



Anastomotic Leak and Length of Stay After Colorectal Resection with Primary Anastomosis: Open Versus Laparoscopic Surgery - A Single-Center Retrospective Study

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Abstract

Background and Aim: Anastomotic Leak (AL) are a major complication after colorectal surgery and a key driver of prolonged length of Stay (LOS). To compare AL incidence and LOS between open and laparoscopic colorectal surgery, quantify the impact of AL on LOS overall and by approach, evaluate prolonged LOS (>14 days) as a clinically meaningful hard endpoint, and explore the association between pathological T/N stage and AL.

Methods: Retrospective cohort study including 315 patients (185 open, 130 laparoscopic) undergoing colorectal resection with anastomosis at Békés County Central Hospital, Gyula, Hungary (2018-2024). Categorical variables were compared using Fisher's exact test; non-parametric continuous variables using Mann-Whitney U. Effect sizes are reported as Relative Risk (RR) and Odds Ratio (OR) with 95% Confidence Intervals (95% CI). Prolonged LOS was analyzed using logistic regression with predictors: surgical approach and AL. In the 260 patients with complete pathological TNM data, AL rates were compared across T and N categories using the Fisher-Freeman-Halton exact test.

Results: AL occurred in 25/315 patients (7.9%), numerically lower after laparoscopy (8/130; 6.2%) than after open surgery (17/185; 9.2%), without statistical significance (Fisher p=0.400; OR 1.54, 95% CI 0.65-3.69). LOS was significantly shorter after laparoscopy (median 6 vs 7 days, p<0.001). AL markedly prolonged LOS (median 17 vs. 7 days, p<0.001) and was the dominant predictor of prolonged hospitalization (>14 days) in the logistic model (adjusted OR 35.02, 95% CI 12.04-101.89, p<0.001), with open surgery also contributing independently (adjusted OR 3.65, 95% CI 1.04-12.80, p=0.043). Among 260 patients with complete TNM data, no significant association was found between pathological T category (p=0.989) or N category (p=0.386) and AL, although N2 disease showed the highest observed leak rate (13.2%).

Conclusions: Laparoscopy is associated with shorter LOS and a numerically lower AL rate. AL remains the dominant determinant of prolonged hospitalization, irrespective of surgical approach. Pathological T and N categories were not significantly associated with AL, although these exploratory findings warrant confirmation in larger, prospective, multicenter studies.

Keywords: Anastomotic leak; Colorectal surgery; Laparoscopy; Open surgery; Length of stay

Introduction

Anastomotic Leak (AL) after colorectal resection is a severe postoperative complication associated with substantial morbidity, reinterventions, and resource use [1,2]. Length of Stay (LOS) is a pragmatic marker of postoperative recovery and healthcare burden, and it is strongly influenced by major complications such as AL [3]. Reported AL rates vary widely in the literature, ranging from approximately 2.8% to 30%, due to heterogeneity in procedures, anastomotic level, and definitions [2]. Therefore, standardized reporting frameworks such as the International Study Group of Rectal Cancer (ISREC) definition and grading are recommended.

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Minimally invasive colorectal surgery has been adopted broadly, largely due to faster recovery and shorter LOS; in a recent U.S. National Cancer Database analysis of 475,001 patients, minimally invasive approaches (laparoscopic and robotic) accounted for 59.6% of colorectal cancer resections by 2020, surpassing open surgery [4]. Randomized trials and large multicenter studies have consistently reported shorter postoperative hospitalization after laparoscopy compared with open surgery in colorectal procedures. A meta-analysis pooling 15 randomized controlled trials (6557 patients) found LOS shorter by 2.64 days with laparoscopy [5], and a large national matched-cohort analysis of 12686 patients similarly reported significantly shorter LOS with laparoscopy [6]. Enhanced Recovery After Surgery (ERAS) pathways further reduce LOS, and meta-analyses combining laparoscopy with fast-track care generally show a 1-2-day reduction in LOS versus open surgery, depending on case-mix and pathway adherence [7-9]. By contrast, differences in major complications such as AL between approaches have generally been smaller and more context-dependent [7-9]. However, few studies have jointly quantified the impact of AL on LOS across surgical approaches, examined prolonged hospitalization (>14 days) as a clinically meaningful hard endpoint, or explored whether pathological T/N stage is associated with AL risk.

This study aimed to compare AL incidence and LOS between open and laparoscopic colorectal surgery, quantify the effect of AL on LOS overall and stratified by surgical approach, evaluate prolonged LOS (>14 days) as a clinically meaningful "hard" endpoint, and explore the association between pathological T/N stage and AL.

Materials and Methods

Study design and population

This was a single-center, observational retrospective cohort study including all consecutive patients who underwent colorectal resection with anastomosis at Békés County Central Hospital, Gyula, Hungary, between January 2018 and December 2024. Relevant clinical data were obtained through structured review of institutional electronic health records, surgical protocols, and discharge documentation. Application of the eligibility criteria yielded 315 patients, grouped by surgical approach into open surgery (n=185) and laparoscopic surgery (n=130). Patients converted from laparoscopic to open surgery were retained in the laparoscopic group, consistent with an intention-to-treat approach.

This sample overlaps with the institutional population previously described in two companion analyses addressing distinct research questions: cumulative surgeon experience as a determinant of AL [10], and emergency surgery as a risk factor for AL in unprotected anastomoses [11]. Those analyses applied additional exclusion criteria (e.g., right colectomies, abdominoperineal resections, Hartmann's procedures, or diverted anastomoses) not applied here, and examined different exposures. The present study is restricted to the comparison of surgical approach (open vs. laparoscopic) and does not overlap in research question or primary exposure with either prior report.

Pathological T and N categories were recorded according to the TNM classification for malignant cases. Complete T- and N-stage data were available for 260 patients, as the remaining 55 patients underwent resection for benign disease and were not staged.

Outcomes

The primary outcome was AL, defined according to ISREC criteria as a loss of integrity of the bowel wall at the anastomotic

site establishing communication between the intraluminal and extraluminal compartments. Only clinically meaningful events corresponding to ISREC grade B or C (leaks prompting active management such as percutaneous drainage, endoscopic intervention, or reoperation) were counted. A leak was registered when identified during the index admission or within 90 days of surgery, based on clinical, radiological, or intraoperative evidence.

The secondary outcome was LOS, defined as the number of postoperative days until discharge. The derived secondary outcome was prolonged LOS, defined a priori as hospitalization >14 days (yes/no).

Statistical analysis

Analyses were performed in IBM SPSS Statistics, version 25 (IBM Corp., Armonk, NY, USA). Normality was assessed using Shapiro-Wilk. Categorical variables were compared using Fisher's exact test or the chi-square test, as appropriate. Non-parametric continuous variables were compared using Mann-Whitney U. For TNM analyses, stage distributions were compared between surgical approaches using the chi-square test, and LOS was compared between approaches within each T or N category using Mann-Whitney U. Associations between AL and the multi-level T and N categories were evaluated with the Fisher-Freeman-Halton exact test using Monte Carlo estimation (200,000 resamples) because of sparse expected cell counts. Prespecified clinically interpretable grouped comparisons (T1-T2 vs. T3-T4 and N0 vs. N1-N2) were assessed using Fisher's exact test, with RR and OR and 95% CI. Effect sizes are otherwise reported as RR and OR with 95% CI.

For prolonged LOS (>14 days), crude RR/OR with 95% CI were computed and a logistic regression model was fitted with predictors: surgical approach (open vs laparoscopic) and AL (yes/no), reporting adjusted OR (aOR) with 95% CI. Statistical significance was set at $\alpha=0.05$.

Results

AL occurred in 25 of 315 patients (7.9%). The leak rate was 17 of 185 (9.2%) after open surgery and 8 of 130 (6.2%) after laparoscopic surgery. This difference did not reach statistical significance (Fisher $p=0.400$), although AL was numerically lower after laparoscopy. The effect estimates favored laparoscopy numerically: RR (open vs. lap) = 1.49 (95% CI 0.66-3.36); OR (open vs. lap) = 1.54 (95% CI 0.65-3.69) (Table 1).

Laparoscopy was associated with earlier discharge compared with open surgery: the median LOS was 6 days (IQR 5-7) after laparoscopy versus 7 days (IQR 7-10) after open surgery ($p<0.001$) (Table 2). AL significantly prolonged LOS. Overall, patients with AL had a median LOS of 17 days (IQR 13-20.5) compared with 7 days (IQR 5-8) in patients without AL ($p<0.001$). This pattern held within each surgical

Table 1: Anastomotic leak incidence by surgical approach.

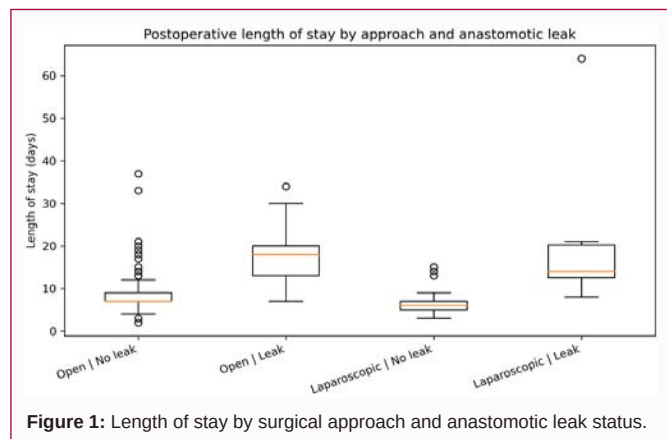
Approach	No AL	AL	Total	AL rate
Open	168	17	185	0.092
Laparoscopic	122	8	130	0.062

Table 2: Length of stay (LOS) by surgical approach.

Approach	LOS mean $\pm$ SD	LOS median (IQR)	p
Open	9.18 $\pm$ 5.19	7 (7-10)	<0.001
Laparoscopic	6.70 $\pm$ 5.83	6 (5-7)	

Table 3: LOS by AL status: overall and stratified by approach.

Group	No AL: median (IQR)	AL: median (IQR)	p
Overall	7 (5–8)	17 (13–20.5)	<0.001
Open	7 (7–9)	18 (13–20.5)	<0.001
Laparoscopic	6 (5–7)	14 (9.5–20.75)	<0.001

**Figure 1:** Length of stay by surgical approach and anastomotic leak status.

approach: in the open group, LOS was 18 days (IQR 13–20.5) with AL vs. 7 days (IQR 7–9) without AL ($p<0.001$); in the laparoscopic group, LOS was 14 days (IQR 9.5–20.75) with AL vs. 6 days (IQR 5–7) without AL ($p<0.001$) (Table 3) (Figure 1).

Prolonged LOS occurred in 22 of 315 patients (7.0%). Prolonged LOS was more frequent after open surgery than after laparoscopy: 18 of 185 patients (9.7%) in the open group exceeded 14 days, compared with 4 of 130 patients (3.1%) in the laparoscopic group ($RR=3.16$, 95% CI 1.10–9.13; $OR=3.40$, 95% CI 1.12–10.28). Prolonged LOS was also far more frequent in patients who developed AL than in those who did not: 13 of 25 patients with AL (52.0%) exceeded 14 days, compared with 9 of 290 patients without AL (3.1%) ($RR=16.76$,

95% CI 7.95–35.30; $OR=33.82$, 95% CI 12.10–94.53). In the logistic regression model, both open surgery and AL remained independently associated with prolonged hospitalization. Open surgery was associated with an adjusted OR of 3.65 (95% CI 1.04–12.80, $p=0.043$), and AL was associated with an adjusted OR of 35.02 (95% CI 12.04–101.89, $p<0.001$) (Table 4).

Pathological TNM data were available for 260 patients, of whom 160 underwent open surgery and 100 underwent laparoscopic surgery. The T-stage distribution differed significantly between approaches (chi-square $p<0.001$). This difference was largely driven by a higher frequency of T4 tumors in the open group (15.0%) than in the laparoscopic group (2.0%), whereas Tis–T2 tumors were relatively more common after laparoscopy. The N-stage distribution also differed between approaches (chi-square $p=0.003$), with N0 disease occurring more frequently after laparoscopic surgery (74.0%) than after open surgery (54.4%). LOS remained shorter after laparoscopy within individual T and N categories: this held for T2 and T3 disease (both $p<0.001$), and for N0, N1 (both $p<0.001$), and N2 disease ($p=0.011$) (Table 5 and 6).

Among the 260 patients with complete pathological TNM data, 21 developed AL (8.1%). By T category, AL occurred in 0 of 7 Tis patients (0.0%), 2 of 23 T1 patients (8.7%), 3 of 45 T2 patients (6.7%), 14 of 159 T3 patients (8.8%), and 2 of 26 T4 patients (7.7%). No significant overall association was found between T category and AL (Fisher-Freeman-Halton exact $p=0.989$). When T stage was grouped as Tis–T2 versus T3–T4, AL occurred in 5 of 75 patients (6.7%) in the lower-stage group versus 16 of 185 patients (8.6%) in the higher-stage group ($RR=1.30$, 95% CI 0.49–3.41; $OR=1.33$, 95% CI 0.47–3.76; Fisher $p=0.802$) (Table 7).

By nodal category, AL occurred in 11 of 161 N0 patients (6.8%), 5 of 61 N1 patients (8.2%), and 5 of 38 N2 patients (13.2%). Although the observed AL rate increased across N categories, this overall association did not reach statistical significance (Fisher-Freeman-

Table 4: Prolonged LOS (>14 days): frequencies, crude effect estimates, and adjusted logistic regression.

Comparison	>14 days (n/N)	Percent	Crude RR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)†	p
Laparoscopic (ref.)	4/130	0.031	1 (ref.)	1 (ref.)	1 (ref.)	—
Open	18/185	0.097	3.16 (1.10–9.13)	3.40 (1.12–10.28)	3.65 (1.04–12.80)	0.043
No AL (ref.)	9/290	0.031	1 (ref.)	1 (ref.)	1 (ref.)	—
AL present	13/25	0.52	16.76 (7.95–35.30)	33.82 (12.10–94.53)	35.02 (12.0–101.89)	<0.001

Table 5: Pathological T stage by surgical approach and postoperative length of stay.

Stage	Open, n (%)	Open LOS, median (IQR)	Laparoscopic, n (%)	Laparoscopic LOS, median (IQR)	Total, n (%)	p*
Tis	2 (1.3%)	5.5 (4.2–6.8)	5 (5.0%)	6 (3–7)	7 (2.7%)	0.839
T1	10 (6.3%)	6.5 (5.2–10)	13 (13.0%)	5 (4–8)	23 (8.8%)	0.132
T2	21 (13.1%)	7 (7–11)	24 (24.0%)	5 (5–6.2)	45 (17.3%)	<0.001
T3	103 (64.4%)	7 (7–9.5)	56 (56.0%)	6 (5–7)	159 (61.2%)	<0.001
T4	24 (15.0%)	7 (7–9.2)	2 (2.0%)	6.5 (6.2–6.8)	26 (10.0%)	0.187

Table 6: Pathological N stage by surgical approach and postoperative length of stay.

Stage	Open, n (%)	Open LOS, median (IQR)	Laparoscopic, n (%)	Laparoscopic LOS, median (IQR)	Total, n (%)	p*
N0	87 (54.4%)	7 (7–10)	74 (74.0%)	6 (5–7)	161 (61.9%)	<0.001
N1	42 (26.3%)	8 (7–10)	19 (19.0%)	5 (5–6.5)	61 (23.5%)	<0.001
N2	31 (19.4%)	7 (7–9)	7 (7.0%)	5 (4.5–6.5)	38 (14.6%)	0.011

Table 7: Anastomotic leak according to pathological T stage.

T stage	No AL, n	AL, n	Total, n	AL rate
Tis	7	0	7	0
T1	21	2	23	0.087
T2	42	3	45	0.067
T3	145	14	159	0.088
T4	24	2	26	0.077

Table 8: Anastomotic leak according to pathological N stage.

N stage	No AL, n	AL, n	Total, n	AL rate
N0	150	11	161	0.068
N1	56	5	61	0.082
N2	33	5	38	0.132

Halton exact $p=0.386$). When node-positive disease (N1-N2) was grouped and compared with N0 disease, AL occurred in 10 of 99 patients (10.1%) versus 11 of 161 patients (6.8%), respectively (RR=1.48, 95% CI 0.65-3.35; OR=1.53, 95% CI 0.63-3.75; Fisher $p=0.358$). These analyses should be interpreted as exploratory, since only 21 AL events occurred within the TNM-complete subgroup (Table 8).

The time to AL diagnosis had a median of 5 days (IQR 4.5-8), with a range of 3 to 63 days. Management strategies included diverting colostomy (32%), Hartmann's procedure (40%), conservative treatment (8%), diverting transverse colostomy (8%), resection with re-anastomosis (4%), anastomosis with ileostomy (4%), and one death (4%).

Discussion

This study highlights two clinically relevant findings and places them in the context of prior evidence. First, laparoscopy was associated with a significantly shorter LOS (median 6 vs. 7 days; $p<0.001$). The magnitude of benefit (≈ 1 day at the median) is comparable to what has been observed in randomized trials and pragmatic colorectal studies, where laparoscopy typically shortens LOS relative to open surgery [12,13] and is synergistic with ERAS-based perioperative care [14,15]. Second, AL was numerically lower after laparoscopy (6.2%) than after open surgery (9.2%), although the difference was not statistically significant ($p=0.400$). Effect estimates (RR/OR) suggest a numerical trend, with wide confidence intervals reflecting the limited number of events. This pattern is compatible with major randomized rectal-cancer trials showing broadly similar rates of major postoperative complications between approaches, while the recovery profile (including LOS) tends to favor laparoscopy [1,13]. Our overall AL rate (7.9%) also falls within published ranges, which vary substantially by definition and anastomotic level [16].

The dominant observation is the magnitude of AL impact on hospitalization, which aligns with prior work linking AL to prolonged LOS, reinterventions, and increased postoperative morbidity [17,18]. AL increased LOS substantially overall (median 17 vs. 7 days) and within both approaches, indicating that prevention, early recognition, and standardized management of AL are critical to reducing resource utilization. The median time-to-leak in our cohort (5 days) is consistent with reports that clinically significant leaks often manifest after several postoperative days and can occur later than expected [19]. Standardized definitions and grading (ISREC) support cross-study comparability and may facilitate benchmarking and

quality improvement initiatives [1,20]. This is further supported by the derived "hard" endpoint: more than half of patients with AL had LOS >14 days (52%), and AL was by far the strongest independent predictor of prolonged LOS (aOR ~ 35), while open surgery also contributed independently (aOR ~ 3.7). The pathological profile of the malignant subgroup was dominated by T3 tumors (61.2%) and node-negative disease (N0, 61.9%), providing additional context for the oncological case-mix of the cohort.

The exploratory TNM analysis did not identify a statistically significant association between pathological T or N category and AL. T-stage-specific leak rates clustered within a relatively narrow range after Tis, and advanced local stage (T3-T4) did not significantly increase AL risk compared with Tis-T2. For nodal status, the leak rate was highest in N2 disease (13.2%) and the combined N1-N2 group had numerically higher risk than N0, but confidence intervals were wide and included the null value. These findings do not exclude a clinically relevant effect of tumor burden; rather, the limited number of AL events in the TNM-complete subgroup (21 events) restricts statistical power and makes the analysis hypothesis-generating. Tumor stage may also be correlated with operative complexity and surgical approach, particularly because T4 disease was more frequent in the open group, and these factors should be considered in larger multivariable datasets.

Our findings are directionally consistent with several landmark randomized trials and large multicenter studies in colorectal surgery. The short-term recovery advantage of laparoscopy, including shorter hospitalization, was demonstrated in the randomized trial by Braga, et al. [12] and in the multicenter MRC CLASICC trial led by Guillou, et al. [21]. In rectal cancer, the COLOR II trial reported by van der Pas, et al. [13] and the subsequent randomized study published by Bonjer, et al. [22] in the New England Journal of Medicine similarly supported favorable short-term recovery profiles with laparoscopy, while major complication rates were broadly comparable. Contemporary randomized trials focused on rectal cancer pathology outcomes also highlight that differences in major complications may be modest and context-dependent [23,24]. Regarding enhanced recovery, the ERAS Society guidelines summarized by Gustafsson, et al. [9] provide a framework that likely contributes to shorter LOS and should be considered when benchmarking institutional outcomes. Finally, our median time-to-leak and its pronounced impact on LOS align with recent evidence on the timing of clinically significant leaks [25], and with ongoing international efforts to standardize AL definitions and reporting, including a recently proposed consensus reporting framework [26] and a systematic evaluation of reporting quality across colorectal trials [27].

This study has several limitations. Its retrospective, single-center design limits generalizability and exposes the analysis to inherent selection and information bias, and surgical approach was not randomized, which likely explains the significant imbalance in T- and N-stage distribution between the open and laparoscopic groups and complicates the interpretation of approach as an independent factor. The logistic regression model for prolonged LOS was restricted to two predictors given the limited number of events, so established confounders such as ASA classification, body mass index, neoadjuvant therapy, and comorbidity burden could not be incorporated, and residual confounding cannot be excluded. The exploratory TNM analyses were based on a small number of AL events (21 among 260 patients with complete staging), limiting statistical power and

warranting a hypothesis-generating interpretation. Given these limitations, the present findings should be regarded as hypothesis-generating rather than definitive, warranting confirmation in larger, prospective, multicenter studies.

Conclusion

In this retrospective sample of 315 patients, laparoscopy was associated with a significantly shorter length of stay compared with open surgery (median 6 vs. 7 days; $p < 0.001$), and the anastomotic leak rate was numerically lower after laparoscopy (6.2% vs. 9.2%), although this difference did not reach statistical significance ($p = 0.400$). Anastomotic leak emerged as the dominant determinant of prolonged hospitalization, markedly increasing the odds of exceeding 14 days of stay (adjusted OR ~35), while surgical approach also contributed independently. Pathological T and N categories were not significantly associated with anastomotic leak in the TNM-complete malignant subgroup, although the N2 category showed the highest observed leak rate. Given the retrospective, single-center design and the limited number of leakage events, these findings should be regarded as hypothesis-generating rather than definitive, supporting the value of laparoscopy for reducing length of stay while underscoring anastomotic leak, rather than surgical approach alone, as the primary target for reducing prolonged hospitalization in colorectal surgery.

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