ORIGINAL RESEARCH

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Prognostic Value of Systemic Immune-inflammation Index in Patients with Pediatric Blunt Abdominal Trauma

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Abstract

Objective: Trauma is a leading cause of morbidity and mortality in children. One in every four patients with trauma has abdominal trauma. Abdominal trauma is the third leading cause of death associated with trauma. Mortality increases in patients with inflammation because of the body's reaction to trauma. The systemic immune-inflammation index (SIII) is a test indicative of body inflammation based on complete blood count alone. Index value may indicate prognosis of pediatric patients with blunt abdominal trauma.

Materials and Methods: The present study was designed as a retrospective, single-center research. The study included pediatric patients with isolated blunt abdominal trauma who were admitted to the emergency department between June 01, 2021 and June 01, 2022 and met the inclusion criteria. Patient demographic data; medical history; leukocytes, platelet, and neutrophil count; SIII; and outcome status were captured in the case form.

Results: The study included 103 patients, of whom 64.1% were male and the mean age was 7.32±5.12 years. Mortality was noted in 6.8% of the patients included in the study. The sensitivity and specificity for a cut-off value of 890.47×10^3/L SIII were 95.7% and 62.5%, respectively (area under the curve: 0.832; 95% confidence interval: 0.820-0.944, $p<0.003$), in pediatric patients with blunt abdominal trauma.

Conclusion: High SIII scores, a rapid, inexpensive, reliable, and radiation-free test, could be used as a predictor of mortality in pediatric patients admitted to the emergency department with blunt abdominal trauma.

Keywords: Systemic immune-inflammation index, blunt abdominal trauma, pediatric patient, mortality

Introduction

Trauma is one of the leading causes of morbidity and mortality in >1-year-old children [1]. Data from the USA indicates that more than 10 million children present to emergency departments each year because of injuries associated with trauma [2]. Approximately 25% of pediatric patients experience abdominal trauma [3]. More than 90% of these injuries are due to blunt trauma [1]. Blunt abdominal trauma is the third most prevalent cause of mortality associated with trauma in children following head and chest injuries [4].

According to World Health Organization data, trauma is responsible for approximately 950,000 deaths annually among children and young people <18 years [5]. The challenges associated with detecting intra-abdominal injuries in children with multiple injuries account for the higher mortality rate [6]. In this patient group, physical examination may provide limited data. Thus, focused assessment with sonography in trauma (FAST) is used in children with blunt abdominal trauma, yet the sensitivity of the FAST test is quite low [7]. Computed tomography (CT) scan is considered the gold standard in these patients; nevertheless, radiation exposure in pediatric patients is associated with an increased risk of malignancy [8]. Patient selection for advanced imaging procedures is crucial. Therefore, clinicians tend to use easier, cheaper, faster, and radiation-free laboratory tests subsequent to physical examination to detect intra-abdominal injury in children [9].

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The inflammation process is induced by biomolecular activation following trauma. Inflammation starts with the activation of various cells due to the release of purinergic receptors and ATP during trauma. Among these cells, neutrophils are one of the first to respond to inflammation, causing tissue damage [10]. Platelets adhere to damaged vessel walls and release platelet granules, inducing thrombus formation. Platelets are also involved in local inflammation. Neutrophils, lymphocytes, and platelets included in the complete blood count parameters play a role in the inflammatory process [11]. The systemic immune-inflammation index (SIII) is a novel inflammatory biomarker used as both a diagnostic and prognostic marker in several internal and surgical conditions [12]. SIII may reflect systemic inflammation in the body [13] and is a biomarker of platelet, neutrophil, and lymphocyte counts [14]. SIII is an easily assessable, inexpensive, and objective parameter composed only of hemogram parameters. Therefore, SIII may be a prognostic indicator in pediatric patients with blunt abdominal trauma.

Materials and Methods

This retrospective single-center study was performed in the emergency department of a training and research hospital upon approval of the University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee (approval number: KAEK/2022.06.212, date: 23.06.2022). The study included pediatric patients who were admitted to the emergency department because of isolated blunt abdominal trauma between June 01, 2021 and June 01, 2022, and who met the inclusion criteria. Patient data were retrieved from the hospital information management system (HIMS). Informed consent was obtained from the patients included in the study.

The study included <18-year-old patients with isolated abdominal trauma, abdominal CT imaging, complete blood count, mortality or discharge status, and complete data in the HIMS. Patients aged >18 years, those with trauma other than abdominal trauma, incomplete data, pregnant women, those with a history of malignancy, those with hematologic or bone marrow pathology, and those with suspected infection were excluded.

Patients' demographic data; medical history; leukocytes, platelet, and neutrophil count; SIII; and mortality or discharge status were retrieved from the HIMS and captured on the case form. Patients were divided into two groups according to mortality status. The study included 133 patients admitted to the emergency department because of isolated abdominal trauma. Of the patients, 17 were excluded because of incomplete data, 5 because of hematologic or bone marrow pathology, 4 because of malignancy, and 4 because of suspected infection. The study was conducted on the remaining 103 patients (Figure 1).

The hemogram results for each patient were used in the calculations. The platelet, neutrophil, and lymphocyte counts were expressed as P, N, and L, respectively. The neutrophil-to-lymphocyte ratio (NLR) (N/L ratio) and SIII [(P×N)/L] were calculated based on these values [12].

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) Software (Version 26.0) was used for data analyses. Number, percentage, mean, standard deviation (SD), median, minimum, and maximum values were used for the presentation of descriptive data. The Kolmogorov-Smirnov test was used to test the normality of the data. In the univariate analysis, continuous variables with normal distribution were expressed as mean±SD and compared using the t-test. The Pearson chi-square test was used to analyze the categorical variables. Fisher's exact test was used when there were less than five categorical variables. The independent samples t-test was used to compare two independent numerical datasets. Diagnostic accuracy was assessed using receiver operating characteristic (ROC) curve analysis. Appropriate cut-off values were determined, and sensitivity and specificity values were calculated for parameters with an area under the curve (AUC) >0.600. A p-level <0.05 was considered statistically significant.

Results

The present study included 103 patients, of whom 64.1% were male, and the mean age was 7.32±5.12 years. Among the included patients, 41.7% were discharged, 24.3% were admitted to the intensive care unit (ICU), and the remaining 34% were admitted to the ward. The length of hospital stay was an average of 3.80±5.99 days. Mortality was observed in

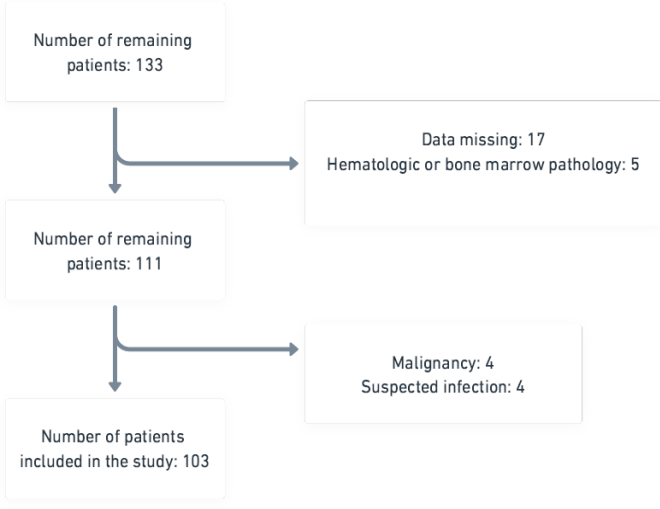

Figure 1. Flowchart of the cases included in the study

6.8% of cases. The mean values for vital signs and laboratory results are presented in Table 1. Accordingly, the mean NLR value and the mean SIII value were 4.25±4.36 and 1217.59×10³±1396.50×10³), respectively (Table 1).

Patients' demographic and clinical data were compared according to mortality status. There were no significant differences between mortality and mean age and sex. Systolic blood pressure, diastolic blood pressure, and saturation were lower in patients who died, whereas the pulse rate was significantly higher in these patients. All patients who died were admitted to the ICU (Table 2).

Laboratory data analysis showed significantly lower hemoglobin levels, whereas platelet, C-reactive protein, alanine transaminase (ALT), aspartate transaminase (AST), amylase, and lipase levels were significantly higher in patients who died than in those who survived. Furthermore, NLR as calculated based on laboratory data was not significant in predicting mortality, whereas the SIII index was significant

Table 1. Assessment of demographic and clinical data of the patients

Parameter		n (%)/mean ± SD
Age (years)		7.32±5.12
Sex	Male	66 (64.1)
	Female	37 (35.9)
Vital signs	SBP (mmHg)	106.20±13.15
	DBP (mmHg)	68.23±14.54
	Pulse rate (beats/min)	108.29±24.80
	Saturation (%)	97.18±6.72
Hospitalization status	None/discharged	43 (41.7)
	Ward admission	35 (34.0)
	ICU admission	25 (24.3)
Length of hospitalization (days)		3.80±5.99
Mortality	Yes	7 (6.8)
	No	96 (93.2)
Laboratory data	WBC (×10³/mm³)	15.78±8.67
	HGB (mg/dL)	11.74±2.09
	PLT (×10³/mm³)	277.88±97.33
	NEU (×10³/mm³)	10.68±7.83
	LEN (×10³/mm³)	4.15±3.68
	ALT (IU)	115.60±224.99
	AST (IU)	190.23±368.00
	Amylase (IU)	70.19±66.62
	Lipase (IU)	53.36±101.94
Indexes	NLR	4.25±4.36
	SIII (×10³)	1217.59±1396.50

SD: Standard deviation; ICU: Intensive care unit, WBC: Leukocytes, HGB: Hemoglobin, PLT: Platelet, NEU: Neutrophils, LEN: Lymphocyte, ALT: Alanine transaminase, AST: Aspartate transaminase, NLR: Neutrophil/lymphocyte ratio, SIII: Systemic immune-inflammation index, min: Minute, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 2. Demographic and clinical data of the patients by mortality status

Parameter		Survivor n (%)/mean ± SD	Excitus n (%)/mean ± SD	p
Age		7.43±5.13	5.86±5.30	0.437
Sex		63 (65.6)	3 (42.9)	0.247
Vital signs	SBP (mmHg)	107.26±12.93	91.71±5.44	0.002
	DBP (mmHg)	69.73±13.58	47.71±12.11	**<0.001**
	Pulse rate (beats/min)	106.48±23.05	133.14±35.63	0.005
Hospitalization status	None/discharged	43 (44.8)	0 (0.0)	0.040
	Ward admission	35 (36.4)	0 (0.0)	
	ICU admission	18 (18.8)	7 (100.0)	
Length of hospitalization (days)		3.50±5.57	7.86±9.96	0.063

Table 2. Continued

Parameter		Survivor n (%)/mean ± SD	Excitus n (%)/mean ± SD	p
Laboratory data	WBC ($\times10^3/mm^3$)	15.61±8.77	18.13±7.34	0.461
	HGB (mg/dL)	11.89±1.93	9.73±3.20	0.008
	PLT ($\times10^3/mm^3$)	262.60±80.67	487.43±55.10	**<0.001**
	NEU ($\times10^3/mm^3$)	10.48±7.95	13.42±5.76	0.340
	LEN ($\times10^3/mm^3$)	4.26±3.78	2.70±1.00	0.280
	ALT (IU)	92.13±200.39	437.57±308.12	**<0.001**
	AST (IU)	157.31±330.74	641.71±561.35	0.001
	Amylase (IU)	65.50±61.03	134.57±106.22	0.007
	Lipase (IU)	40.99±68.94	223.00±255.69	**<0.001**
Indexes	NLR	4.10±4.30	6.22±4.98	0.215
	SIII ($\times10^3$)	1086.69±1215.38	3012.76±2394.08	<0.001

SD: Standard deviation, ICU: Intensive care unit, WBC: Leukocytes, HGB: Hemoglobin, PLT: Platelet, NEU: Neutrophils, LEN: Lymphocyte, ALT: Alanine transaminase, AST: Aspartate transaminase, NLR: Neutrophil/lymphocyte ratio, SIII: Systemic immune-inflammatory index, min: Minute, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

in predicting mortality and was significantly higher in mortal cases than in survivors (Table 2).

ROC analyses were conducted to determine the sensitivity and specificity of NLR and SIII according to cut-off values for predicting mortality in pediatric patients with blunt abdominal trauma. The sensitivity and specificity for a cut-off value of 890.47×10^3/L SIII were 95.7% and 62.5%, respectively [AUC: 0.832; 95% confidence interval (CI): 0.820-0.944, p<0.003], in pediatric patients with blunt abdominal trauma. There were no significant differences between the mean NLRs for predicting mortality in pediatric patients with trauma. SIII was a successful index for predicting mortality in pediatric patients with trauma (Figure 2 and Table 3).

Discussion

Trauma is a leading cause of mortality, particularly in pediatric patients. Although it is a social problem affecting all age groups, abdominal trauma can cause death in this patient group. Thus, several parameters have been used as prognostic markers, particularly in pediatric patients with blunt abdominal trauma. The present study investigated the SIII, an inexpensive, fast, easy, and radiation-free test, as a prognostic parameter in this patient group. In particular, SIII could be an indicator of mortality in pediatric patients with blunt abdominal trauma because of its cut-off value of 890.47×10^3/L, sensitivity of 95.7%, and specificity of 62.5%.

Several previous studies have suggested that NLR is a good predictor of mortality associated with abdominal trauma [15-17]. Nevertheless, to the best of our knowledge, no study has compared NLR and SIII in pediatric patients with blunt abdominal trauma. The present study showed that SIII was a marker of mortality associated with intra-abdominal injury in pediatric patients admitted to the emergency department because of blunt abdominal trauma. SIII had higher sensitivity and specificity and was statistically significant in predicting mortality in pediatric patients with blunt abdominal trauma compared with NLR.

In a study by Spijkerman et al. [18], the mean age of patients admitted because of pediatric blunt abdominal injury was 12 years, and the proportion of male patients was 68%. In another study, the mean age was 8 years, and the proportion of male patients was 66.7% [19]. In the present study, both the average age and male ratio were consistent with those reported in the literature. This is attributed to the fact that intra-abdominal injuries are more prevalent in children in this age group owing to the proportionally larger size of the organs than the body. Furthermore, the fact that boys were more active in this age group might have contributed to the higher prevalence rates.

A cohort study of patients with blunt abdominal trauma reported that intra-abdominal organ injury in hemodynamically unstable patients (hypotensive patients) resulted in mortality [20]. In addition, another study showed that patients with stable hemodynamic status survived even when not admitted to the ICU [21]. Consistent with previous studies, mortal patients were hemodynamically unstable in the present study. This may be attributed to the fact that unstable patients can rapidly progress to multiorgan failure due to impaired perfusion.

Elevated ALT and AST levels indicate intra-abdominal organ injury, particularly in pediatric patients with blunt abdominal trauma [22]. Furthermore, previous studies reported that the levels of ALT and AST were higher in mortal patients [16]. Pancreatic enzymes (amylase and lipase) are increased in patients with blunt abdominal trauma, both in cases of mortality and intra-abdominal organ injury [6,23]. Similarly, in the present study, both liver function tests and pancreatic enzyme levels were elevated in mortal patients. The severity of the injury, which increased the severity of the trauma and led to larger solid organ injuries in the early period, might have accounted for the above outcome.

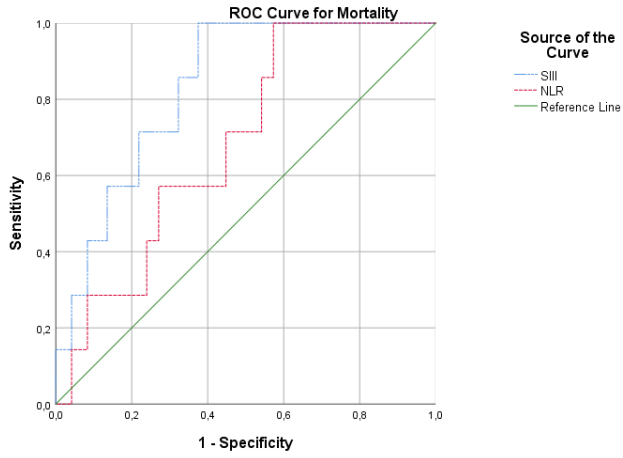

Figure 2. ROC analysis for determining the mortality of the cases

SIII: Systemic immune-inflammatory index, NLR: Neutrophil/lymphocyte ratio, ROC: Receiver operating characteristic

Table 3. ROC analysis results for determining the mortality of the cases

Parameter	Cut-off value	Sensitivity	Specificity	Area under the curve	95% CI		p
					Lower bound	Upper bound	
NLR	2.09	93.2	42.7	0.686	0.525	0.847	0.101
SIII ($\times 10^3$/L)	890.47	95.7	62.5	0.832	0.820	0.944	0.003

NLR: Neutrophil/lymphocyte ratio, SIII: Systemic immune-inflammatory index, CI: Confidence interval, ROC: Receiver operating characteristic

A previous study involving patients with trauma reported that NLR was increased in cases of severe trauma [15]. Another study found that the NLR value calculated at the time of initial presentation predicted 30-day survival in patients with trauma [15]. In a study by Dilektasli et al. [24], the sensitivity and specificity of NLR for predicting mortality in patients with trauma were 70.8% and 61.9%, respectively. The cut-off value of NLR for pediatric patients with trauma was 2.77, and the sensitivity and specificity as indicators of mortality were 70% and 77%, respectively [16]. Unlike in previous studies, although the cut-off value of the NLR was 2.09 with a sensitivity and specificity of 93.2% and 42.7%, respectively, the NLR was not significant as an indicator of mortality in the present study. This might be attributed to the fact that the patients included in previous studies had a more severe inflammatory response due to multi-trauma.

There are no previous studies on the use of SIII as a prognostic marker in pediatric patients with blunt abdominal trauma. Nevertheless, it was reported that SIII was useful in demonstrating brain damage, particularly in patients with head trauma [25]. Another study suggested that SIII was a useful indicator of traumatic brain injury [26]. The present study indicated that SIII could be used as a mortality indicator in pediatric patients with blunt abdominal trauma with a cut-off value of 890.47×10^3/L, sensitivity of 95.7%, and specificity of 62.5%. Therefore, it will be possible to determine prognosis based only on whole blood count results and to start early follow-up and treatment of pediatric patients admitted to the emergency department due to trauma.

Study Limitations

The fact that this was a retrospective study is the most important limitation of this study. The other limitations include the single-center nature of the study and comparatively lower number of cases. The present study determines the short-term mortality outcomes of the included patients. Therefore, it does not provide information about long-term complications. The inclusion criteria were those with hematological or bone marrow pathology, a history of malignancy, and suspected infection and the exclusion of pregnant women, resulting in a relatively small sample size for the study. A larger sample size would provide more robust and reliable results, especially when assessing the predictive value of biomarkers such as the SIII. Future prospective studies with larger sample sizes are required to confirm the predictive values of the parameters investigated in the present study.

Conclusion

The mortality rate of pediatric patients with blunt abdominal trauma is extremely high. Therefore, the survival rate of patients may vary according to the extent of the inflammatory process induced by abdominal trauma. The results of the present study suggest that a higher SIII value at initial presentation in pediatric patients with abdominal trauma can be used to

predict patient mortality. However, this hypothesis needs to be supported by future prospective multicenter studies with larger sample sizes.

Ethics

Ethics Committee Approval: This retrospective single-center study was performed in the emergency department of a training and research hospital upon approval of the University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee (approval number: KAEK/2022.06.212, date: 23.06.2022).

Informed Consent: Informed consent was obtained from the patients included in the study.

Authorship Contributions

Surgical and Medical Practices: E.A., R.G., Concept: E.A., İ.A., A.Ç., R.G., Design: E.A., S.K., Data Collection or Processing: E.A., İ.A., K.Ş., S.K., Analysis or Interpretation: E.A., İA., A.Ç., K.Ş., R.G., Literature Search: E.A., İ.A., A.Ç., Writing: E.A., A.Ç., K.Ş., S.K., R.G.

Conflict of Interest: No conflict of interest was declared by the authors.

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