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Rhabdomyolysis with Aki: Exploring Clinical Presentation and Unveiling the Mortality Benefit of Early Detection of Disease Severity and Treatment Approach in Tertiary Care Hospital

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ABSTRACT:

Background: Rhabdomyolysis is a serious condition characterized by skeletal muscle breakdown leading to the release of intracellular contents, including myoglobin, into the bloodstream, often resulting in acute kidney injury (AKI). This study aims to investigate the clinical characteristics, etiologies, and management approaches for rhabdomyolysis, with a focus on the prognosis and treatment outcomes.
Methods: This retrospective observational study was conducted at Saveetha Medical College's Department of Medicine. It involved 30 patients with AKI secondary to rhabdomyolysis, confirmed through elevated serum CPK levels. Data on demographics, etiology, clinical presentation, and treatment were analyzed.
Results: The study predominantly involved young to middle-aged males, reflecting specific occupational or lifestyle risk factors. The most common etiologies were physical trauma and AKI with hypokalemia. Clinical data indicated prevalent renal impairment and muscle damage, with varying levels of urea, creatinine, CPK, and electrolytes. The qSOFA score distribution and ICU stay durations indicated varied patient severity, with most requiring short ICU stays. Hemodialysis was more commonly employed over conservative fluid management. Correlation analysis showed significant associations between certain biochemical markers, like potassium and CPK, and the duration of hospital stays.
Conclusion: Our findings highlight the need for early detection and tailored management strategies for rhabdomyolysis, given its varied presentations and severe potential outcomes. The reliance on hemodialysis points to the severity of renal complications. Future research should focus on larger, multicenter studies to explore diverse demographics, and long-term outcomes, and compare treatment modalities.

Keywords: Rhabdomyolysis, Acute Kidney Injury, Clinical Characteristics, Etiology, Management, Prognosis.

1. Introduction

Rhabdomyolysis, a clinical condition characterized by the rapid breakdown of skeletal muscle, leads to the release of intracellular contents, including myoglobin, into the bloodstream.[1] This cascade can result in acute kidney injury (AKI), a severe complication that significantly contributes to patient morbidity and mortality. The pathophysiology of rhabdomyolysis-induced AKI involves myoglobin deposition in the renal tubules, causing tubular obstruction and renal vasoconstriction.[2] Despite advances in understanding the mechanistic pathways, the clinical presentation of rhabdomyolysis with concurrent AKI varies widely, posing challenges in early diagnosis and management.

Rhabdomyolysis is a multifaceted disorder marked by the disintegration of damaged skeletal muscle tissues. This breakdown releases various intracellular muscle components, such as myoglobin, creatine phosphokinase (CPK), lactate dehydrogenase, and electrolytes, into the bloodstream.[3] A key diagnostic feature of rhabdomyolysis is myoglobinuria, which is the detection of myoglobin in the urine. This condition can lead to severe and potentially fatal complications, including electrolyte imbalances, acute kidney injury (AKI), shock, and disseminated intravascular coagulation. In severe cases, these complications can elevate mortality rates to as high as 37%.[4]

One of the most concerning outcomes of rhabdomyolysis is AKI, which is responsible for 7-10% of all acute renal failure cases.[5] A retrospective study of 2371 patients with rhabdomyolysis, all presenting CPK levels above 5000 U/L, highlighted this risk. In this group, a striking 47.7% developed AKI, and the associated mortality rate during hospitalization was observed to be 14.1%.[6]

Rhabdomyolysis can present with a spectrum of symptoms, from asymptomatic elevations in creatine kinase (CK) levels to life-threatening complications like AKI. This variability makes early diagnosis challenging, and a better understanding of the clinical presentation can aid in more prompt and accurate diagnosis. AKI is associated with increased mortality and morbidity, particularly in the context of rhabdomyolysis.[7] Investigating the factors contributing to the severity of AKI in these patients is crucial for improving patient outcomes. Timely identification of disease severity and initiation of appropriate treatment are pivotal in managing rhabdomyolysis-induced AKI.[8] The study aims to evaluate the mortality benefit of early detection and intervention.

There is a lack of consensus on the optimal treatment approach for rhabdomyolysis-induced AKI. This study will compare the effectiveness of different treatment modalities, including fluid resuscitation, renal replacement therapy, and pharmacological interventions, in improving patient outcomes. Conducting this study in a tertiary care hospital provides an opportunity to observe a diverse patient population with varying degrees of disease severity, allowing for a comprehensive analysis of clinical presentations and treatment outcomes.

Aim

- To analyze patients with rhabdomyolysis who presented to emergency departments and identify their distribution of related disease and prognostic factors.

2. Methodology

Study design: This observational study, conducted in the Department of Medicine at Saveetha Medical College, aims to determine the prevalence and clinical-etiologic profile of Rhabdomyolysis and its clinical significance.

Participants: The study includes patients diagnosed with AKI secondary to Rhabdomyolysis, confirmed through elevated serum CPK levels at our hospital. A thorough clinical history and examination were conducted for all participants.
Study Parameters:
Sample Size: 30
Study Type: Retrospective study
Sampling Method: Simple random sampling

Inclusion criteria

- Patients with serum CPK values above a certain threshold (not specified).
  Exclusion criteria:
- Patients unwilling to give consent.
- Patients with Autoimmune myositis.
- Patients with Chronic kidney disease.
- Post-transplant patients.

Data Collection: Data including demographic details (sex, age), arrival mode, final diagnosis, statin use, rhabdomyolysis triggers, and serum levels of CPK, myoglobin, creatinine, sodium, potassium, phosphate, calcium, and lactate were gathered from medical records for analysis.
Definition of AKI: AKI is defined as per the 2012 Kidney Disease: Improving Global Outcomes (KDIGO) guidelines, which include an increase in serum creatinine by 0.3 mg/dL or more within 48 hours, an increase by 1.5 times or more within 7 days, or urine output below 0.5 mL/kg/h for 6 hours.
Statistical Analysis:
Categorical variables were presented as means and percentiles and analyzed using chi-squared or Fisher's exact test. Continuous variables were expressed as means with standard deviations (SDs) or medians with interquartile ranges (IQRs), analyzed using Student's t-test or the Mann–Whitney U test. A p-value of less than 0.05 was considered statistically significant. All statistical analysis was performed using SPSS version 26.0

3. Results

In Table 1, which outlines the baseline characteristics of study participants, we see a diverse age representation among the 30 patients involved in the study. The age group of 18-40 years comprises the largest segment, with 12 individuals accounting for 40% of the total, indicating a strong presence of younger adults. The 41-60 years age group is also well-represented with 10 participants, making up 33.3% of the study population, while those over 60 years old form the smallest group with 8 participants, or 26.7%. This distribution suggests the study primarily includes younger and middle-aged adults, with a lesser focus on the older population. Regarding gender, the study shows a significant male predominance, with 23 male participants (76.7%), compared to 7 females (23.3%).

Table 1: Baseline characteristics of study participants

Patient Demographics	**Number of Patients n=30 (%)**
Age Group	
18-40 years	12 (40)
41-60 years	10 (33.3)
>60 years	8 (26.7)
Gender	
Male	23 (76.5)

Female	7 (23.5)

Table 2 provides an insightful overview of the various etiologies of rhabdomyolysis among 30 patients. The most common causes in this sample are soft tissue injury due to road traffic accidents and AKI with hypokalemia, each accounting for 23.3% of cases. This highlights the significant impact of physical trauma and kidney-related issues on the development of rhabdomyolysis. Statin-induced rhabdomyolysis and sepsis-induced rhabdomyolysis (specifically due to E. coli) are also notable causes, representing 13.3% and 10% of the cases respectively. The presence of multiple drug poisoning, recurrent seizures, right lower limb cellulitis in conjunction with chronic kidney disease stage 5, and grade 4 renal injury due to parenchymal laceration, though less frequent, underscores the diversity of factors that can lead to rhabdomyolysis. Interestingly, singular instances of snakebite and hypokalemic periodic paralysis as causes account for a smaller percentage (3.3% each), illustrating the varied and sometimes rare etiologies of this condition.

Table 2: Etiology of Rhabdomyolysis

Etiology	**Number of Patients n=30 (%)**
Snakebite	1 (3.3)
Statin-induced rhabdomyolysis	4 (13.3)
Sepsis-induced (E. coli) rhabdomyolysis	3 (10)
Hypokalemic periodic paralysis	1 (13.3)
Multiple drug poisoning	2 (6.67)
Recurrent seizures	1 (3.3)
Soft tissue injury (Road traffic accident)	7 (23.3)
Right lower limb cellulitis/CKD stg 5	2 (6.67)
Grade 4 Renal injury (Parenchymal Laceration)	1 (3.3)
RTA/ rhabdomyolysis/ AKI Stg 3	1 (3.3)
AKI with Hypokalemia	7 (23.3)

Table 3 reveals that the median urea level is 98 with an interquartile range (IQR) of 19, indicating potential renal impairment in these patients. The mean creatinine level is 3.85 with a standard deviation (SD) of 1.22, further suggesting compromised kidney function, which is a significant concern in conditions such as rhabdomyolysis. Creatine Phosphokinase (CPK) levels, crucial for diagnosing muscle damage, show a median of 1142 with an IQR of 1506, highlighting substantial muscle injury or stress. Potassium levels are near the upper normal limit, with a median of 4.90 and an IQR of 0.60, posing a risk for hyperkalemia. Lactate levels, indicating metabolic stress, are elevated with a median of 3.60 and an IQR of 2.80. In contrast, calcium levels appear to be within the normal range, with a mean of 8.05 and an SD of 0.54, suggesting that calcium imbalance is not a major issue in this group. Overall, these findings point towards significant muscle breakdown and possible kidney dysfunction, along with signs of metabolic stress, all of which are critical in assessing the prognosis of the condition under study.

Table 3: Prognostic factors

Factor	**Value**
Urea #	98 (19)
Creatinine *	3.85 (1.22)

CPK #	1142 (1506)
Potassium #	4.90 (0.60)
Lactate #	3.60 (2.80)
Calcium *	8.05 (0.54)

* - Mean (SD); # - Median (IQR)

Figure 1 shows that a significant portion, 41.2% (12 patients), have a qSOFA score of 0, indicating a lower risk of severe outcomes or organ failure, suggesting these patients may be in a relatively stable condition. In contrast, 35.3% (11 patients) score 1 on the qSOFA scale, which points to a moderate risk of complications like sepsis or organ dysfunction, necessitating closer monitoring. More concerning are the 17.6% (5 patients) with a score of 2, denoting a high risk of poor outcomes and likely requiring immediate and aggressive intervention. Lastly, a small yet critical group of 5.9% (2 patients) score the highest at 3, indicating a very high risk of critical illness or mortality, and thus, likely requiring the most intensive care and vigilance.

Figure 1: qSOFA scores in the study participants

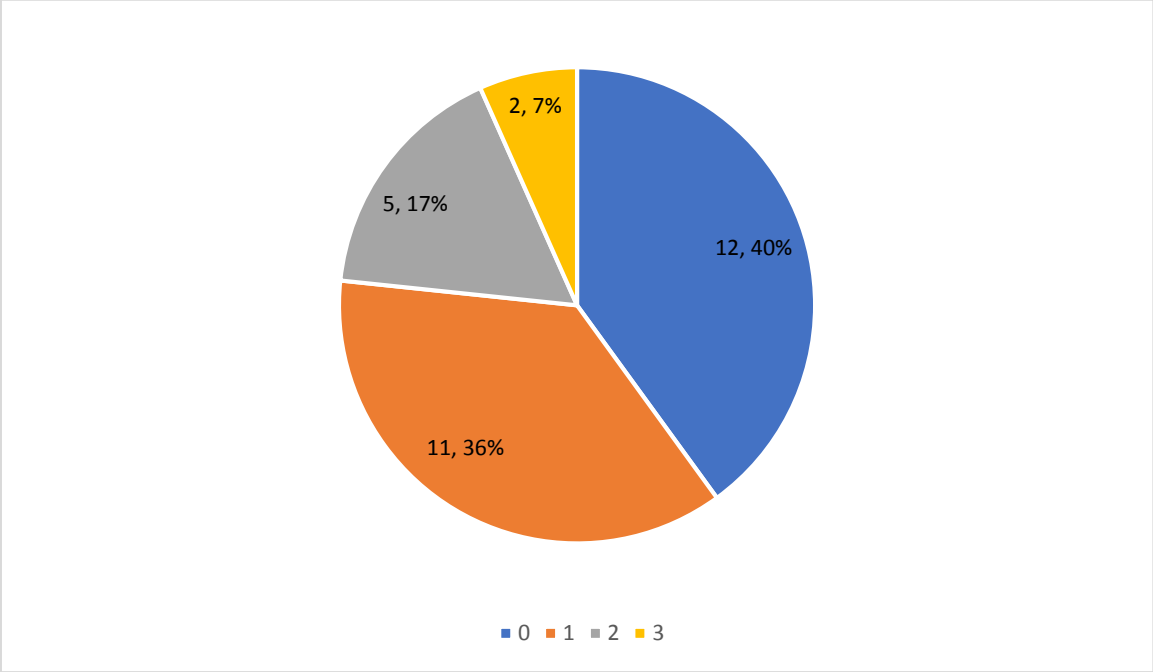

Figure 2 shows a notable 29.4% of the patients (9 out of 30) spent just one day in the ICU, suggesting they either had minor complications or responded well to treatment. The largest proportion, 47.1% (14 out of 30), stayed for two days, indicating a moderate severity in their conditions requiring an extended period of intensive care. A smaller group, 11.8% (4 out of 30), needed three days in the ICU, possibly due to more complex medical needs or longer monitoring. Only 5.9% (2 out of 30) stayed for four days, and an equal percentage (another 5.9% or 1 out of 30) had the longest stay of six days, suggesting these patients faced particularly severe medical challenges.

Figure 2: Duration of ICU stay in the study participants

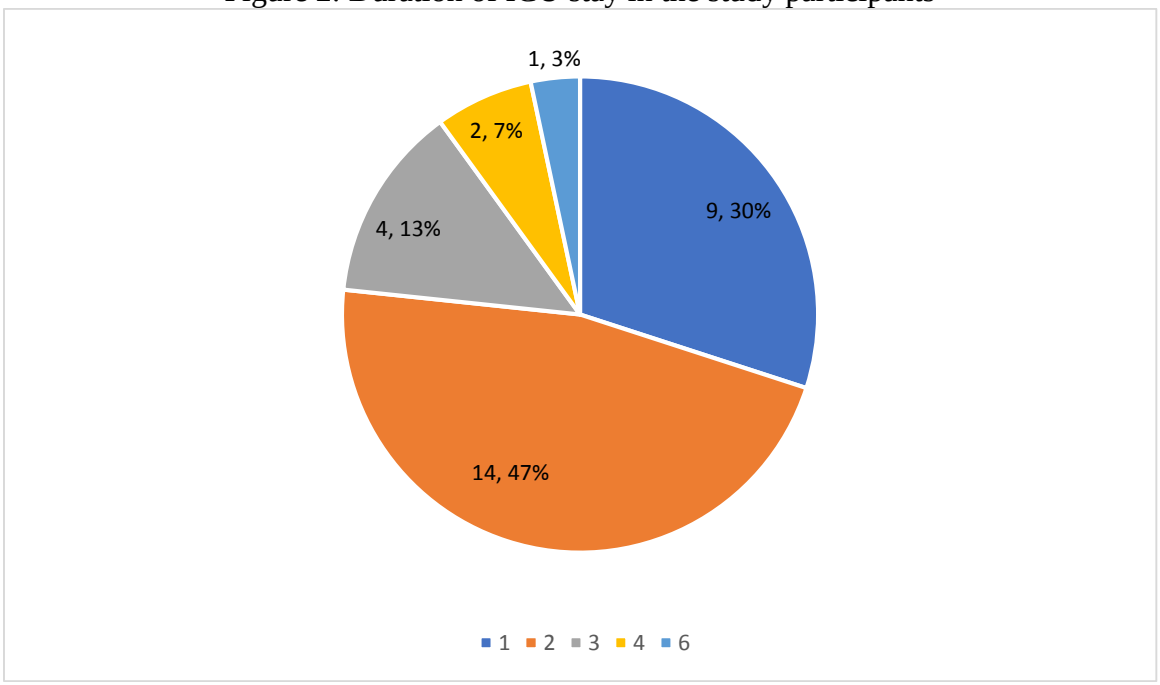

Figure 3 presents that out of the total patient count, only 5.9% (11 patients) were treated with conservative fluid management. This relatively small percentage suggests that in the majority of cases, a more aggressive or interventionist treatment than simple fluid management was deemed necessary. In contrast, a significant 64.7% of the patients (19 out of 30) underwent hemodialysis, indicating that a majority of the cases involved severe renal complications or other conditions requiring renal support. The high reliance on hemodialysis points to the seriousness of the patient's conditions, as hemodialysis, is typically reserved for more severe cases where the kidneys are unable to filter waste from the blood effectively.

Figure 3: Management of Rhabdomyolysis

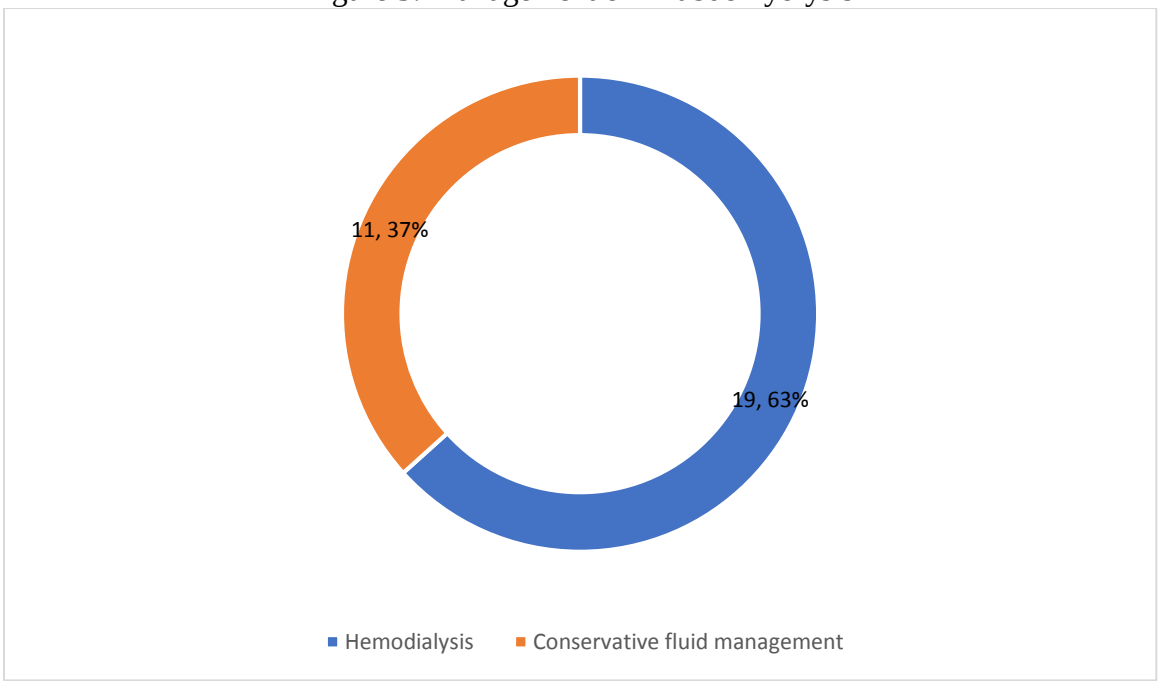

Table 4 presents a correlation analysis examining the relationship between various biochemical variables and the duration of hospital stay. Notably, potassium and creatinine phosphokinase (CPK) show strong positive correlations with hospital stay durations, evidenced by their high correlation coefficients (0.791 and 0.806, respectively) and highly significant p-values (< 0.001). This suggests that higher levels of potassium and CPK are associated with longer hospital stays. Similarly, lactate and the qSOFA score also exhibit significant positive correlations (0.688 and 0.626, respectively) with hospital stay durations, with p-values indicating statistical significance. On the other hand, calcium shows a strong negative correlation (-0.753) with hospital stay duration, with a highly significant p-value (< 0.001), indicating that higher calcium levels might be associated with shorter hospital stays. Urea and creatinine, however, do not show a significant correlation with the duration of hospital stay, as indicated by their relatively low correlation coefficients (0.370 and 0.035, respectively) and non-significant p-values. This analysis suggests that certain biochemical markers, particularly potassium, CPK, calcium, lactate, and the qSOFA score, are important indicators of the length of hospitalization in this patient population.

Table 4: Correlation analysis between different variables and duration of hospital stay

Variable	Correlation coefficient	p-value
Creatinine	0.035	0.894
Potassium	0.791	< 0.001
Calcium	-0.753	< 0.001
Lactate	0.688	0.002
Urea	0.370	0.143
Creatinine Phosphokinase	0.806	< 0.001
qSOFA score	0.626	0.007

4. Discussion

The results of our study offer significant insights into the clinical characteristics and management of rhabdomyolysis. Table 1 reveals a young to middle-aged demographic predominance, with a substantial male majority, which could reflect specific occupational or lifestyle risk factors in these groups. Table 2 highlights the diverse etiologies of rhabdomyolysis, emphasizing the impact of road traffic accidents and acute kidney injury with hypokalemia, alongside other causes like statin use and sepsis. This diversity underscores the need for multifaceted diagnostic approaches in emergency care. Our study (Table 1) predominantly identified younger to middle-aged males as the most affected group. This aligns with findings from several other studies, which also reported a male predominance in rhabdomyolysis cases, often attributed to higher engagement in physical activities or occupations that predispose to muscle injury.[9] However, some studies have reported a more evenly distributed age range, suggesting that risk factors for rhabdomyolysis could be diverse and not limited to younger populations.[10]

Table 3 provides valuable clinical data, indicating prevalent renal impairment and muscle damage in patients, as shown by elevated levels of urea, creatinine, and CPK. The proximity of potassium levels to the upper normal limit and the elevated lactate levels suggest an electrolyte imbalance and metabolic stress, respectively, which are critical factors in patient prognosis. In our research (Table 2), the most common causes were related to physical trauma and kidney issues (soft tissue injury and AKI with hypokalemia). This is consistent with other studies where trauma, especially from road accidents, was identified as a leading cause.[11] However, other research has emphasized drug-induced rhabdomyolysis as a predominant etiology, particularly in populations with high medication use or substance abuse, which was

less pronounced in our findings.[12] Our study noted significant renal impairment and muscle damage, as indicated by elevated urea, creatinine, and CPK levels (Table 3). These findings are in line with other studies that have also identified these markers as key indicators of rhabdomyolysis severity.[13] Interestingly, some studies have found a more pronounced elevation in these markers, suggesting potential variations in the severity of the condition based on the underlying etiology or the time of presentation.[14]

Figure 1's qSOFA score distribution reflects varied patient conditions upon admission, with a significant portion displaying low scores, suggesting relatively stable conditions. However, the presence of patients with higher qSOFA scores points to the potential for severe outcomes, necessitating varying levels of clinical intervention. Figure 2's insights on ICU stay durations illustrate the range of care intensity required, with most patients needing a short ICU stay. However, a noteworthy portion required longer stays, indicative of more severe complications or slower response to treatment. The varied ICU stay durations and qSOFA scores in our study (Figures 2 and 1) indicate differing severity levels among patients. This variation is a common finding in other research, where the length of ICU stay has been correlated with the severity of the initial presentation and the underlying causes of rhabdomyolysis.[14] However, some studies have reported shorter average ICU stays, possibly due to differences in healthcare systems, patient demographics, or treatment protocols.[15]

Figure 3 shows a predominant reliance on hemodialysis over conservative fluid management, highlighting severe renal complications in the majority of our patients. This finding is particularly critical, as it underscores the necessity for immediate and aggressive treatment strategies in similar clinical scenarios. Our significant reliance on hemodialysis (Figure 3) is consistent with other studies where severe renal impairment necessitated renal replacement therapy.[16] However, the extent of hemodialysis use varies across studies, possibly reflecting differences in clinical guidelines, availability of resources, and the stage at which patients receive medical care.[17]

Lastly, Table 4’s correlation analysis establishes significant associations between certain biochemical markers and the duration of hospital stay. Particularly, the strong positive correlations of potassium and CPK levels with longer hospital stays emphasize their importance in prognostic assessments. Conversely, higher calcium levels being linked to shorter stays present a curious inverse relationship worth further exploration. The correlations observed in our study (Table 4) between biochemical markers and hospital stay duration mirror findings in other research. Elevated potassium and CPK levels are commonly associated with more severe presentations and longer hospital stays.[18] However, the inverse relationship between calcium levels and hospital stay duration observed in our study is less commonly reported and could be a unique finding worth further investigation.[19]

The study, while providing valuable insights into rhabdomyolysis, is not without limitations. Its small sample size and focus on a young to middle-aged male demographic in a single tertiary care hospital may limit the generalizability of the findings. As a retrospective study, it faces the usual constraints of such designs, including potential selection bias and limitations in data scope. The diversity of etiologies presented, though informative, may not fully represent the frequency and spectrum of causes due to the limited number of cases per category. Additionally, the lack of long-term follow-up omits insights into chronic complications and recovery patterns. The study’s quantitative nature also means qualitative aspects like patient experiences and psychosocial impacts aren't explored. Future research directions include larger, multicenter studies with more diverse demographics, prospective and longitudinal designs for a comprehensive and representative analysis, qualitative research to capture patient-reported outcomes, and comparative studies on treatment modalities. Exploring molecular and genetic factors contributing to rhabdomyolysis and focusing on preventive strategies,

especially in high-risk groups, could significantly enhance understanding and management of the condition.

5. Conclusion

Clinical data from our study indicate prevalent renal impairment and muscle damage in patients, as evidenced by elevated levels of urea, creatinine, and CPK. These findings are critical for understanding patient prognosis and underscore the importance of early detection and intervention. The qSOFA scores and ICU stay durations further illustrate the variable severity of rhabdomyolysis presentations and the consequent demand for tailored clinical management strategies. A significant reliance on hemodialysis over conservative fluid management was observed, highlighting the severity of renal complications in our patient group. This finding points to the need for aggressive treatment approaches in similar clinical scenarios. Moreover, the study establishes a correlation between certain biochemical markers and the duration of hospital stays, providing a basis for future prognostic assessments.

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