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Risk Factors for Intestinal Anastomotic Leakage After Hemicolectomy: A Single-Center Retrospective Study

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Abstract

Background: Colorectal anastomotic leakage is currently an acute problem in the surgical treatment of colorectal cancer. This study aims to identify early predictors of intestinal anastomotic leakage after hemicolectomy.

Methods and Results: The study, conducted at Ulyanovsk Regional Clinical Oncology Dispensary from 2019 to 2024, included a retrospective analysis of 583 patients who underwent elective hemicolectomy and sigmoid colon resection. Patients with fatal outcomes due to comorbid pathology and emergency operations were excluded. Complications were assessed according to the Clavien-Dindo classification, and tumors were staged using the TNM classification. Statistical analysis included methods for comparing quantitative and categorical data, assessing odds, and constructing a predictive model using logistic regression and ROC analysis.

Colorectal anastomotic leakage (CAL) occurred in 48 patients (8.24%). Compared with patients without CAL, patients with CAL had lower serum albumin concentrations preoperatively and on postoperative days 1 and 5, higher neutrophil counts on postoperative days 1 and 5, a lower lymphocyte count on postoperative day 1, and higher neutrophil-to-lymphocyte ratio (NLR) values on postoperative days 1 and 5. In the multivariable model, preoperative colostomy, multiorgan resection, preoperative albumin, albumin on postoperative days 1 and 5, neutrophils on postoperative day 5, and operation time remained statistically significant. The model showed an area under the ROC curve of 0.940.

Conclusion: Lower perioperative albumin and a more pronounced postoperative inflammatory response, together with preoperative colostomy, multiorgan resection, and operative duration, were associated with CAL and may support early risk stratification after hemicolectomy.(**International Journal of Biomedicine. 2026;16(3):364-371.**)

Keywords: intestinal anastomosis • resection • colorectal anastomotic leakage

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Introduction

Colorectal cancer (CRC) is the third most common newly diagnosed malignant neoplasm annually among both men and women worldwide.[1] The growing incidence of CRC in recent decades is a significant socioeconomic problem because high morbidity and a high risk of an unfavorable outcome require the involvement of more oncologists and surgeons.[1] Regular CRC screening affects early diagnosis of this disease and has been shown to improve long-term oncological outcomes.[2] Surgical treatment is central to the treatment of both localized and locally advanced CRC. Despite advances in surgical technique and comprehensive perioperative patient management, the complication rate remains stable and, according to Russian and international authors, ranges from 2% to 17%. [3,4]

Colorectal anastomotic leakage has the greatest impact on treatment outcomes; it occurs in 4.4% to 24% of cases.[5,6] Hospital stay increases two- to threefold [7], and mortality in this group of patients reaches 40%.[6,8] CAL is usually associated with higher reoperation rates and an increased risk of postoperative death.[9-11] CAL is usually diagnosed within

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7-12 days after surgery.[12,13] Nevertheless, in some cases, anastomotic leakage may be diagnosed more than one month after surgical treatment.[12]

Although predictive models for CAL already exist, there is currently no consensus on the model that is optimal for clinical practice. The present study aimed to identify early predictors of intestinal anastomotic leakage after hemicolectomy performed in the Department of Surgical Abdominal Oncology of the Regional Clinical Oncology Dispensary in Ulyanovsk.

Materials and Methods

The study was conducted at the Department of Surgical Abdominal Oncology of the Regional Clinical Oncology Dispensary in Ulyanovsk from January 1, 2019, to May 1, 2024. The retrospective analysis included patients who underwent left-sided or right-sided hemicolectomy or sigmoid colon resection [database, patent No. 2024622330]. Patients who underwent midline laparotomy were included. Medical records were analyzed according to a unified protocol. Patients who did not meet the criteria were excluded from the study. Complications were assessed using the Clavien-Dindo classification of surgical complications.[14] Tumor status was assessed according to the TNM classification. Upon admission to the department, height and weight were measured, and body mass index (BMI) was calculated. Venous blood samples were obtained preoperatively and on postoperative days 1 and 5. Serum albumin was measured using a colorimetric dye-binding method and total protein using the Biuret colorimetric method; both were reported in g/L. Hemoglobin was determined photometrically in EDTA-anticoagulated whole blood and reported in g/L. Absolute neutrophil and lymphocyte counts were obtained using an automated hematology analyzer with leukocyte differential and reported as $\times 10^9$/L. The NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count and is dimensionless. Other routine biochemical and hemostatic tests, blood group, and Rh factor were determined according to the standard operating procedures of the hospital laboratory.

Inclusion criteria:

-Right-sided or left-sided hemicolectomy, or sigmoid colon resection

-Verified malignant neoplasm of the colon

-Elective surgical interventions.

Exclusion criteria:

-Death due to comorbid pathology in the postoperative period not related to colorectal anastomotic leakage

- Patients who underwent obstructive colon resections with formation of a single-barrel colostomy without reconstruction

- Surgical interventions performed for emergency indications.

Completed cases associated with colorectal anastomotic leakage were analyzed. A database comprising 583 patients was formed.

Statistical analysis: Quantitative indicators were assessed for conformity to a normal distribution using the Kolmogorov-Smirnov test. Quantitative indicators with a normal distribution were described using arithmetic means (M), standard deviations (SD), and 95% confidence interval (95% CI) limits. When quantitative data did not follow a normal distribution, they were described using the median (Me) and the lower and upper quartiles (Q1-Q3). Categorical data were described as absolute values and percentages.

The 95% confidence intervals for proportions were calculated using the Clopper-Pearson method. Two groups were compared for a normally distributed quantitative variable under the assumption of equal variances using Student's t-test. Two groups were compared for a quantitative variable with a non-normal distribution using the Mann-Whitney U test. Proportions in fourfold contingency tables were compared using Pearson's chi-square test (when expected frequencies exceeded 10). Odds ratios with 95% confidence intervals (OR; 95% CI) were used as a quantitative measure of effect when comparing relative indicators. Proportions in multiway contingency tables were compared using Pearson's chi-square test. A P-value of <0.05 was considered statistically significant. Predictive modeling for the probability of a specific outcome was performed using logistic regression. Nagelkerke's R2 served as the coefficient of determination indicating the proportion of variance explained by logistic regression. ROC-curve analysis was used to assess the diagnostic significance of quantitative variables for predicting a specific outcome. The cutoff value of a quantitative variable was determined at the point with the highest Youden index.

Statistical analysis was performed using StatTech v. 4.1.0 (StatTech LLC, Russia).

Results

The median age of the study patients was 67.83 years; 246 (42.3%) patients were men and 336 (57.7%) were women.

The main clinical and anamnestic characteristics of the study patients are presented in Table 1.

Univariate statistical analysis of clinical and anamnestic parameters depending on the presence of CAL identified length of hospital stay as a statistically significant parameter.

Oncological parameters of the patient study groups are presented in Table 2. Univariate statistical analysis of oncological parameters depending on the presence of CAL identified oncological stage, T extent of the primary tumor, and the presence of primary tumor metastases as statistically significant.

Patient intraoperative parameters are presented in Table 3. Univariate statistical analysis of surgical parameters depending on the presence of CAL identified operation time, preoperative colostomy, multiorgan resection, Clavien-Dindo complications, blood loss volume, and type of surgery as statistically significant. Clavien-Dindo complications are presented in Table 4. Analysis of the table showed that the most frequent complication in our study was grade IIIB.

Analysis of operation types depending on the presence of CAL also showed that right-sided hemicolectomy and sigmoid colon resection were the most frequent (P=0.008).

Table 1.
Clinical and anamnestic parameters of the patient study groups.

Indicator	Category	CAL		*P*-value
		No	Yes	
Age, Me (Q1-Q3)		67.85 (62.23 - 73.04)	67.71 (59.32 - 77.01)	0.678
Sex, n (%)	Female	311 (58.2)	25 (52.1)	0.408
	Male	223 (41.8)	23 (47.9)	
BMI status, n (%)	Underweight	15 (2.8)	1 (2.1)	0.697
	Normal	381 (71.3)	37 (77.1)	
	Obesity	138 (25.8)	10 (20.8)	
DM, n (%)	No	447 (83.7)	42 (87.5)	0.492
	Yes	87 (16.3)	6 (12.5)	
HTN, n (%)	No	286 (53.6)	28 (58.3)	0.525
	Yes	248 (46.4)	20 (41.7)	
IHD, n (%)	No	391 (73.4)	30 (63.8)	0.160
	Yes	142 (26.6)	17 (36.2)	
CHF, n (%)	No	394 (73.8)	35 (72.9)	0.896
	Yes	140 (26.2)	13 (27.1)	
BMI, Me (Q1-Q3)		26.67 (23.68 - 30.11)	25.18 (21.89 - 28.81)	0.058
Height, Me (Q1-Q3), m		1.65 (1.60 - 1.73)	1.68 (1.60 - 1.73)	0.985
Length of hospital stay, Me (Q1-Q3)		13.00 (11.00 - 15.00)	21.00 (17.00 - 30.25)	<0.001

DM, diabetes mellitus; HTN, hypertension; IHD, ischemic heart disease; CHF, chronic heart failure; BMI, body mass index.

Table 2.
Oncological parameters of the patient study groups.

Indicator	Category	Anastomotic leakage		*P*-value
		No	Yes	
Stage, n (%)	I	35 (6.6)	2 (4.2)	0.024
	II	259 (48.5)	23 (47.9)	
	III	197 (36.9)	13 (27.1)	
	IV	43 (8.1)	10 (20.8)	
T, n (%)	t1	15 (2.8)	0 (0.0)	0.005
	t2	50 (9.4)	3 (6.2)	
	t3	393 (73.6)	29 (60.4)	
	t4	76 (14.2)	16 (33.3)	
N, n (%)	n0	309 (57.9)	28 (58.3)	0.498
	n1	153 (28.7)	11 (22.9)	
	n2	72 (13.5)	9 (18.8)	
M, n (%)	m0	495 (92.7)	38 (79.2)	0.001
	m1	39 (7.3)	10 (20.8)	
ypT, n (%)	t0	503 (94.2)	43 (89.6)	0.434
	t1	5 (0.9)	1 (2.1)	
	t2	2 (0.4)	0 (0.0)	
	t3	22 (4.1)	3 (6.2)	
	t4	2 (0.4)	1 (2.1)	
ypN, n (%)	n0	525 (98.3)	46 (95.8)	0.472
	n1	5 (0.9)	1 (2.1)	
	n2	4 (0.7)	1 (2.1)	

Table 3.
Intraoperative parameters of the studied patients depending on the presence of anastomotic leakage.

Indicator	Category	Anastomotic leakage		*P*-value
		No	Yes	
Operation time, Me (Q1-Q3)		100.00 (80.00 - 130.00)	130.00 (90.00 - 180.00)	0.002
Lymph nodes removed, Me (Q1-Q3)		11.00 (6.00 - 15.00)	10.00 (6.00 - 15.00)	0.576
Involved lymph nodes, Me (Q1-Q3)		0.00 (0.00 - 1.00)	0.00 (0.00 - 1.00)	0.760
Tumor size, Me (Q1-Q3), mm		50.00 (40.00 - 70.00)	50.00 (40.00 - 70.00)	0.834
Blood loss volume, Me (Q1-Q3), mL		100.00 (100.00 - 300.00)	225.00 (100.00 - 500.00)	< 0.001
Resection margin R, n (%)	r0	522 (98.9)	46 (95.8)	0.143
	r1	5 (0.9)	2 (4.2)	
	r2	1 (0.2)	0 (0.0)	
Preoperative colostomy, n (%)	No	511 (95.7)	34 (70.8)	< 0.001
	Yes	23 (4.3)	14 (29.2)	
Diverting colostomy, n (%)	No	496 (92.9)	41 (85.4)	0.064
	Yes	38 (7.1)	7 (14.6)	
Multiorgan resection, n (%)	No	505 (94.6)	24 (50.0)	< 0.001
	Yes	29 (5.4)	24 (50.0)	

Table 4.
Complications in the patient study group according to the Clavien-Dindo classification, depending on CAL development.

Indicator	Category	Anastomotic leakage		*P*-value
		No	Yes	
Clavien-Dindo complications, n (%)	0	420 (78.7)	0 (0.0)	< 0.001
	I	3 (0.6)	0 (0.0)	
	II	15 (2.8)	0 (0.0)	
	III	1 (0.2)	0 (0.0)	
	IIIA	0 (0.0)	0 (0.0)	
	IIIB	94 (17.6)	48 (100.0)	
	IV	1 (0.2)	0 (0.0)	
	IVA	0 (0.0)	0 (0.0)	
	IVB	0 (0.0)	0 (0.0)	
	V	0 (0.0)	0 (0.0)	

Compared with patients without CAL, patients with CAL had lower preoperative albumin concentrations and, on postoperative days 1 and 5, lower lymphocyte counts on postoperative day 1, higher neutrophil counts on postoperative days 1 and 5, and higher NLR values on postoperative days 1 and 5 (all *P*<0.001). Total protein and hemoglobin at all time points, preoperative neutrophil, lymphocyte, and NLR values, and the lymphocyte count on postoperative day 5 did not differ significantly between groups (Table 5).

Using binary logistic regression, a predictive model was developed to determine the probability of colorectal anastomotic leakage depending on preoperative colostomy, multiorgan resection, preoperative albumin, neutrophils on postoperative day 5, albumin on postoperative day 1, albumin on postoperative day 5, and operation time.

The area under the ROC curve was 0.940 +/- 0.024, with a 95% CI of 0.892-0.987. The resulting model was statistically significant (*P*<0.001) (Figure 1).

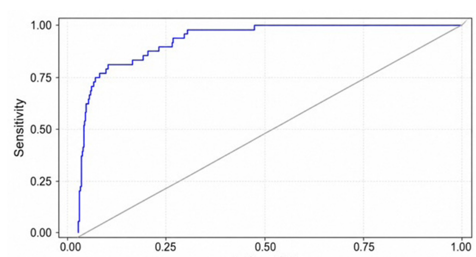

Figure 1. *ROC Curve Depicting the Relationship Between the Probability of Colorectal Anastomotic Leakage and the Logistic Function Value (P).*

Table 5.

Laboratory parameters of the studied patients depending on the presence of anastomotic leakage.

Indicator	Category	CAL		*P*-value
		No	Yes	
Preoperative albumin, Me (Q1-Q3)		37.50 (34.42 - 40.70)	33.40 (31.70 - 35.67)	< 0.001
Albumin on postoperative day 1, Me (Q1-Q3)		37.20 (34.50 - 40.92)	31.85(29.68 - 33.83)	< 0.001
Albumin on postoperative day 5, Me (Q1-Q3)		38.59 (33.82 - 41.97)	31.50 (30.30 - 34.50)	< 0.001
Preoperative total protein, Me (Q1-Q3)		70.50 (66.70 - 73.80)	70.70 (67.50 - 73.28)	0.811
Total protein on postoperative day 1, Me (Q1-Q3)		59.30 (55.30 - 63.60)	59.45 (56.33 - 65.17)	0.540
Total protein on postoperative day 5, Me (Q1-Q3)		58.10 (54.00 - 62.65)	57.00 (52.35 - 61.77)	0.268
Preoperative hemoglobin, M +/- SD (95% CI)		113.61 ± 21.38 (111.80 - 115.43)	108.77 ± 20.09 (102.94 - 114.61)	0.131
Hemoglobin on postoperative day 1, Me (Q1-Q3)		111.00 (98.00 - 125.00)	107.00 (99.75 - 116.25)	0.305
Hemoglobin on postoperative day 5, Me (Q1-Q3)		108.00 (96.00 - 121.00)	104.00 (95.75 - 116.00)	0.307
Preoperative neutrophils, Me (Q1-Q3)		4.50 (3.40 - 5.83)	4.69 (3.74 - 6.21)	0.234
Neutrophils on postoperative day 1, Me (Q1-Q3)		7.60 (5.60 - 10.10)	9.90 (6.99 - 12.40)	< 0.001
Neutrophils on postoperative day 5, Me (Q1-Q3)		4.67 (3.40 - 6.24)	6.46 (4.50 - 9.72)	< 0.001
Preoperative lymphocytes, Me (Q1-Q3)		1.70 (1.39 - 2.20)	1.67 (1.29 - 2.03)	0.438
Lymphocytes on postoperative day 1, Me (Q1-Q3)		1.40 (1.00 - 1.80)	1.08 (0.80 - 1.30)	< 0.001
Lymphocytes on postoperative day 5, Me (Q1-Q3)		1.50 (1.14 - 1.90)	1.21 (1.00 - 1.88)	0.054
Preoperative NLR, Me (Q1-Q3)		2.52 (1.82 - 3.68)	3.00 (2.15 - 4.07)	0.140
NLR on postoperative day 1, Me (Q1-Q3)		5.37 (3.39 - 8.52)	9.37 (5.69 - 13.35)	< 0.001
NLR on postoperative day 5, Me (Q1-Q3)		3.11 (2.24 - 4.58)	5.09 (2.72 - 8.04)	< 0.001

NLR, neutrophil-to-lymphocyte ratio (dimensionless). Albumin, total protein, and hemoglobin are reported in g/L; absolute neutrophil and lymphocyte counts are reported in ×10⁹/L.

Table 6.

Logistic regression.

Predictors	Unadjusted		Adjusted	
	COR; 95% CI	*P*-value	AOR; 95% CI	*P*-value
Preoperative colostomy: yes	8.478; 3.951 - 18.192	< 0.001	20.937; 6.424 - 68.238	< 0.001
Multiorgan resection: yes	16.655; 8.406 - 32.983	< 0.001	156.867; 37.450 - 657.208	< 0.001
Preoperative albumin	0.785; 0.717 - 0.859	< 0.001	0.792; 0.689 - 0.910	0.001
Albumin day 1	0.801; 0.748 - 0.857	< 0.001	0.792; 0.695 - 0.902	< 0.001
Albumin day 5	0.833; 0.783 - 0.885	< 0.001	0.905; 0.825 - 0.992	0.032
Neutrophils day 5	1.174; 1.094 - 1.259	< 0.001	1.134; 1.027 - 1.251	0.012
Operation time	1.008; 1.003 - 1.013	0.004	0.991; 0.982 - 1.000	0.048

The cutoff value of the logistic function P corresponding to the highest Youden index was 0.143. Leakage was predicted when the logistic function P was greater than or equal to this value. The sensitivity and specificity of the model were 80.9% and 92.5%, respectively.

The resulting regression model was statistically significant (P<0.001). Based on the Nagelkerke coefficient of determination, the model explained 60.7% of the observed variance in the presence of leakage.

Preoperative colostomy was associated with substantially higher adjusted odds of CAL (AOR = 20.937; 95% CI: 6.424-68.238; P<0.001) compared with no preoperative colostomy.

Multiorgan resection was also associated with substantially higher adjusted odds of CAL (AOR = 156.867;

95% CI: 37.450-657.208; *P*<0.001) compared with standard resection.

For preoperative albumin, each 1 g/L increase was associated with lower adjusted odds of CAL (AOR = 0.792; 95% CI: 0.689-0.910; *P*=0.001) (Table 6). Thus, lower preoperative albumin was associated with greater risk.

Albumin on postoperative days 1 and 5 showed the same direction of association. Each 1 g/L increase was associated with lower adjusted odds of CAL on day 1 (AOR = 0.792; 95% CI: 0.695-0.902; P<0.001) and day 5 (AOR = 0.905; 95% CI: 0.825-0.992; *P*=0.032).

For the neutrophil count on postoperative day 5, each 1 $\times 10^9$/L increase was associated with higher adjusted odds of CAL (AOR = 1.134; 95% CI: 1.027-1.251; *P*=0.012).

Operation time showed a small but statistically significant association with CAL. In unadjusted analysis, each additional minute was associated with higher odds (COR = 1.008; 95% CI: 1.003-1.013; *P*=0.004), whereas after adjustment the direction reversed (AOR = 0.991; 95% CI: 0.982-1.000; *P*=0.048). This reversal suggests confounding or model instability and warrants cautious interpretation.

Discussion

Colorectal anastomotic leakage is currently an acute problem in the surgical treatment of colorectal cancer. The issue of early predictors and prediction of CAL remains debated.

International authors have noted an association between CAL and patient sex.[15,16] These studies report an increased risk of CAL in male patients and link it to androgen activity and the subsequent characteristics of intestinal microcirculation after hormonal exposure. In our study, no statistically significant parameters related to patients' sex were identified. According to the study by Yu et al.,[17] taller patient height predisposes to CAL due to smaller pelvic dimensions, particularly the pelvic inlet and intertuberous distance. This parameter was not statistically significant in our study.

Previous studies have associated advanced tumor stage and metastatic disease with CAL. [18,19] In our cohort, CAL was more frequent among patients with stage IV disease (20.8% vs. 8.1%), T4 tumors (33.3% vs. 14.2%), and distant metastases (M1: 20.8% vs. 7.3%); stage, T category, and M category were statistically significant in univariate analysis. In contrast, measured tumor size did not differ between the groups (median 50 mm in both groups).

Preoperative colostomy was associated with an increased risk of CAL. A previous colostomy was most often created for acute intestinal obstruction; therefore, this variable may identify a clinically more compromised subgroup with prior surgical trauma and impaired nutritional or inflammatory status. Consistent with this interpretation, the CAL group in our cohort had lower perioperative albumin concentrations but a stronger postoperative inflammatory response, reflected by higher neutrophil counts and NLR values rather than a uniform reduction in all laboratory parameters.[20]

Noteworthy are the results regarding the effect of BMI on the risk of colorectal anastomotic leakage. International colleagues note that BMI >30 kg/m^2 is considered an independent risk factor for CAL.[21,22] In our study, this parameter was not significant, apparently because patients with obesity were compensated, and this pathological condition therefore did not have a negative effect.

International sources identify poor nutrition and malnutrition as predictors of CAL.[23] Although low BMI was not statistically significant in our study, the direction of the albumin changes was consistent and clinically relevant: patients who developed CAL had lower median serum albumin preoperatively (33.40 vs. 37.50 g/L) and on postoperative days 1 (31.85 vs. 37.20 g/L) and 5 (31.50 vs. 38.59 g/L). Accordingly, odds ratios below 1 for albumin indicate that higher albumin concentrations were associated with lower odds of CAL, whereas lower albumin concentrations were associated with higher risk.

The surgeon's vigilance is important for early diagnosis of CAL, because delayed diagnosis is associated with an unfavorable prognosis. Inflammatory markers and clinical signs of peritonitis should therefore be monitored carefully.[24] In our study, the NLR was higher in patients who developed CAL on postoperative day 1 (median 9.37 vs. 5.37) and day 5 (5.09 vs. 3.11; both *P*<0.001). This upward change in NLR, rather than the absolute level alone, may help identify patients who require timely additional imaging to verify the complication.

The cellular components showed the same directional pattern: neutrophil counts were higher in the CAL group on postoperative day 1 (9.90 vs. 7.60 $\times 10^9$/L) and day 5 (6.46 vs. 4.67 $\times 10^9$/L), whereas the lymphocyte count was lower on postoperative day 1 (1.08 vs. 1.40 $\times 10^9$/L). The day-5 lymphocyte count was also numerically lower, but the difference did not reach statistical significance (*P*=0.054). Total protein and hemoglobin did not differ significantly at any assessed time point, and preoperative neutrophil, lymphocyte, and NLR values were not significant. Because an automated leukocyte differential is simple and inexpensive, these directional changes may help surgeons suspect CAL even in settings with limited diagnostic resources.

Longer operation time may indicate more complex surgical manipulations, which are already associated with a higher expected risk of postoperative complications. Our study demonstrated the influence of operation time on the risk of CAL development, which is confirmed by multiple international and Russian studies.[25-28]

International colleagues note that intraoperative blood loss greater than 100 mL increases the risk of CAL.[29] Our analysis confirms this effect: in the CAL group, the median blood loss was 225 mL, significantly higher than in the group with a favorable postoperative period, where it was 100 mL.

The authors also identified an association between CAL and multiorgan resection during surgery. Expansion of the surgical procedure leads to greater trauma to the body and an increased risk of postoperative complications.[30]

Conclusion

In our study, the incidence of colorectal anastomotic leakage was 48 cases (8.24%). In univariate analyses, CAL was associated with advanced oncological stage, T category, M category, longer operation time and hospital stay, preoperative colostomy, multiorgan resection, Clavien-Dindo complications, greater blood loss, type of surgery, lower albumin concentrations preoperatively and on postoperative days 1 and 5, higher neutrophil counts on postoperative days 1 and 5, a lower lymphocyte count on postoperative day 1, and higher NLR values on postoperative days 1 and 5. In the multivariable model, preoperative colostomy, multiorgan resection, preoperative albumin, albumin on postoperative days 1 and 5, neutrophils on postoperative day 5, and operation time remained statistically significant. These findings support combined assessment of nutritional and inflammatory markers for early postoperative risk stratification.

Author Contributions

Eugene A. Toneev: Conceptualization, Methodology, Investigation, Formal Analysis, Writing—Review and Editing, Supervision and Project Administration.
Daniil D. Prokhorov: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing—Original Draft Preparation, Review and Editing.
Marina A. Iglina: Investigation, Data Curation.
Syumbel R. Ziganshina: Investigation, Data Curation, Writing—Original Draft Preparation.
Daniil R. Pyatikop: Investigation, Data Curation, Writing—Original Draft Preparation.
Daria V. Golovko: Investigation, Data Curation, Writing—Original Draft Preparation.
Zainap Yu. Yunkina: Investigation, Data Curation, Writing—Original Draft Preparation.
All authors have read and approved the final version of the manuscript.

Information on Support Sources

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Statement

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Regional Clinical Oncology Dispensary and Ulyanovsk State University, Ulyanovsk. The study involved a retrospective analysis of routinely collected medical records and no study-specific intervention. The procedure for obtaining or waiving individual informed consent followed the decision of the approving ethics committee and applicable regulations.

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