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The role of basic blood parameters in determining the viability of intestinal tissue in incarcerated hernias

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Abstract

Objective: Abdominal hernia repair is a common surgery, with incarcerated hernias accounting for 15% of all cases. In these cases, early diagnosis of intestinal ischaemia and necrosis is crucial to prevent mortality and morbidity. Biomarkers that can predict ischaemic or necrotic status are of vital importance. The aim of this study was to reveal the roles of basic blood parameters in determining ischaemic or necrotic status.

Methods: Patients were divided into three groups. Group I included 24 patients with normal bowels, Group II included 31 patients with intestinal ischaemia without necrosis, and Group III included 10 patients who underwent bowel resection for necrosis. Patients' demographic characteristics and blood parameters were retrospectively analysed.

Results: A total of 65 patients were operated for incarcerated abdominal hernias. There was no significant difference between the groups in terms of age, sex, comorbidity or complications ($P > .05$). Group III had the longest length of hospital stay ($P < .001$). There were significant differences between the groups in terms of serum white blood cell (WBC), neutrophil, lymphocyte (LYM), neutrophil-lymphocyte ratio (NLR), urea, creatinine, total bilirubin, indirect bilirubin, lipase, C-reactive protein (CRP) and lymphocyte-to-C-reactive protein (CRP) ratio (LCR) values ($P < .05$).

Conclusion: Blood parameters combining with clinical symptoms and radiological examination may contribute to predicting intestinal resection. Preoperative WBC, neutrophil, NLR, urea, creatinine and total bilirubin levels can contribute to predict the onset of intestinal ischaemia. Serum creatinine, total bilirubin, indirect bilirubin, phosphorus, lactate dehydrogenase (LDH) and lipase levels can contribute to deciding on bowel resection.

1 | INTRODUCTION

Anterior abdominal wall hernias are caused by congenital or acquired weakness of the muscular tissue and fascia that cover the abdominal cavity. The primary symptom is often the swelling of the herniated area of the anterior abdominal wall that spontaneously reduces. If this swelling does not reduce spontaneously or manually, it is called an incarcerated hernia. The primary symptoms of incarceration include pain, nausea and vomiting. Ischaemia occurs in cases where the blood supply to the incarcerated tissue is restricted, eventually progressing to necrosis. This leads to an urgent requirement for surgery, even sometimes tissue or organ resection.[1,2]

Despite all their advances in terms of preoperative care, antisepsis, antibiotics, fluid replacement and anaesthesia, the morbidity and mortality rates of emergency operations for incarcerated abdominal wall hernias remain high.[3,4]

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For strangulated hernias, early diagnosis of intestinal ischaemia and necrosis and timing and planning of operation are the key to reduce mortality and morbidity.[5] Numerous studies have investigated a number of new techniques and haematological and biochemical indicators for early diagnosis.[1,2,5,6] However, there is yet to be a standard marker with a high diagnostic value to determine the degree of intestinal ischaemia. Studies in the relevant literature have mostly divided incarcerated hernia patients into groups with and without resection.[1,5-9] However, patients with partially deteriorating intestinal viability and restored by techniques such as hot application during reduction surgery constitute a critical group, making up a significant proportion of incarcerated hernias. Nevertheless, they have not been addressed as a separate group. Furthermore, studies have not excluded patients with factors that affect blood parameters but included all herniated tissues. The presence of intestinal tissue remains the main determinant of mortality and morbidity.[1,6,7,10] Here, patient selection and grouping were carried out carefully, only examining patients with herniated intestinal tissue.

The aim of the present study was to reveal the roles of blood parameters that are easily accessible even in primary health care institutions in determining the viability of intestinal tissue in incarcerated hernias.

What's known

- Abdominal wall hernias are among the most common surgical operations. 5%-15% of these cases present to the emergency room with incarcerated hernias.
- Mortality and morbidity rates increase in herniated tissues, particularly in intestinal tissue.
- It is difficult to predict clinically strangulated incarcerated hernias upon admittance to the emergency department.
- There is still no standard marker that shows ischaemia or necrosis in herniated tissues.

What's new

- WBC, neutrophil, NLR, urea, creatinine and total bilirubin values can contribute to predict the deterioration of intestinal viability.
- Creatinine, total bilirubin, indirect bilirubin, phosphorus, LDH and lipase can be useful for deciding on the requirement for bowel resection.

2 | MATERIALS AND METHODS

The approval for the study was obtained from the Ethics Committee of Erzurum Training and Research Hospital (No. 2020/19-188). Patients who underwent surgery for incarcerated abdominal hernias at the general surgery unit of Mus State Hospital between 1 January 2016 and 1 December 2020 were retrospectively analysed. The study included patients who had bowel loops with herniated tissue. Patients with herniated tissues not related to the intestines and those with unavailable data were excluded from the study. Moreover, patients with a known haematological disease, allergic disease, malignant or inflammatory disease, or receiving drugs that may affect laboratory parameters were also excluded.[11]

The data were collected from the patients' files and the hospital's electronic software system. Patients' demographic characteristics, type of hernia, comorbidities, type of surgery (laparoscopic, open), length of hospital stay and complications were recorded. Postoperative complications were compared between the groups using the Clavien–Dindo classification (CDC).[12] Furthermore, preoperative hemogram, biochemistry, and blood gas values were examined (white blood cell (WBC), neutrophil, neutrophil-to-lymphocyte ratio (NLR), lymphocyte (LYM), HTC, MCV, MCH, MCHC, RDW, platelet, PLR, MPV, PDW, AST, ALT, albumin, ALP, lactate dehydrogenase (LDH), amylase, urea, creatinine, creatinine kinase, phosphorus, lactate, d-dimer, C-reactive protein (CRP), LCR). Markers with statistically significant results and a high diagnostic value (high AUC (Area under the curve) value, high sensitivity and specificity) were discussed. Though there was a significant difference between the groups in terms of CRP and LCR values, these were not addressed because of their low AUC values. CRP values of only 53 patients were reached, which may have contributed to the decrease in the diagnostic value of CRP. Patients were divided into three groups based on the viability and severity of their herniated bowel loops. Group I consisted of patients with herniated bowel loops and without impaired blood supply or obstruction. Group II included patients with deteriorated blood supply to the bowel loop but restored by hot application. Finally, Group III consisted of patients with irreversible deterioration of the herniated bowel loop who underwent resection. The status of the necrotic bowel was pathologically confirmed.

2.1 | Statistical analysis

Descriptive data were expressed as mean and standard deviation for numerical variables and as numbers and percentages for categorical variables. The normality distribution of the data was examined with the skewness test. Moreover, histogram charts were used to support whether the distribution was normal or not. In addition, considering the homogeneity of variances, the posthoc tests of one-way analysis of variance (ANOVA), Kruskal–Wallis test and Tamhane test were used for data analysis. A one-way ANOVA test was used because the variables of WBC and neutrophil showed a normal distribution. The Kruskal–Wallis test was used because the NLR, urea, creatinine, total bilirubin, indirect bilirubin, lipase, CRP and LCR values were non-normally distributed. Tamhane test was used for variables that did not follow a normal distribution in the posthoc analysis. Receiver operating characteristic (ROC) curves were created to measure the ability of laboratory values to distinguish between resection status and intestinal viability in abdominal hernias. While performing

ROC analysis, markers with high AUC values were selected first. Specificity, sensitivity and cut-off values were determined according to the highest LR+ values of these data. ROC analyses were carried out both for patients who underwent bowel resection and did not undergo bowel resection (Table 2, Figure 2). Additionally, separate ROC analyses were performed for those with complete intestinal viability and deteriorated intestinal viability (Table 3, Figure 3). A *P*-value of <.05 was considered statistically significant. All statistical analyses were carried out using SPSS version 23.0 software.

3 | RESULTS

During the study period of 5 years, 112 consecutive patients were operated for incarcerated abdominal hernias. Within the scope of this study, 47 patients (41.9%) were excluded, with 25 because of herniated tissues not related to the intestines, 14 because of unavailable data such as blood parameters and 8 because of comorbidities that could affect blood parameters (three because of comorbid chronic disease, two because of malignant disease, one because of haematological disease, one because of acute pancreatitis and one because of cellulitis). After the exclusion of these patients, Group I included 24 patients (36.92%), Group II included 31 (47.69%) patients and Group III included 10 (15.38%) patients, with the final sample consisting of a total of 65 patients, 38 males and 27 females. The mean age of the patients was 55.83 ± 18.84 (range, 21-97) years. Seventeen patients (26.2%) had comorbid diseases. The mean length of hospital stay was 4.86 ± 3.11 (range, 1-20) days. The patients' demographic and clinical characteristics are presented in Table 1.

Group III had the longest mean length of stay (9.4 ± 4.24 days), which was significantly different among the groups ($P < .001$) (Table 1).

Although none of the patients died, postoperative complications were observed in 13 patients (20%) (ileus in two patients, scrotal oedema in two patients, wound haematoma and discharge in nine patients). According to the CDC, seven patients were classified as Grade 1, five patients as Grade 2 and one patient as Grade 3. Grade 1 complications (Table 1). Grade 1 complications were followed up without any treatment, while grade 2 complications were treated medically. One patient who developed Grade 3 complications was treated with a nasogastric tube and rectal tube.

There was no significant difference between the groups in terms of age, sex, comorbidity or complications ($P > .05$).

The hernia types were inguinal in 37 patients, femoral in 10 patients, incisional in 8 patients, umbilical in 6 patients, Spigelian in 2 patients and epigastric in 2 patients (Figure 1). Of the patients who underwent bowel resection, 5 had inguinal hernias (50%), 2 had umbilical hernias, 2 had incisional hernias and 1 had a femoral hernia. Three patients were laparoscopically operated, while 62 patients underwent open surgery.

All numerical data were analysed for their distribution according to ischaemic and resection status. There were significant differences between the groups in terms of WBC, neutrophil, NLR, urea, creatinine, total bilirubin, indirect bilirubin, lipase, CRP and LCR values ($P < .05$). Although not significantly different between the groups, phosphorus and LDH levels were found to have a high diagnostic value ($P > .05$).

ROC curves were created to examine the discriminatory power of laboratory parameters between intestinal viability and resection status. AUC and cut-off values were determined for some parameters and their sensitivity, specificity and LR+ cut-off points were calculated. Group I and Group II + III were compared by intestinal viability. Moreover, Group III and Group I + II were compared by bowel resection status (Figures 2 and 3 and Tables 2 and 3).

Creatinine, total bilirubin, indirect bilirubin, phosphorus, LDH and lipase were found to be the biomarkers to decide on the requirement of bowel resection (Table 2, Figure 2). WBC, neutrophil, NLR, urea, creatinine and total bilirubin values were found to be the biomarkers to predict the deterioration of intestinal viability (Table 3, Figure 3).

4 | DISCUSSION

Abdominal wall hernia repair is a widely performed surgical operation worldwide. Of these cases, 5%-15% present to the emergency

TABLE 1 Comparison of demographic and clinical features of the patients

		Group I	Group II	Group III	*P* value
Sex	Male	13	21	4	**.261**
	Female	11	10	6	
Age		50.83 ± 16.87	57.84 ± 19.644	61.60 ± 19.83	**.228**
Concomitant disease	Present	4	8	5	**.001**
	Absent	20	23	5	
Length of stay		3.29 ± 1.33	4.61 ± 2.24	9.4 ± 4.24	**.001**
Complications	Grade 1	3	4	0	**.688**
Clavien-Dindo	Grade 2	2	2	1	
Calcification	Grade 3	0	0	1	

Concomitant disease and Length of stay p values will be bold, their p values 0.01.

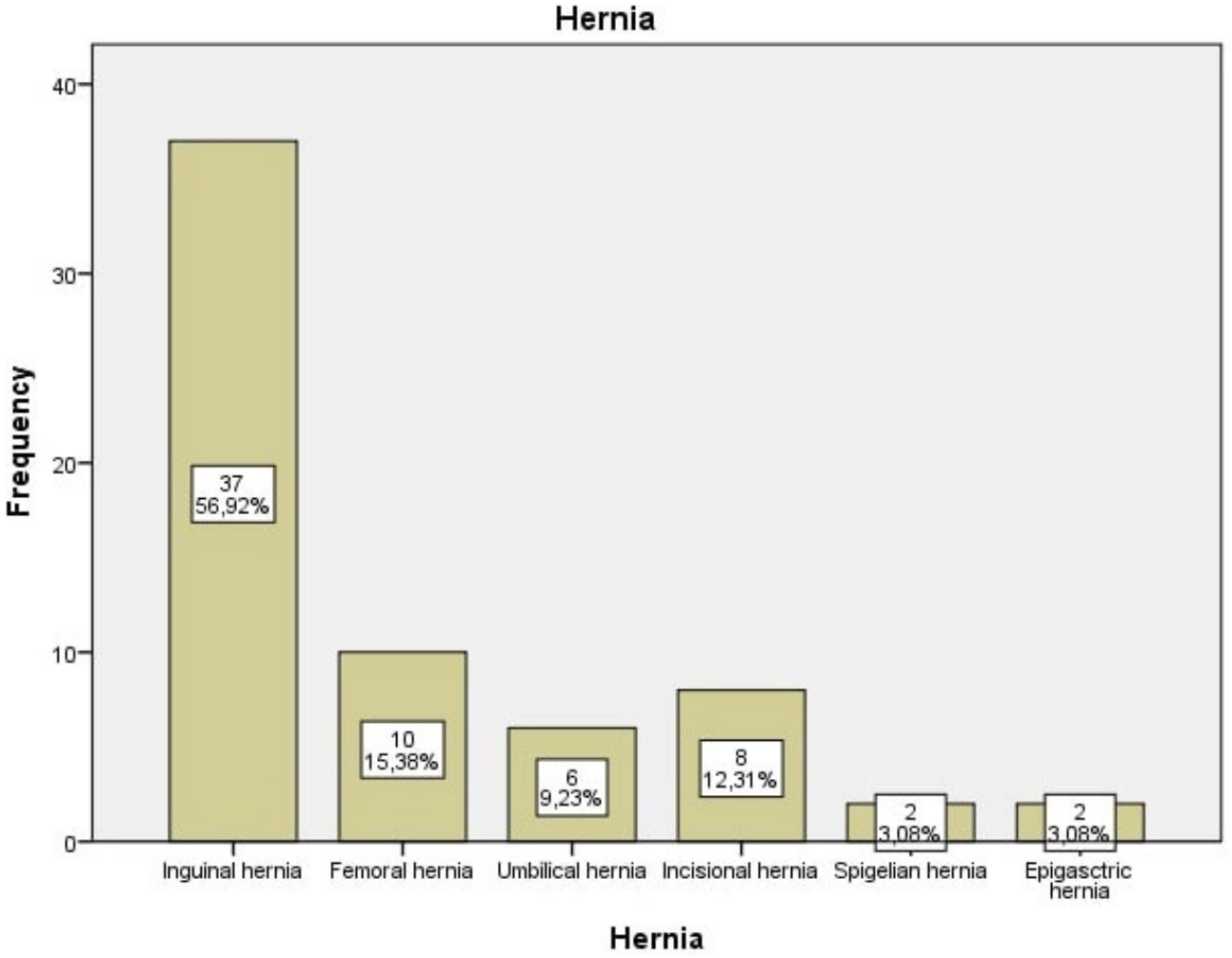

FIGURE 1 Hernia types

TABLE 2 ROC curve results and sensitivity, specificity and likelihood ratio (+) values of incarcerated hernia patients with and without bowel resection (Group I + II, Group III)

Parameters	Cutt-off value	AUC (*P*)	Sensitivity (%)	Specificity (%)	LR+
Creatinine (mg/dL)	0.98	0.702 (<.122)	60	82	3.3
Total bilirubin (mg/dL)	0.69	0.755 (<.050)	70	77	2.97
Indirect bilirubin (mg/dL)	0.46	0.809 (.018)	70	83	4.11
Phosphorus (mg/dL)	4.15	0.804 (.020)	71	69	2.25
Lactate dehydrogenase (U/L)	256	0.632 (.313)	71	77	3.1
Lipase (U/L)	26.5	0.766 (.041)	71	82	3.97

room with incarcerated hernias.[1,4] The most common types of incarcerated hernia are inguinal (40.3%-55.8%), umbilical (20.9%-21.1%), incisional (14.7%-19.4%) and femoral (8.4%-19.4%).[3,6] Some studies have found incarcerated hernias to be more common in men,[1,3,8,13,14] while others have found them to be more common in women.[1] Despite the relatively higher frequency of femoral hernias in our study, we also observed inguinal, femoral, incisional and umbilical hernias in descending order, similar to the literature. The ratio of male patients was higher in our study.

Incarceration of hernias often requires an emergency operation. It is difficult to predict clinically strangulated incarcerated hernias during the presentation to the emergency department. Bacterial materials that are released from ischaemic intestinal walls because of strangulation result in an inflammatory response, which can be measured in peripheral blood. A prolonged response can lead to sepsis, septic shock or even death.[8,9] Anticipating these complications and planning surgery are of vital importance. Hence, any marker or technique that might reveal undesired situations beforehand is of great clinical importance.

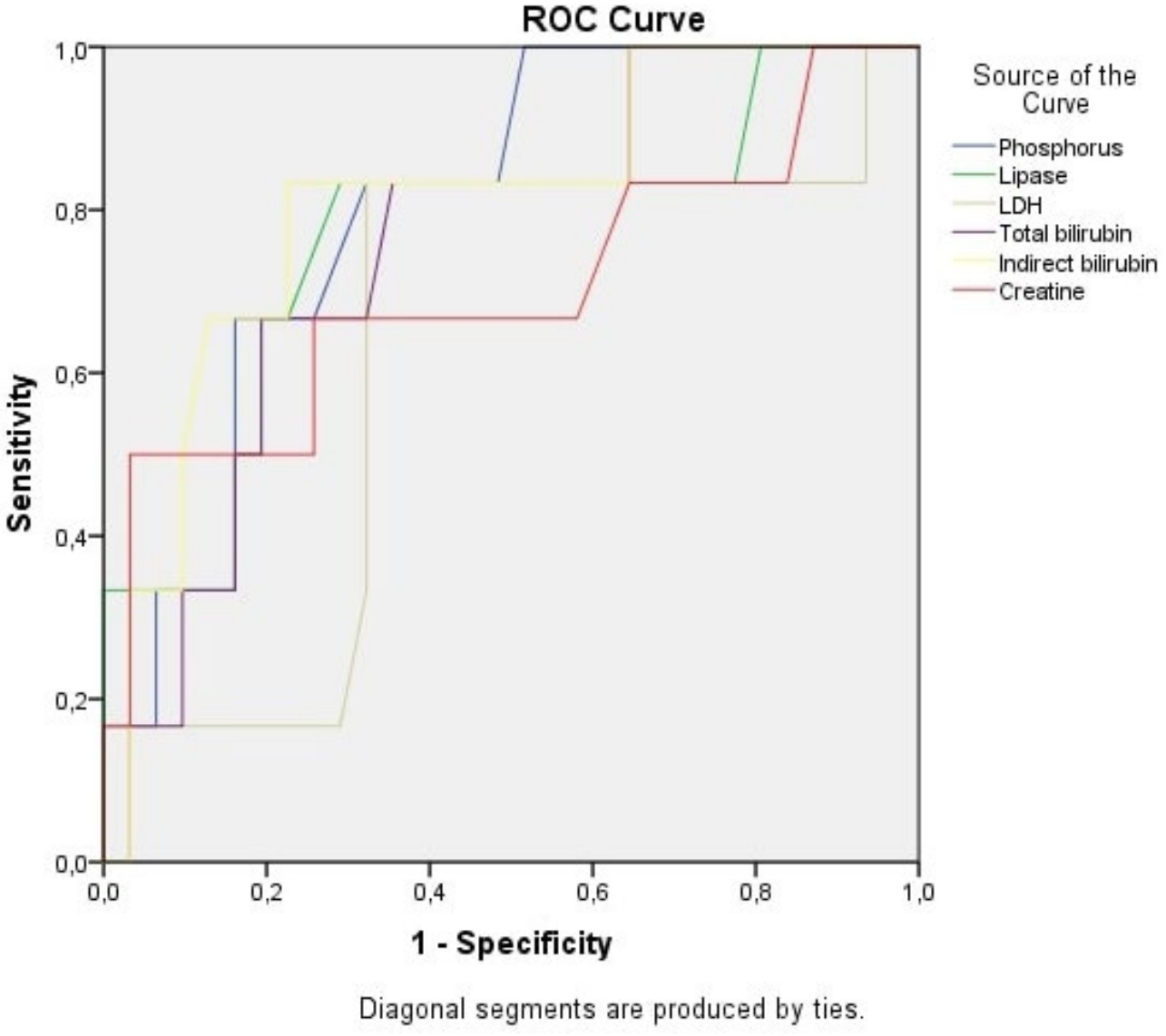

FIGURE 2 ROC curve results of phosphorus, lipase, LDH, indirect and total bilirubin, creatine levels of patients with and without bowel resection

TABLE 3 ROC curve results and sensitivity, specificity and likelihood ratio (+) values of incarcerated hernia patients with complete intestinal viability and deteriorated intestinal viability (Group I and Group II + III)

Parameters	Cut-off value	AUC (*P*)	Sensitivity (%)	Specificity (%)	LR+
WBC ($\times 10^3/mm^3$)	10.75	0.756 (.001)	65	75	2.63
Neutrophil ($\times 10^3/mm^3$)	6.18	0.778 (<.001)	82	63	2.21
NLR	2.68	0.815 (<.001)	87	54	1.23
Urea (mg/dL)	40.50	0.831 (<.001)	56	96	12.9
Creatinine (mg/dL)	0.83	0.740 (.002)	56	92	6.73
Total bilirubin (mg/dL)	0.60	0.710 (.007)	59	82	3.24

Abbreviations: +LR, Positive likelihood ratio; AUC, Area under the curve; NLR, Neutrophil-lymphocyte ratio; WBC, White blood cell.

Recent studies have focused on diagnostic markers that can predict intestinal ischaemia or necrosis. Complete blood count (CBC), D-dimer and blood gas analysis are among the classic laboratory tests used in cases of suspected intestinal ischaemia. However, especially in recent years, these biomarkers have increased in variety. WBC, neutrophil, lymphocyte, NLR, thrombocyte, PLR, PDW, MPV, RDW, CRP, albumin, C-reactive protein-to-albumin ratio (CAR) and LCR are some of the markers with a diagnostic value.[1,8,16] One of the

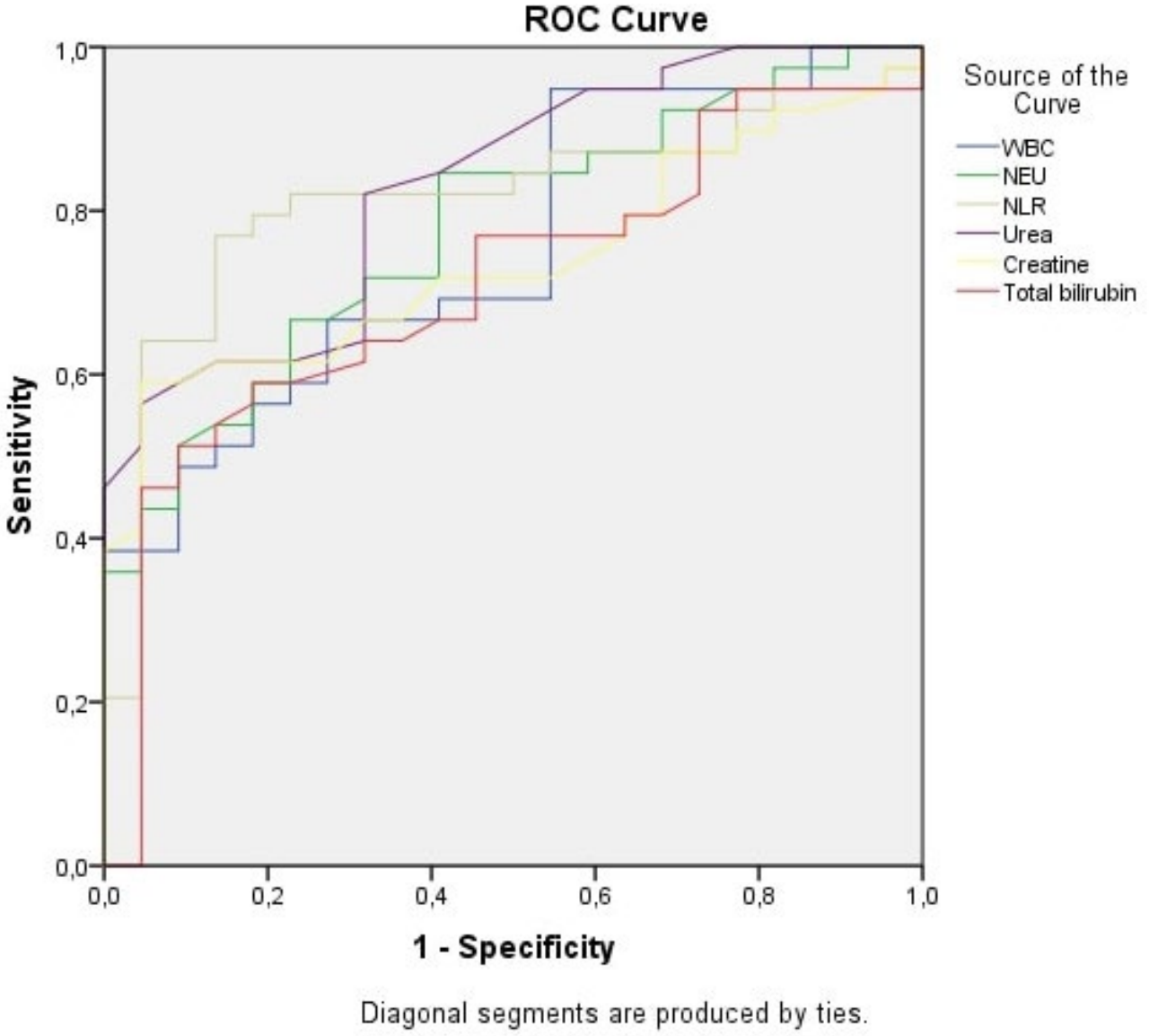

FIGURE 3 ROC curve of WBC, NEU, NLR, urea, creatine, total bilirubin levels of patients with complete intestinal viability and deteriorated intestinal viability

important limitations of these studies is that patients with diseases that may affect blood values were not excluded. Serum blood levels are affected by diseases such as malignant or inflammatory diseases, the current course of chemotherapy or radiotherapy, pregnancy, known haematological diseases, more than one comorbid disease, and the use of drugs.[11,17] In line with the objective of our study, patients with such diseases were excluded from the study. Although comorbid diseases were more common in Group II and Group III in our study, there was no statistically significant difference between the groups. These comorbid diseases do not affect blood values or affect them minimally. Patients with more than one comorbid disease were excluded from the study. There are a limited number of studies excluding diseases that may affect blood values. About 7.1% of patients were excluded from the present study for these reasons. This study is also important in this respect. There is a need for more comprehensive studies considering these criteria.

For incarcerated hernias, WBC, neutrophil and NLR are mostly used as haematological inflammatory markers.[8,18] Leukocyte count increases in proportion to the severity of ischaemia. It has been found to be significantly higher in incarcerated hernia patients undergoing resection.[9,19] Neutrophil count increases during inflammation and relatively leads to lymphopenia. Thus, the NLR increases. In cases of acute appendicitis, acute pancreatitis and mesenteric ischaemia, these markers have been used for the early prediction of inflammation. Studies on abdominal hernias have shown NLR as a biomarker to determine resection. In addition, NLR has been observed to have better diagnostic efficiency than WBC and neutrophil.[8,18-20]

In this study, contrary to the literature, WBC, neutrophil and NLR values were not found to be biomarkers with high diagnostic efficacy for deciding on bowel resection, although they had a high diagnostic value for the deterioration of intestinal viability. Moreover, NLR had higher AUC and sensitivity values than other

CBC sub-parameters (cut-off value: 2.68, AUC: 0.815, Sensitivity: 87%).

Serum lactate dehydrogenase levels help predict intestinal gangrene.[2] Sahin et al[6] showed that LDH levels could be used as a marker for determining the requirement for bowel resection. We found serum LDH levels to be a biomarker with acceptable diagnostic efficiency for deciding on bowel resection.

Studies on acute mesenteric ischaemia have shown that phosphorus joins the circulation because of ischaemic damage to the intestinal tissue, decreasing renal phosphorus excretion and hepatic clearance of phosphorus. Therefore, blood levels of phosphorus increase within hours because of intestinal ischaemia.[21] To the best of our knowledge, phosphorus levels have not yet been studied in incarcerated hernias. In this study, blood levels of phosphorus were found to be significant for deciding on bowel resection.

We could not find any studies on the diagnostic value of urea, creatinine or lipase levels in incarcerated hernias. However, studies on mesenteric ischaemia have shown that intestinal ischaemia leads to impaired renal functions and increased urea and creatinine levels.[22,23] In the present study, serum creatinine was found to be a biomarker for the deterioration of intestinal viability and for deciding on resection. Urea was found to have the highest AUC and specificity values, despite having a low sensitivity for the deterioration of intestinal viability (cut-off value: 40.5 mg/dL, AUC: 0.831, sensitivity: 56%, specificity: 96%, LR+: 12.9). Studies on ischaemia have shown an increase in amylase levels but no increase in lipase levels.[22,24] Our result regarding the significance of lipase levels as a marker for deciding on bowel resection is the first in the literature.

The number of studies on the link between bilirubin levels and intestinal ischaemia is limited; however, bilirubin levels have been shown to increase in inflammatory diseases.[25] In systemic infection cases, certain bacteria, especially *E. coli*, cause haemolysis and endotoxemia. In endotoxemia, hepatic uptake decreases and leads to the canalicular excretion of bilirubin, increasing blood bilirubin levels.[26] Incarceration is an inflammatory process. Depending on the severity of ischaemia, bacterial translocation can occur, ultimately leading to hyperbilirubinaemia. The present study demonstrated that the severity of ischaemia increased in parallel with indirect and total bilirubin levels, suggesting their high diagnostic value. In addition, indirect bilirubin appeared to have the highest diagnostic value for determining the requirement for bowel resection (cut-off value: 0.46 mg/dL, AUC: 0.809, sensitivity: 70%, specificity: 83%, LR+: 4.11).

Although the correlation between total bilirubin and creatinine levels and intestinal ischaemia remains unclear, according to our results, they drew attention as markers for demonstrating the onset of ischaemia and deciding on bowel resection. Large-scale studies particularly on these markers can shed light on the subject.

To the best of our knowledge, the present study is the first to demonstrate the diagnostic values of total bilirubin, indirect bilirubin, urea, creatinine and lipase levels in incarcerated hernias. These biomarkers can be defined as new diagnostic markers.

Studies have reported bowel resection rates ranging from 23.9% to 25% in incarcerated hernias.[6,8] The resection rates are particularly high in incarcerated femoral hernias (30.8%-46.4%),[9] with a rate of 15% in incarcerated inguinal hernias.[4] However, the highest resection rate was observed in patients with inguinal hernias since the incidence of inguinal hernias is higher.

Bowel resection was performed on 15.38% of our patients. Nearly 50% of resected hernias lead to inguinal hernias, with a resection rate of 13.5%. The distribution of resected hernias in the present study is similar to that reported in the literature, although the rates for all hernias remain below the average in the literature. This can be explained by the fact that patients with complications or a high risk of bowel resection are referred to more advanced centres.

Female sex and advanced age (over 65 years) have been determined to be risk factors for small bowel resection.[9,27,28] In the present study, age was not determined to be a factor for resection and/or demonstrating intestinal viability, and patients who underwent resection were dominantly females, which supports the data in the literature.

Patients undergoing bowel resection have a longer length of hospital stay, postoperative complication rates (6%-47%), and mortality rates (1%-7%).[9,29-31]

In our sample, Group III had the highest complication rate, while Group I had the lowest complication rate (20%). Although the complication rate minimally increased as the severity of intestinal ischaemia increased, no significant difference was found between the groups. None of our patients died. Considering the literature, our complication rate is higher than those of some studies. However, in a general manner, our complication rate is lower. This might be associated with several factors. Since our hospital is a secondary healthcare institution, patients with multiple comorbidities, advanced age and complications are referred to tertiary hospitals. Furthermore, patients with any disease that could affect blood parameters were excluded from the study.

Our study has certain strengths and limitations. The strengths of the study are the exclusion of patients with possibly affected blood parameters, the inclusion of intestinal hernia patients and dividing our sample into three groups based on disease severity. Another strength is the identification of some biomarkers with high diagnostic value, which were not investigated in other studies. The major limitation of our study was its retrospective design. Accordingly, some patients with unavailable data had to be excluded. The relatively low number of patients and the single-centre nature of the study are some other limitations. The reason for the low number of patients can be explained by the exclusion of 42% of the study population within the scope of the study.

5 | CONCLUSION

Identification of intestinal viability and determination of the timing of surgery is crucial for patients who are clinically and radiologically

diagnosed with incarcerated hernias. Although laboratory parameters are not accepted specific markers for deciding intestinal viability, combining with clinical symptoms and radiological examination may contribute to predict intestinal resection in the preoperative period. Preoperative WBC, neutrophil, NLR, urea, creatinine and total bilirubin values can help predict the deterioration of intestinal viability. Furthermore, creatinine, total bilirubin, indirect bilirubin, phosphorus, LDH and lipase can be useful for deciding on the requirement for bowel resection. There is still a need for further prospective studies with larger samples and good patient selection.

DISCLOSURES

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. In order for us to share patient data with you, we need permission from the hospital.

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