ORIGINAL ARTICLE

Acute kidney injury in burns in the intensive care unit: A retrospective research

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ABSTRACT

BACKGROUND: Acute kidney injury (AKI) is one of the common complications, associated with high mortality and morbidity in patients with burn injuries. This study aimed to determine the frequency of AKI development, its affective factors, and mortality rates according to kidney disease improving global outcomes (KDIGO) criteria in the burn patients.

METHODS: The study included patients who are hospitalized for at least 48 h and aged >18 years, whereas patients with a renal transplant, chronic renal failure, undergoing hemodialysis, <18 years of age, with a glomerular filtration rate of <15 on admission, and toxic epidermal necrolysis was excluded from the study. KDIGO criteria were used to evaluate the occurrence of AKI. Burn mechanism, total body surface area, inhalation injury respiratory tract burn, fluid replacement at 72 h with Parkland Formula, mechanical ventilator support, inotrope/vasopressor support, intensive care unit, lenght of stay, mortality, abbreviated burn severity index (ABSI), acute physiology, and chronic health evaluation II (APACHE II) ve Sequential organ failure assessment (SOFA) were recorded.

RESULTS: A total of 48 patients were included in our study, of which 26 (54.2%) developed AKI (+), whereas 22 (45.8%) did not (−). The mean total burn surface area was 47.30% in the AKI (+) group and 19.88% in the AKI (−) group. Mean scores of ABSI, II (APACHE II), and SOFA, the mechanical ventilation and inotrope/vasopressor support and the presence of sepsis were significantly higher in the AKI (+). No mortality was determined in the AKI (−) group, whereas 34.6% in the AKI (+) group which was significantly high.

CONCLUSION: AKI was related to high morbidity and mortality in patients with burns. Using KDIGOs, classification in daily follow-up is useful in early diagnosis.

Keywords: Acute kidney injury; burns; kidney disease improving global outcomes; mortality.

INTRODUCTION

Treatment of patients with a severe burn injury is still an important multidisciplinary clinical problem. Burns are injuries that occur due to factors, such as contact with high temperatures, chemicals, electrical energy, and radiation, that cause tissue damage. The number and variety of burn cases increased in parallel with the development of industry and technology. Burn is not only a regional injury but a systemic trauma that increasingly affects the whole body, especially with increased burn surface area and depth.[1]

Acute kidney injury (AKI) is a clinical syndrome that can develop within hours, days, or weeks due to a rapid kidney function loss due to decreased glomerular filtration rate (GFR).[2] AKI is a frequently seen complication with a high mortality rate in severe burn patients.[3] The incidence of AKI (38%) and mortality (up to 80%) in severe burn patients is still high, although significant improvements were achieved in intensive care, fluid administer, and renal replacement therapy (RRT) technology in recent years.[4] In addition, AKI increases the length of the intensive care unit (ICU) stay.[5] Patients who survive from AKI tend to develop chronic kidney disease, with a high risk of morbidity and mortality in the long term.[6] Further, AKI can significantly increase treatment costs for the health-care system, especially for RRT.[7]

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Early AKI detection will effectively help avoid nephrotoxicity, thus maintaining adequate fluid management and consequently faster recovery. Today, kidney disease improving global outcomes (KDIGO) criteria was developed for AKI diagnosis using a single simple definition based on the validity of the Risk/Injury/Failure/Loss/End-stage (RIFLE) and AKI Network (AKIN) criteria.[8]

This study aimed to determine AKI incidence, the factors involved in its development, and AKI mortality rate according to the KDIGO criteria in burn patients.

MATERIALS AND METHODS

Electronic records of patients who are followed between 2018 and 2020 were retrospectively reviewed after obtaining permission from the Ethics Committee. In addition, the incidence of AKI development, related factors, and mortality were examined. In this study, patients over 18 years old who are followed in the ICU for at least 48 h were included in the study. Patients with a renal transplant, chronic renal failure-End-Stage Renal Disease, undergoing hemodialysis, <18 years of age, with GFR of <15 on admission, and toxic epidermal necrolysis were excluded from the study. Relevant data were recorded, including patients' demographic data, burn etiology, burn surface area percentage, burn degree, presence of inhalation burn, the fluid amount administered in the 1st 72 h, need for inotropes at AKI diagnosis, need for mechanical ventilation (MV), acute physiology and chronic health evaluation (APACHE) II, sequential organ failure assessment (SOFA) on admission, Abbreviated Burn Severity Index (ABSI) scores, ICU stay, presence of mortality, and sepsis. AKI was diagnosed and classified according to the KDIGO criteria based on the highest creatinine value during hospitalization or the highest creatinine value that required RRT treatment. The lowest creatinine value in the 1st 7 days of hospitalization was noted as the baseline creatinine value. Patients who received RRT therapy were also noted. The KDIGO classification is that, a 0.3 mg/dL increase in serum creatinine within 48 h, a 1.5-fold increase in serum creatinine at baseline, or a decrease in urine output value <0.5 mL/kg/h throughout 6 h. Our study diagnosed AKI according to the increasing rate of creatinine values and KDIGO classification. The AKI developed in the early or late stages was determined and dates of diagnosis were noted. The burned surface area of each patient who was admitted to the ICU was calculated and the amount of fluid to be administered according to the Parkland formula was replaced. Fluid therapy was continued according to the hemodynamic status and urine output of patients. Sepsis was diagnosed according to the infection parameters (leukocyte, C-reactive protein, and procalcitonin) and culture results of patients, and its association with AKI was evaluated.

Statistical Analysis

Data obtained were evaluated in EUMF Biostatistics and Medical Informatics Department. Data analysis was implemented using the Statistical Package for the Social Sciences version 24 (IBM®). Descriptive statistics were presented in the study, concerning the distribution of the responses to independent variables; and numbers and percentages for categorical variables; and mean standard deviation, and median for numerical variables. The Kolmogorov–Smirnow test was used to evaluate the conformity of continuous variables with the assumption of normal distribution and the Shapiro–Wilk test for the conformity of continuous variables with the normal distribution. The Chi-square test was used to examine the distribution relationship between categorical variables, whereas the t-test for two independent groups was used to compare the numerical data. The Student's t-test or Mann–Whitney U test was used for two independent groups and the one-way analysis of variance or Kruskal–Wallis method was used for more than two groups in the comparison of numerical variables between groups. Bonferroni or Dunn Test was performed after multiple analyses. In addition, receiver operating characteristic analysis was applied to determine the cut-off point for numerical variables. Binary logistic regression analysis was used for multiple analyses when data structure was appropriate. The results were evaluated within a 95% confidence interval, considering $p<0.05$ as significant.

RESULTS

Of 51 patients that we followed between March 2018 and January 2020, 48 were included in the study. Three patients were excluded because they were followed in the ICU for <48

Table 1. Patients' demographic data

	AKI (+) (n=26)	AKI (−) (n=22)
Sex (M/F)	21/5	20/2
Age	46.50±17.92	41.14±12.95
Diseases in the medical history (n)	19	20
Yes	7	2
DM	0	1
DM+HT	3	1
HT+CAD	4	0
Burn mechanism, n (%)		
Flame	21 (80.8)	12 (54.5)
Hot liquid	3 (11.5)	0
Electrical burn	1 (3.8)	8 (36.4)
Chemical	1 (3.8)	2 (9.1)
Patients' TBSA, n (%)		
0%–20%	4 (15.3)	13 (59.1)
20%–60%	13 (50)	9 (40.9)
≥60%	9 (34.6)	0 (0.0)

AKI: Acute kidney injury; M: Male; F: Female; HT: Hypertension; DM: Diabetes mellitus; CAD: Coroner artery disease; TBSA: Total body surface area.

h. The mean age of patients was 44±15.9 years. The sample consisted of 41 (85.4%) male and 7 (14.6%) female patients (Table 1). Concomitant diseases of patients are shown in Table 1. Total body surface area (TBSA) was 0–20% in 17 (35.4%), 20–60% in 12 (45.8%), and ≥60% in 9 (18.8%) patients.

Patients were divided into two groups as those with AKI (AKI +) and those without (AKI−). The AKI (+) group consisted of 26 (54.2%) patients, whereas 22 (45.8%) in the AKI (−). AKI developed in all nine patients with TBSA of ≥60%. Mean TBSA was 47.3% in the AKI (+) group, whereas 19.88% in the AKI (−) group (Table 2). A TBSA of ≥25% were found to have 78.9% specificity and 84.6% sensitivity in AKI development. The flame burn was the most common cause in the burn etiology (68.8%). AKI developed in 63.6% of patients with flame burns. Other causes of burn are shown in Table 2. First-degree burns was determined in 1 (2.1%) patient, second-degree in 15 (31.3%), and third-degree in 32 (66.7%). AKI developed in 7 patients (46.7%) with second-degree burn, whereas 19 patients (59.4%) with a third-degree burn. The rate of AKI development was higher in third-degree burns, although no statistically significant relationship was found between the AKI development and the degree of burn. Inhalation burns were determined in 8 (16.7%) patients, of whom 7 (87.5%) developed AKI, which was statistically significant (p=0.042) (Table 2). A total of 11 patients was found to need inotropes, and a significant correlation was detected between the development of AKI and the need for inotropes (p<0.0005) (Table 2). MV support was given to 42.3% of patients with AKI, which was found to be significantly high (p=0.001) (Table 2). Sepsis developed in 76.9% (n=20) of patients with AKI, which was significantly high (p<0.005). The mean creatinine value on admission was 0.82 g/dL in the AKI (−), whereas 1.01 g/dL in the AKI (+). The mean value of the highest recorded creatinine measurements was 0.79 g/dL in the AKI (−), whereas 2.7 g/dL in the AKI (+) group (Table 2). The total amount of fluid given in the first 72 h was 2.176 mL in the AKI (+), whereas 1.315 mL was in the AKI (−). AKI diagnosis was established in the 1st 72 h in four patients, whereas after 72 h in 22 patients. The mean length of ICU stay was 45.2 days in the AKI (+) group, whereas 15.6 days in the AKI (−) group. The mean APACHE II score was 13.12 and 5.5, ABSI score was 9.08 and 5.55, SOFA score on admission was 2.35 and 0.55 in AKI (+) and AKI (−) groups, respectively, displaying

Table 2. Factors associated with acute kidney injury

	AKI (+)	AKI (−)	p
TBSA (mean %)*	47.30±25.2	19.88±16.6	0.003
Respiratory tract burn (n)*	7	1	0.042
APACHEII on admission (mean)*	13.12±8.26	5.5±3.34	<0.001
ABSI (mean)*	9.08±3.08	5.55±1.96	<0.001
SOFA on admission (mean)*	2.35±2.07	0.55±0.73	<0.001
Mean of highest creatinine (g/dL)*	2.7±2.3	0.79±0.13	<0.001
Sepsis (%)*	76.9	13.6	<0.001
ICU length of stay (days)*	45.23±39.9	15.68±18.1	0.001
Endotracheal mechanical ventilation (%)*	42.3	0.00	0.001
Inotrope/vasopressor (%)*	42.3	0.00	<0.001
Fluid replacement at 72h (mL)*	21.760±10.394	13.151±6888	0.006
Mortality (%)*	34.6	0.00	0.002

AKI: Acute kidney injury; TBSA: Total body surface area; ABSI: Abbreviated burn severity index; SOFA: Sequential organ failure assessment; APACHE II: Acute physiology and chronic health evaluation II *p<0.05.

Table 3. The relationship between TBSA and KDIGO stage

TBSA	0%–20%	20%–40%	40%–60%	>60%	Total
KDIGO stage	(n)	(n)	(n)	(n)	(%)
1	2	6	1	1	38.5
2	0	0	1	2	11.5
3	2	1	4	6	50.0
Total, n (%)	4 (15.4)	7 (26.9)	6 (23.1)	9 (34.6)	

TBSA: Total Body Surface Area; KDIGO: Kidney Disease Improving Global Outcomes.

a statistically significant difference between the two groups (Table 2) (p<0.005).

AKI was seen at a rate of 38.5% in Stage 1, 11.5% in Stage 2, and 50.0% in Stage 3 burns in patients based on the KDIGO criteria (Table 3). Four (15.4%) patients received RRT.

The mortality rate was determined as 18.8% in all groups. The mortality rate was 34.6% in patients with AKI. It was observed that AKI developed in nine patients with mortality and was Stage 3 according to the KDIGO criteria. This was statistically significant between mortality and AKI (p=0.002) (Table 2).

DISCUSSION

This study examined AKI, a frequently seen health problem that causes a high mortality rate due to burns in terms of its incidence, related factors, and mortality. Our study results determined the related factors to AKI as increased body surface area burned, sepsis, need for inotropes, need for MV support, ABSI, APACHE II, and SOFA scores, and amount of fluid administered.

Recent studies revealed an increased number of AKI in patients with burns, indicating the need for dialysis to be 2 times more compared to normal patients. The emergence of this problem was attributed to prolonged patients' life span and increased survival in many severe cases.[9,10] Early AKI detection is very important for initiating treatment and reducing mortality in burn patients.

AKI's diagnostic criteria were changed in the past few years, and KDIGO criteria started to be used instead of RIFLE and AKIN criteria.[11] After the burn injury, early AKI occurs in the 1st days, and generally results from rapid fluid loss due to surface area burned, impaired GFR and creatinine values, respiratory failure, hypotension, and hypoproteinemia. Late AKI occurs in weeks after injury and it is caused by drug nephrotoxicity and sepsis complications.[12]

A high incidence of AKI has been reported with severe burns patients.[5] AKI is a heterogeneous condition ranging from subclinical dysfunction in the kidneys to the requirement of RRT. Folkestad et al.[3] reported that 38% of 8200 patients with burns in the ICU developed AKI. Mustonen and Vuola[13] examined 1380 patients with burns, of whom 238 needed to stay in ICU and 39.1% of patients in the ICU developed AKI. Mosier et al.[14] indicated that early AKI development was associated with multiple organ failure and increased mortality in patients with severe burns and that AKI developed in 28% of their patients. Witkowski et al.[10] determined AKI developed in 40% of their patients, and 30% of these patients developed early AKI and 10% late AKI. Of the 48 patients with burns in our study, 54.2% (n=26) were found to have AKI (+) according to the KDIGO criteria. Early AKI was detected in 15.4%, whereas late AKI in 84.6% of patients.

KDIGO criteria enable early AKI detection and facilitate early intervention.[15,16] Our study revealed a 38.5% AKI incidence in Stage 1, 11.5% in Stage 2, and 50.0% in Stage 3 according to KDIGO criteria. In addition, RRT was applied in 4 patients (15.4%) in our study. The study of Chen et al.[8] revealed that early AKI in 36 (28.1%) of 128 patients with burns and 69.4% (25/36) of these patients were found to be at Stage 1, 13.9% (5/36) at Stage 2, and 16.7% (6/36) at Stage 3. In their study on patients in the ICU, Hoste et al.[17] reported that 57% of patients developed early AKI according to the KDIGO criteria, and 13.5% of them received RRT. Our study revealed that 42.3% of patients who developed AKI required MV support, which was significantly high (p=0.001). Chen et al.,[8] (2020) determined that 22 (56.7%) patients with burns who developed AKI needed MV (p=0.042), similar to our study. Coca et al.[18] reported that AKI developed in 26% of 304 patients with severe burn injuries, and this was associated with longer MV requirements and ICU stay. The study of Witkowski et al.[10] revealed that respiratory failure developed in 62.4% of patients with burns with AKI and needed MV.

Mortality due to AKI in patients with burns is generally associated with prolonged ICU stay.[18] Mortality rate in our patients with AKI was 34.6% (p=0.002). Our study results confirmed the relationship between the mortality rate and the presence of AKI. Chen et al.[8] reported that mortality occurred in all patients with Stage 3 burns and with AKI according to the criteria of KDIGO. Folkestad et al.[3] reported mortality in 43% of patients with burns who developed AKI. Mustonen and Vuola[13] revealed that patients who are hospitalized in the ICU due to burn trauma have a mortality rate of 44.1% in patients with AKI and 6.9% in those without AKI (p<0.001).

The most common causes of mortality in ICUs are sepsis and septic shock. They are also taken responsibility for 35–50% of AKI in the ICU. The balance between the production and destruction of cytokines changes in sepsis. Direct endothelial damage develops as a result of increased cytokine production. AKI develops due to renal perfusion damage. AKI in sepsis that developed burn patients is associated with a high risk of death.[19] Our study revealed sepsis in 76.9% of patients with AKI, which was considered statistically significant (p<0.005). Studies revealed that AKI incidence can be reduced by establishing standard fluid resuscitation in patients with burns. Hypovolemia and early renal complications can largely be avoided through transfusion of high volumes of fluid, mainly crystalloids, about several liters per day during the early treatment period.[10] Our study calculated the amount of fluid according to the Parkland formula and was replaced in patients in the ICU. Larger volumes were replaced in the AKI (+), and a significant difference was detected between two groups. Contrarily, studies revealed that excessive volume overload can aggravate kidney damage.[20]

Our study revealed that four patients were diagnosed with AKI in the 1st 72 h, whereas 22 after 72 h. The study of Fol-

kestad et al.[3] revealed that AKI diagnosis ranged from 1 to 17 days. Our study revealed approximately 30 days mean ICU stay in AKI (+), which was longer than the AKI (−). The study of Folkestad et al.[3] revealed that the mean ICU stay was 8.6 (4–13.2) days longer in patients with burn who developed AKI.

Our study revealed the mean APACHE II score of 13.12, ABSI of 9.08, and SOFA at admission of 2.35 in the AKI (+) group, displaying a statistically difference between two groups ($p<0.005$). Similarly Folkestad et al.[3] found the mean APACHE II score as 6.6, ABSI score as 7, and SOFA score on admission as 4.9. Chen et al.,[8] (2020) found the mean ABSI score of patients with burns who developed AKI as 6.25. Palmieri et al.[21] indicated that the SOFA score was 6.3±2.5, the APACHE II score was 15.8 (11–19), the ABSI score was 8.5±1.4, and the TBSA score was 42.2±17 in patients with burns who developed AKI.

Conclusion

Our study revealed the high incidence of AKI in burn patients in our ICU and defined the factors that are associated with AKI, and evaluated the relationship of AKI with mortality.

The incidence of AKI increases as the burned body surface area increases. Sepsis, need for inotrope use, need for MV support, ABSI, APACHE II, and SOFA scores, and liters of fluid administered are the factors associated with AKI. The development of AKI is associated with high mortality. KDIGO criteria have an important role in early diagnosis of AKI, help in predicting prognosis of patients with severe burn injury, and reduce the length of hospital stay and treatment process. KDIGO classification in daily follow-up may be useful in early diagnosis.

Ethics Committee Approval: This study was approved by the Ege University Medical Research Ethics Committee (Date: 05.02.2020, Decision No: 20-2T/31).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Yanık yoğun bakım hastalarında akut böbrek hasarı: Retrospektif araştırma

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AMAÇ: Akut böbrek hasarı, yanık travmalı hastalarda yüksek mortalite ve morbidite ile ilişkili yaygın komplikasyonlardan biridir. Bu çalışmada, yanık hastalarında KDIGO kriterlerine göre akut böbrek hasarı gelişme sıklığı, etkileyen faktörleri ve mortalite oranlarının belirlenmesi amaçlanmıştır.

GEREÇ VE YÖNTEM: Çalışmaya en az 48 saat hastanede yatan ve 18 yaşından büyük hastalar dahil edilirken, böbrek transplantasyonu olan, kronik böbrek yetersizliği olan, hemodiyaliz uygulanan, 18 yaşından küçük, başvuru sırasında glomerüler filtrasyon hızı <15 olan hastalar ve toksik epidermal nekroliz tanılı hastalar çalışma dışı bırakılmıştır. Akut böbrek hasarı, KDIGO sınıflamasına göre saptandı. Hastaların yaş, cinsiyet, yanık etiyolojileri, yanık yüzdeleri, inhalasyon hasarının varlığı, ilk 72 saatte Parkland formülü ile verilen total sıvı miktarı, mekanik ventilatör desteği, inotrop/vazopresör ihtiyacı, yoğun bakım kalış süresi, mortalite, Abbreviated Burn Severity Index (ABSI), Acute Physiology and Chronic Health Evaluation II (APACHE II) ve Sequential Organ Failure Assessment (SOFA) değerleri kaydedildi.

BULGULAR: Çalışmamıza akut böbrek hasarı gelişen (+) grupta 26 (%54.2), akut böbrek hasarı gelişmeyen (-) grupta 22 (%45.8) olmak üzere toplam 48 hasta dahil edildi. Akut böbrek hasarı (+) grubunda ortalama toplam yanık yüzey alanı %47.30, akut böbrek hasarı (-) grubunda ise %19.88 idi. Abbreviated Burn Severity Index (ABSI), Acute Physiology and Chronic Health Evaluation II (APACHE II) ve Sequential Organ Failure Assessment (SOFA), mekanik ventilasyon ve inotrop/vazopresör desteği ve sepsis varlığının akut böbrek hasarı (+) olan grupta anlamlı olarak daha yüksekti. Akut böbrek hasarı (-) grubunda mortalite saptanmazken, akut böbrek hasarı (+) grubunun mortalite oranı %34.6 olduğu görüldü ve anlamlı derecede yüksekti.

TARTIŞMA: Akut böbrek hasarının, yanıklı hastalarda yüksek morbidite ve mortalite ile ilişkili olduğu görüldü. Kidney Disease Improving Global Outcomes sınıflandırmasının günlük takipte kullanılması erken tanıda faydalıdır.

Anahtar sözcükler: Akut böbrek hasarı; Kidney Disease Improving Global Outcomes; mortalite; yanık.

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