



The role of C-reactive protein (CRP) and procalcitonin in predicting anastomotic leakage after lower gastrointestinal system operations

CRP and procalcitonin in anastomotic leakage

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Abstract

Aim: Anastomotic leakage is a significant problem in lower gastrointestinal surgery that can lead to serious complications. This study aimed to investigate the effects of CRP and procalcitonin on anastomotic leakage in patients undergoing lower gastrointestinal surgery.

Methods: The study included 303 patients who underwent lower gastrointestinal surgery at the Department of General Surgery at Istanbul Medipol University Mega Hospital Complex between March 2013 and May 2016. Patients were divided into two categories: leakage ($n = 29$) and non-leakage ($n = 274$). Patient demographics and clinical data, along with CRP, leukocyte count, and procalcitonin levels on postoperative days 3 and 5, were analyzed.

Results: The ileocolic anastomosis region was significantly more common in the leaking group ($P < .05$). Complication rates differed significantly, with a higher rate of wound infection in the leaking group ($P < .05$). Sensitivity of CRP on the 3rd day was 79.3%, and on the 5th day, 72.4%. For procalcitonin, sensitivity on the 3rd day was 79.3% and on the 5th day after the operation was 75.9%. ROC analysis results showed that the area under the curve was the highest for CRP on the 5th day, followed by procalcitonin on the 3rd day, CRP on the 3rd day, and procalcitonin on the 5th day. All predictive values for both indicators on both measuring days were over 70%.

Conclusion: CRP and procalcitonin levels on postoperative days 3 and 5 may be diagnostic of anastomotic leaks in lower gastrointestinal surgery. Further studies on this topic are recommended for greater predictive value.

Keywords

lower gastrointestinal tract, anastomotic leak, CRP, procalcitonin

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Introduction

In lower gastrointestinal surgery, many types of anastomoses can be performed between two bowel segments.¹ The anastomosis can be end-to-end, end-to-side, side-to-end, or side-to-side. The anastomotic technique can be hand-sewn or stapled.² The submucosal layer of the bowel, which is the strongest part of the bowel wall, must be included in the anastomosis to ensure healing.³ The choice of anastomosis depends on the surgical anatomy and the surgeon's preference.⁴ Although many surgeons favor one technique, no technique has been proven superior.

Anastomotic leaks often present between the 5th and 7th postoperative days. Morbidity and mortality are higher with earlier leaks.⁵ Because there is no intra-abdominal adhesion, the infection cannot be localized, and the patient develops signs of sepsis after leakage.⁶ If symptoms are evident, emergency laparotomy is performed. For anastomotic leaks that develop more than 48 hours after surgery, a treatment plan can be developed based on the location of the leak.^{7,8} Anastomotic leaks are the most important and serious cause of increased morbidity and mortality. The incidence of anastomotic leaks has been reported in the literature to range from 1% to 40%, depending on the definition used.⁹⁻¹¹ Early detection of anastomotic leakage and initiation of appropriate treatment may reduce the need for reoperation and stoma formation, thereby maintaining the patient's quality of life.

Diagnosis of anastomotic leak should be made as early as possible to reduce associated morbidity and mortality. CRP, an acute-phase protein synthesized by the liver, is used as a marker of complications after abdominal surgery.¹²⁻¹⁴ Due to its short half-life, CRP is a reliable indicator of the systemic inflammatory response and a marker of surgical-related complications, and it tends to normalize as the patient recovers.¹⁵ Procalcitonin levels are usually elevated after major abdominal, vascular, and thoracic surgeries but remain low in patients undergoing minor surgeries and aseptic procedures.¹⁶ Procalcitonin levels are thought to be induced by intestinal anastomotic preparation, transient bacterial contamination during surgery, or bacterial translocation.^{17,18} In addition, elevated procalcitonin levels are frequently observed in patients with abnormal postoperative outcomes compared to patients with normal postoperative outcomes.

Anastomotic leakage is a serious problem in lower gastrointestinal surgery and can lead to serious complications. The aim of this study was to investigate the effect of CRP and procalcitonin on anastomotic leakage in patients undergoing lower gastrointestinal surgery and anastomosis.

Materials and Methods

Research Model

The study was designed as a retrospective study. The medical records of patients who underwent lower gastrointestinal surgery were retrospectively analyzed and described using a descriptive screening model. Then, a correlation screening model was used to examine the relationship between patients' CRP and procalcitonin levels and anastomotic status.

Patients

The study included patients who underwent lower gastrointestinal surgery in the Department of General Surgery, Medipol University Complex, Istanbul, between March 2013 and May 2016.

Inclusion Criteria

- Patients over 18 years old,
- Patients who underwent lower gastrointestinal surgery,

- Patients with complete medical records,

Exclusion Criteria

Emergency surgery,

- Patients under 18 years old,
- Patients who underwent hyperthermic intraperitoneal chemotherapy,
- Patients without anastomosis.

Data Collection

Demographic data, comorbidities, variables related to the underlying disease and preoperative treatment (if any), surgery-related data (type of surgery, type of resection, type of anastomosis, anastomosis technique), and data related to complications up to the 30th postoperative day were collected. Procedure: During the study period, all patients in our clinic received antibiotics (ceftriaxone/cefazolin plus metronidazole) throughout the postoperative hospital stay. Oral fluid intake was started on the second postoperative day, and solid food intake on the third postoperative day. In addition, CRP and procalcitonin levels were determined regularly on the third and fifth postoperative days. Contrast agent was administered orally, intravenously, or rectally to patients with purulent or intestinal contents drained through the abdominal cavity, elevated procalcitonin levels (> 2 ng/mL) against the background of fever (> 38 °C), or signs of peritoneal irritation. Abdominal computed tomography (CT) was performed.

Patients with elevated CRP or procalcitonin levels on postoperative day 3, but no clinical findings, were visually assessed on postoperative day 5. If patients developed infectious complications despite antibacterial therapy, antibacterial therapy was initiated after consultation with an infectious disease specialist.

Patients were discharged after they were able to tolerate their usual diet and their bowel function had recovered. However, if symptoms or signs of complications developed, additional examinations and treatments were performed, which prolonged the hospital stay. Percutaneous intervention was performed if anastomotic leakage was suspected or if abscesses or fluid collections were not amenable to medical treatment. Patients who developed generalized peritonitis underwent a repeat operation with abdominal lavage, anastomotic diversion, and end colostomy.

Ethical Approval

This study was approved by the Medipol University Non-invasive Clinical Research Ethics Committee (Date: 26.04.2017, Decision No: 160).

Statistical Analysis

Nominal and ordinal parameters were described with frequencies. Scale parameter normality was assessed using the Kolmogorov-Smirnov test. Normally distributed parameters were characterized by means and standard deviations, and their differences were tested with an Independent-Samples t-test. Non-normally distributed parameters were described with medians and ranges, and their differences were tested with the Mann-Whitney U test. Receiver Operating Characteristic (ROC) analysis was used to assess the predictive value of CRP and procalcitonin levels. SPSS 25.0 for Windows was used for analysis at a 95% Confidence Interval and a 0.05 significance level.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

Results

The mean age of the non-leaking group was higher than that of

Table 1. ROC Analysis Results for Predictive Value of CRP and Procalcitonin at 3rd and 5th Day After Operation

Parameters	Sensitivity	Specificity	Negative predictive	Cut off level	Area under curve	P
CRP at 3rd day	79.3	65.9	96.7	158.5 mg/L	0.741	.000
Procalcitonin at 3rd day	79.3	64.2	96.7	0.65 ng/ml	0.756	.000
CRP at 5th day	72.4	73.4	96.2	75 mg/L	0.782	.000
Procalcitonin at 5th day	75.9	59.5	95.9	0.25 ng/ml	0.730	.000

the leaking group. In the non-leaking group, 40.5% of patients were female, whereas 37.9% of patients in the leaking group were female. Hypertension and diabetes mellitus were more common in the non-leaking group. Chronic artery disease, chronic obstructive pulmonary disease, and chronic heart failure were more common in the leaking group. Age, gender, comorbidities, ASA score, diagnosis, malignancy, ileus, and perforation frequency differences between patient groups were insignificant ($P > .05$) (Supplementary Table S1).

95.8% of the non-leaking group and 75.0% of the leaking group had neoadjuvant therapy. Low anterior resection, anterior resection, and IB anastomosis were more common in the non-leaking group. Right hemicolectomy, colocolic anastomosis, extended right hemicolectomy, and IPAA were more frequent in the leaking group. Neoadjuvant treatment, type of operation, minimally invasive approach, stromal deflection, anastomosis type, and differences in technique between patient groups were not significant ($P > .05$). The ileocolic anastomosis region was significantly more common in the leaking group ($P < .05$) (Supplementary Table S2).

Antibiotic type differences were insignificant for both groups ($P > .05$). However, complication differences were significant with high wound infection in the leaking group ($P < .05$) (Supplementary Table S2).

Leukocyte, CRP, and procalcitonin differences on the 3rd and 5th days after operation were significantly higher in the leaking group ($P < .05$) (Supplementary Table S2).

Sensitivity of CRP on the 3rd day was 79.3%, and on the 5th day, 72.4%. For procalcitonin, sensitivity on the 3rd day was 79.3%, and on the 5th day after the operation, 75.9%. ROC analysis results showed that the area under the curve was the highest for CRP on the 5th day, followed by procalcitonin on the 3rd day, CRP on the 3rd day, and procalcitonin on the 5th day. All predictive values for both indicators on both measuring days were over 70% (Table 1).

Discussion

This study investigated the effects of CRP and procalcitonin on anastomotic leakage in patients undergoing lower gastrointestinal surgery. The medical records of 303 patients were analyzed, 29 of whom had anastomotic leakage. The findings suggest that CRP and procalcitonin levels on days 3 and 5 may serve as a statistically significant indicator of anastomotic leakage.

Ileoileal, ileocolic, ileorectal, coloanal, colonic, colorectal, and ileoanal anastomoses were performed after lower gastrointestinal surgeries. In patients with septic complications after these surgeries, CRP levels peak on the third postoperative day and tend to stabilize thereafter.¹⁹ The combination of a minimally invasive approach and the ERAS protocol can safely reduce the average hospital stay to 4 days after surgery.²⁰ In 2012, Warshkow and colleagues published a meta- analysis evaluating the predictive value of CRP for infectious complications after colorectal surgery.²¹ They found that CRP testing on postoperative day 4 achieved satisfactory accuracy in predicting anastomotic leak, with a

negative predictive value of 89%, suggesting a cutoff of 135 mg/L. Singh and colleagues published another meta-analysis predicting anastomotic leak using CRP on postoperative days 3, 4, and 5.²² They observed comparable diagnostic accuracy for CRP values on days 3, 4, and 5, as reported in this meta-analysis. They found a high negative predictive value (97%) but a low positive predictive value (21–23%). These results confirmed that CRP is a valid negative test but not a good positive test for predicting anastomotic leak. Similarly, in our study, we found high negative predictive values for CRP at 158 mg/L on postoperative day 3 and at 75 mg/L on postoperative day 5 (96.7% and 96.2%, respectively).

In our study, the ileocolic anastomosis region was significantly more common in the leaking group, and complication rates were significantly higher, with a higher rate of wound infection. Sensitivity of CRP on the 3rd day was 79.3%, and on the 5th day, 72.4%. For procalcitonin, sensitivity on the 3rd day was 79.3% and on the 5th day after the operation was 75.9%. ROC analysis results showed that the area under the curve was the highest for CRP on the 5th day, followed by procalcitonin on the 3rd day, CRP on the 3rd day, and procalcitonin on the 5th day. All predictive values for both indicators on both measuring days were over 70%.

Low CRP and procalcitonin levels have satisfactory negative predictive values for preventing septic complications and ensuring safe hospital discharge.^{23–25} However, the decision to re-intervene is based on low positive predictive values of both CRP and procalcitonin. Therefore, when signs of septic complications were observed along with high CRP and procalcitonin levels, the patients’ hospital stay was prolonged with additional investigations and treatment.

Limitations

In cases of abscesses/collections that could not be treated medically due to a suspected anastomotic leak, percutaneous intervention was performed. Patients who developed generalized peritonitis underwent reoperation to lavage the peritoneum, take down the anastomosis, and create an end colostomy. The decision to operate is often difficult and is based on additional imaging studies and clinical judgment.

Conclusion

Measurements of CRP and procalcitonin at 3 and 5 days after lower gastrointestinal surgery may serve as useful, supportive serum markers to identify patients at low risk of anastomotic leak and enable their safe discharge within early postoperative recovery protocols. However, with the addition of further tests, their reliability in the early detection of anastomotic leak improves; however, further studies to identify more specific markers are recommended.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments, or comparable ethical standards.

Informed Consent

The requirement for informed consent was waived by the Ethics Committee due to the study's retrospective design.

Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy reasons, but are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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Author Contributions (CRediT Taxonomy)

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AI Usage Disclosure

The authors declare that no AI-assisted technologies were used.

Abbreviations

CRP: C-reactive protein
CT: Computed tomography
ERAS: Enhanced recovery after surgery
ROC: Receiver operating characteristic
SPSS: Statistical package for the social sciences

References

1. Nandakumar G, Stein SL, Michelassi F. Anastomoses of the lower gastrointestinal tract. *Nat Rev Gastroenterol Hepatol.* 2009;6(12):709-16. doi:10.1038/nrgastro.2009.185

2. González-Campoy JM. Bariatric procedures. In bariatric endocrinology: evaluation and management of adiposity, adiposopathy and related diseases. Cham: Springer International Publishing, 2018;p.413-42.

3. Ho YH, Ashour MA. Techniques for colorectal anastomosis. *World J Gastroenterol.* 2010;16(13):1610-21. doi:10.3748/wjg.v16.i13.1610

4. Gunaydin M, Tander B, Demirel D, et al. Different techniques for biliary diversion in progressive familial intrahepatic cholestasis. *J Pediatr Surg.* 2016;51(3):386-9. doi:10.1016/j.jpedsurg.2015.08.011

5. Turrentine FE, Denlinger CE, Simpson VB, et al. Morbidity, mortality, cost, and survival estimates of gastrointestinal anastomotic leaks. *J Am Coll Surg.* 2015;220(2):195-206. doi:10.1016/j.jamcollsurg.2014.11.002

6. Weledji EP, Ngowe MN. The challenge of intra-abdominal sepsis. *Int J Surg.* 2013;11(4):290-5. doi:10.1016/j.ijsu.2013.02.021

7. Peters JWR, Smallwood N, Hyman, NH. Prevention, diagnosis, and management of anastomotic leak. In *Shackelford's Surgery of the Alimentary Tract, 2 Volume Set* Elsevier, 2019. p.2137-46.

8. Girard E, Messenger M, Sauvanet A, et al. Anastomotic leakage after gastrointestinal surgery: diagnosis and management. *J Visc Surg.* 2014;151(6):441-50. doi:10.1016/j.jvisc.2014.10.004

9. Snijders HS, Wouters MW, van Leersum NJ, et al. Meta-analysis of the risk for anastomotic leakage, the postoperative mortality caused by leakage in relation to the overall postoperative mortality. *Eur J Surg Oncol.* 2012;38(11):1013-9. doi:10.1016/j.ejso.2012.07.111

10. Bruce J, Krukowski ZH, Al-Khairi G, Russell EM, Park KG. Systematic review of the definition and measurement of anastomotic leak after gastrointestinal surgery. *Br J Surg.* 2001;88(9):1157-68. doi:10.1046/j.0007-1323.2001.01829.x

11. Zarnescu EC, Zarnescu NO, Costea R. Updates of risk factors for anastomotic leakage after colorectal surgery. *Diagnostics (Basel).* 2021;11(12):2382. doi:10.3390/diagnostics11122382

12. Matthiessen P, Henriksson M, Hallböök O, Grunditz E, Norén B, Arlman G. Increase of serum C-reactive protein is an early indicator of subsequent symptomatic anastomotic leakage after anterior resection. *Colorectal Dis.* 2008;10(1):75-80. doi:10.1111/j.1463-1318.2007.01300.x

13. Mustard RA Jr, Bohnen JM, Haseeb S, Kasina R. C-reactive protein levels predict

postoperative septic complications. *Arch Surg.* 1987;122(1):69-73. doi:10.1001/archsurg.1987.01400130075011

14. Welsch T, Müller SA, Ulrich A, et al. C-reactive protein as early predictor for infectious postoperative complications in rectal surgery. *Int J Colorectal Dis.* 2007;22(12):1499-507. doi:10.1007/s00384-007-0354-3

15. Lopez-Pascual A, Trayhurn P, Martínez JA, González-Muniesa P. Oxygen in metabolic dysfunction and its therapeutic relevance. *Antioxid Redox Signal.* 2021;35(8):642-87. doi:10.1089/ars.2019.7901

16. Perrella A, Giuliani A, De Palma M, et al. C-reactive protein but not procalcitonin may predict antibiotic response and outcome in infections following major abdominal surgery. *Updates Surg.* 2022;74(2):765-71. doi:10.1007/s13304-021-01172-7

17. Giaccaglia V, Salvi PF, Cunsolo GV, et al. Procalcitonin, as an early biomarker of colorectal anastomotic leak, facilitates enhanced recovery after surgery. *J Crit Care.* 2014;29(4):528-32. doi:10.1016/j.jcrc.2014.03.036

18. Muñoz JL, Álvarez MO, Cuquerella V, et al. Procalcitonin and C-reactive protein as early markers of anastomotic leak after laparoscopic colorectal surgery within an enhanced recovery after surgery (ERAS) program. *Surg Endosc.* 2018;32(9):4003-10. doi:10.1007/s00464-018-6144-x

19. MacKay GJ, Molloy RG, O'Dwyer PJ. C-reactive protein as a predictor of postoperative infective complications following elective colorectal resection. *Colorectal Dis.* 2011;13(5):583-7. doi:10.1111/j.1463-1318.2010.02236.x

20. Greco M, Capretti G, Beretta L, Gemma M, Pecorelli N, Braga M. Enhanced recovery program in colorectal surgery: a meta-analysis of randomized controlled trials. *World J Surg.* 2014;38(6):1531-41. doi:10.1007/s00268-013-2416-8

21. Warschkow R, Beutner U, Steffen T, et al. Safe and early discharge after colorectal surgery due to C-reactive protein: a diagnostic meta-analysis of 1832 patients. *Ann Surg.* 2012;256(2):245-50. doi:10.1097/SLA.0b013e31825b60f0

22. Singh PP, Zeng IS, Srinivasa S, Lemanu DP, Connolly AB, Hill AG. Systematic review and meta-analysis of use of serum C-reactive protein levels to predict anastomotic leak after colorectal surgery. *Br J Surg.* 2014;101(4):339-46. doi:10.1002/bjs.9354

23. Hassan J, Khan S, Zahra R, et al. Role of procalcitonin and C-reactive protein as predictors of sepsis and in managing sepsis in postoperative patients: a systematic review. *Cureus.* 2022;14(11):e31067. doi:10.7759/cureus.31067

24. Liang P, Yu F. Value of CRP, PCT, and NLR in prediction of severity and prognosis of patients with bloodstream infections and sepsis. *Front Surg.* 2022;9:857218. doi:10.3389/fsurg.2022.857218

25. Ryoo SM, Han KS, Ahn S, et al. The usefulness of C-reactive protein and procalcitonin to predict prognosis in septic shock patients: a multicenter prospective registry-based observational study. *Sci Rep.* 2019;9(1):6579. doi:10.1038/s41598-019-42972-7

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