ORIGINAL ARTICLE

The effect of blood urea nitrogen (BUN)/albumin ratio in evaluating mortality in pediatric burn patients with 20% or greater total body surface area involvement

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ABSTRACT

BACKGROUND: This study aims to evaluate the predictive value of the blood urea nitrogen (BUN)/albumin ratio for in-hospital mortality in pediatric burn patients with a total body surface area (TBSA) of 20% or greater and to compare its performance with established scoring systems, namely the Abbreviated Burn Severity Index (ABSI) and the Pediatric Baux Score (P-Baux).

METHODS: Patients hospitalized with burns involving 20% or greater TBSA in our pediatric burn unit between 2018 and 2023 were reviewed retrospectively. Patients were analyzed for demographic information, basic clinical data, cause of burn, operative interventions, ABSI and P-Baux scores and the follow-up period. The BUN/albumin ratio was calculated using BUN and albumin values measured at the time of index hospital admission. Data were evaluated for in-hospital mortality.

RESULTS: A total of 212 patients were included in the study. Patients were divided into two groups: survivors and non-survivors. The non-survivor group had significantly higher TBSA involvement, full-thickness burns, inhalation injuries, and operative requirements ($p<0.001$). The overall mortality rate was 4.5%. Receiver operating characteristic (ROC) analysis demonstrated that the BUN/albumin ratio is a strong predictor of in-hospital mortality, with predictive power similar to that of the ABSI and P-Baux scores. The cut-off value for mortality prediction using the BUN/albumin ratio was >5.24.

CONCLUSION: The BUN/albumin ratio is a simple and easily accessible marker that demonstrates strong statistical value in predicting in-hospital mortality in pediatric patients with burns covering 20% or more of the body. Given its availability from routine blood tests, we believe it may serve as a practical and helpful tool for clinicians caring for pediatric burn patients.

Keywords: Pediatric burn; blood urea nitrogen (BUN); albumin; mortality; Abbreviated Burn Severity Index (ABSI); Pediatric Baux Score (P-Baux).

INTRODUCTION

Burn injuries are most commonly seen in males younger than 2 years of age and most frequently occur as scald burns.[1] Despite significant advances in burn care, burn injuries continue to represent a major and preventable cause of mortality and morbidity among the pediatric population worldwide.[2] Several mortality-predictive classifications exist for adult burn patients.[3] However, there is no classification specifically designed for children. The Abbreviated Burn Severity Index (ABSI) is one of the most commonly used scoring systems for adult patients and is also applied to pediatric burn patients. Another mortality prediction score for burn patients is the Baux score. For pediatric patients, a modified version of the

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Revised Baux Score, known as the P-Baux score, has been defined.[4]

Therefore, it is important to identify useful and easily available prognostic parameters for predicting mortality in pediatric burn patients to ensure appropriate treatment through proper triage.

ABSI Score

This scoring system, first defined in 1982, is based on age, gender, total body surface area (TBSA), inhalation injury, and full-thickness burn parameters, and it has been widely used since its introduction.[5]

In children, second-degree burns with a total burned surface area of 10% or greater, third-degree burns greater than 5%, inhalation injuries, electrical burns, chemical burns, accompanying traumatic injuries, and facial and genital burns are classified as severe burns and require close follow-up and hospital admission to a burn center due to the high risk of mortality. As the percentage of TBSA burned increases, the risk of mortality also increases.

P-Baux Score

In adult patients, the Baux score was developed using TBSA and patient age to predict mortality in severe burn cases. However, the importance of inhalation injury led the literature to revise the scoring system to include this parameter, resulting in the Revised Baux (R-Baux) score. The revised score is calculated using the formula: R-Baux score = (TBSA + age + [17 × R]), where R=1 if the patient has an inhalation injury and R=0 if not. For pediatric patients, the P-Baux score has been defined and calculated as the Pediatric Baux score = (TBSA – age + [18 × R]) or pBAUX score = TBSA + (3 × Age) [6]. BAUX >100, rBAUX >105, and pBAUX >80 indicate a very high risk of mortality. Although the increase in score is not linear, the risk of mortality rises as the score increases (low, moderate, high, and very high risk).[7]

Researchers have defined many biochemical parameters that predict mortality in adult and critically ill patients.[8] The relationship between mortality and parameters such as white blood cell count (WBC), blood lactate level, serum creatinine, and blood urea nitrogen (BUN) has been demonstrated in previous studies.[9,10] Albumin, synthesized by the liver, is a protein that serves as a negative acute-phase reactant and reflects the patient's nutritional status.[8] Hypoalbuminemia is associated with increased mortality in severe conditions such as shock and sepsis.[11] Blood urea nitrogen levels increase due to dehydration and inflammation during physiological stress,[12] and elevated BUN levels indicate a poor prognosis.[8]

Studies conducted with the hypothesis that the BUN/albumin ratio could predict mortality have shown that this ratio has predictive value, based on observations of low albumin levels and high BUN levels in intensive care patients.[13]

As a tertiary care center with a high volume of pediatric burn admissions, we recognized the need for a rapid and easily accessible marker to predict in-hospital mortality. The potential utility of the BUN/albumin ratio as a practical and reliable predictor of mortality is also highlighted, particularly in peripheral or resource-limited settings where accurate estimation of TBSA—required for scoring systems such as ABSI and P-Baux—may be difficult to achieve. This study aimed to evaluate the prognostic value of the BUN/albumin ratio in predicting in-hospital mortality among pediatric burn patients and to compare its predictive performance with that of the widely used ABSI and P-Baux scoring systems.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee (Date: 25/05/2023, No: 822) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Due to the retrospective design of the study, signed informed consent from the patients was not required.

Data from 219 burn patients with TBSA involvement of 20% or greater who were admitted to our pediatric burn center between 2018 and 2023 were retrospectively analyzed. Patients who continued treatment at another hospital, left the hospital before completing treatment, had age-appropriate low body mass index (BMI), showed signs of malnutrition, or had additional comorbid illnesses were excluded from the study. Patient age, gender, TBSA, cause of burn, burn depth, presence of inhalation injury, BUN and albumin levels obtained from index admission blood tests, operative intervention, need for mechanical ventilation, length of hospital stay, and ABSI and P-Baux scores were analyzed. Patients were divided into two groups: survivors and non-survivors.

Although we defined BUN and albumin levels as those measured after initial resuscitation, it should be noted that the exact timing of blood sampling varied slightly among patients due to logistical factors during admission. However, all patients were evaluated and treated according to the standardized early burn care protocol at our center, which includes immediate intravenous fluid resuscitation based on the Parkland formula using lactated Ringer's solution, clinical stabilization, and initial laboratory workup within the first 1–2 hours after admission. Since all patients were admitted within the first 8 hours post-injury and stabilized before blood sampling, we believe that the BUN/albumin ratio reflects a comparable physiological window across patients. In future prospective studies, standardized sampling time points after burn injury and more detailed fluid balance monitoring will be implemented to further improve precision.

A history of burns, burned nasal hair, coarse voice, and carbonaceous deposits in the oral cavity, as well as airway bronchoscopy findings, were evaluated to determine the presence of inhalation injury. TBSA was calculated according to the Lund-Browder diagram.[14]

Statistical Analysis

Data were analyzed using IBM SPSS Statistics Standard Concurrent User version 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics were presented as number of cases (n), percentage (%), and mean ± standard deviation values. The normal distribution of numerical variables was assessed using the Shapiro-Wilk normality test. For comparisons between two groups, the independent samples t-test was used for normally distributed data, and the Mann-Whitney U test was used when the data were not normally distributed. Relationships between categorical variables were evaluated using Pearson's chi-square test and Fisher's exact test. A p-value of <0.05 was considered statistically significant. Receiver operating characteristic (ROC) analysis was performed to determine the predictive power of BUN, albumin, and BUN/albumin ratio levels, as well as ABSI and P-Baux scores, for in-hospital mortality.

Post hoc power for ROC area under the curve (AUC) was calculated using the Hanley–McNeil variance with α=0.05, based on class sizes (non-survivors n=10; survivors n=202). For each model, power to reject H_0: AUC=0.5 was evaluated. The minimal detectable AUC at 80% power was also determined.

RESULTS

The study included 212 pediatric burn patients who met the inclusion criteria. The mean age of the patients was 5.41 years (range: 1 –16 years), and 62% were male. The majority of patients sustained scald burns (79.7%). The median TBSA was 27% (20–80%). A total of 40.6% of patients required surgical intervention (debridement and grafting). The requirement for mechanical ventilation was higher in the non-survivor group (p<0.05). The median length of hospital stay was 28 days (5–131) (Table 1).

No significant differences were observed between the two groups in terms of age, gender, or cause of burn. Statistically significant differences were found between the groups regarding TBSA (%), presence of inhalation injury, burn depth, escharotomy, and need for mechanical ventilation (p<0.05). The remaining variables were similar between the two groups (p>0.05) (Table 1).

The mean BUN levels in survivors and non-survivors were 12.54±4.57 mg/dL (2-28.7) and 15.22±11.38 mg/dL (2-42), respectively (p>0.05). The mean albumin level in non-survivors was lower than in survivors (2.33±0.7 g/dL [1.4-3.5] vs. 3.88±2.33 g/dL [1.9-35.8], respectively; p<0.05). The mean BUN/albumin ratio was higher in non-survivors than in survivors (7.6±7.5 [0.71-26.25] vs. 3.41±1.32 [0.44-7.83] respectively; p<0.05) (Table 2). The overall in-hospital mortality rate was 4.5%. Both ABSI and P-Baux scores showed statistically significant differences between the groups (p<0.05) (Table 2).

The receiver operating characteristic analysis results for the

Table 1. Demographic and clinical characteristics of pediatric burn patients according to survival status

	Total	Survivors	Non-survivors	p-value
Age (years)	5.41±4.51 (1-16)	5.32±4.51 (1-16)	7.36±4.28 (1-12)	0.152
Male sex	129 (62)	121 (61.1)	8 (80)	0.324
Burn type (%)				
Electrical	4 (1.9)	4 (2)	0 (0)	0.061
Flame	37 (17.5)	32 (15.8)	5 (50)	
Scald	169 (79.7)	164 (81.2)	5 (50)	
Other	2 (0.9)	2 (1)	0 (0)	
TBSA (%)*	27.49±10.27 (20-80)	26.46±8.2 (20-65)	48.2±21.71 (20-80)	0.002
Inhalation injury (%)	26 (12.3)	19 (9.4)	7 (70)	<0.001
Burn depth (%)				
Partial thickness	178 (84)	174 (86.1)	4 (40)	0.001
Full thickness	34 (16)	28 (13.9)	6 (60)	
Operation (%)	86 (40.6)	79 (39.1)	7 (70)	0.094
Escharotomy	38 (17.9)	33 (16.3)	5 (50)	0.018
Grafting	76 (35.8)	72 (35.6)	4 (40)	0.748
Mechanical ventilation (%)	0.22±1.5 (0-16)	0.03±0.49 (0-7)	4±5.52 (0-16)	<0.001
Length of hospital stay (days)	28.08±19.6 (5-131)	28.32±19.26 (5-131)	23.1±26.26 (10-69)	0.146

Non-survivors had significantly larger TBSA involvement, a higher frequency of full-thickness burns, inhalation injury, escharotomy, and a greater need for mechanical ventilation compared with survivors (p<0.05). Fisher's exact test, Mann-Whitney U test. Abbreviations: TBSA: Total body surface area.

Table 2. Distribution of blood urea nitrogen (BUN), albumin, BUN/albumin ratio, Abbreviated Burn Severity Index (ABSI), and Pediatric Baux (P-Baux) scores according to survival status

	Total	Survivors	Non-survivors	p-value
BUN	12.65±5.02 (2-42)	12.54±4.57 (2-28.7)	15.22±11.38 (2-42)	0.571
Albumin	3.81±2.3 (1.4-35.8)	3.88±2.33 (1.9-35.8)	2.33±0.7 (1.4-3.5)	<0.001
BUN/Albumin Ratio	3.59±2.13 (0.44-26.25)	3.41±1.32 (0.44-7.83)	7.6±7.5 (0.71-26.25)	0.009
ABSI Score	4.63±1.54 (3-11)	4.48±1.34 (3-10)	7.6±2.32 (5-11)	<0.001
P-Baux Score	33.6±15.19 (20.4-101)	32.09±12.89 (20.4-82)	64.08±24.83 (30.8-101)	<0.001

Non-survivors showed significantly lower albumin levels and higher BUN/albumin ratios, ABSI scores, and P-Baux scores compared to survivors (p<0.05). Mann-Whitney U test. Abbreviations: BUN: Blood urea nitrogen; ABSI: Abbreviated Burn Severity Index; P-Baux: Pediatric Baux score.

Table 3. Receiver operating characteristic (ROC) analysis of blood urea nitrogen/albumin ratio (BUN/albumin ratio), Abbreviated Burn Severity Index (ABSI), and Pediatric Baux (P-Baux) score for predicting in-hospital mortality

	BUN/Albumin Ratio	ABSI Score	P-Baux Score
Cut-off	>5.24	>4	>41
Sensitivity	66.67	100	80.0
95% CI	29.9-92.5	69.2-100.0	44.4-97.5
Specificity	90.1	63.37	81.19
95% CI	85.1-93.8	56.3-70.0	75.1-86.3
+LR	6.73	2.73	4.25
95% CI	3.6-12.5	2.3-3.3	1.8-6.5
-LR	0.37	0	0.25
95% CI	0.1-0.9		0.007-0.90
+PV	23.1	11.9	17.4
95% CI	9.0-43.6	5.9-20.8	7.8-31.4
-PV	98.4	100	98.8
95% CI	95.3-99.7	97.2-100.0	95.7-99.9
AUC	0.759	0.897	0.890
95% CI	0.696-0.815	0.848-0.934	0.840-0.929
P-value	0.019	0.0011	<0.0001

The BUN/albumin ratio cut-off value of >5.24 yielded high specificity (90.1%) but moderate sensitivity (66.7%). ABSI and P-Baux scores demonstrated higher overall predictive accuracy, with AUCs of 0.897 and 0.890, respectively. ROC: Receiver operating characteristic; AUC: Area under the curve; BUN: Blood urea nitrogen; ABSI: Abbreviated Burn Severity Index; P-Baux: Pediatric Baux score; CI: Confidence interval; +LR: Positive likelihood ratio; –LR: Negative likelihood ratio; +PV: Positive predictive value; –PV: Negative predictive value.

BUN/albumin ratio, ABSI, and P-Baux scores in predicting in-hospital mortality among pediatric burn patients are shown in Table 3. Among the three parameters, the ABSI score demonstrated the highest sensitivity (100%; 95% confidence interval [CI]: 69.2–100.0) and an excellent AUC (0.897; 95% CI: 0.848–0.934), indicating strong predictive performance. The P-Baux score also showed a high AUC (0.890; 95% CI: 0.840–0.929), with a sensitivity of 80.0% and a specificity of 81.19%. The BUN/albumin ratio, with a cutoff value >5.24, demonstrated a statistically significant AUC of 0.759 (95% CI: 0.696–0.815; p=0.019), suggesting moderate discriminative ability. It showed high specificity (90.1%; 95% CI: 85.1–93.8), supporting its potential role as a valuable rule-in parameter. Its positive likelihood ratio (+LR) of 6.73 and negative predictive value (NPV) of 98.4% also indicate clinical utility in excluding low-risk patients (Table 3, Figure 1).

Cox regression analysis did not show a statistically significant effect of BUN values alone on mortality (p>0.05). Howev-

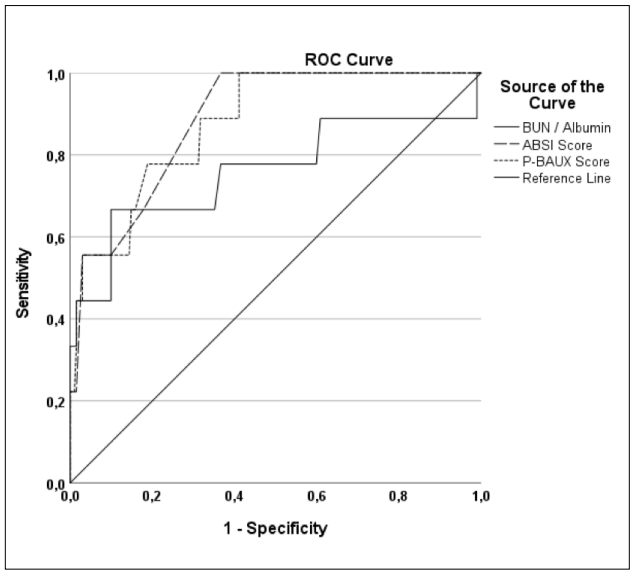

Figure 1. ROC curves of BUN/Albumin ratio and ABSI and P-BAUX score

er, the BUN/albumin ratio, ABSI, P-Baux score values were found to be statistically significant predictors of mortality ($p<0.05$) (Table 4).

Post hoc power calculations were performed to evaluate the adequacy of the study sample. With 10 non-survivors and 202 survivors, the observed AUC of the BUN/albumin ratio (0.759) corresponded to approximately 82% power to reject the null hypothesis of no discrimination (AUC=0.5) at a two-sided $\alpha=0.05$. The minimal detectable AUC for 80% power in this cohort was ~0.754, indicating that only moderate-to-large effect sizes could be reliably detected. Both ABSI (AUC=0.897) and P-Baux (AUC=0.890) achieved near-complete power (>99%). These findings suggest that although the number of events was limited, the study was sufficiently powered to support the main inference that the BUN/albumin ratio predicts mortality better than chance; however, direct comparisons between models should be interpreted with caution.

DISCUSSION

In adult burn patients, several scoring systems have been developed to predict mortality, including ABSI, R-Baux, FLAMES score (Fatality by Longevity, APACHE II score, Measured Extent of burn, and Sex), and others.[5-15-16] Studies have shown that ABSI scoring is the most valid among adults compared to other classifications.[3] There is no classification specifically designed to predict mortality in pediatric burn patients. Although ABSI and P-Baux scoring maintain their validity in pediatric burn patients, they typically require comprehensive clinical assessment and specialized burn care knowledge, which can limit their practicality for prompt use in emergency department settings. Our study addresses this gap by demonstrating that routine blood tests, specifically the BUN/albumin ratio, can predict mortality at the time of hospital admission.

To the best of our knowledge, this ratio represents a novel, easily obtainable marker derived from routine admission laboratory tests, potentially enhancing early mortality risk stratification and clinical decision-making in pediatric burn care, with predictive strength comparable to that of ABSI and P-Baux.

An epidemiological study of pediatric burns showed that 35.4% of patients were between aged 1–4 years, and boys were twice as many as girls (71,2%).[17] In our study, similar to the literature, male predominance was observed, and the mean age was 5.41 years.

As demonstrated in adult studies, older age, higher total body surface area, flame burns, presence of inhalation injury, third-degree burns, need for mechanical ventilation, and operative requirements have been identified as poor prognostic factors for survival in burn patients.[18]

A recent study demonstrated that the gender parameter in ABSI scoring does not influence mortality prediction, while the validity of the other parameters of the scoring system remains intact.[19] Female gender is considered a poor prognostic factor for mortality in ABSI scoring. In our study, the overall mortality rate was 4.5% (10 patients), with males accounting for 80% of the deceased patients. While no statistically significant difference was observed, in light of these find-

Table 4. Multivariate logistic regression analysis for predictors of in-hospital mortality

	B	SE	Wald	p-value	Exp(B)	95% CI
BUN	-0.003	0.050	0.003	0.959	0.997	0.904-1.101
BUN/Albumin Ratio	0.206	0.046	19.836	<0.001	1.229	1.122-1.346
ABSI Score	0.667	0.179	13.948	<0.001	1.949	1.373-2.766
P-Baux Score	0.082	0.018	21.025	<0.001	1.086	1.048-1.125

BUN/Albumin ratio, ABSI score, and P-Baux score were independent predictors of mortality ($p<0.001$), whereas BUN alone was not statistically significant. BUN: Blood urea nitrogen; ABSI: Abbreviated Burn Severity Index; P-Baux: Pediatric Baux score; SE: Standard error; Exp(B): Exponentiated coefficient; CI: Confidence interval.

ings, the validity of modified ABSI scoring in pediatric patients should be investigated in future studies.[19]

Albumin is a protein synthesized by the liver that maintains intravascular oncotic pressure. Researchers have used blood albumin levels to monitor patients' nutritional status and as a negative acute-phase reactant.[11] Hypoalbuminemia is associated with increased morbidity and mortality in critically ill patients.[20]

Poor nutrition and inflammation lead to decreased albumin synthesis. As albumin is also a negative acute-phase reactant, obtaining initial values upon admission (before initiating intravenous hydration and nutritional support) is important for reliable results.[21]

In acute physiological stress, blood urea nitrogen levels increase secondary to dehydration and inflammation. Previous studies have shown that elevated BUN levels are indicators of poor prognosis in such patients.[22] In our study, deceased patients had higher BUN levels and lower albumin levels than survivors.

Burn injuries induce a hypermetabolic state, leading to nutritional derangement. Due to factors such as hypermetabolism and increased susceptibility to infection in pediatric burn patients, accurately predicting prognosis is essential to guide appropriate treatment and clinical decision-making.[13]

The BUN/albumin ratio enables evaluation of renal function, degree of inflammation, and nutritional status. Recent studies have shown that a high BUN/albumin ratio is associated with increased mortality in critically ill adult patients in intensive care units.[8]

In summary, both ROC and regression analysis demonstrated that index admission values of ABSI, P-Baux score, and the BUN/albumin ratio are predictors of survival in pediatric patients with severe burns. The BUN/albumin ratio is an independent marker for predicting mortality, without being affected by factors that influence scoring systems, such as age, gender, TBSA, burn depth, and presence of inhalation injury.

Limitations

This study has several limitations that should be considered. First, it was conducted in a single-center setting, which may limit the generalizability of the findings to institutions with different patient populations, care protocols, or resource availability. Second, the retrospective design introduces potential challenges such as incomplete data documentation, selection bias, and unmeasured confounding variables. Third, although BUN and albumin levels were obtained at index admission, the exact timing of laboratory testing relative to the burn injury varied among patients. This temporal variation may have influenced the reliability of the BUN/albumin ratio in accurately reflecting physiological stress and nutritional status. Lastly, the study did not evaluate dynamic changes in BUN or albumin levels during the clinical course, which may provide more precise prognostic information than single time-point measurements.

Future prospective, multicenter studies with larger sample sizes and serial biomarker monitoring are warranted to validate and expand upon these findings.

CONCLUSION

In conclusion, this study highlights the need for rapid and readily available parameters to assess survival in pediatric burn patients. While established scoring systems such as ABSI and P-Baux remain valuable, identifying the BUN/albumin ratio as a significant predictor of mortality offers a simpler and more practical alternative.

Ethics Committee Approval: This study was approved by the Dr. Behcet Uz Pediatric Diseases and Surgery Training and Research Hospital Ethics Committee (Date: 25.05.2023, Decision No: 822).

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ORİJİNAL ÇALIŞMA - *ÖZ*

%20 ve üzeri yanık alanı olan pediatrik hastalarda mortaliteyi değerlendirmede bun/albümin oranının etkisi

AMAÇ: Bu çalışmanın amacı, %20 ve üzeri toplam vücut yüzey alanı (TVYA) yanığı olan pediatrik hastalarda kan üre azotu (BUN)/Albümin oranının hastane içi mortaliteyi öngörmedeki etkinliğini değerlendirmek ve Abbreviated Burn Severity Index (ABSI) ile Pediatrik BAUX (P-BAUX) skorları ile karşılaştırılmasını değerlendirmektir.
GEREÇ VE YÖNTEM: Yanık ünitemizde 2018-2023 yılları arasında, %20 ve üzeri TVYA yanığı ile yatırılan 212 pediatrik hastanın verileri retrospektif olarak incelendi. Hastaların demografik bilgileri, temel klinik verileri, yanık nedeni, operasyon ihtiyacı, ABSI ile P-BAUX skorları ve takip süreçleri analiz edildi. BUN/Albümin oranı, hastaneye ilk başvuru sırasında ölçülen BUN ve albümin değerleriyle hesaplandı. Veriler hastane içi mortalite ile ilişkilendirilerek değerlendirildi.
BULGULAR: Hastaların %37'si kız, %63'ü erkekti ve medyan yaş 4 yıldı. Genel mortalite oranı %4,5 olarak saptandı. ROC analizi, hem ABSI ve P-BAUX skorunun hem de BUN/Albümin oranının mortaliteyi öngörmede benzer düzeyde anlamlı olduğu gösterildi. BUN/Albümin oranı için mortaliteyi öngören eşik değeri >5,24 olarak belirlendi. Eksitus olan hastaların medyan BUN/Albümin oranı, sağ kalan hastalara kıyasla anlamlı derecede daha yüksekti (5,27; 3,41 p = 0,009).
SONUÇ: BUN/Albümin oranının, özellikle %20 ve üzeri toplam yanık yüzey alanına sahip pediatrik hastalarda, hastane içi mortaliteyi öngörmede istatistiksel olarak anlamlı, hızlı, kolay erişilebilir ve uygulanabilir bir biyokimyasal belirteç olduğu ortaya konmuştur. Bu bulgu, söz konusu oranın pediatrik yanık hastalarında erken dönem risk sınıflandırması amacıyla klinik uygulamalarda kullanılabilecek değerli bir prognostik araç olabileceğini düşündürmektedir.

Anahtar sözcükler: ABSI; albümin; BUN; mortalite; P-BAUX; pediatrik yanık.

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