

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

**Objective:** Abdominal hernia repair is a common surgery, with 15% of patients presenting as incarcerated hernias. In these cases, early diagnosis of intestinal ischemia and necrosis is crucial for mortality and morbidity. Biomarkers that can predict ischemia or necrosis status are vital. In this study, we aimed to reveal the roles of basic blood parameters in determining ischemia or necrosis status.

**Methods:** The patients were divided into three groups as normal bowels (Group I: 24 patients), intestinal ischemia without necrosis (Group II: 31 patients), and Group III who underwent bowel resection because of necrosis (10 patients). Patients' demographic characteristics and blood parameters were retrospectively analyzed.

**Results:** 65 patients operated for incarcerated abdominal hernias. There was no significant difference between the groups in terms of age, sex, comorbidity, or complications ( $p>0.05$ ).

The highest length of stay was observed in Group III ( $p<0.001$ ). 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 CRP/LYM levels ( $p<0.05$ ).

**Conclusion:** Preoperative WBC, neutrophil, NLR, urea, creatinine, and total bilirubin levels can be used to predict the onset of intestinal ischemia. Serum creatinine, total bilirubin, indirect bilirubin, phosphorus, lactate dehydrogenase (LDH), and lipase levels can be used for bowel resection.

**Key Words:** Abdominal wall hernia, incarceration, bowel resection, biomarker

## **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 ischemia or necrosis in herniated tissues.

## **WHAT'S NEW?**

\*WBC, neutrophil, NLR, urea, creatinine, and total bilirubin values can be used as biomarkers to predict the deterioration of intestinal viability.

\*Creatinine, total bilirubin, indirect bilirubin, phosphorus, LDH, and lipase can be used as biomarkers to decide on the necessity of bowel resection.

## **INTRODUCTION**

Anterior abdominal wall hernias are caused by congenital or acquired weakening of the muscular tissue and fascia that cover the abdominal cavity. The most important symptom is often the swelling of the herniated area on the anterior abdominal wall, with spontaneous reduction. If not reduced spontaneously or manually, this swelling is called an incarcerated hernia. The main symptoms of incarceration are pain, nausea, and vomiting. Ischemia occurs

when blood flow to the incarcerated tissue is restricted, eventually progressing to necrosis. This leads to an urgent need for surgery, sometimes even requiring tissue or organ resection.<sup>1,2</sup>

Despite all the advances in preoperative care, antisepsis, antibiotics, fluid replacement, and anesthesia, morbidity and mortality rates of emergency operations for incarcerated abdominal wall hernias remain high.<sup>3,4</sup>

For strangulated hernias, early diagnosis of intestinal ischemia and necrosis and operation timing and planning are key for reducing mortality and morbidity.<sup>5</sup> A number of new methods and hematological and biochemical indicators for early diagnosis have been researched in many studies.<sup>6-8</sup> Although, there is yet to be a standard marker with high diagnostic value to determine the degree of intestinal ischemia. Studies in the relevant literature have mostly divided incarcerated hernia patients into groups with and without resection. However, cases whose intestinal viability partially deteriorates and is brought back to normal by methods like hot application during reduction surgery constitute a critical group, making up a significant portion of incarcerated hernias. Yet, they have not been handled as a separate group. Also, patients with factors that affect blood parameters have not been excluded and all herniated tissues have been included. The presence of intestinal tissue remains the main determinant of mortality and morbidity.<sup>1,6,9,10</sup> Here, patient selection and grouping were carried out carefully, only examining patients with herniated intestinal tissue.

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

## **MATERIALS AND METHODS**

Approval was obtained from the Ethics Committee of Erzurum Training and Research Hospital (No. 2020/19-188). Patients undergoing surgery for incarcerated abdominal hernias

at the general surgery unit of Muş state hospital between January 1st, 2016 and December 1st, 2020 were retrospectively analyzed. Patients who had bowel loops with herniated tissue were included. Patients with herniated tissues not related to the intestines, those with diseases that affect blood levels, and those with unavailable data were excluded. Patient data were analyzed by the hospital's electronic software system. Patients' demographic characteristics, type of hernia, comorbidities, type of surgery (laparoscopic, open), length of stay, and complications were recorded. Besides, preoperative hemogram, biochemistry, and blood gas values were examined (White blood cell (WBC), neutrophil, neutrophil-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), LYM/CRP). Markers with statistical significance and high diagnostic value were included. Though there was a significant difference between the groups in terms of CRP and LYM/CRP levels, these were not discussed due to their low diagnostic values. The 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 consisted of patients in whom the blood supply of the bowel loop began to deteriorate but it was recovered by hot application. Finally, group III consisted of patients undergoing resection, with irreversible deterioration of the herniated bowel loop. The state of the necrotic bowel was confirmed pathologically.

### **Statistical Analysis**

Descriptive data were expressed as mean and standard deviation for the numerical variables and as number and percentages for the categorical variables. The distribution of the data was examined with Skewness test and histogram graphics. In addition, by looking at the homogeneity of variances, One Way Anova, Kruskal Wallis test and Tamhane test from Post-

Hoc tests were used to data analysis. Receiver operating characteristic (ROC) curves were created to measure the ability of laboratory values to distinguish of resection status and intestinal viability in abdominal hernias. The area under curve (AUC) and cut-off value of each measurement were determined. Specificity, Sensitivity and positive likely-hood ratio (LR+) cut-off values were calculated and evaluated together. A p value of  $<0.05$  was considered statistically significant. Statistical analysis was performed using SPSS version 23.0 software.

## RESULTS

During a five-year period, 112 patients were operated for incarcerated abdominal hernias. Within the aims of this research, 47 patients (41.9%) were excluded: 25 cases with herniated tissues not related to the intestines, 14 with unavailable data like blood parameters, and 8 with comorbidities that affected blood parameters. After the excluded patients, group I had 24 cases (36.92%), Group II had 31 (47.69%), Group III had 10 (15.38%). The final sample consisted of 65 patients, 38 males and 27 females. The patients had a mean age of  $55.83 \pm 18.84$  (21-97) years. Comorbid diseases were present in 17 (26.2%) cases. 4 patients in group I, 8 patients in group II, and 5 patients in group III have co-morbid disease. (5 patients with hypertension, 4 patients with controlled diabetes mellitus, 3 patients with cerebrovascular disease, 2 patients with dysrhythmia, 1 patient with osteoporosis, 1 patient with dementia, and 1 patient with depression). Mean length of hospital stay was  $4.86 \pm 3.11$  (1-20) days. The patients' demographic and clinical characteristics are shown in Table 1.

There was no significant difference between the groups in terms of age, sex, comorbidity, or complications ( $p > 0.05$ ). Mean length of stay was the highest in group III ( $9.4 \pm 4.24$  days), significantly different among the groups ( $p < 0.001$ ) (Table 1).

Types of hernias were inguinal in 37 cases, femoral in 10, incisional in 8, umbilical in 6, spigelian in 2, and epigastric in 2 (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 femoral hernia. 3 patients were operated laparoscopically, while 62 underwent open surgery. Postoperative complications were observed in 13 patients (20%) (ileus in 2, scrotal edema in 2, wound hematoma and discharge in 9), although with no mortality (Table 1).

All numerical data were analyzed for their distribution according to ischemia 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 CRP/LYM levels. Although not significantly different between the groups, phosphorus and LDH levels were found to have high diagnostic value.

ROC curves were created for the discrimination of laboratory parameters between intestine 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 (Figure. 2, 3 and Table 2, 3).

## **DISCUSSION**

Repairing abdominal wall hernias is a very common surgical operation worldwide. 5-15% of these cases present to the emergency room with incarcerated hernias.<sup>1,4</sup> The most common incarcerated hernias are inguinal (40.3-55.8%), umbilical (20.9-21.1%), incisional (14.7-19.4%), and femoral (8.4-19.4%) (3,6). Incarcerated hernias have been found to be more common in men in some studies,<sup>3,11-13</sup> while they were found to be more common in women in others.<sup>1</sup> In our study, although femoral hernias were relatively more frequent, both inguinal, femoral, incisional, and umbilical hernias were observed, in a descending order, similar to the literature. Our rate of male patients was higher.

The incarceration of hernias often requires emergency operation. It is difficult to predict clinically strangulated incarcerated hernias upon admittance to the emergency department. Bacterial materials that are released from ischemic intestinal walls due to strangulation result in an inflammatory response that can be measured in peripheral blood. Prolonged response can lead to sepsis, septic shock, or even death.<sup>13,14</sup> Anticipating these complications and planning surgery are vital. Hence, any markers or methods that might reveal undesired situations beforehand are of great clinical importance.

Recent research has focused on diagnostic markers that can predict intestinal ischemia or necrosis. Complete blood count (CBC), D-DIMER, and blood gas analysis are among classic laboratory tests when intestinal ischemia is suspected.<sup>15</sup> However, particularly in recent years, these biomarkers have increased in variety. WBC, neutrophil, lymphocyte, NLR, thrombocyte, PLR, PDW, MPV, RDW, CRP, albumin, CRP/albumin, and lymphocyte/CRP are some of the markers with diagnostic value.<sup>1,13,16</sup> One of the important deficiencies in these studies is that patients with diseases in which blood values are affected were not excluded from the study. Serum blood levels affected by diseases such as malignant or inflammatory disease, current course of chemotherapy or radiotherapy, pregnancy, known hematological disease, more than one comorbid disease, and receiving drugs.<sup>17,18</sup> In accordance with the purpose 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 co-morbid diseases do not affect blood values or affect them minimally. Patients with more than one co-morbid disease were excluded from the study. There are a limited number of studies excluding diseases in which blood values are affected. About 7.1% of patients were excluded from the present study. This study is also important in this aspect. There is a need for more comprehensive studies considering these criteria.

For incarcerated hernias, WBC, neutrophil, and NLR are mostly used as hematological inflammatory markers.<sup>13,19</sup> Leukocyte count increases in proportion to the severity of ischemia. It is significantly higher in incarcerated hernias undergoing resection.<sup>14,20</sup> Neutrophil count increases during inflammation and relatively leads to lymphopenia. Thus, the neutrophil-lymphocyte ratio increases. For acute appendicitis, acute pancreatitis, and mesenteric ischemia cases, these markers have been used for early prediction of inflammation. Studies on abdominal hernias has shown NLR as a biomarker to determine resection. Again, NLR is observed to have a better diagnostic efficiency than WBC and neutrophil.<sup>13,19-21</sup>

Here, contrary to the literature, WBC, neutrophil, and NLR levels were not observed as biomarkers with high diagnostic efficacy for deciding on bowel resection, although they had high diagnostic value for the deterioration of intestinal viability. Again, NLR has higher AUC and sensitivity values than the other CBC sub-parameters (cut off value: 2.68, AUC: 0,815, Sensitivity: 87%).

Serum lactate dehydrogenase levels help in the prediction of intestinal gangrene.<sup>2</sup> Şahin et al.<sup>6</sup> showed that LDH levels can be used as a marker for bowel resection. We found serum LDH levels to be a biomarker with acceptable diagnostic efficiency for deciding on bowel resection.

Research on acute mesenteric ischemia has shown that "phosphorus" joins the circulation due to ischemic damage to the intestinal tissue, decreasing phosphorus excretion in the kidney and the hepatic clearance of phosphorus. Therefore, blood phosphorus levels increase within hours due to intestinal ischemia.<sup>22</sup> To the best of our knowledge, "phosphorus" levels in incarcerated hernias have not been studied yet. In the current study, "phosphorus" levels in blood 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, research on mesenteric ischemia shows that intestinal ischemia leads to impaired renal functions and increased urea and creatinine levels.<sup>23,24</sup> 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, although with low sensitivity for the deterioration of intestinal viability (cut off value: 40.5mg/dl, AUC: 0,831, Sensitivity: 56%, Specificity:96%, LR+:12.9). Research on ischemia has shown an increase in amylase levels, but no increase in lipase levels.<sup>23,25</sup> Our finding regarding the significance of lipase levels as a marker for deciding on bowel resection is a first in the literature.

Research on the link between bilirubin levels and intestinal ischemia is scarce, though bilirubin levels have been shown to increase in inflammatory diseases.<sup>26</sup> In systemic infection cases, certain bacteria, E. coli in particular, cause hemolysis and endotoxemia. In endotoxemia, hepatic uptake decreases and leads to the canalicular excretion of bilirubin, increasing blood bilirubin levels.<sup>27</sup> Incarceration is an inflammatory process. Depending on the degree of ischemia, bacterial translocation can occur, ultimately leading to hyperbilirubinemia. Here, we observed that the degree of ischemia increased in parallel with indirect and total bilirubin levels, suggesting their high diagnostic value. Again, indirect bilirubin seems to have the highest diagnostic value for determining 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 ischemia remains unclear, according to our findings, they draw attention as markers for showing the onset of ischemia and for deciding on bowel resection. Large-scale research particularly on these markers can shed light on the matter.

To the best of our knowledge, the current 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 that bowel resection rates in incarcerated hernias range from 23.9 to 25%.<sup>6,13</sup> Resection rates are particularly high in incarcerated femoral hernias (30.8-46.4%),<sup>14</sup> with a 15% rate in incarcerated inguinal hernias.<sup>4</sup> However, since the incidence of inguinal hernias is higher, the highest resection rate in all patients was observed in inguinal hernias.

Bowel resection was performed in 15.38% of our patients. Nearly 50% of resected hernias lead to inguinal hernias, which have a resection rate of 13.5%. The distribution of resected hernias we found here is similar to the literature, although the rates in all hernias remains below the average data in the literature. The fact that patients with complications or a high risk of bowel resection are referred to more advanced centers may explain this.

Female sex and advanced age (over 65) have been determined as risk factors for small bowel resection.<sup>14,28,29</sup> In the current study, age was not found to be a factor for resection and or for demonstrating intestinal viability, patients who undergoing resection were significantly dominantly females, which supports the data in the literature.

Patients undergoing bowel resection have higher length of hospital stay, postoperative complication rates (6-47%), and mortality rates (1-7%).<sup>14,30-32</sup>

In our sample, the complication rates were found to be the highest in Group III and the lowest in Group I (20%). Although the complication rate increases as the degree of ischemia of the bowel is increased, no significant difference was found between the groups. No mortality was seen in any of our patients. When the literature is examined, although our complication rate is higher than some studies, our complication rate is at lower levels when looked at in a general way. 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. Also, we excluded patients with any disease that could affect blood parameters.

Our study has certain strengths and limitations. The strengths are the exclusion of patients whose blood parameters might be affected, the inclusion of intestinal hernia cases, and dividing our sample into three groups according to disease severity. Another strength is the identification of some biomarkers with high diagnostic value, which were left unexamined in other studies. On the other hand, the main limitation of our study was its retrospective nature. Accordingly, some patients with unavailable data had to be excluded. The relatively low number of patients and the single-center 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 research population within the aims of the study.

## **CONCLUSION**

For patients who are clinically and radiologically diagnosed with incarcerated hernias, identifying intestinal viability and determining surgical timing accordingly are crucial. Preoperative WBC, neutrophil, NLR, urea, creatinine, and total bilirubin values can be used as biomarkers to predict the deterioration of intestinal viability. Again, creatinine, total bilirubin, indirect bilirubin, phosphorus, LDH, and lipase can be used as biomarkers to decide on the necessity of bowel resection. There is still a need for further prospective studies with larger samples and good patient selection.

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