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Risk factors for anastomotic leakage following radical one-stage surgical interventions in colorectal surgery

The aim of the work: to identify the main factors affecting the risk of colorectal anastomotic leak following radical one-stage surgical interventions in colorectal surgery.

Materials and Methods. A retrospective study was conducted of surgical treatment outcomes in 44 patients who underwent radical one-stage colonic operations with primary anastomosis. Anterior resection of the rectum was performed in 28 patients (63.5 %), left hemicolectomy in 11 (25 %), and right hemicolectomy in 5 (11.5 %). The classification of risk factors into modifiable and non-modifiable, preoperative, operative, and postoperative categories was used. Statistical analysis included calculation of odds ratios (OR) with 95 % confidence intervals (CI) and relative risk (RR) using SPSS 26.0.

Results. The overall anastomotic leak rate was 13.6 %. The most significant modifiable pre-operative factors were hypoproteinemia (OR=3.74), malnutrition (OR=3.05), and obesity (OR=2.32). Among operative factors, the highest risk was associated with inadequate blood supply to the anastomosis (OR=5.21), poor blood supply to the resection site (OR=4.56), and absence of a diverting stoma (OR=3.52). Among non-modifiable factors, ASA IV (OR=3.68), Charlson Comorbidity Index ≥5 (OR=3.53), tumor location <5 cm from the anal verge (OR=4.16), and emergency surgery (OR=3.75) were prominent. Post-operative massive blood transfusion demonstrated OR=4.18. A risk stratification model was developed: high risk (≥3 factors) – 27.8 %, intermediate risk (1–2 factors) – 8.6 %, low risk (0 factors) – 3.1 %.

Conclusions. Colorectal anastomotic leak is a multifactorial complication. Identification and correction of modifiable risk factors, particularly nutritional status, ensuring adequate vascularization of the anastomosis, and use of a diverting stoma in low resections, allows for individualization of the approach to anastomotic leak prevention and improvement of surgical treatment outcomes.

Key words: colorectal surgery; colorectal anastomosis; anastomotic leak; risk factors; risk stratification; postoperative complications.

Problem Statement and Analysis of Research and Publications. Anastomotic leakage of colorectal anastomoses remains one of the most dangerous complications in abdominal surgery, characterized by high mortality rates (reaching 15–20 %), significant morbidity, and the need for repeat surgical interventions [1, 2]. The incidence of this complication varies from 2–3 % during operations on right-sided segments of the colon and can reach 15–20 % in low anterior resections of the rectal zone [3, 4].

Understanding the factors that increase the likelihood of anastomotic dehiscence is crucial for developing preventive strategies and improving perioperative patient management. Identification of modifiable risk factors enables surgeons to improve treatment outcomes through preoperative patient optimization, selection of the best surgical technique, and adequate postoperative monitoring [5].

The aim of the work: to establish the main factors affecting the risk of anastomotic leakage in colorectal anastomoses following radical single-stage surgical interventions in colorectal surgery.

Materials and Methods. A retrospective study was conducted of surgical treatment outcomes in 44 patients who underwent radical single-stage operations on the colon with primary anastomosis formation.

Inclusion criteria: age over 18 years, performance of radical single-stage operations with primary anastomosis, availability of complete clinical documentation, postoperative monitoring period of at least 30 days.

Exclusion criteria: palliative surgical interventions, multi-stage procedures, absence of complete clinical documentation, loss of patient contact in the early postoperative period.

Anastomotic dehiscence was established based on clinical symptoms (elevated temperature, abdominal pain, signs of peritonitis), laboratory parameters (elevated leukocyte count, increased C-reactive protein levels), instrumental studies (contrast CT, endoscopic examination – Olympus CF-Q165L fibercolonoscope), and intraoperative findings during repeat interventions (Karl Storz Image-1 HD LVS laparoscopic system).

Of the 44 operated patients, anterior rectal resection was performed in 28 (63.5 %): high anterior

resection was performed in 13 (29.5 %), low anterior resection in 7 (16 %), and ultralow anterior resection in 8 (18 %) patients. Manual anastomosis formation during anterior rectal resection was performed in 19 (43 %) patients, in high anterior resection in 7 (25 %), in low resection in 7 (57 %) patients, while in ultralow resection, stapled anastomosis formation was performed in all 44 (100 %) cases (Table 1).

Anastomotic leakage in colorectal anastomoses during anterior rectal resections was observed in 5 (17.8 %) of the 28 operated patients. Among them, with manual anastomosis formation, leakage was detected in 3 of 20, accounting for 11.5 %. Of the 28 patients, 24 had no protective ileostomy, and only 4 patients received a protective ileostomy. The overall anastomotic leakage rate among the 44 operated patients was 13.6 %. Among these, high anterior resection had 15.4 %, low resection 14.3 %, and ultralow resection 25 %. Anastomotic leakage with manual formation was 27.2 %. Only 12.5 % developed leakage in ultralow anterior resection after stapled anastomosis formation, while without protective ileostomy, it was 18 % in patients.

SPSS 26.0 software was used for predicting the risk of colorectal anastomotic leakage. Statistical analysis included calculation of odds ratios (OR) with 95 % confidence intervals (CI) and relative risk (RR). Results were considered statistically significant at $p<0.05$.

Results. The studied risk factors were divided into four categories: modifiable preoperative, operative, postoperative, and non-modifiable.

Investigation of modifiable preoperative factors demonstrated (Table 2) that according to multivariate analysis, the most significant impact on anastomotic leakage occurrence was from nutritional status indicators (hypoproteinemia – OR=3.74 and hypotrophy OR=3.05, $p<0.001$), patient's harmful habits (OR=2.46, $p<0.001$), and excessive body weight (OR=2.32, $p<0.001$).

Among modifiable operative factors identified (Table 3): inadequate blood supply to the anastomosis – 5.21 (95 % CI: 3.82–7.10, $p<0.001$), poor blood supply to the resection area – 4.56 (95 % CI: 3.27–6.35, $p<0.001$), absence of preventive stoma – 3.52 (95 % CI: 2.59–4.78, $p<0.001$).

Table 1. Type of Surgical Interventions

Type of Operation			Methods of Anastomosis Formation		Without Protective Ileostomy	With Protective Ileostomy
			Manual	Stapled		
Anterior rectal resection, n (%)	High anterior resection	13 (29.5)	7 (2)	6	11 (2)	2
	Low anterior resection	7 (16)	4 (1)	3	5 (1)	2
	Ultralow anterior resection	8 (18)	0	8 (2)	8 (2)	–
Left hemicolectomy, n (%)		11 (25)	10 (1)	1	11 (1)	–
Right hemicolectomy, n (%)		5 (11.5)	4	1	5	–
Total operations, n		44	33	11	40	4

Table 2. Modifiable Preoperative Risk Factors

Risk Factor	Odds Ratio	95 % Confidence Interval	p-value	Relative Risk
Smoking	2.46	1.74–3.48	<0.001	2.08
Excessive alcohol consumption	1.98	1.28–3.07	<0.001	1.76
Obesity (BMI >30)	2.32	1.63–3.29	<0.001	1.97
Hypotrophy	3.05	2.14–4.35	<0.001	2.43
Hypoproteinemia	3.74	2.68–5.22	<0.001	2.87
Mechanical bowel preparation*	0.58	0.37–0.91	0.018	0.64

Note. * – mechanical bowel preparation acts as a protective factor (OR<1).

Table 3. Modifiable Operative Risk Factors

Risk Factor	Odds Ratio	95 % Confidence Interval	p-value	Relative Risk
Inadequate blood supply to resection area	4.56	3.27–6.35	<0.001	3.45
Hand-sewn anastomosis	1.32	0.98–1.77	0.069	1.25
Stapled anastomosis	0.77	0.57–1.02	0.069	0.81
Open surgery	1.88	1.41–2.50	<0.001	1.62
Laparoscopic surgery	0.53	0.40–0.71	<0.001	0.62
Absence of prophylactic pelvic drainage	2.18	1.63–2.92	<0.001	1.84
Absence of preventive stoma*	3.52	2.59–4.78	<0.001	2.73
Inadequate blood supply to anastomosis	5.21	3.82–7.10	<0.001	3.78

Note. * – when performing low anterior rectal resections.

Modifiable postoperative risk factors (Table 4) include hemostasis and tissue oxygenation disorders associated with blood loss. Massive blood transfusion of more than two units demonstrated the highest risk of anastomotic leakage with OR=4.18 (95 % CI: 2.87–6.09, p<0.001). Severe anemia with hemoglobin concentration below 90 g/L was characterized by OR=2.83 (95 % CI: 2.10–3.81, p<0.001), while moderate anemia with hemoglobin concentration of 90–110 g/L showed OR=1.75 (95 % CI: 1.27–2.41, p<0.001).

The most statistically significant modifiable risk factors for anastomotic leakage according to multifactorial analysis were: inadequate blood supply to the anastomosis, inadequate blood supply to the resection area, massive blood transfusion (>2 units), hypoproteinemia, and absence of preventive stoma, which are prerequisites for colorectal anastomotic leakage (Fig. 1).

Among non-modifiable preoperative factors (Table 5), the most important were ASA classification

Table 4. Modifiable Postoperative Risk Factors

Risk Factor	Odds Ratio	95 % Confidence Interval	p-value	Relative Risk
Anemia (Hb<90 g/L)	2.83	2.10–3.81	<0.001	2,34
Moderate anemia (Hb 90–110 g/L)	1.75	1.27–2.41	<0.001	1.56
Blood transfusion in postoperative period	3.26	2.41–4.41	<0.001	2.62
Massive blood transfusion (>2 units)	4.18	2.87–6.09	<0001	3.12

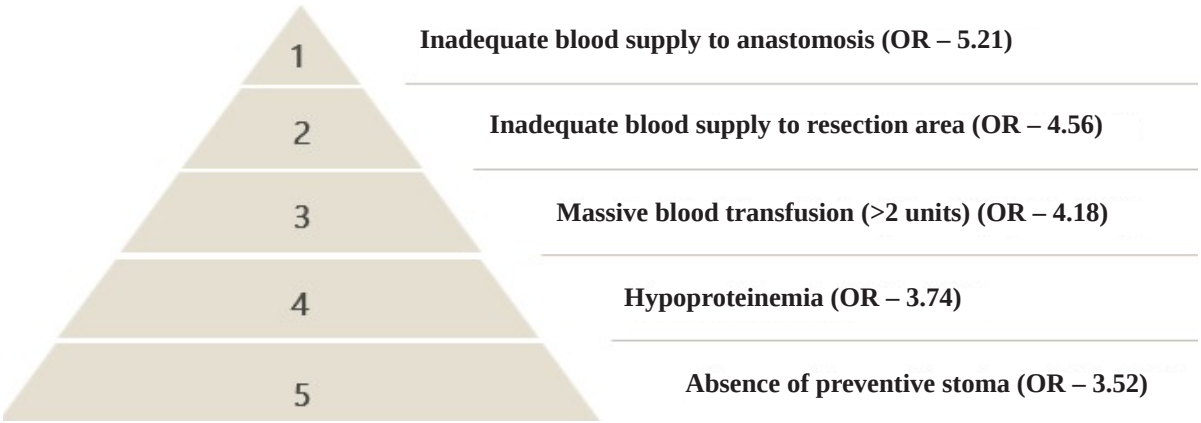

Fig. 1. Statistically significant modifiable risk factors.

Table 5. Non-modifiable Preoperative Risk Factors

Risk Factor	Odds Ratio	95 % Confidence Interval	p-value	Relative Risk
Male gender	1.76	1.32–2.34	<0.001	1.57
ASA III	2.32	1.73–3.11	<0.001	1.96
ASA IV	3.68	2.47–5.48	<0.001	2.84
Charlson comorbidity index 1–2	1.45	1.03–2.04	0.034	1.36
Charlson comorbidity index 3–4	2.29	1.64–3.19	<0.001	1.94
Charlson comorbidity index ≥5	3.53	2.38–5.24	<0.001	2.74

class and comorbid pathology. ASA class IV showed OR=3.68 (95 % CI: 2.47–5.48, p<0.001), Charlson comorbidity index of five points and above was characterized by OR=3.53 (95 % CI: 2.38–5.24, p<0.001), age of eighty years and older showed OR=2.87 (95 % CI: 1.96–4.21, p<0.001).

Among operative factors (Table 6), the highest risk of anastomotic dehiscence included: tumor location less than five centimeters from the anal orifice with OR=4.16 (95 % CI: 3.05–5.67, p<0.001) and emergency operation with OR=3.75 (95 % CI: 2.82–4.98, p<0.001).

Surgical intervention duration exceeding 240 minutes was characterized by OR=3.16 (95 % CI: 2.29–4.36, p<0.001).

Among the most statistically significant predictors of anastomotic leakage risk, according to multifactorial analysis, was tumor distance to the anal ring <5 cm, which should be considered when choosing the extent and technique of surgical intervention (Fig. 2).

Based on the conducted analysis and mathematical model for predicting anastomotic leakage risk, three degrees of predicted anastomotic failure were

Table 6. Non-modifiable Operative Risk Factors

Risk Factor	Odds Ratio	95 % Confidence Interval	p-value	Relative Risk
Tumor distance to anal ring <5 cm	4.16	3.05–5.67	<0.001	3.12
Tumor distance to anal ring 5–10 cm	2.53	1.87–3.42	<0.001	2.11
Tumor distance to anal ring 10–15 cm	1.42	1.03–1.95	0.032	1.34
Emergency operation	3.75	2.82–4.98	<0.001	2.89
Elective operation	0.27	0.20–0.35	<0.001	0.35
Operation duration >180 min	2.31	1.74–3.06	<0.001	1.95
Operation duration >240 min	3.16	2.29–4.36	<0.001	2.53

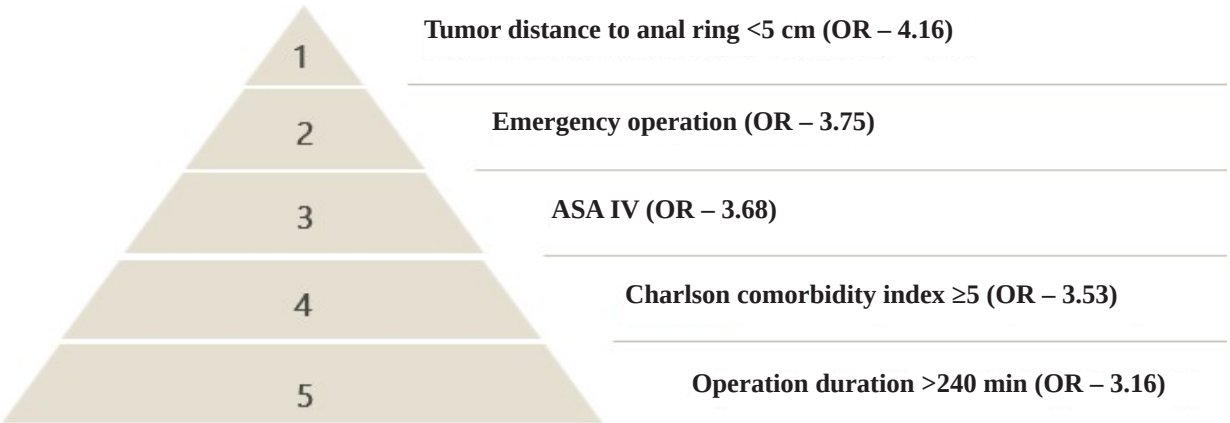

Fig. 2. Statistically significant non-modifiable risk factors.

identified: high risk (presence of 3 or more factors), anastomotic leakage rate was 27.8 %, moderate risk (1–2 factors) – 8.6 %, low risk (0 factors) – 3.1 % (Table 7).

Table 7. Degrees of Risk for Anastomotic Leakage in Colorectal Anastomoses

Risk Degree	Number of Risk Factors	Predicted Frequency of Anastomotic Leakage, %
High risk	≥3	27.8
Moderate risk	1–2	8.6
Low risk	0	3.1

Discussion. The obtained results confirm the multifactorial etiology of colorectal anastomotic dehiscence and demonstrate prospects for improving surgical treatment outcomes through intervention on modifiable risk factors. The most important modifiable factors are nutritional status disorders (hypoproteinemia and hypotrophy) and inadequate vascularization in the anastomotic area, indicating the need for careful preoperative patient preparation with correction of protein-energy deficiency and intraoperative assessment of tissue viability. The significance of surgical intervention duration emphasizes the importance of concentrating complex colorectal operations in specialized centers with adequate surgical volume.

Body weight and nutritional status play an important role in the development of anastomotic failure. Hypotrophy and preoperative weight loss impair natural tissue healing processes, as the body lacks sufficient resources for regeneration. On the other hand, obesity with body mass index exceeding 30 kg/m² is also a risk factor, especially in low rectal anastomoses, as excess visceral fat creates mechanical tension in the anastomotic area [7]. Visceral obesity is associated with prolonged operation duration, higher rates of infectious complications, and increased frequency of anastomotic leakage.

Comorbidities significantly worsen the prognosis for anastomotic healing. Diabetes mellitus [9], cardiovascular diseases [10], chronic obstructive pulmonary disease [11], and renal failure negatively affect the patient's general condition and recovery capacity after surgery. Patients with ASA class III and higher [8] or Charlson comorbidity index greater than three have a higher risk of developing anastomotic leakage compared to healthy patients [6].

Anastomotic location is one of the most important risk factors [12]. Anastomoses located less than five to seven centimeters from the anal canal have a 4.16 times higher risk of failure, explained by technical difficulties of operating in the narrow pelvis and poorer healing conditions in extraperitoneal anastomoses [13]. Adequate vascularization of bowel segments is critically important for anastomotic healing [14]. Inadequate blood supply to the anastomosis after vessel division significantly increases the risk of failure by 5.21 times. Modern visualization methods using intraoperative peak flowmetry and indocyanine green [15] allow assessment of perfusion quality and modification of the resection line when necessary, reducing the leakage rate [16].

Emergency operations are accompanied by significantly higher risk of anastomotic leakage due to the severe general condition of patients with peritonitis or intestinal obstruction [17]. Operation duration exceeding 3 hours is also associated with increased leakage frequency, as prolonged anesthesia and surgical trauma negatively affect the patient's body [18]. Anemia with hemoglobin level below 90 g/L impairs oxygen delivery to anastomotic tissues, which can cause ischemia and healing disruption [19]. Intraoperative blood loss intensifies this effect, directly causing ischemia in the anastomotic area. Blood transfusions, while correcting anemia, cause immunological suppression, increasing the risk of infectious complications around the anastomosis [20].

Conclusions. Anastomotic leakage in colorectal surgery is a multifactorial complication; consideration of modifiable and non-modifiable factors allows individualization of the approach to preventing anastomotic failure in colorectal anastomoses after primary resection operations in colorectal surgery.

Prospects for Further Research. Conducting larger-scale prospective studies to confirm the obtained results and create an anastomotic leakage risk assessment system is relevant. A promising direction remains studying the effectiveness of modern enhanced recovery after surgery protocols in preventing this complication. Research on optimal methods of preoperative patient preparation is important. Development of practical recommendations for choosing surgical treatment tactics considering individual risk factors of each patient is necessary.

Conflict of Interest. The authors declare no conflict of interest.

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ФАКТОРИ РИЗИКУ ПОРУШЕННЯ ЦІЛІСНОСТІ ШВІВ ТОВСТО-ТОВСТОКИШКОВИХ АНАСТОМОЗІВ ПІСЛЯ РАДИКАЛЬНИХ ОДНОЕТАПНИХ ХІРУРГІЧНИХ ВТРУЧАНЬ У КОЛОРЕКТАЛЬНІЙ ХІРУРГІЇ

Мета роботи: встановити основні фактори, що впливають на ризик порушення цілісності швів колоректальних анастомозів після радикальних одноетапних хірургічних втручань у колоректальній хірургії.

Матеріали і методи. Проведено ретроспективне дослідження результатів хірургічного лікування 44 пацієнтів, яким виконували радикальні одноетапні операції на товстій кишці з накладанням первинного анастомозу. Передню резекцію прямої кишки виконано у 28 пацієнтів (63,5 %), лівобічну геміколектомію – в 11 (25 %), правобічну геміколектомію – у 5 (11,5 %). Використовували класифікацію факторів ризику на модифіковані та немодифіковані, передопераційні, операційні та післяопераційні. Статистичний аналіз включав обчислення відношення шансів (ВШ) з 95 % довірчими інтервалами (ДІ) та відносного ризику (ВР) із використанням SPSS 26.0.

Результати. Загальна частота неспроможності швів склала 13,6 %. Найсуттєвішими модифікованими передопераційними факторами виявилися гіпопротеїнемія (ВШ=3,74), гіпотрофія (ВШ=3,05) та ожиріння (ВШ=2,32). Серед операційних факторів найвищий ризик асоціювався з недостатнім кровопостачанням анастомозу (ВШ=5,21), поганим кровопостачанням ділянки резекції (ВШ=4,56) та відсутністю превентивної стоми (ВШ=3,52). З-поміж немодифікованих факторів виділялися ASA IV (ВШ=3,68), індекс коморбідності за Чарлсоном ≥5 (ВШ=3,53), локалізація пухлини <5 см від анального отвору (ВШ=4,16) та ургентна операція (ВШ=3,75). Післяопераційна масивна гемотрансфузія продемонструвала ВШ=4,18. Розроблено модель стратифікації прогнозу ризику: високий (≥3 фактори) – 27,8 %, середній (1–2 фактори) – 8,6 %, низький (0 факторів) – 3,1 %.

Висновки. Неспроможність швів колоректальних анастомозів є мультифакторним ускладненням. Виявлення та корекція модифікованих факторів ризику, зокрема нутрітивного статусу, забезпечення адекватної васкуляризації анастомозу та використання превентивної стоми при низьких резекціях, дозволяє індивідуалізувати підхід до попередження неспроможності швів та покращити результати хірургічного лікування.

Ключові слова: колоректальна хірургія; колоректальний анастомоз; неспроможність швів; фактори ризику; стратифікація ризику; післяопераційні ускладнення.

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