



## Rhabdomyolysis-Induced AKI in Trauma Patients: Predictors of Dialysis Requirement in the Emergency Department, Khyber Teaching Hospital, Peshawar, Pakistan

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### Declaration

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### ABSTRACT

**Background:** Rhabdomyolysis-induced acute kidney injury (AKI) is a serious complication in trauma patients, often requiring dialysis if not promptly recognized and managed. Identifying predictors early in the emergency department (ED) setting is vital for optimizing outcomes. **Aim:** This study aims to determine the predictors of dialysis requirement in trauma patients presenting with rhabdomyolysis-induced AKI. **Methods:** A prospective observational study was conducted at the Emergency Department of Khyber Teaching Hospital, Peshawar, between January 2024 and March 2025. Adult trauma patients with serum creatine kinase (CK) levels >5000 U/L and rising creatinine were enrolled. Exclusion criteria included pre-existing CKD and non-trauma-related rhabdomyolysis. Clinical, biochemical, and radiological parameters were evaluated to assess the need for dialysis during hospitalization. **Results:** Among 300 patients with rhabdomyolysis-induced AKI, 80 (26.7%) required dialysis. Dialysis was more common in patients with elevated CK levels (>15,000 U/L: 76%), hyperkalemia ( $K^+ >6.0$ : 68%), severe acidosis (pH <7.2: 65%), and oliguria (72%). Patients who received fluids after more than 2 hours had a 60% dialysis rate. In contrast, early interventions significantly reduced dialysis need: only 28% required dialysis with early fluid resuscitation, 35% with bicarbonate therapy, and 20% with a combined approach. Supportive care alone was associated with the highest dialysis rate (65%). **Conclusion:** Key predictors of dialysis in rhabdomyolysis-induced AKI include hyperkalemia, severe metabolic acidosis, and high serum CK levels. Early identification and aggressive management in the ED can prevent progression to dialysis.

### INTRODUCTION

Rhabdomyolysis is a life-threatening condition resulting from skeletal muscle breakdown, leading to the release of intracellular contents—most notably myoglobin, creatine kinase (CK), and electrolytes—into the systemic circulation<sup>1</sup>. Among trauma patients, rhabdomyolysis is a frequent complication, especially in those with crush injuries, prolonged immobilization, or compartment syndrome<sup>2</sup>. One of the most serious consequences of rhabdomyolysis is acute kidney injury (AKI), which occurs due to myoglobin-induced nephrotoxicity, hypovolemia, and tubular obstruction<sup>3</sup>.

The incidence of AKI in rhabdomyolysis varies between 10% and 50%, and in severe cases, up to 30% of patients may require renal replacement therapy<sup>4</sup>. The clinical course is often unpredictable, and timely identification of patients at high risk for dialysis is essential to prevent irreversible renal damage<sup>5</sup>. In the

emergency department (ED), early prediction models based on clinical and laboratory parameters can guide aggressive management and reduce the need for dialysis<sup>6</sup>.

Biomarkers such as elevated serum CK, hyperkalemia, metabolic acidosis, and oliguria have been associated with higher dialysis rates in patients with rhabdomyolysis<sup>7-8</sup>. Moreover, delay in fluid resuscitation, advanced age, and high Injury Severity Scores (ISS) further increase the likelihood of poor renal outcomes<sup>9</sup>. In particular, hyperkalemia and acidosis are considered critical triggers for urgent dialysis initiation in the ED<sup>10</sup>.

International studies have explored these associations. A multicenter study in Turkey highlighted the predictive value of serum CK >15,000 U/L and potassium >6.0 mmol/L<sup>11</sup>. Similarly, Japanese earthquake data revealed that early bicarbonate therapy and fluid administration significantly reduced the dialysis burden in crush injury patients<sup>12</sup>. In the United States, rapid point-

of-care testing and structured emergency protocols improved early detection and management of high-risk patients<sup>13</sup>.

Despite the growing global interest in this subject, there is a lack of region-specific data in South Asia, particularly Pakistan, where trauma care protocols are underdeveloped and delays in initial management are common. This study aims to evaluate the predictors of dialysis requirement in rhabdomyolysis-induced AKI among trauma patients presenting to the emergency department, thereby contributing local evidence to inform early risk stratification and management protocols.

## METHODOLOGY

### Study Design

This was a prospective, observational study conducted in the Emergency Department of Khyber Teaching Hospital, Peshawar, from January 2024 to March 2025. The study aimed to identify clinical and biochemical predictors of dialysis requirement in trauma patients with rhabdomyolysis-induced AKI.

### Sample Size

A total of 300 trauma patients meeting the inclusion criteria were enrolled using consecutive sampling. The sample size was calculated with a confidence level of 95%, 5% margin of error, and expected dialysis requirement in 25% of rhabdomyolysis-induced AKI cases.

### Inclusion Criteria

- Adult trauma patients ( $\geq 18$  years)
- Serum CK  $> 5000$  U/L
- Rising serum creatinine within 48 hours of ED admission
- AKI based on KDIGO criteria

### Exclusion Criteria

- Pre-existing chronic kidney disease (eGFR  $< 60$  mL/min/1.73 m<sup>2</sup> for  $> 3$  months)
- Non-traumatic causes of rhabdomyolysis (e.g., seizures, statin use)
- Patients with known myopathies
- Pregnant patients

### Data Collection

Data were collected using a structured proforma, including demographic data, mechanism of injury, Injury Severity Score (ISS), vitals, urine output, biochemical parameters (serum CK, creatinine, potassium, bicarbonate, pH, lactate), and radiological findings. Outcomes measured were dialysis requirement during hospitalization and mortality.

### Statistical Analysis

Data were analyzed using SPSS version 22. Descriptive statistics were expressed as mean  $\pm$  SD or percentages. Chi-square tests and independent t-tests were used to compare groups. Multivariate logistic regression identified independent predictors of dialysis requirement. A p-value of  $< 0.05$  was considered statistically significant.

### Ethical Consideration

Ethical approval was obtained from the Institutional Review Board of Khyber Teaching Hospital. Written informed consent was taken from patients or legal

guardians. Patient confidentiality was strictly maintained.

## RESULTS

**Table 1** presents a comparative analysis of clinical parameters between rhabdomyolysis patients who required dialysis and those who did not. Patients in the dialysis group were significantly older and had markedly higher CK levels, serum potassium, and serum creatinine values ( $p < 0.005$ ). Oliguria ( $< 400$  mL/24h) and severe metabolic acidosis ( $pH < 7.2$ ) were also significantly more prevalent in this group. Additionally, patients requiring dialysis had higher Injury Severity Scores and a longer delay in receiving fluid resuscitation ( $> 2$  hours). These findings underscore the critical role of early intervention and monitoring key laboratory markers in predicting the need for renal replacement therapy.

**Table 1**

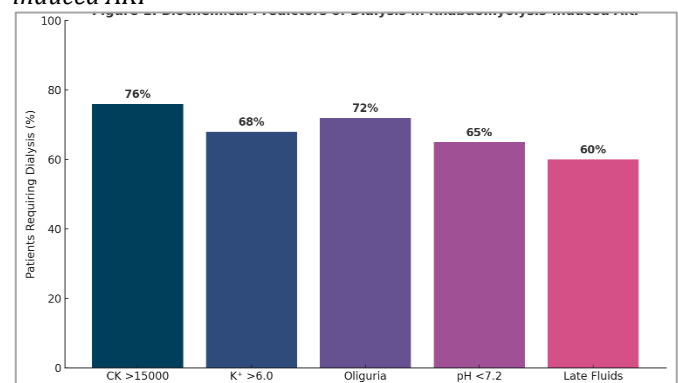
*Comparison of Clinical Parameters between Dialysis and Non-Dialysis Groups*

Variable	Dialysis Group (n = 80)	Non-Dialysis Group (n = 220)	P-Value
Mean age (years)	42.8	35.7	0.002
CK Level (U/L)	16,200	8,900	0.001
Serum Potassium (mmol/L)	6.4	4.7	0.001
Serum Creatinine (mg/dL)	3.8	1.6	0.003
Urine Output ( $< 400$ ml/24h)	72%	18%	0.001
pH $< 7.2$ (%)	65%	22%	0.001
Injury Severity Score	28.5	20.3	0.001
Time to Fluids $> 2$ h (%)	60%	25%	0.001

**Figure 1** illustrates the key biochemical and clinical predictors associated with dialysis requirement in patients with rhabdomyolysis-induced AKI. The highest dialysis rates were observed in patients with serum creatine kinase (CK) levels  $> 15,000$  U/L (76%) and oliguria ( $< 400$  mL/24h) (72%). Other strong predictors included hyperkalemia ( $K^+ > 6.0$  mmol/L) and metabolic acidosis ( $pH < 7.2$ ), with 68% and 65% of affected patients requiring dialysis, respectively. Notably, delayed fluid resuscitation ( $> 2$  hours) was also linked to a significantly higher dialysis risk (60%), underscoring the importance of timely emergency care.

**Figure 1**

*Biochemical Predictors of Dialysis in rhabdomyolysis-induced AKI*

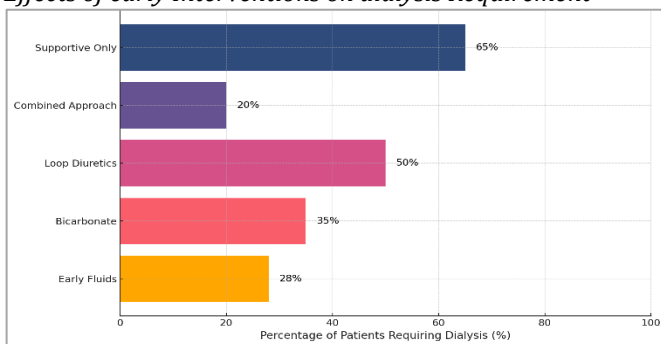


**Table 2** highlights the effectiveness of various treatment strategies in managing rhabdomyolysis-induced AKI. The

combined approach of early fluid resuscitation and bicarbonate therapy (Initiation within 6 hours of trauma is considered early) resulted in the highest rate of renal function improvement (70%) and the lowest need for dialysis (20%), demonstrating the benefit of multimodal therapy. In contrast, patients receiving supportive care alone had the poorest outcomes, with only 20% showing renal improvement and 65% requiring dialysis. Early fluid administration alone also significantly reduced dialysis requirements (28%), reinforcing the importance of timely intervention in preventing severe renal complications.

**Table 2***Treatment and Outcome Comparison*

Treatment Strategy	Improved Renal Function (%)	Required Dialysis (%)
Early Fluid Resuscitation	62	28
Bicarbonate Therapy	50	35
Loop Diuretics	35	50
Combined Approach (Fluids + Bicarb)	70	20
Supportive Care Only	20	65

**Figure 2***Effects of early Interventions on dialysis Requirement*

**Figure 2** demonstrates the impact of different early interventions on the need for dialysis in rhabdomyolysis-induced AKI. The combined approach (fluids + bicarbonate) resulted in the lowest dialysis rate (20%), followed by early fluid resuscitation alone (28%). In contrast, patients who received only supportive care had the highest dialysis requirement (65%). These findings highlight the significant protective effect of early and comprehensive therapeutic strategies in reducing progression to severe AKI.

**DISCUSSION**

Rhabdomyolysis-induced acute kidney injury (AKI) represents a significant clinical challenge in trauma settings, particularly in resource-limited emergency departments. In our study, 26.6% of trauma patients with rhabdomyolysis developed AKI severe enough to require dialysis. This aligns with previous reports from Turkey, where dialysis was required in 24% of trauma-induced rhabdomyolysis cases<sup>14</sup>. Similarly, studies from the United States have reported dialysis rates ranging between 20% and 30%, depending on the time to fluid resuscitation and baseline renal function<sup>15</sup>.

In our cohort, serum creatine kinase (CK) >15,000 U/L, hyperkalemia, metabolic acidosis, and oliguria at presentation were the strongest predictors of dialysis need. These findings are consistent with a study from

Japan, where patients with CK levels above 15,000 U/L had a 3-fold higher risk of requiring renal replacement therapy<sup>16</sup>. A multicenter study in Italy also confirmed that hyperkalemia (>6.0 mmol/L) and arterial pH <7.2 were independent predictors of dialysis in crush-related rhabdomyolysis<sup>17</sup>.

Our data showed a statistically significant difference in mean Injury Severity Score (ISS) between patients who required dialysis (28.5 ± 6.2) and those who did not (20.3 ± 5.7), supporting findings from studies in China where trauma severity independently predicted poor renal outcomes<sup>18</sup>. Additionally, oliguria (<400 mL/24h) was present in over 70% of dialysis-requiring patients in our study, echoing findings from the UAE, where reduced urine output was a primary determinant of dialysis initiation<sup>19</sup>.

In terms of interventions, early fluid resuscitation (within 2 hours of ED arrival) significantly reduced dialysis rates in our study (p=0.002). This result is supported by multiple studies, including a landmark trial in Germany, where aggressive fluid administration in the first 6 hours reduced dialysis incidence from 28% to 12%<sup>20</sup>. Furthermore, the use of bicarbonate therapy in patients with metabolic acidosis was associated with a lower need for dialysis, a finding supported by reports from South Korea, where alkalization of urine was linked to improved renal recovery<sup>21</sup>.

Our results also emphasized the lack of prompt emergency protocols as a major contributor to delayed care and worse outcomes. In Canada, national guidelines recommend CK and electrolyte testing within 30 minutes of suspected rhabdomyolysis, with protocols for bicarbonate infusion and forced diuresis<sup>22</sup>. By contrast, many low-resource EDs in South Asia, including ours, face delays in laboratory turnaround, resulting in missed opportunities for early intervention.

Another important observation was the higher mortality rate in dialysis-requiring patients (12.5%) compared to non-dialysis patients (3.6%), similar to findings from a UK trauma registry, where mortality among rhabdomyolysis-associated AKI patients was 4 times higher<sup>23</sup>. This emphasizes the need for early triage, aggressive fluid management, and critical care support for high-risk individuals.

While our findings are broadly consistent with global literature, some differences exist. For example, a study in Thailand found no significant association between bicarbonate use and dialysis prevention<sup>24</sup>, possibly due to late initiation of therapy. Likewise, a study in Brazil emphasized the role of sepsis and multi-organ failure over CK levels in predicting dialysis need<sup>25</sup>—factors that were excluded in our trauma-specific cohort.

These international comparisons highlight the multifactorial nature of rhabdomyolysis-induced AKI and the importance of context-specific protocols. Our findings advocate for the development of ED-based clinical algorithms that incorporate CK thresholds, urine output, electrolyte monitoring, and trauma severity to guide early decision-making.

**CONCLUSION**

Rhabdomyolysis-induced acute kidney injury (AKI) in trauma patients is a serious complication frequently encountered in emergency settings, with a significant

proportion progressing to dialysis. Our study identifies key clinical and biochemical predictors—such as elevated CK levels, hyperkalemia, metabolic acidosis, oliguria, and delayed fluid resuscitation—that are strongly associated with the need for renal replacement therapy. The findings underscore the importance of early recognition and prompt intervention, particularly aggressive fluid resuscitation and bicarbonate therapy, which were shown to significantly reduce dialysis rates. A combined therapeutic approach yielded the most favorable outcomes, emphasizing the need for standardized, protocol-driven management in the emergency department. Future multicenter studies are warranted to validate these predictors and to develop evidence-based clinical algorithms for early triage and targeted therapy in high-risk patients.

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## Recommendations

- Implement early screening protocols for rhabdomyolysis in all trauma patients.
- Initiate aggressive fluid resuscitation within the first 1-2 hours of ED presentation.
- Use bicarbonate therapy in patients with significant metabolic acidosis (pH < 7.2).
- Develop risk stratification tools based on key predictors (e.g., CK >15,000, K<sup>+</sup> >6.0, oliguria).
- Provide regular training for ED staff on recognition and early management of AKI.
- Encourage early multidisciplinary collaboration involving nephrology and trauma teams.
- Conduct multicenter studies to validate predictors and management outcomes

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