of Oradea, 410087 Oradea, Romania

² Bekes County Central Hospital, 5700 Gyula, Hungary

³ Faculty of Dental Medicine, "Victor Babes"
University of Medicine and Pharmacy, 300041
Timisoara, Romania

⁴ Bihor County Emergency Hospital, 410167 Oradea,
Romania

⁵ Department of Surgical Disciplines, Faculty of
Medicine and Pharmacy, University of Oradea,
410087 Oradea, Romania

⁶ Department of Dentistry, Faculty of Medicine and
Pharmacy, University of Oradea, 410087 Oradea,
Romania

Corresponding author: Ramona Amina Popovici
Faculty of Dental Medicine, "Victor Babes"
University of Medicine and Pharmacy, Piața
Efimie Murgu nr. 2, 300041 Timișoara,
Romania

Email: ramona.popovici@umft.ro

Disclaimers: None declared

INTRODUCTION

Anastomotic leakage is one of the most consequential adverse events after colorectal resection. It is associated with reintervention, prolonged hospitalisation, intensive care use, mortality and impaired oncological recovery, and therefore functions not only as a clinical complication but also as an indicator of surgical quality and resource utilisation [1,2]. The economic implications are substantial. Contemporary reviews show that leakage increases hospital costs mainly through prolonged admission, readmission, intensive care and additional procedures [3,4]. From a management perspective, reducing preventable leakage is therefore relevant to patient safety, institutional performance and efficient use of surgical resources [5].

Reported incidence rates of anastomotic leakage vary considerably across the literature, ranging from approximately 1% to over 20%, a discrepancy attributable in large part to the absence of a universally applied definition and to heterogeneity in diagnostic criteria across studies [6]. This variability complicates direct comparison between institutions and hinders the identification of consistently

BACKGROUND: Anastomotic leakage remains a major determinant of morbidity, mortality and resource use after colorectal resection. Although several technical variables are under direct surgical control, evidence on their individual contribution to leakage risk remains inconsistent, and local audit data linking technique to outcome are scarce.

METHODS: This retrospective observational study included 315 consecutive adult patients undergoing colorectal resection with primary anastomosis at a single centre between January 2018 and December 2024. Anastomoses were categorised as hand-sewn (by configuration, suture calibre and pattern) or mechanically stapled (by circular stapler diameter). Anastomotic leakage was defined according to the International Study Group of Rectal Cancer criteria. Categorical comparisons used Fisher's exact and Fisher-Freeman-Halton exact tests, with odds ratios and 95% confidence intervals calculated for selected comparisons.

RESULTS: Overall leakage occurred in 25 of 315 anastomoses (7.9%). Leakage rates did not differ significantly between hand-sewn (6.5%) and stapled (9.7%) techniques (odds ratio 0.65, 95% CI 0.28–1.47; $p=0.306$). Within hand-sewn anastomoses, neither configuration, suture calibre nor suturing pattern was significantly associated with leakage. Among stapled anastomoses, leakage rates ranged from 0% to 22.2% across diameters, with no significant global association ($p=0.240$); a post hoc comparison showed higher odds of leakage with 33-mm than 32-mm staplers (odds ratio 4.79, 95% CI 1.07–21.47; $p=0.050$), based on only 18 patients.

CONCLUSION: In this single-centre cohort, no technical variable showed a statistically robust association with anastomotic leakage, although the signal observed with larger circular staplers warrants further investigation. These findings support systematic documentation of anastomotic technique and continuous outcome audit as tools for local quality management, pending prospective multicentre validation.

Keywords: Anastomotic Leak; Colorectal Surgery; Surgical Staplers; Suture Techniques; Quality Improvement

modifiable risk factors. Among the few technical variables shown to influence leakage rates with reasonable consistency, surgeon operative volume and the choice of anastomotic construction in specific anatomical contexts (for example, stapled versus hand-sewn ileocolic anastomosis) have emerged as relevant determinants in pooled analyses of randomised evidence [7,8]. This underscores the need for centre-level data that can help disentangle technique-related variation from case-mix and definitional heterogeneity.

The integrity of a colorectal anastomosis depends on multiple patient, disease and procedural factors [9]. Although many patient-related determinants cannot be modified immediately, several technical variables are under direct surgical control. These include the choice between hand-sewn and stapled construction, anastomotic configuration, suture calibre, continuous or interrupted suturing and, when a circular stapler is used, device diameter. Previous systematic reviews have not established a universal advantage of stapled over hand-sewn colorectal anastomosis [10,11]. Evidence regarding the finer technical details of hand-sewn anastomoses remains less consistent, while recent analyses have renewed interest in the relationship between circular stapler diameter and leakage [12,13].

Variation in technique may also reflect local practice patterns and individual surgeon preference. For healthcare organisations, systematic documentation of these choices and linkage to postoperative outcomes can transform routine clinical data into a quality-management instrument [14]. The objective of this study was therefore to evaluate the relationship between technical characteristics of colorectal anastomosis and anastomotic leakage in a single-centre cohort, with particular emphasis on potentially modifiable factors that could inform local standardisation and audit.

MATERIALS AND METHODS

This retrospective observational study included consecutive adult patients undergoing colorectal resection with primary anastomosis at a single surgical centre between January 2018 and December 2024. Cases with a protective stoma, right colectomy, abdominoperineal resection or transanal total mesorectal excision were excluded in order to preserve a more homogeneous cohort for technical comparison. Rectal cancer patients in the cohort received neoadjuvant treatment according to institutional oncological protocols. The final study population comprised 315 procedures.

For each operation, the anastomotic technique was extracted from the operative record. Anastomoses were categorised as hand-sewn or mechanically stapled. Hand-sewn anastomoses were classified by configuration as end-to-end, side-to-end, end-to-side or side-to-side; by suture calibre as 2/0 or 3/0; and by suture pattern as continuous or interrupted. Mechanical anastomoses were classified by circular stapler diameter: 28, 29, 31, 32 or 33 mm. Anastomotic leakage was defined in accordance with the International Study Group of Rectal Cancer concept as a defect of intestinal wall integrity at the anastomotic site, creating a communication between the intra- and extraluminal compartments [14]. Both clinically and radiologically diagnosed leaks were included, with or without reintervention.

Categorical variables are reported as counts and percentages. Leakage rates were calculated for each technical subgroup. For two-group comparisons with small expected frequencies, Fisher's exact test was used. For multi-category contingency tables containing sparse cells, the Fisher–Freeman–Halton exact test was used rather than Pearson's chi-squared test. Odds ratios and 95% confidence intervals were calculated for selected two-group comparisons. A two-sided *p* value below 0.05 was considered statistically significant. Because only 25 leakage events occurred and several technical categories were small, subgroup findings were considered exploratory, and no high-dimensional multivariable model was fitted; this approach was chosen to reduce the risk of model overfitting and spurious precision. The comparison between 33-mm and 32-mm staplers was a post hoc exploratory analysis; no adjustment for multiple comparisons was performed, and this result should therefore be regarded as hypothesis-generating.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Békés County Central Hospital, Gyula, Hungary

(protocol code F/271-1/2025, date of approval 31 January 2025), and by the Research Ethics Subcommittee of the University of Oradea, Romania (protocol code No. 90, date of approval 31 March 2026).

RESULTS

Among the 315 colorectal anastomoses, 25 leaks were identified, corresponding to an overall rate of 7.9%. A total of 170 anastomoses were hand-sewn and 145 were mechanically stapled. Leakage occurred in 11 hand-sewn cases (6.5%) and 14 stapled cases (9.7%). Hand-sewn construction was therefore associated with lower unadjusted odds of leakage, although the difference was not statistically significant (odds ratio 0.65, 95% confidence interval 0.28–1.47; Fisher's exact *p*=0.306) (Table 1).

Table 1. Anastomotic leakage according to principal construction technique

Technique	N	Leaks, n (%)	Odds ratio (95% CI)	p value
Hand-sewn	170	11 (6.5)	0.65 (0.28-1.47)	0.306
Stapled	145	14 (9.7)	Reference	

Data source: authors' own retrospective clinical database. CI, confidence interval.

Among the hand-sewn anastomoses, end-to-end was the most frequent configuration (114 cases), followed by side-to-end (46 cases). Leakage occurred in 7 end-to-end anastomoses (6.1%), 3 side-to-end anastomoses (6.5%), no end-to-side anastomoses (0/5) and 1 side-to-side anastomosis (20.0%; 1/5). The overall distribution did not demonstrate a statistically significant association between configuration and leakage (Fisher–Freeman–Halton exact *p*=0.537). The apparently high percentage observed in the side-to-side subgroup was based on only five procedures and should not be interpreted as evidence of excess risk (Table 2).

Table 2. Anastomotic leakage according to hand-sewn anastomotic configuration

Hand-sewn configuration	n	Leaks, n (%)
End-to-end	114	7 (6.1)
Side-to-end	46	3 (6.5)
End-to-side	5	0 (0.0)
Side-to-side	5	1 (20.0)
Global comparison	170	Fisher-Freeman-Halton exact <i>p</i> =0.537

Data source: authors' own retrospective clinical database. Fisher–Freeman–Halton exact test was used because of sparse cells.

Within the 170 hand-sewn anastomoses, 99 were performed with 2/0 sutures and 71 with 3/0 sutures. Leakage occurred in 8.1% and 4.2% of cases, respectively (odds ratio 1.99, 95% confidence interval 0.51–7.79; Fisher's exact *p*=0.363). Continuous suturing was used in 96 cases and interrupted suturing in 74. Leakage occurred in 9 of 96 continuous anastomoses (9.4%) compared with 2 of 74 interrupted anastomoses (2.7%). The estimated odds ratio was 3.72 (95% confidence interval 0.78–17.79), although the difference did not reach statistical significance (Fisher's exact *p*=0.116) (Table 3).

Table 3. Anastomotic leakage according to suture calibre and suture pattern

Technical factor	Category	n	Leaks, n (%)	Odds ratio (95% CI)	p value
Suture calibre	2/0	99	8 (8.1)	1.99 (0.51-7.79)	0.363
	3/0	71	3 (4.2)	Reference	
Suture pattern	Continuous	96	9 (9.4)	3.72 (0.78-17.79)	0.116
	Interrupted	74	2 (2.7)	Reference	

Data source: authors' own retrospective clinical database. CI, confidence interval.

Table 4. Anastomotic leakage according to circular stapler diameter

Stapler diameter	n	Leaks, n (%)
28 mm	12	1 (8.3)
29 mm	1	0 (0.0)
31 mm	43	5 (11.6)
32 mm	71	4 (5.6)
33 mm	18	4 (22.2)
Global comparison	145	Fisher-Freeman-Halton exact p=0.240
Post hoc exploratory 33 vs 32 mm		OR 4.79 (95% CI 1.07-21.47); Fisher p=0.050

Data source: authors' own retrospective clinical database. Global comparison used the Fisher-Freeman-Halton exact test. The 33-versus-32-mm comparison was post hoc and exploratory; no adjustment for multiple comparisons was performed.

Among the 145 stapled anastomoses, the most commonly used diameter was 32 mm (71 cases), followed by 31 mm (43 cases), 33 mm (18 cases), 28 mm (12 cases) and 29 mm (1 case). Leakage rates were 8.3% for 28 mm, 0% for 29 mm, 11.6% for 31 mm, 5.6% for 32 mm and 22.2% for 33 mm. The global association across stapler diameters was not statistically significant (Fisher-Freeman-Halton exact p=0.240). In a post hoc exploratory comparison, 33-mm staplers were associated with higher observed odds of leakage than 32-mm staplers (odds ratio 4.79, 95% confidence interval 1.07–21.47; Fisher's exact p=0.050). No adjustment for multiple comparisons was performed; this result should therefore be regarded as hypothesis-generating. Compared with all other stapler sizes combined, the 33-mm group showed a non-significant trend towards higher leakage (odds ratio 3.34, 95% confidence interval 0.92–12.09; p=0.075) (Table 4).

DISCUSSION

The present cohort demonstrates that the broad choice between hand-sewn and mechanically stapled colorectal anastomosis was not significantly associated with leakage. This finding is consistent with systematic evidence showing no clear overall superiority of one construction method over the other for colorectal anastomoses [10,11], including comparisons that additionally considered compression anastomosis as a third, less widely adopted alternative [15]. From a quality-management perspective, this suggests that institutional policy should not focus exclusively on a binary manual-versus-stapled rule. Instead, standardisation should address the complete technical process, patient selection, anastomotic level,

tissue perfusion, tension and consistent documentation [16].

The hand-sewn subgroup yielded two clinically interesting but statistically uncertain signals. The observed leakage rate was numerically higher with 2/0 than with 3/0 sutures and higher after continuous than interrupted suturing. Neither comparison reached statistical significance, and the wide confidence intervals preclude prescriptive recommendations. Nevertheless, these findings support detailed technical documentation. Previous systematic work found that several elements of hand-sewn colorectal anastomosis, including suture material, calibre and pattern, remain incompletely standardised [17], although prospective observational data suggest that slowly absorbable monofilament material performs comparably to braided sutures in this setting [18]. A local quality programme could therefore record configuration, material, calibre and suture pattern as a minimum operative data set.

The most notable exploratory finding concerned circular stapler diameter. The 33-mm subgroup had a leakage rate of 22.2% versus 5.6% with 32 mm. A 2025 meta-analysis of 24,511 patients similarly found more leakage with 31/33-mm than with 28/29-mm circular staplers [12]. Conversely, a 2026 systematic review of low colorectal anastomoses found no significant difference in leakage between smaller and larger staplers, although larger devices reduced stricture [19]. These data suggest that diameter does not act in isolation and is confounded by anatomy, bowel diameter, anastomotic level and pathology. Device technology itself may add a further layer of variability, since recent meta-analyses suggest that powered circular staplers may be associated with lower leakage rates than manual devices [20,21], a variable not captured in the present dataset.

The 33-mm result must be interpreted cautiously, because only 18 patients received this stapler and four developed leakage. The 33-versus-32-mm comparison was selected post hoc after inspection of subgroup rates, only marginally reached the conventional significance threshold and was one of several subgroup analyses. No multiplicity correction was applied. It should therefore be treated as a surveillance signal and hypothesis-generating observation rather than a causal finding. Including stapler diameter and device type in prospective operative registries, alongside adjunctive intraoperative assessments such as air-leak testing or perfusion imaging that have been associated with lower leakage rates in prior meta-analyses [22,23], and periodically reviewing risk-adjusted outcomes would be a reasonable quality-management response. Emerging adjunctive technologies, including staple-line reinforcement and biodegradable intraluminal devices, may further inform future protocol development, although evidence for these remains heterogeneous [24].

Such audit has organisational relevance because leakage increases length of stay, readmission, reoperation and intensive care use [3,4]. Structured morbidity-and-mortality review has itself been shown to reduce anastomotic failure rates when embedded within a continuous improvement cycle [25], and standardised presentation formats have been shown to improve the quality and educational value of such reviews [26]. Linking process measures, including anastomotic technique and device choice, to outcomes can support morbidity review, procurement, training and local protocol development. From an organisational perspective, systematic collection of anastomotic configuration, suture pattern, suture calibre and stapler diameter could allow hospitals to establish procedure-specific benchmarks [27], identify outlier patterns and integrate technical variables into morbidity-and-mortality review. Standardisation should preserve appropriate surgeon judgement while making technical variation visible, measurable and auditable.

This study is limited by its retrospective single-centre design, non-randomised technique selection and only 25 leakage events. Anastomotic technique and stapler diameter were not randomly assigned and were likely influenced by bowel diameter, anastomotic level, pelvic anatomy, pathology, disease severity, operative approach and surgeon preference; confounding by indication therefore cannot be excluded. Several configurations and stapler sizes were represented by very small groups, and the post hoc subgroup comparisons were not adjusted for multiple testing. These limitations precluded a reliable high-dimensional multivariable model. The results therefore identify associations and quality-improvement signals rather than independent causal effects. Strengths include a consecutive multi-year cohort, detailed technical categorisation and direct linkage of operative technique with a clinically relevant outcome.

CONCLUSIONS

In this single-centre cohort, hand-sewn and mechanically stapled colorectal anastomoses showed no statistically significant difference in anastomotic leakage. Within hand-sewn procedures, the higher observed leakage rates associated with continuous suturing and 2/0 sutures did not reach statistical significance. Among stapled procedures, the 33-mm diameter showed a higher observed leakage rate in a small post hoc subgroup comparison, but this finding is exploratory and hypothesis-generating. These findings support the systematic recording of anastomotic characteristics, protocol-based review of local practice and continuous outcome audit as components of surgical quality management. Prospective multicentre validation with risk adjustment is required before specific technical recommendations can be made.

References

1. Gielen AHC, Heuvelings DJI, Sylla P, et al. Impact of Anastomotic Leakage After Colorectal Cancer Surgery on Quality of Life: A Systematic Review. *Dis Colon Rectum*. 2025;68(2):154-170.
2. Tsalikidis C, Mitsala A, Mentonis VI, et al. Predictive Factors for Anastomotic Leakage Following Colorectal Cancer Surgery: Where Are We and Where Are We Going? *Curr Oncol*. 2023;30(3):3111-3137.
3. Nijssen DJ, Wienholts K, Postma MJ, et al. The economic impact of anastomotic leakage after colorectal surgery: a systematic review. *Tech Coloproctol*. 2024;28(1):55.
4. Weber MC, Berlet M, Stoess C, et al. A nationwide population-based study on the clinical and economic burden of anastomotic leakage in colorectal surgery. *Langenbecks Arch Surg*. 2023;408(1):55.
5. Taskforce Anastomotic Leakage. Optimizing intraoperative conditions in patients undergoing elective colorectal surgery to prevent anastomotic leakage: SmartCheck study. *Br J Surg*. 2025;112(12):znaf236.
6. Shogan BD, Carlisle EM, Alverdy JC, Umanskiy K. Do we really know why colorectal anastomoses leak? *J Gastrointest Surg*. 2013;17(9):1698-1707.
7. Wallace B, Schuepbach F, Gaukel S, et al. Evidence according to Cochrane Systematic Reviews on Alterable Risk Factors for Anastomotic Leakage in Colorectal Surgery. *Gastroenterol Res Pract*. 2020;2020:9057963.
8. Choy PY, Bissett IP, Docherty JG, et al. Stapled versus handsewn methods for ileocolic anastomoses. *Cochrane Database Syst Rev*. 2011;(9):CD004320.
9. Horváth RS, Moca AE, Gozman-Pop A, et al. Emergency Surgery and the Risk of Anastomotic Leakage After Colorectal Resection with Primary Anastomosis for Benign and Malignant Disease: A Single-Center Retrospective Study. *J Clin Med*. 2026;15(14):5551.
10. Kanani F, Riya N, Mayaleh MAA, et al. Evidence-Based Approaches to Reduce Anastomotic Leakage in Colorectal Surgery: A Systematic Review of Techniques and Prevention Strategies. *Indian J Surg*. 2025.
11. Ijaz Ul Haq HM, Shiekh IG, Raza SH. Comparing Stapled and Hand-Sutured Colorectal Anastomoses: A Systematic Review and Meta-Analysis of Observational Cohorts Assessing Short- and Long-Term Complications. *Cureus*. 2026;18(1):e100676.
12. Fiorillo C, Tondolo V, Biffoni B, et al. Circular staplers and anastomotic leakage in colorectal surgery: meta-analysis. *BJS Open*. 2025;9(2):zrae170.
13. Alkurt EG, Akdoğan MY, Tutan MB, Kartal B, Turhan VB. Impact of Circular Stapler Diameter on Anastomotic Leakage in Left-Sided Colorectal Cancer: A Retrospective Single-Center Case-Control Analysis. *Medicina (Kaunas)*. 2025;61(12):2231.
14. European Society of Coloproctology (ESCP) COR-REA Collaborating Group. Towards safer colorectal surgery worldwide: Outcomes and benchmarks from the ESCP CORREA 2022 audit. *Colorectal Dis*. 2025;27(11):e70281.

References continues on the next page

References continues from the previous page

15. Steger J, Jell A, Ficht S, et al. Systematic Review and Meta-Analysis on Colorectal Anastomotic Techniques. *Ther Clin Risk Manag.* 2022;18:523-539.
16. Nachiappan S, Askari A, Currie A, Kennedy RH, Faiz O. Intraoperative assessment of colorectal anastomotic integrity: a systematic review. *Surg Endosc.* 2014;28(9):2513-2530.
17. Slieker JC, Daams F, Mulder IM, Jeekel J, Lange JF. Systematic review of the technique of colorectal anastomosis. *JAMA Surg.* 2013;148(2):190-201.
18. Baumann P, Kim J, Ahn SH, et al. Mid-term absorbable monofilament is safe and effective for gastrointestinal anastomosis - PROMEGAT - A single-arm prospective observational study. *Ann Med Surg (Lond).* 2018;30:1-6.
19. Stylianidi MC, Vaghiri S, Pandkhahi A, et al. Impact of circular stapler size on anastomotic complications after low colorectal anastomosis: a systematic review and meta-analysis. *Minerva Surg.* 2026;81(1):49-58.
20. Martín-Arévalo J, Moro-Valdezate D, Pérez-Santiago L, et al. Current evidence on powered versus manual circular staplers in colorectal surgery: a systematic review and meta-analysis. *Int J Colorectal Dis.* 2025;40(1):13.
21. Ohtani H, Shibutani M, Tatsunari F, Kasashima H, Maeda K. A Meta-analysis of Powered Circular Stapler Versus Manual Circular Stapler for Colorectal Anastomosis. *In Vivo.* 2025;39(4):2165-2175.
22. Meyer J, Joshi H, Buchs NC, Ris F, Davies J. Fluorescence angiography likely protects against anastomotic leak in colorectal surgery: a systematic review and meta-analysis of randomised controlled trials. *Surg Endosc.* 2022;36(10):7775-7780.
23. Kryzauskas M, Bausys A, Jakubauskas M, et al. Intraoperative testing of colorectal anastomosis and the incidence of anastomotic leak: A meta-analysis. *Medicine (Baltimore).* 2020;99(47):e23135.
24. Gravante G, Annicchiarico A, Melcarne R, et al. Novel adjunctive technologies for the prevention of colorectal anastomotic leakage: a systematic review. *Tech Coloproctol.* 2026;30(1):43.
25. Vogel P, Vassilev G, Kruse B, Cankaya Y. Morbidity and Mortality conference as part of PDCA cycle to decrease anastomotic failure in colorectal surgery. *Langenbecks Arch Surg.* 2011;396(7):1009-1015.
26. Mitchell EL, Lee DY, Arora S, et al. Improving the quality of the surgical morbidity and mortality conference: a prospective intervention study. *Acad Med.* 2013;88(6):824-830.
27. Kolfshoten NE, Marang-van de Mheen PJ, Wouters MW, et al. A combined measure of procedural volume and outcome to assess hospital quality of colorectal cancer surgery, a secondary analysis of clinical audit data. *PLoS One.* 2014;9(2):e88737.