original article

Prospective evaluation of serum and peritoneal fluid markers as indicators of postoperative complications in patients with enteric anastomosis

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BACKGROUND: Postoperative complications of colorectal cancer surgery contribute to increased morbidity and mortality in patients.

OBJECTIVES: Investigate the role of biochemical markers in serum and peritoneal fluid in the development of postoperative complications in patients with enteral anastomosis.

DESIGN: Prospective.

SETTING: University hospitals.

PATIENTS AND METHODS: The studied population consisted of patients who underwent surgical treatment with created anastomosis or Hartmann's resection from April 2022 to April 2024, conducted at the Clinical-Hospital Center Kosovska Mitrovica and the University Clinical Center Kragujevac. Spearman's correlation coefficient (r_s) was used to test associations between categorical variables.

MAIN OUTCOME MEASURES: Lactate, albumin, lactate dehydrogenase, and IgA antibodies were monitored as predictors of anastomotic dehiscence and general postoperative complications.

SAMPLE SIZE: 52

RESULTS: The concentration of lactate in the drain fluid on the third postoperative day was statistically significantly higher in patients who did not develop anastomotic dehiscence (*P*=.006). The concentration of IgA antibodies in the drain fluid on the third and fifth days post-surgery showed a moderate negative correlation with lactate concentration (r_s=-.670, *P*=.012; r_s=-.577, *P*=.039), repectively. There was a significantly higher concentration of albumin in the drain fluid on the third day post-surgery in patients who developed dehiscence (*P*=.040), and on the seventh day post-surgery in those who did not develop dehiscence (*P*=.001). The concentration of LDH on the third day in the drain fluid after surgery was statistically significantly higher in patients who did not develop dehiscence (*P*=.020). There was a statistically significant difference in lactate concentration in the drain fluid on the third (*P*<.001) and fifth days (*P*=.041) post-surgery, as well as in albumin concentration on the third day post-surgery (*P*=.024) with respect to the development of general postoperative complications.

CONCLUSION: This study revealed significant differences in the concentrations of lactate, albumin, and LDH in the drain fluid on the third and fifth days post-surgery with respect to the development of complications. These results suggest that monitoring these markers may

help in the early identification of patients at risk of complications such as dehiscence.
LIMITATIONS: Limited literature on specific aspects of this study, including the absence of a control group, small sample size, and two-center study.
CONFLICT OF INTEREST: None.

Colorectal cancer exhibits various inheritance patterns, including sporadic, familial, and hereditary forms. Diet, physical activity, smoking, and alcohol consumption are factors that can influence the risk of colorectal cancer.[1] Characteristic symptoms of colorectal cancer include changes in bowel habits, blood in the stool, pain, weight loss, and anemia.[1] After a right hemicolectomy, an L-L anastomosis is recommended, particularly for colorectal adenocarcinoma.[2] However, primary resection and anastomosis in patients with colorectal cancer obstruction require complex surgical techniques and may be associated with high mortality and morbidity rates.[3] Recent years of research emphasize the importance of the increased systemic inflammatory response being associated with reduced survival in patients with colorectal cancer, regardless of tumor stage.[4]

Hartmann's procedure, which includes rectosigmoid resection, closure of the rectal stump, and formation of a colostomy, is applied in cases of obstruction or perforation of the left side of the colon.[5] Studies comparing postoperative outcomes of Hartmann's resection and resection with primary anastomosis suggest similar mortality and morbidity rates.[2] Treatment of Meckel's diverticulum usually involves surgical resection of the small intestine, often with end-to-end anastomosis.[3] Gastrointestinal stromal tumors (GISTs) require radical resection, especially if the tumor is larger than 2 cm.[6]

Albumin (g/L), as an important predictor of surgical risk, correlates with the degree of malnutrition and can be an indicator of poor outcomes in hospitalized patients.[7] Postoperative hyperlactatemia is associated with microcirculation damage and decreased tissue ability to extract oxygen. Elevated lactate (mol/L) levels arise due to increased aerobic glycolysis. Lactic acidosis occurs in two clinical scenarios: hypoxic and metabolic.[8] IgA antibodies provide the first line of defense in the mucosa of the respiratory, gastrointestinal, and genitourinary tracts against bacteria and viruses. Increased concentrations of immunoglobulins in the blood have been observed in various conditions, including infections and chronic diseases.[9] Lactate dehydrogenase (LDH) is an important enzyme in anaerobic metabolism and is used as an indicator of acute and chronic diseases. Elevated LDH levels are associated with various conditions, including muscular dystrophy and pathological fluid accumulation.[9]

Anastomotic dehiscence is a serious complication in surgery that can lead to systemic and local complications. The International Study Group of Rectal Cancer recommends grading the severity of this complication. The frequency of dehiscence varies depending on different factors, including the type of surgery and timing of resection.[10-14] Complications of surgical treatment for colorectal cancer contribute to increased morbidity and mortality among patients. Comparison of different anastomosis methods has not revealed significant differences in complication rates.[15] Anastomotic dehiscence is potentially the most dangerous complication of surgical treatment in patients. Risk factors for anastomotic dehiscence are classified into three categories: patient-related factors, operative factors, and disease-related factors.[16]

Nutritional support plays a crucial role in wound healing and postoperative recovery, and poor nutritional status is strongly associated with delayed wound healing and longer hospital stays after surgery.[17] Patients who experience anastomotic dehiscence undergo a "double blow," first as a result of the surgery and second due to sepsis.[18]

The main objective of this study was to examine the role of biochemical markers in serum and peritoneal fluid in the development of postoperative complications in patients with enteral anastomosis.

PATIENTS AND METHODS

Our study was planned as a prospective research study, using a panel study design that combines a cohort study with a cross-sectional study. The research was conducted at the Clinical-Hospital Center Kosovska Mitrovica and the University Clinical Center Kragujevac. Approval for the implementation of this research was obtained from the Ethics Committee of the institution where the research was conducted, as well as from the Ethics Committee of the Faculty of Medicine, University of Pristina, with temporary headquarters in Kosovska Mitrovica. The research was carried out from April 2022 to April 2024.

In this study, the first cross-sectional study included biochemical analyses on patients hospitalized with a diagnosis of colorectal cancer, intestinal diverticulum, or GIST. Patients were monitored during the entire treatment process, and in the postoperative period, a second cross-sectional study was conducted, during which certain parameters were monitored on the third, fifth, and seventh postoperative days. The study included patients with a diagnosis of colorectal cancer, intestinal diverticulum, or GIST, confirmed by radiological methods and histopathology, of both sexes, aged 18 years and older. After being informed about the purpose and conduct of the study, written consent was obtained from all participants for their participation in the study and the use of their blood samples and peritoneal drainage fluid for research purposes.

As part of the study, sociodemographic data and blood samples were collected in the preoperative period, as well as blood samples and peritoneal drainage fluid in the postoperative period on the third, fifth, and seventh days after surgery. Sociodemographic data analyzed include gender and age. Clinical parameters collected included: serum albumin, lactate, IgA antibody, and LDH levels before surgery, as well as on the third, fifth, and seventh postoperative days in serum and peritoneal drainage fluid; specific postoperative complications (anastomotic dehiscence); general postoperative complications (urinary tract infection, renal failure, deep vein thrombosis, pneumonia); day of postoperative occurrence of anastomotic dehiscence; localization of the pathological process; type of surgical intervention; type of operation (anastomosis/Hartmann resection); and mortality outcome. Processing and analysis of samples were performed in the laboratory of CHC Kosovska Mitrovica, according to standard protocols and using commercial reagents. The primary outcome variable was the presence of specific complications in patients undergoing surgical treatment.

For the analysis of these parameters, commercial reagents were used on the Beckman Coulter AU 480 automatic analyzer platform (Beckman Coulter, Brea, CA, USA). Commercial calibrators traceable to NIST (National Institute of Standards and Technology) standard reference material and Beckman Coulter Master calibrators were used for method calibration. Test tubes without additives (BD Vacutainer) were used to obtain serum. After free blood coagulation, the sera were separated by centrifugation (15 minutes, 3000 revolutions/minute), aliquoted, and stored at a temperature of -80 degrees Celsius until analysis. Peritoneal drainage fluid was taken in one tube of 1 mL from the abdominal drain. Plastic sterile test tubes without additives, centrifuged, aliquoted, and properly labeled were used. Samples of peritoneal drainage fluid were taken with a sterile syringe on the valve of the abdominal drainage bag, using sterile gloves.

The sample size was determined based on average albumin values as predictors of complication occurrence. According to the literature, 52 patients are required to achieve a study power of 80% and a significance level of .05.[16,19] Statistical analyses were carried out with IBM SPSS for Windows version 21 statistical software. Continuous variables are presented as median (range) and categorical variables as frequencies and percentages. Distributions of the numeric variables were examined by Kolmogorov-Smirnov test for normality. For numeric variables, differences between the groups were determined by the Mann-Whitney test. The chi-square test and the Fisher's exact test were used to determine associations between categorical variables. Spearman's correlation coefficient (rs) was used to test the association. A *P* value of less than .05 was considered statistically significant.

RESULTS

In this study, data collected from 52 patients with a diagnosis of colorectal cancer, diverticulum of the bowel, or GIST were analyzed. Sociodemographic data revealed that the median (IQR) age of the participants was 65.5 [50.5-73.25]) years, with a gender distribution of 59.6% males and 40.4% females (**Tables 1 and 2**).

There was no statistically significant difference in the age of participants concerning the occurrence of dehiscence (*P*=.655). The average age of patients without dehiscence was (SD 65.9 [9.4]) years, while the median (IQR) age of patients with dehiscence was 65.5 (14) years. There was no statistically significant difference by gender regarding the occurrence of dehiscence (*P*=.870) (**Table 3**). There was no statistically significant difference in the incidence of dehiscence based on the type of surgical procedure (*P*=.196) (**Tables 4 and 5**). The highest number of dehiscences was recorded in patients with the pathological process localized to the sigmoid colon, while the fewest cases were noted in other parts of the colon (**Table 6**).

There was a statistically significant difference in lactate concentration in the drain on the third postoperative day concerning the occurrence of dehiscence (**Table 7**). Lactate concentration was significantly higher

Table 1. Variables included in the study (n=52).

Variables	
Age	65.5 (59.5-73-25)
Gender	
Male	31 (59.6)
Female	21 (40.4)
Operative intervention Entero-entero	4 (7.7)
Ileo-colon	24 (46.2)
Colon-colon	7 (13.5)
Colon-recto	4 (7.7)
Hartman	13 (25)
Anastomosis/Hartman	
Anastomosis	39 (75)
Hartman	13 (25)
Localization of pathological process ascendant colon	24 (46.2)
Transverse colon	—
Descendant colon	2 (3.8)
Sigmoid colon	21 (40.4)
Rectal diverticulum	1 (1.9)
Small intestine	3 (5.8)
GIST	1 (1.9)
Dehiscence	
Yes	13 (25)
No	39 (75)
Day of dehiscence	
Third	5 (9.6)
Fifth	6 (11.5)
Seventh	2 (3.8)
General complications	
Yes	16 (30.8)
No	36 (69.2)
Fatal outcome	
Yes	9 (17.3)
No	43 (82.7)

Data are median (25th-75th percentile) for age and number (percentage) for categorical data.

Table 2. Concentration of lactate, albumin, IgA, and LDH in serum and drain fluid (n=52).

Variable	
Serum before surgery	
Lactate (mol/L)	1.8 (0.8-11.8)
Albumin (g/L)	36.5 (20-59)
IgA (IU)	1.5 (0.4-5.8)
LDH (IU)	252 (17-938)
Serum on the third day after surgery	
Lactate (mol/L)	2.1 (0.6-11.4)
Albumin (g/L)	33 (24-55)
IgA (IU)	1.4 (0.4-5.0)
LDH (IU)	291 (57-789)
Serum on the fifth day after surgery	
Lactate (mol/L)	1.9 (0.5-19.2)
Albumin (g/L)	31 (25-56)
IgA (IU)	1.3 (0.3-4.8)
LDH (IU)	261 (16-1152)
Serum on the seventh day after surgery	
Lactate (mol/L)	2.5 (0.6-23.7)
Albumin (g/L)	33.5 (20-55)
IgA (IU)	1.7 (0.3-4.5)
LDH (IU)	313.5 (45-1263)
Drain on the third day after surgery	
Lactate (mol/L)	8.7 (0.01-37.5)
Albumin (g/L)	26 (15-54)
IgA (IU)	0.7 (0.2-4.2)
LDH (IU)	972.5 (95-10770)
Drain on the fifth day after surgery	
Lactate (mol/L)	9.3 (0.5-35.6)
Albumin (g/L)	30 (12-55)
IgA (IU)	0.9 (0.2-5.8)
LDH (IU)	953 (86-19500)
Drain on the seventh day after surgery (range)	
Lactate (mol/L)	5.4 (0.9-28.3)
Albumin (g/L)	32 (21-44)
IgA (IU)	0.9 (0.2-4.1)
LDH (IU)	1063 (93-30400)

Data are median (minimum-maximum). IU: international unit

Table 3. Frequency of dehiscence by sex.

	Dehiscence		*P*
	Yes	No	
Gender			
Male	8 (61.5)	23 (59)	.870
Female	5 (38.5)	16 (41)	

Data are number (percentage).

Table 4. Frequency of anastomotic dehiscence by surgical procedure.

	Dehiscence		*P*
	Yes	No	
Surgical procedure			
Entero-entero	4 (30.8)	0 (0)	
Ileo-colon	3 (23.1)	21 (53.8)	
Colon-colon	0 (0)	7 (17.9)	.0017
Colon-recto	1 (7.7)	3 (7.7)	
Hartmann	5 (38.5)	8 (20.5)	

Data are number (percentage).

Table 5. Frequency of anastomotic dehiscence by surgical technique.

	Dehiscence		*P*
	Yes	No	
Surgical technique			
Anastomosis	8 (61.5)	31 (79.5)	.196
Hartmann	5 (38.5)	8 (20.5)	

Data are number (percentage).

in the drainage fluid on the third day after surgery in patients who did not develop dehiscence. Additionally, the concentration of albumin in the drainage fluid on the third postoperative day was statistically significantly higher in patients who developed dehiscence, whereas albumin concentration on the seventh postoperative day was statistically significantly higher in patients who did not develop dehiscence. LDH concentration was statistically significantly higher on the third postoperative day in patients who did not develop dehiscence.

There was a statistically significant strong positive correlation between lactate concentration and IgA antibodies in serum on the fifth postoperative day (rs=.748, *P*=.003). An increase in lactate values was accompanied by an increase in IgA antibody levels (**Table 8**).

There was a statistically significant moderate negative correlation between lactate concentration and IgA antibodies in the drain on the third postoperative day (rs=-.670, *P*=.012). An increase in IgA antibody levels was accompanied by a decrease in lactate values. There was also a statistically significant moderate negative correlation between lactate concentration and IgA antibodies in the drain on the fifth postoperative day (rs=-.577, *P*=.039). An increase in IgA antibody levels was associated with a decrease in lactate values (**Table 9**).

There was a statistically significant strong positive correlation between serum IgA antibody concentration and IgA antibodies in the drain on the third, fifth, and seventh days after surgery in patients who developed dehiscence. Elevated serum IgA antibody levels were associated with elevated IgA antibody levels in the drain (**Table 10**).

There was a statistically significant difference in the age of patients concerning the occurrence of general postoperative complications (*P*=.006). The median (minimun-maximum) age of patients who did not develop complications was 65.5 (40.0-88.0) years. General postoperative complications were more common in older patients.

There was also a statistically significant difference in the frequency of general postoperative complications

Table 6. Frequency of anastomotic dehiscence by localization of pathological process.

	Dehiscence		*P*
	Yes	No	
Localization of pathological process			
Ascendant colon	3 (23.1)	21 (53.8)	
Transvese colon			
Descendant colon	0 (0)	2 (5.1)	
Sigmoid colon	5 (38.5)	16 (41)	.003
Rectal diverticulum	1 (7.7)	0 (0)	
Small intestine	3 (23.1)	0 (0)	
GIST	1 (7.7)	0 (0)	

Data are number (percentage).

Table 7. Biochemical parameters in serum and peritoneal drainage fluid in relation to the development of dehiscence.

Biochemical parameters	Dehiscence		*P*
	Yes	No	
Serum lactates			
Preoperatively	1.9 (0.8-4.5)	1.8 (0.8-11.8)	.479
Third day after surgery	2.1 (0.6-3.1)	2.24 (0.7-11.4)	.281
Fifth day after surgery	1.7 (0.5-4.8)	2.5 (0.7-19.2)	.171
Seventh day after surgery	1.5 (0.6-23.7)	3.2 (0.7-20.8)	.145
Lactates in drainage fluid			
Third day after surgery	2.2 (0.01-15.1)	9.8 (0.5-37.5)	**.006**
Fifth day after surgery	6.2 (1.8-24.1)	8.9 (0.5-35.6)	.353
Seventh day after surgery	5.4 (1.8-28.3)	6.0 (0.9-20.2)	.545
Serum albumin			
Preoperatively	33 (20-49)	37 (25-59)	.340
Third day after surgery	33 (27-49)	33 (24-55)	.849
Fifth day after surgery	31 (28-44)	32.5 (25-56)	.406
Seventh day after surgery	34 (20-55)	34 (28-45)	.800
Albumin in drainage fluid			
Third day after surgery	30 (21-45)	25 (15-54)	**.040**
Fifth day after surgery	31 (16-39)	25 (12-55)	.370
Seventh day after surgery	29 (21-39)	38 (32-44)	**.001**
IgA in serum			
Preoperatively	1.4 (0.4-3.1)	1.5 (0.5-5.8)	.342
Third day after surgery	1.0 (0.4-3.9)	1.4 (0.5-5.0)	.212
Fifth day after surgery	1.3 (0.3-4.7)	1.3 (0.4-4.8)	.883
Seventh day after surgery	1.3 (0.3-4.5)	1.7 (0.4-4.3)	.866
IgA in drainage fluid			
Third day after surgery	0.6 (0.2-4.2)	0.8 (0.2-3.2)	.672
Fifth day after surgery	0.6 (0.4-5.8)	0.9 (0.2-2.9)	.100
Seventh day after surgery	0.9 (0.2-4.1)	1.0 (0.5-2.6)	.657
LDH in serum			
Preoperatively	251 (17-628)	253 (86-938)	.866
Third day after surgery	301 (57-753)	291 (135-789)	.642
Fifth day after surgery	276 (16-954)	248 (94-1152)	.901
Seventh day after surgery	383 (51-1219)	293 (45-1263)	.287
LDH in drainage fluid			
Third day after surgery	623 (251-1210)	1622 (95-10770)	**.020**
Fifth day after surgery	738 (86-19500)	1186.5 (137-14980)	.821
Seventh day after surgery	1063 (128-30400)	783 (93-3350)	.600

Data are median (minimum-maximum).

Table 8. Correlation of IgA antibody and lactate concentrations in preoperative and postoperative serum (Spearman's correlation coeffcient).

	Lactate preoperatively	Lactate on the third day after surgery	Lactate on the fifth day after surgery	Lactate on the seventh day after surgery
IgA antibodies preoperatively	-.352			
IgA antibodies on the third day after surgery		.440		
IgA antibodies on the fifth day after surgery			.748[a]	
IgA antibodies on the seventh day after surgery				.500

[a]<.05 (Quantifies the likelihood of a correlation between the two variables).

Table 9. Correlation of IgA antibody and lactate concentrations in drainage fluid (Spearman's correlation coeffcient).

	Lactate on the third day after surgery	Lactate on the fifth day after surgery	Lactate on the seventh day after surgery
IgA antibodies on the third day after surgery	-.670[a]		
IgA antibodies on the fifth day after surgery		-.577[a]	
IgA antibodies on the seventh day after surgery			-.218

[a]<.05 (Quantifies the likelihood of a correlation between the two variables).

Table 10. Correlation of IgA antibody concentrations in serum and peritoneal drainage fluid (Spearman's correlation coeffcient).

	IgA antibodies on the third day after surgery, drain	IgA antibodies on the third day after surgery, drain	IgA antibodies on the third day after surgery, drain
IgA antibodies on the third day after surgery, serum	.786[a]		
IgA antibodies on the fifth day after surgery, serum		.786[a]	
IgA antibodies on the seventh day after surgery, serum			.845[a]

[a]<.05 (Quantifies the likelihood of a correlation between the two variables).

Table 11. Frequency of postoperative complications by surgical technique (Spearman's correlation coeffcient).

	General postoperative complications		*P*
	Yes	No	
Surgical technique, n (%)			
Anastomosis	30 (83.3)	9 (56.3)	.037
Hartmann	6 (16.7)	7 (43.8)	

Table 12. Biochemical parameters in serum and peritoneal drainage fluid relative to the development of general complications.

Biochemical parameters	General complications		*P*
	Yes	No	
Serum lactate			
Preoperatively	1.5 (0.8-2.9)	1.9 (0.8-11.8)	.078
Third day after surgery	1.9 (0.6-3.7)	2.4 (0.8-11.4)	.326
Fifth day after surgery	1.9 (0.5-5.1)	2.3 (0.7-19.2)	.418
Seventh day after surgery	1.9 (0.6-23.7)	2.8 (0.7-20.8)	.439
Lactates in drainage fluid			
Third day after surgery	2.2 (0.01-15.1)	10.5 (0.5-37.5)	**.001**
Fifth day after surgery	4.8(0.6-24.1)	10.0 (0.5-35.6)	**.041**
Seventh day after surgery	4.2 (0.9-28.3)	8.2 (1.4-23.7)	.683
Serum albumin			
Preoperatively	38 (20-50)	36 (24-59)	.662
Third day after surgery	34 (26-52)	32 (24-55)	.138
Fifth day after surgery	31 (28-48)	32 (25-56)	.460
Seventh day after surgery	33.5 (28-51)	33.5 (20-55)	.755
Albumin in drainage fluid			
Third day after surgery	30 (16-48)	25 (15-54)	**.024**
Fifth day after surgery	34 (16-49)	25 (12-55)	.065
Seventh day after surgery	30 (21-44)	34 (28-43)	.151
IgA in serum			
Preoperatively	1.4 (0.4-3.2)	1.5 (0.6-5.8)	.234
Third day after surgery	1.4 (0.4-3.9)	1.4 (0.5-5.0)	.138
Fifth day after surgery	1.3 (0.4-4.8)	1.2 (0.3-4.7)	.924
Seventh day after surgery	1.5 (0.3-4.5)	1.7 (0.4-4.3)	.866
IgA in drainage fluid			
Third day after surgery	0.8 (0.2-4.2)	0.7 (0.2-2.9)	.812
Fifth day after surgery	0.9 (0.3-5.8)	0.9 (0.2-2.9)	.430
Seventh day after surgery	1.0 (0.2-4.1)	0.9 (0.5-2.6)	.870
LDH in serum			
Preoperatively	282.5 (17-938)	245 (86-724)	.378
Third day after surgery	355 (57-789)	261.5 (135-730)	.194
Fifth day after surgery	291.5 (16-1152)	246 (94-974)	.306
Seventh day after surgery	296 (51-1263)	313.5 (45-1178)	.899
LDH in drainage fluid			
Third day after surgery	603 (155-1308)	1673 (95-10770)	**.002**
Fifth day after surgery	583.5 (86-3060)	1224 (137-19500)	.193
Seventh day after surgery	1008 (128-2814)	1858 (93-30400)	.369

Data are median (minimum-maximum).

based on the type of surgical procedure (*P*=.037). General complications were more frequent with the anastomosis technique compared to the Hartmann procedure (**Table 11**).

There was a statistically significant difference in lactate concentration in the drainage fluid on the third and fifth days after surgery with respect to the development of general postoperative complications. The average lactate value in the drainage fluid on the third and fifth days after surgery is significantly higher in patients who did not develop general postoperative complications. There is also a statistically significant difference in albumin concentration in the drainage fluid on the third day after surgery concerning the development of general postoperative complications. The average albumin value in the drainage fluid on the third day after surgery is significantly higher in patients who developed general postoperative complications. Additionally, there is a statistically significant difference in LDH concentration in the drainage fluid on the third day after surgery with respect to the development of general postoperative complications. The average LDH value in the drainage fluid on the third day after surgery is significantly higher in patients who did not develop general postoperative complications (**Table 12**).

DISCUSSION

In this study, data from patients with colorectal cancer, diverticulum of the intestine, and GIST were analyzed to investigate the association between various factors and the occurrence of dehiscence, as well as general postoperative complications. The results indicate that there was no statistically significant difference in age or gender concerning dehiscence, nor in the incidence of dehiscence based on the type of surgical procedure, suggesting that these factors may not play a significant role in the development of dehiscence. However, significant differences in lactate and albumin concentrations in the drainage fluid suggest the potential value of these markers in predicting dehiscence. Additionally, findings of a positive correlation between lactate and IgA antibodies in serum in the early postoperative days are significant, as they indicate a possible induction of an immune response in the presence of stress. Analysis of general postoperative complications highlights the significant difference in age, with older patients showing a higher incidence of complications.

In the prospective study by Su'a et al,[20] 16 patients (5.7%) experienced a specific postoperative complication, namely anastomotic dehiscence, which is a lower percentage compared to the results of this study. This difference can be explained by the fact that Su'a et al's research was conducted in four public hospitals with a significantly larger number of participants compared to this study.

In the study by Paliogiannis et al,[21] the majority of participants were male, and the average age was 65.3 years (±14.1%). This male predominance may be explained by the higher prevalence of colorectal cancer in men. In contrast, our study did not find a statistically significant difference in the age of participants concerning the occurrence of dehiscence (*P*=.655). The average age of patients without dehiscence was (SD 65.9 [9.4]) years, while the average age of patients with dehiscence was (SD 67.5 [14]) years.

This study suggests that there is no statistically significant difference in serum albumin concentration before surgery concerning the development of dehiscence. Similar results were obtained by Shimura et al[22] in their study, where they monitored preoperative serum albumin values in patients with intestinal anastomosis dehiscence.

The current study demonstrated that serum albumin values on the third, fifth, and seventh postoperative days were not significant as predictors for anastomotic dehiscence. In contrast, significantly higher concentrations of albumin in the abdominal drainage fluid on the third and seventh postoperative days were significant in patients with anastomotic dehiscence. These results are contrary to previous research findings that showed early postoperative hypoalbuminemia, determined on the first and third postoperative days from serum, was a useful predictor for anastomotic leakage.[22] This discrepancy in results may be explained by different biological roles and dynamics of albumin in serum and drainage fluid. Serum albumin reflects the overall nutritional and metabolic status of the patient, which can be influenced by many factors such as nutritional status, inflammation, and liver function. In contrast, albumin in drainage fluid directly reflects local conditions at the surgical site, including the degree of inflammation, exudation, and tissue integrity in the abdominal cavity. Increased albumin concentration in drainage fluid may indicate increased capillary permeability and local inflammatory reactions associated with anastomotic dehiscence. Therefore, measuring albumin in drainage fluid may be a more sensitive and specific indicator of local postoperative complications compared to serum albumin measurement. An initial low level of albumin may indicate stress on the body due to surgery, while its subsequent increase may be a sign of successful recovery and restoration of the functional capacity of the liver. This fluctuation may be related to the stages of tissue regeneration and the stabilization of postoperative metabolism, which reduce the risk of dehiscence. In other words, patients who show a rapid recovery of albumin after a temporary drop may have a better potential for wound healing.[23]

Lactate values were determined in serum on the third, fifth, and seventh postoperative days, but no association with anastomotic dehiscence was found. Also, lactate values in abdominal drainage fluid on the same days were measured, where only on the third postoperative day was a significantly higher concentration of lactate identified in patients with dehiscence. Overall, only 5 (9.6%) patients had anastomotic dehiscence on the third postoperative day. In contrast to these findings, Sparreboom et al[24] also measured lactate values in serum but did not find a significant difference on the third postoperative day. A high lactate level usually signals anaerobic glycolysis, indicating tissue hypoxia or ischemia. However, elevated lactate in patients who have not developed dehiscence may be indicative of a successful adaptive response to temporary ischemia. Short-term ischemia can trigger regenerative mechanisms in tissues, such as angiogenesis (formation of new blood vessels), which improves perfusion of the anastomosis and reduces the risk of dehiscence.[25]

The concentration of LDH in abdominal drainage fluid on the third postoperative day was statistically significantly higher in patients who did not develop dehiscence. Elevated LDH in drainage fluid may indicate adequate removal of damaged cells and tissues, contributing to better and faster wound healing. Conversely, in patients who developed dehiscence, lower LDH concentration may indicate inadequate metabolic response and the inability of tissue to recover properly after surgical intervention. These findings suggest that LDH may play an important role in the healing process and that its concentration in drainage fluid may be a useful indicator of recovery success. It should be noted that we did not find studies in the available literature directly investigating the concentration of LDH in drainage fluid in the context of anastomotic dehiscence. Therefore, our results may represent a new contribution to understanding this area and indicate the need for further research to better understand the role of LDH and its potential application as a biomarker in assessing the risk of postoperative complications.

This study demonstrates a statistically significant and strong positive correlation between lactate concentration and IgA antibodies in the serum on the fifth postoperative day (r_s=.748, *P*=.003). This result suggests that an increase in lactate levels, which is an indicator of metabolic stress or hypoxia, correlates with an increase in IgA antibody levels, which are part of the immune response to inflammatory and infectious agents. This correlation may indicate that both parameters are responses to postoperative inflammatory or stress conditions. The increase in lactate might stimulate the production of IgA antibodies as part of the immune response to inflammatory stimuli. As we did not find similar studies in the available literature. Our result represents a new insight into the relationship between these parameters in the postoperative period.

In this study, a statistically significant moderate negative correlation was identified between lactate concentration and IgA antibodies in the drain on the third and fifth postoperative days (r_s=-.670, *P*=.012 and r_s=-.577, *P*=.039). These results indicate that an increase in IgA antibody levels correlates with a decrease in lactate levels in the drain fluid. This negative correlation may suggest that elevated levels of IgA antibodies, which play a role in the immune response to inflammatory stimuli, could be associated with improved patient conditions, resulting in reduced lactate levels. Lactate is often an indicator of metabolic stress and hypoxia, so an increase in IgA antibodies might be part of a positive immune response leading to decreased metabolic burden. Since similar studies were not found in the available literature, our result provides a new insight into the dynamics between these parameters in the postoperative period.

Additionally, the study found a statistically significant strong positive correlation between serum IgA antibody levels and IgA antibody levels in the drain on the third, fifth, and seventh postoperative days in patients who developed anastomotic dehiscence. This positive correlation indicates that an increase in IgA antibodies in the serum is accompanied by an increase in the same antibodies in the drain fluid. Given that IgA antibodies are crucial in the local immune response to inflammation and infections, elevated levels of these antibodies may indicate an active immune response in the anastomosis area. This suggests that the immune response, represented by increased IgA levels, could be an important factor in the development of dehiscence, potentially as a reaction to inflammatory processes or infections affecting wound healing. Since we did not find similar studies in the literature exploring this aspect, our results may offer new and significant insights into the relationship between serum and drain IgA antibodies in the context of postoperative complications such as anastomotic dehiscence. A low level of IgA in this context may mean less inflammatory reaction in the abdominal cavity. Excessive inflammation can lead to tissue damage and impaired healing, which increases the risk of dehiscence. Low IgA, in this case, could reflect a reduction in the inflammatory response, which may help preserve the integrity of the anastomosis, especially if the inflammation is controlled by other mechanisms of the immune system.[26]

The study showed statistically significant differences in the concentrations of certain biochemical parameters in drain fluid with respect to the development of general postoperative complications. The concentration of lactate in the drain fluid on the third and fifth postoperative days was significantly higher in patients who did not develop general postoperative complications. This finding suggests that elevated lactate levels might be associated with better stability and a lower inflammatory response in the immediate postoperative period in patients without complications.

Additionally, the concentration of LDH in the drain fluid on the third postoperative day was significantly higher in patients who did not develop general postoperative complications. This finding may indicate more active metabolism and recovery in the early phase of recovery among patients without complications, potentially reflecting better overall health or a more successful healing process. These results are intriguing and may highlight the complex role of these parameters in monitoring and managing postoperative conditions. Since similar studies were not found in the available literature, our results may offer new insights and encourage future research to explore how these biochemical markers could influence the prognosis and management of postoperative complications.

In this study, 38.5% of patients who underwent Hartmann's procedure experienced specific postoperative complications, including dehiscence of the rectal stump that was closed blindly. Similarly, but with a slightly higher complication rate, the study by Hut et al[27] found that 44% of patients who underwent the same procedure developed postoperative complications. These data highlight a significant risk of specific postoperative complications in patients undergoing Hartmann's procedure, and the differences in complication rates may be attributed to varying treatment protocols or patient sample variations.

Rectal diverticulum is a rare condition with an etiology that remains poorly understood.[28] An interesting angiomorphological study from Portugal, involving 80 human cadavers, proposed the hypothesis that the low prevalence of rectal diverticula may be related to the course of the vasa recta.[28] In cases of acute presentation, when conservative treatment fails and there is significant clinical urgency, emergency intervention in the form of rectal resection or Hartmann's procedure is considered.[28] During the observation period of our study, we identified only one case of rectal diverticulum perforation that required emergency surgical intervention via Hartmann's procedure. This indicates the rarity of this complication but also highlights the need for prompt and decisive surgical action in such cases. The patient who required emergency surgery due to perforation of a rectal diverticulum was a 66-year-old woman. Diverticular disease of the colon is a common condition affecting about 50% of individuals over the age of 80.[29] This high prevalence underscores the necessity for careful monitoring and timely response in older patients exhibiting symptoms of this disease, as complications, though rare, may necessitate urgent and serious surgical interventions.

GISTs account for approximately 1% of primary gastrointestinal tract cancers.[30] A study by Kassimi et al28 presented a case of a 79-year-old woman diagnosed with GIST. In our study, we included a 40-year-old woman with the same diagnosis during the observation period. This age difference highlights that GISTs can affect various age groups, which is significant for clinical practice in terms of early recognition and diagnosis of this rare but serious disease.

The strengths of this study include a comprehensive analysis of concentrations of various biochemical parameters in serum and drain fluid, which allows for a deeper understanding of their role in predicting and managing postoperative complications such as anastomotic dehiscence and general postoperative complications. This study is also one of the first to investigate the relationship between lactate and IgA antibody concentrations in both drain fluid and serum, providing new insights into their potential significance as indicators for postoperative monitoring. Additionally, the limited availability of literature specifically addressing certain aspects of this research highlights the need for further investigation to confirm and clarify the obtained results.

The lack of a control group in our study represents a limitation we consciously accepted, taking into account the specific characteristics of the patient population and the nature of postoperative complications associated with enteric anastomoses. The decision not to include a control group was based on several key factors:

First, ethical considerations played a significant role. A control group would have involved patients who were not subjected to surgical intervention, from whom peritoneal fluid would have been collected for comparison with operated patients. Collecting peritoneal fluid from patients who were not undergoing an anastomosis would have constituted an unnecessary invasive procedure without clear clinical benefit for those patients.

In accordance with the ethical principles of medical research, our priority was to minimize risks and discomfort for the patients.

Second, the nature of complications following enteric anastomoses is such that they occur exclusively in operated patients. A control group of non-operated patients would not have provided relevant data for analysis because these patients have no potential to develop the postoperative complications that were the focus of our research, such as anastomotic leakage, peritoneal infection, and other similar complications. Therefore, comparison with a non-operated control group would not have contributed to a deeper understanding of the markers we were investigating, as postoperative changes in serum and peritoneal fluid are directly related to the surgical procedure itself.

Our approach was to closely monitor serial samples of peritoneal fluid and serum in operated patients and thoroughly analyse changes in biological markers before and after the onset of complications. This strategy allowed for longitudinal tracking of each patient as a kind of internal control, which increased the strength of our design and enabled more precise identification of markers associated with complications.

In order to further investigate the relationships between biochemical markers and postoperative complications, future studies should include larger patient samples. This would allow a more detailed analysis and improve the understanding of these relationships.

The concentration of biochemical markers in drain fluid can serve as a valuable indicator for assessing postoperative complications, including anastomotic dehiscence. This research demonstrated significant differences in the concentrations of lactate, albumin, and LDH in drain fluid on the third and fifth days after surgery, in relation to the development of complications. These results suggest that monitoring these markers may aid in the early identification of patients at risk for complications, such as dehiscence. Specifically, significant variations in lactate and LDH concentrations point to potential mechanisms associated with postoperative outcomes.

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