ORIGINAL ARTICLE

Management of pediatric splenic trauma

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ABSTRACT

BACKGROUND: In this study, we aimed to present the management and treatment processes of patients with splenic trauma, discuss nonoperative treatment approaches, and share our institutional experience.

METHODS: A total of 244 patients hospitalized for splenic trauma between January 2010 and January 2020 were retrospectively analyzed.

RESULTS: Splenic injury was present in 22% of trauma patients who presented to the emergency department and were consulted by pediatric surgery. The most common cause of splenic injury was falls (60%). Forty-three percent of patients were of school age. Ninety percent of patients had Grade I-III splenic injuries. The mean age at presentation was 7.90 years. The mean hematocrit level was 32% and the mean hemoglobin level was 10.90. Blood transfusion was administered to 29% of patients. Additional injuries were present in 45.9% of cases, with the lung being the most frequently affected organ. The mean length of hospital stay was 6.03 days. Mortality occurred in five patients, and morbidity was observed in five patients. There was a statistically significant correlation between blood pressure, urine output, and mortality. A statistically significant association was also found between platelet-to-lymphocyte ratio, blood transfusion, hemoglobin level, Glasgow Coma Scale (GCS) score, and mortality ($p<0.001$). Furthermore, significant correlations were identified between GCS score, length of hospital stay, neutrophil count, and the presence of additional injuries ($p<0.001$). A strong negative correlation was observed between lactate levels and blood transfusion ($r=-0.610$), as well as between lactate levels and GCS score ($r=-0.645$). In the ROC analysis evaluating lactate as a predictor of additional injury, a sensitivity of 58% and specificity of 83% were identified at a cutoff value of 1.9.

CONCLUSION: We recommend nonoperative management for patients with splenic injury, as it reduces mortality, morbidity, and healthcare costs. Treatment protocols for these patients should be scientifically standardized.

Keywords: Nonoperative treatment; pediatric splenic trauma.

INTRODUCTION

Trauma remains the leading cause of mortality and morbidity in the pediatric population worldwide. In 2015, trauma caused more deaths and morbidity burden in the United States than all other childhood diseases combined.[1] After injuries to the head and extremities, the abdomen is the third most frequently affected region. Each year, 1 in 10,000 children in the United States experiences abdominal trauma.[2] A study conducted in the United States reported that 3% of all trauma cases presenting between 1994 and 2014 involved splenic injuries, of which 79.6% were isolated splenic injuries.[3]

In 2000, due to variability in the management of pediatric

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abdominal traumas, the trauma committee of the American Pediatric Surgical Association published guidelines and criteria for the management of solid organ injuries.[4] As the management of intra-abdominal solid organ injuries became standardized, hospital length of stay decreased and the success rate of nonoperative management increased.[4,5] Over time, these guidelines have been periodically updated, with the most recent systematic review published in 2019. Recent evidence suggests that shorter hospital stays, followed by a reduced period of bed rest after discharge, are safe.[5] The primary advantage of nonoperative management is the avoidance of postoperative complications. Patients managed nonoperatively have demonstrated shorter hospital stays, fewer blood transfusions, and improved quality of life.[6] Current scientific data indicates that the success rate of nonoperative management exceeds 90%.

Although nonoperative management is widely accepted for hemodynamically stable patients, there remains ongoing debate regarding the optimal management and follow-up of hemodynamically unstable patients. Additionally, there is no clear consensus on the role of angiographic interventions in splenic trauma.

In this study, we aimed to retrospectively review the management and treatment processes of patients who were followed in our intensive care unit for splenic trauma between January 2010 and January 2020, to discuss nonoperative management strategies, and to evaluate our institutional experience.

MATERIALS AND METHODS

Between January 2010 and December 2019, all patients who presented to the emergency department due to trauma and were referred to the pediatric surgery department were examined. A total of 244 patients with splenic trauma were included in the study. Eight patients with splenic trauma whose medical records were inaccessible were excluded.

This study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the Academic Committee of the Department of Pediatric Surgery (19/05/2021). Subsequently, ethical approval was granted by the Ethics Committee (15/12/2021-86).

The following variables were analyzed: demographic characteristics, mechanism of injury, injury grade, presence of comorbidities, need for blood transfusion, length of hospital stay, and presence of concomitant injuries. Blood pressure, hematocrit (HCT), hemoglobin (Hb), platelet (PLT), neutrophil (NEU), lymphocyte (LYM), and lactate levels were recorded. The neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) were calculated. Glasgow Coma Scale (GCS) scores, urine output, mortality, morbidity, radiological investigations performed, and treatment approaches were also assessed.

Initial patient data were obtained from emergency department records at the time of admission. In cases with additional injuries, consultations from relevant specialties were reviewed. The clinical course of all patients during hospitalization was evaluated.

Statistical Analysis

Statistical analyses were performed using SPSS Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were presented as frequency, percentage, mean, and standard deviation. The normality of data distribution was assessed. The Pearson chi-square test was used to compare qualitative data. The independent samples t-test was applied for comparisons of normally distributed quantitative data. For variables that did not follow a normal distribution, the Mann–Whitney U test was used. Spearman correlation analysis was performed to evaluate correlations between variables. Receiver operating characteristic (ROC) curve analysis was conducted to determine sensitivity and specificity. A p-value of ≤0.05 was considered statistically significant for all analyses.

RESULTS

Between January 2010 and December 2019, splenic injury was identified in 22% of pediatric patients admitted to the emergency department due to trauma. Among patients with splenic trauma, 43% were between 7 and 12 years of age. The most common mechanism of injury was falls, accounting for 60% of cases, and 74.2% of the patients were male. The distribution of age, sex, and mechanisms of injury are presented in Table 1.

Table 1. Age distribution, sex, and mechanism of trauma

	n	%
Age (years)		
0-3	40	16.4
4-6	59	24.2
7-12	105	43
13-17	40	16.4
Sex		
Male	181	74.8
Female	63	25.2
Mechanism of trauma		
Fall	148	60.3
Motor vehicle accident (MVA)	46	18.9
Road traffic accident (RTA)	21	8.9
Bicycle crash accident (BCA)	15	6.1
Blunt abdominal trauma (BAT)	8	3.3
Penetrating trauma (PT)	3	1.2
Gunshot wound (GSW)	3	1.2

Table 2. Distribution of injury grades

Injury Grade	n	%
I	86	35.2
II	84	34.4
III	50	20.5
IV	19	7.8
V	5	2.0
Total	244	100

Focused Assessment with Sonography for Trauma (FAST) was performed in 235 patients, and computed tomography (CT) was performed in 182 patients. It was assumed that patients who did not undergo CT at our institution had previously undergone CT at the referring hospital; however, these imaging data were not accessible.

The most common injury grade was Grade I, accounting for 35.2% of cases. The distribution of injury grades is presented in Table 2.

The mean age of the patients was 7.9 years. The descriptive characteristics of the study population are presented in Table 3.

Isolated splenic injuries accounted for 54.2% of cases, while 45.9% of patients had concomitant injuries. The lungs were the most frequently affected additional organ (21%). The distribution of associated injuries is shown in Table 4.

Three patients (1%) had comorbidities. One female patient with iron deficiency anemia presented with a Grade I splenic injury following a fall. No additional injuries were identified. Her HCT was 29.27% and Hb was 9.13 g/dL. She did not receive a transfusion and was discharged after nonoperative management. The second patient, a female with depression and behavioral disorder, presented with a Grade I splenic injury due to a gunshot wound. She had bilateral pneumothorax, right-sided hemothorax, and a Grade II liver injury. A total of three units of erythrocyte suspension (ES) were administered. She was discharged following nonoperative management. The third patient, a male with acute myeloid leukemia, presented with a Grade I splenic injury after a fall. No additional injuries were detected. Although his HCT and Hb levels were within normal limits, thrombocytopenia was present. He did not receive ES and was discharged with nonoperative management.

The mean length of hospital stay was 6.03 days. The distribution of hospital stay according to injury grade and mechanism of trauma is presented in Tables 5 and 6, respectively.

Twenty-six patients were hypotensive, while 218 were normotensive at presentation. Decreased urine output was observed in 15 patients. The relationship between blood pressure, urine output, and mortality is shown in Table 7.

A statistically significant association was found between both blood pressure and urine output and mortality ($p<0.001$).

A total of five patients died, three of whom died in the emergency department. One patient died during the surgical procedure, and another died in the postoperative period. Among these patients, three had Grade V splenic injuries and two had Grade IV splenic injuries. Four of the five deceased patients had concomitant high-grade liver injuries.

Five patients experienced morbidity. One patient discontinued school and developed substance abuse following the

Table 3. Characteristics of the patients

	Minimum	Maximum	Mean	Standard Deviation
Age (years)	1	17	7.9	4.133
Blood transfusion	1	6	1.64	1.110
HCT (%)	13.9	46.44	32.90487	5.4390932
Hb (g/dL)	7	14	10.90	2.283
GCS	3	15	14.37	1.934
Lactate (mmol/L)	0.6	14	2.377083	2.4192701

Table 4. Distribution of concomitant injuries

Injured Organ	n	%
Lung	50	21%
Skeletal system	49	20%
Liver	27	11%
Cranial injury	25	10%
Kidney	21	8%
Adrenal gland	6	2%
Intestinal injury	2	0.8%

Table 5. Length of hospital stay according to injury grade

Injury Grade	n	Mean	Standard Deviation	Minimum	Maximum
I	86	5.36	2.361	2	17
II	84	6.00	2.630	3	21
III	50	6.48	1.705	5	13
IV	19	8.05	3.504	2	17
V	5	6.00	7.071	1	16
Total	244	6.03	2.674	1	21

Table 6. Trauma mechanism and length of hospital stay

Trauma Mechanism	Mean	Standard Deviation	Minimum	Maximum
Fall	5.79	2.155	1	17
MCA	6.52	2.676	4	12
RTA	6.13	2.729	1	16
BCA	5.33	1.799	4	9
PT	4.00	1.732	2	5
BAT	7.88	5.866	3	21
GSW	13.67	4.933	8	17
Total	6.03	2.674	1	21

trauma, suggestive of post-traumatic stress disorder (PTSD). One patient underwent splenectomy due to instability and was subsequently treated for post-traumatic anxiety disorder. One patient developed a left ocular contracture. Another developed paraparesis. One patient developed atrophy of the left kidney.

Six patients underwent surgical intervention, two of whom died. Of the remaining four patients, three underwent splenectomy for Grade V splenic injuries. One patient with a Grade II splenic injury underwent surgery for a ureteral injury, during which splenic laceration repair was performed.

The mechanisms of trauma and the patients who underwent surgery are presented in Table 8. A statistically significant association was found between the mechanism of trauma and the need for surgery ($p<0.001$).

Patients involved in traffic accidents and gunshot wounds had significantly higher rates of additional injuries (Table 9). A statistically significant association was identified between the

Table 7. Association between blood pressure, urine output, and mortality

	Mortality	Total
Blood pressure		
Hypotensive	5	26
Normotensive	0	218
Total	5	244
Urine output		
Decreased	5	17
Normal	0	227
Total	5	244

Table 8. Association between trauma mechanism and surgical intervention

Trauma Mechanism	Surgery	Total
Fall	3	148
RTA I	46	
MCA	0	21
BCA	0	15
BAT	0	8
PT	0	3
GSW	2	3
Total	6	244

Table 9. Association between trauma mechanism and additional injury

Trauma Mechanism	Additional Injury	Total
Fall 60	148	
MCA	28	46
RTA	14	21
BCA	3	15
BAT	3	8
PT	1	3
GSW	3	3
Total	112	244

Table 10. Variables associated with mortality

Mortality	p Value
PLR	0.000
Blood transfusion	0.000
Hb	0.000
GCS	0.000
NLR	0.013
Lactate	0.001

Table 11. Variables associated with additional injury

Additional Injury	p Value
Blood transfusion	0.014
Hospital stay	0.000
GCS	0.000
NEU	0.000
NLR	0.001
Lactate	0.023

mechanism of trauma and the presence of additional injuries ($p<0.01$).

No significant association was found between platelet count, neutrophil count, or patient age and mortality. However, significant associations were observed between NLR, lactate level, PLR, blood transfusion requirement, Hb level, and GCS score and mortality ($p<0.05$). Additionally, the presence of additional injuries was significantly associated with mortality ($p<0.05$) (Table 10).

A statistically significant association was identified between blood transfusion requirement and lactate levels and the presence of additional injuries ($p<0.05$). A statistically significant association was also found between NLR and the presence of additional injuries ($p<0.01$). Furthermore, GCS score, length of hospital stay, and neutrophil count were significantly associated with the presence of additional injuries ($p<0.001$) (Table 11).

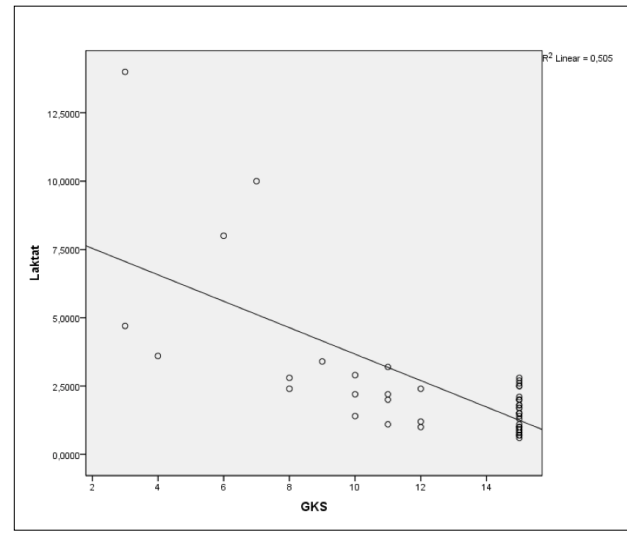

Figure 1. Correlation curve between lactate level and Glasgow Coma Scale (GCS) score

A strong negative correlation was observed between lactate level and GCS score ($r=-0.610$), as well as between blood transfusion requirement and GCS score ($r=-0.645$). A moderate negative correlation was found between lactate level and Hb ($r=-0.594$) and between blood transfusion requirement and Hb ($r=-0.517$). A moderate positive correlation was observed between NEU and lactate level ($r=0.419$). Additionally, a moderate negative correlation was identified between lactate level and HCT ($r=-0.595$), while a moderate positive correlation was found between lactate level and blood transfusion requirement ($r=0.446$). No statistically significant correlations were found between length of hospital stay, age, PLT, LYM, NLR, or PLR and other variables. The correlation curve between lactate level and GCS score is presented in Figure 1.

In the ROC analysis evaluating lactate level as a predictor of additional injuries, a cutoff value of 1.9 yielded a sensitivity of 58% and a specificity of 83% (area under the curve [AUC]: 72%).

DISCUSSION

In our study, 97% of patients with splenic injuries were successfully managed nonoperatively. Patients continue to be followed up, and no complications have been detected to date. Therefore, we recommend nonoperative management for patients with splenic injuries, as it reduces mortality, morbidity, and healthcare costs.

Most splenic traumas are isolated injuries. Falls are the most common mechanism of trauma, and boys are more frequently affected than girls. The majority of patients present with low-grade injuries. As the injury grade increases, the need for blood transfusion also rises.

Due to socioeconomic differences, the mechanisms of trauma vary among countries. In our study, falls were the most common cause of splenic trauma in children. In the literature, Rialon et al.[7] reported that traffic accidents were the leading cause of splenic injury, whereas Aoki et al.[8] identified falls as the most common mechanism, particularly in high-grade splenic injuries. We hypothesize that sleeping on rooftops in rural areas during the summer may be an important contributing factor to fall-related splenic injuries. Additionally, children in our region spend most of their time outdoors during the summer months, which may increase the incidence of falls.

Rialon et al.[7] reported a mean age of 12 years among children presenting with splenic injuries, Leeper et al.[9] reported a mean age of 11 years, Aoki et al.[8] found a mean age of 10 years, and Knight et al.[10] reported a mean age of 14 years. In our study, the median age was lower (7.89 years). We believe this may be attributable to socioeconomic factors, including increased outdoor activity during the summer and insufficient traffic safety measures for children.

In our cohort, 35.2% of patients had Grade I splenic injuries, 34.4% had Grade II, 20.5% had Grade III, 7.8% had Grade IV, and 2% had Grade V injuries. Approximately 90% of patients had Grade I-III injuries. In the American Pediatric Surgical Association (APSA) systematic review, most patients were reported to have Grade II-IV injuries.[11] We believe that the higher proportion of Grade I injuries in our study may be related to the predominance of fall-related trauma, particularly during the summer months, when lower-grade splenic injuries are more common.

In our study, 29% of patients received blood transfusions. The transfusion rates according to injury grade were 6% for Grade I, 15% for Grade II, 56% for Grade III, 94% for Grade IV, and 100% for Grade V splenic injuries. A statistically significant association was demonstrated between blood transfusion requirement and injury grade ($p<0.001$). In the literature, the reported need for blood transfusion in patients with splenic injuries ranges from 10% to 20%. We believe that the higher transfusions rate observed in our study may be attributed to the high prevalence of concomitant traumatic injuries. Seventy-two patients had Hb levels between 8-10 at admission; however, transfusion became necessary as Hb levels decreased due to ongoing bleeding, particularly in patients with additional injuries. Another contributing factor may be our transfusion threshold for unstable patients, which was set at an Hb level of 8, consistent with recommendations in the literature. Previous studies report an Hb threshold between 7.5-9.5 as an indication for transfusion in critically ill patients.[12,13] The ATOMAC (American Pediatric Surgical Association (APSA) Outcomes and Transfusion in the Management of Pediatric Solid Organ Injury) guidelines and several publications recommend transfusion at an Hb level below 7. However, in patients with high-grade splenic injuries or concomitant injuries, Hb levels may decline during follow-up due to ongoing bleeding. We also consider an Hb level below 7 as an indication for transfusion in stable patients, while supporting transfusion at Hb levels below 8 in unstable patients with ongoing bleeding (e.g., high-grade or vascular injuries).

The mean length of hospital stay in our study was 6.03 days. In the literature, Rialon et al.[7] reported a mean stay of 4 days, Aoki et al.[8] reported 10 days for high-grade injuries, McDonald et al.[14] reported 5.5 days, and the APSA systematic review reported 3.9 days.[11] Cost-effective treatment strategies are becoming increasingly important worldwide, and prolonged hospital stay is a well-established factor associated with increased healthcare costs. We believe that the longer hospital stay observed in our study may be related to the presence of additional injuries. However, when compared with the literature, particularly studies published after the 2019 APSA systematic review, our length of stay is consistent with reported data.

In our study, the mortality rate was 2% (5/244). Although some studies in the literature report no mortality, Rialon et al.[7] reported a mortality rate of 4%. Among the deceased patients in our study, three were involved in road traffic accidents (RTAs) and two sustained injuries due to falls. All deceased patients had concomitant injuries and were unstable upon arrival at the emergency department. Due to the small number of deaths, it was not possible to conduct comprehensive statistical analyses to evaluate risk factors for mortality. However, in the analyses performed, statistically significant associations were identified between NLR, lactate level, PLR, blood transfusion requirement, Hb level, and GCS score and mortality. Therefore, admission GCS score and laboratory parameters such as Hb, lactate, neutrophil, lymphocyte, and platelet counts are clinically valuable, particularly in the management of high-risk patients. As the number of patients increases, more robust scientific data will be obtained in future studies.

Given the statistically significant association between the mechanism of trauma and the presence of additional injuries, it should be emphasized that nearly 60% of patients involved in traffic accidents had concomitant injuries. Additional injuries should be carefully evaluated using CT and managed with a multidisciplinary approach. Schalamon et al.[15] reported that 68% of children with multiple trauma presented following traffic accidents. In our study, a statistically significant association was found between GCS score and neutrophil count and the presence of additional injuries. Therefore, elevated neutrophil levels on complete blood count (CBC) may serve as an indicator of concomitant injuries.

In our correlation analysis, a strong negative correlation was observed between lactate level and GCS score, as well as between blood transfusion requirement and GCS score. As GCS decreases, the likelihood of transfusion increases. Therefore, in patients presenting with low GCS scores, it may be beneficial to prepare ES immediately upon admission while laboratory evaluations are ongoing.

In our ROC analysis evaluating lactate level as a predictor of

additional injuries, a cutoff value of 1.9 demonstrated a sensitivity of 58% and a specificity of 83%. Careful interpretation of blood gas analysis, which is the fastest available diagnostic test, is essential. Patients with lactate levels above 1.9 are more likely to have concomitant injuries. In these cases, ES should be prepared promptly, CT should be performed without delay for diagnostic evaluation, and consultations with the relevant specialties should be initiated immediately.

As we did not encounter any complications requiring angiographic embolization, this intervention was not utilized in our cohort. Furthermore, angiographic embolization has not been shown to preserve splenic function. Given the high success rate of nonoperative management, even in high-grade injuries, further scientific studies are needed to better define the role of angiographic embolization.

Limitations

The principal limitation of this study is its retrospective design. Access to much of the data was challenging. Because some patients were referred from other hospitals, certain data were inaccessible. As this was a single-center study, the findings, particularly those related to mortality and morbidity risk factors, should be evaluated in multicenter studies with larger patient populations. Additionally, the absence of complications in our cohort may be related to the sample size, and as the number of patients increases, we may be able to present new data on complication management, particularly regarding angiographic embolization.

CONCLUSION

A multidisciplinary approach grounded in current scientific evidence is the most critical factor in ensuring survival in pediatric trauma patients. From the moment of admission to the emergency department, management should follow a standardized protocol based on scientific data. All injuries must be systematically identified, and treatment should be initiated without delay. Multicenter scientific studies will further strengthen the existing body of evidence, supporting the nonoperative management of most patients and facilitating discharge without long-term sequelae.

Ethics Committee Approval: This study was approved by the Dicle University Non-Interventional Studies Ethics Committee (Date: 15.12.2021, Decision No: 86).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.T., E.B., S.A., B.A., M.H.O., M.K.Ç.; Design: S.T., E.B., S.A., B.A., M.H.O., M.K.Ç.; Supervision: S.T., E.B., S.A., B.A., M.H.O., M.K.Ç.; Resource: S.T., E.B., M.H.O.; Materials: S.T., E.B., S.A., B.A., M.H.O., M.K.Ç.; Data collection and/or processing: S.T., E.B.; Analysis and/or interpretation: S.T., E.B., M.K.Ç.; Literature review: S.T., S.A., B.A.; Writing: S.T., E.B., M.H.O.; Critical review: S.T., E.B., M.K.Ç.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Çocuklarda dalak travmalarının yönetimi

AMAÇ: Dalak travmalı hastaların yönetim ve tedavi süreçlerini sunmayı, nonoperatif tedavi yönetimini tartışmayı ve deneyimlerimizi paylaşmayı amaçlıyoruz.
GEREÇ VE YÖNTEM: Ocak 2010 ile Aralık 2019 tarihleri arasında dalak travması nedeniyle hastaneye yatırılan 244 hasta çalışmaya dahil edildi ve retrospektif olarak analiz edildi.
BULGULAR: Acil servise başvuran ve çocuk cerrahisi ile konsülte edilen travma hastalarının %22'sinde dalak yaralanması mevcuttu. Dalak yaralanmasının en sık nedeni düşme (%60) idi. Hastaların %43'ü okul çağındaydı. Hastaların %90'ında evre 1-2-3 dalak yaralanması vardı. Başvuru anında ortalama yaş 7.90, ortalama hematokrit 32, ortalama hemoglobin 10,90 idi. Hastaların %29'una transfüzyon yapıldı. Hastaların %45.9'unda ek yaralanma vardı ve en sık yaralanan organ akciğerdi. Ortalama hastanede kalış süresi 6,03 gündü. 5 hastada mortalite, 5 hastada ise morbidite görüldü. Kan basıncı ve idrar çıkışı ile mortalite arasında istatistiksel olarak anlamlı bir ilişki vardı. ($p<0.05$) Trombosit/lenfosit oranı, kan transfüzyonu, hemoglobin ve GCS ile mortalite arasında istatistiksel olarak anlamlı bir ilişki bulundu. ($p<0.001$) GCS, hastanede kalış süresi, nötrofil sayısı ve ek yaralanma arasında istatistiksel olarak anlamlı ilişki bulundu. ($p<0.001$) Laktat ve kan transfüzyonu ile GKS arasında yüksek düzeyde negatif korelasyon olduğu görüldü. (sırasıyla r=-0,610 ve r=-0,645) Laktat ile ek yaralanma için yapılan ROC analizinde laktat cut off değeri 1,9'da duyarlılık %58, özgüllük %83 olarak belirlendi.
SONUÇ: Dalak yaralanmalı hastalara ameliyatsız tedaviyi hem mortaliteyi, hem morbiditeyi hem de maliyeti azalttığı için öneriyoruz. Hastaların tedavi yönetimi bilimsel olarak standardize edilmelidir.

Anahtar sözcükler: Çocuklarda dalak travmaları; nonoperatif tedavi; pediatrik travma.

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