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Updates on Acute Kidney Injury in Trauma Patients Admitted to the ICU: A Systematic Review

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Abstract

Objectives: To the current evidence on incidence, risk factors, and clinical outcomes regarding acute kidney injury (AKI) among trauma patients being admitted to the intensive care unit (ICU). ***Methods*:** A total of 432 pertinent publications were found after a comprehensive search across four databases. 38 full-text publications were examined after duplicates were eliminated using Rayyan QCRI and relevance was checked; seven studies finally satisfied the requirements for inclusion. ***Results*:** We included seven studies with a total of 31,222 participants and the majority 26,267 (84.1%) were males. AKI is a frequent complication in trauma patients, and its incidence depends on the kind of trauma and patient-related factors. Incidence is higher in abdominal and polytrauma patients, particularly in those who are obese or with subcutaneous adipose tissue. AKI in polytrauma is associated with longer ventilation, longer lengths of stay in the ICU, and higher mortality. Although less frequent compared to AKI in penetrating trauma, AKI is associated with longer hospitalization and higher fatality in young patients. Severe trauma has the highest incidence of AKI largely due to coagulopathy, hemodynamic instability, rhabdomyolysis, sepsis, and nephrotoxic drugs. ***Conclusion*:** AKI poses a significant challenge in ICU trauma management, leading to longer hospital stays, higher mortality, and complex clinical cases. Key risk factors such as trauma severity, obesity, and hemodynamic instability necessitate early diagnosis and targeted intervention. Effective AKI management involves optimizing fluid balance and minimizing nephrotoxic exposure. Future research should focus on developing standardized prevention protocols and assessing long-term renal outcomes in trauma patients.

Keywords: Atypical anorexia nervosa; Eating disorders; Children; Adolescents; Systematic review.

INTRODUCTION

The understanding of AKI's epidemiology and clinical implications has greatly improved since a standard definition was established. AKI contributes significantly to acute morbidity and mortality, affecting 30–60% of critically sick patients. According to recent data, the burden of AKI goes far beyond the acute phase and can result in repeated AKI episodes, increased long-term mortality, a higher risk of cardiovascular problems, and the development of chronic kidney disease (CKD) [1].

AKI can occur in trauma patients hospitalized to the ICU; however, the prevalence of post-traumatic AKI might vary greatly according on the study population and the criteria of AKI utilized [2, 3]. All AKI severities are covered by consensus definitions of the condition, which also enable cross-study comparison. These definitions include the kidney disease: Improving Global Outcomes (KDIGO) criteria [4] and the Risk, Injury, Failure, Loss of kidney function, and End-stage kidney disease (RIFLE) [5], which were later changed to the Acute Kidney Injury Network (AKIN) [6].

AKI is a common and serious complication of trauma admission to the intensive care unit, with a high impact on morbidity, mortality, and overall clinical outcomes. The physiological stress and hemodynamic

instability after trauma are often superimposed on pre-existing renal dysfunction, and thus early recognition and timely management become crucial. Recent advances in critical care management, fluid resuscitation strategies, and renal replacement therapy require a reevaluation of the incidence of AKI, its risk factors, and treatment modalities. A systematic review helps in consolidating the emerging evidence, mapping the gaps in the current practices, and thus dictating future research and clinical protocols for improved patient outcomes.

This systematic review outlines the current evidence on incidence, risk factors, and clinical outcomes regarding AKI among trauma patients being admitted to the ICU.

METHODS

Search Strategy

The PRISMA and GATHER criteria were followed for the systematic review. An overall search was conducted to identify relevant studies related to the current evidence on incidence, risk factors, and clinical outcomes regarding AKI among trauma patients. The following five electronic databases were used by the reviewers for searching: SCOPUS, Embase, Web of Science, Cochrane, and PubMed. We removed any duplicates and uploaded all the titles and abstracts we could find through electronic searches onto Rayyan. Studies published within the last five years (2019-2024) were included. After that, all the study texts that met the inclusion criteria based on the abstract or title were collected for a full-text examination. Two reviewers independently evaluated the extracted papers' suitability and discussed any discrepancies.

Study Population—selection

The PEO (Population, Exposure, and Outcome) factors were implemented as inclusion criteria for our review: (i) Population: Trauma patients admitted to the ICU, (ii) Exposure: Exposure under consideration involves the physiological and medical stressors that trauma patients endure during their ICU stay, which predispose them to AKI, (iii) Outcome: the development, severity, and progression of acute kidney injury in trauma patients within the ICU setting. Key outcomes include the incidence of AKI, the need for renal replacement therapy (RRT), and overall renal recovery post-discharge. Mortality rates, length of ICU stay, and potential progression to CKD are also critical outcomes of interest.

Data Extraction

Data from studies that satisfied the inclusion requirements were extracted by two objective reviewers using a predetermined and uniform methodology. The following information was retrieved and recorded: (i) First author (ii) Year of publication, (iii) Study design, (iv) Country, (v) Sample size, (vi) Age, (vii) Gender, (viii) ICU stay (in days), (ix) Type of trauma, (x) Incidence of AKI, (xi) Clinical outcomes/ Associated risk factors.

Quality Review

Since bias resulting from omitted factors is frequent in studies in this field, we used the ROBINS-I technique to assess the likelihood of bias since it enables a thorough examination of confounding. The ROBINS-I tool can be used for cohort designs where individuals exposed to different staffing levels are tracked over time and is designed to assess non-randomized studies. Each paper's risk of bias was evaluated independently by two reviewers, and any differences were settled by group discussion [7].

RESULTS

The specified search strategy yielded 432 publications (Figure 1). After removing duplicates (n = 211), 221 trials were evaluated based on title and abstract. Of these, 181 failed to satisfy eligibility criteria, leaving just 38 full-text articles for comprehensive review. A total of 7 satisfied the requirements for eligibility with evidence synthesis for analysis.

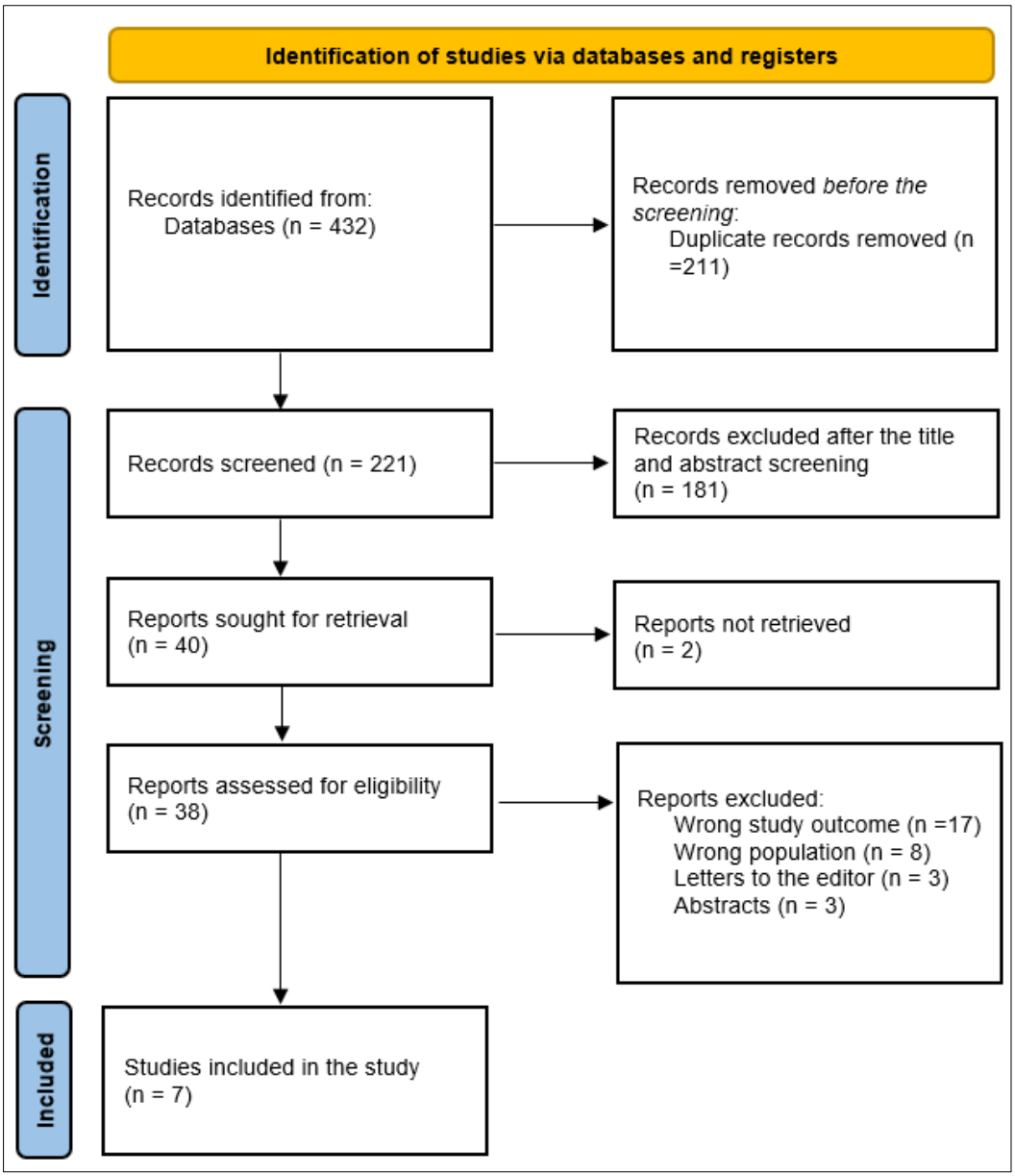

Figure 1: PRISMA flowchart [8]

Sociodemographic and clinical outcomes

We included seven studies with a total of 31,222 participants and the majority 26,267 (84.1%) were males. Regarding study designs, all studies were retrospective in nature, three were cohorts [9, 10, 13], and four were observational studies [10, 11, 13, 14]. One study was implemented in China [9], one in Australia [10], one in the UAE [11], one in Qatar [12], one in the USA [13], one in Spain [14], and one in Egypt [15].

The prevalence of AKI in traumatic patients ranged from 0.8% [12] to 46.2% [15], with a total prevalence of 4438 (14.2%). In this view, among trauma patients, abdominal trauma represents a high-risk group for the development of AKI, especially in the presence of subcutaneous adipose tissue, thus suggesting a link between body composition and renal vulnerability. Another emerging important factor is obesity: higher levels of BMI correlate with increased incidence of AKI and longer lengths of stay in the ICU, thus suggesting specific management in obese trauma patients [9, 10].

In polytrauma, the trajectory is more serious, with AKI increasing the need for mechanical ventilation and extending the length of stay in hospitals. This, in turn, leads to greater ventilator days and higher mortality rates, emphasizing the importance of AKI as a critical determinant of long-term outcomes in complex trauma scenarios [11]. In contrast, AKI following blunt trauma is rare but with longer hospitalization and higher mortality in younger patients, which further underlines the possible importance of age and type of injury as predictive variables [12].

Generally, the most severe traumas have the highest incidence of AKI, with transient but frequent

occurrences upon ICU admission. Higher stages of AKI are invariably associated with longer hospitalization, higher mortality rates, and discharge to other facilities rather than home. This once again emphasizes the point that the severity of AKI is directly proportional to the adverse outcomes, early intervention and continuous monitoring being highly essential [13, 14].

The presence of coagulopathy, hemodynamic instability, rhabdomyolysis, and shock adds to the risk factors, thereby making AKI in trauma patients even more complex. Severe sepsis and the use of nephrotoxic medications also play a crucial role, underlining the need for a comprehensive renal protective strategy in the ICU [15].

Table 1: Outcome measures of the included studies

Study ID	Study design	Country	Sociodemographic	ICU stay (days)	Trauma type	AKI incidence (%)	Associated factors/ outcomes
Xi *et al.*, 2023 [9]	Retrospective cohort	China	N= 324 Mean age: 43 Males: 261 (80.6%)	7	Abdominal trauma	67 (20.7%)	Patients with abdominal injuries were more likely to develop AKI if they had subcutaneous adipose tissue.
Colbran *et al.*, 2023 [10]	Retrospective cohort	Australia	N= 207 Mean age: 51 Males: 164 (79.2%)	5	Major trauma	15 (7.2%)	Obese people with the highest BMI are more prone to experience complications like AKI and need a lengthier hospital and intensive care unit stay.
Wankhade *et al.*, 2023 [11]	Retrospective observational study	UAE	N= 457 Age range: 18-60 Males: 408 (89.3%)	7 - 23	Polytrauma	144 (31.5%)	AKI following polytrauma increases the need for mechanical ventilation, lengthens hospital and intensive care unit stays, increases ventilator days, and raises fatality rates. Their prognosis may be greatly impacted by AKI.
Al-Thani *et al.*, 2023 [12]	Retrospective observational study	Qatar	N= 17,341 Mean age: 31 Males: 15,596 (89.9%)	4 - 35	Blunt trauma	140 (0.8%)	AKI is rare in juvenile trauma victims and is linked to a longer hospital stay and a greater death rate. In trauma patients, this study found variables that independently predicted the onset of AKI and its consequences.

Hatton *et al.*, 2021 [13]	Retrospective cohort	USA	N= 7049 Mean age: 41 Males: 5087 (72%)	NM	Severe trauma	3153 (45%)	Upon arrival, post-traumatic AKI was common and often transient. On adjusted analyses, duration was independently linked to mortality, discharge destination other than home, and longer hospitalization. It also corresponded with the highest AKI stage.
Chico-Fernández *et al.*, 2020 [14]	Prospective observational study	Spain	N= 5740 Mean age: 55.2 Males: 4663 (81.2%)	13.2	Severe trauma	871 (15.2%)	An elevated crude and adjusted mortality rate was linked to trauma intensive care unit patients. Risk variables for AKI included age, coagulopathy, hemodynamic instability, rhabdomyolysis, and AIS abdomen > 3.
Salama *et al.*, 2022 [15]	Prospective observational study	Egypt	N= 104 Age range: 2-80 Males: 88 (84.6%)	1 - 35	Severe trauma	48 (46.2%)	Trauma sufferers' AKI etiologies are complex. Severe sepsis, coagulopathy, nephrotoxic medications, shock, and rhabdomyolysis are risk factors for trauma-associated AKI. Increased mortality and hospital length of stay are closely linked to the development of AKI following severe trauma.

Table 2: Risk of bias assessment using ROBINS-I

Study ID	Bias due to confounding	Bias in the selection of participants into	Bias in the classification of interventions	Bias due to deviations from the intended interval	Bias due to missing data	Bias in the measurement of outcomes	Bias in the selection of reported result	Overall bias
Xi *et al.*, 2023 [9]	Mod	Mod	Low	Low	Low	Low	Low	Low
Colbran *et al.*, 2023 [10]	Low	Low	Low	Low	Low	Low	Mod	Low
Wankhade *et al.*, 2023 [11]	Low	Mod	Low	Low	Low	Mod	Low	Low
Al-Thani *et al.*, 2023 [12]	Low	Low	Low	Low	Low	Low	Mod	Low
Hatton *et al.*, 2021 [13]	Mod	Mod	Low	Low	Low	Mod	Mod	Moderate
Chico-Fernández *et al.*, 2020 [14]	Mod	Low	Mod	Mod	Low	Low	Mod	Moderate
Salama *et al.*, 2022 [15]	Mod	Mod	Low	Low	Low	Mod	Mod	Moderate

DISCUSSION

Key features of this systematic review accentuate the high burden among trauma patients with AKI who are admitted to intensive care. Trauma cases, especially polytraumatic cases and abdominal injuries, highly predispose patients to kidney injury, which may be exacerbated by factors like obesity, coagulopathy, and sepsis. AKI was related to longer mechanical ventilation times, longer lengths of stay in the ICU, and increased mortality, thus emerging as a critical determinant of adverse outcomes in this population. The incidence of AKI was highly variable, being lower with blunt trauma, which points to the need for a differential prevention strategy according to the injury profile. In a systematic review and meta-analysis Søvik *et al.*, also found that while severe AKI requiring RRT is rare, AKI is somewhat common among trauma patients hospitalized to the intensive care unit. It is important to anticipate AKI and try to prevent it, particularly in individuals who are elderly, have diabetes mellitus, chronic hypertension, severe structural injury, or exhibit significant physiological abnormalities. Increased morbidity and mortality are closely linked to the development of post-traumatic AKI. The economic effects of post-traumatic AKI and long-term patient outcomes are not well documented [16].

Almost every non-renal organ may be impacted by AKI, especially in patients who are very sick. The consequences of underlying illnesses like shock and systemic inflammation on many organ systems may be partially reflected in this widespread systemic impact. However, organ cross-talk—the mutual influence of failing organs—is another important aspect. Other organ failures, such as cardiorenal syndrome (caused by a failing heart) and hepatorenal syndrome (caused by a failing liver), can result in AKI. Kidney function may potentially be impacted by ARDS and the mechanical breathing method [1].

Although there may be other causes, significant bleeding is typically the cause of shock in trauma victims. It is unclear from the studies on abdominal trauma if renal function was impacted by direct trauma to the kidneys or urinary system. Kidney function may also be impacted when the abdomen is packed during damage control surgery for severe intra-abdominal or retroperitoneal injuries. Because it results in both hypoperfusion [17] and inflammatory insult, sepsis in the intensive care unit is recognized as a primary cause of AKI. A high APACHE II score was linked to AKI. The APACHE score includes indicators of inflammation, respiratory and circulatory instability, and creatinine levels. AKI was less common in patients who received intravenous contrast agents [18, 19], however this conclusion is subject to various limitations. There was no mention of the type, dosage, or concurrent fluid therapy of the contrast. Additionally, in patients believed to be at a higher risk of AKI, contrast may have been avoided [19].

Clinical Implications: Early recognition and management of AKI among trauma patients may decrease the complication burden and improve overall outcomes. Regular assessment of renal function, especially among those at high risk-for example, polytrauma and obese patients-could provide opportunities for timely intervention. Besides, minimizing exposure to nephrotoxins, fluid resuscitation optimization, and infection control could also be proposed as strategies to reduce both incidence and severity of AKI. The strong association between AKI and prolonged ICU stays necessitates multidisciplinary approaches to reduce hospitalization time and improve recovery.

Strengths

The data for this review were combined from geographically different areas and types of trauma; hence, it provided a comprehensive overview of the

incidence and risk factors of AKI in ICU trauma patients. The presence of both retrospective and prospective studies strengthened the analysis to provide appropriate real-world implications of AKI and enhanced generalizability across different healthcare settings.

Limitations

Several limitations must be recognized. The heterogeneity of the included studies, in particular, the differences in the definitions of AKI, the criteria for diagnosis, and the patient populations, may introduce bias. The heterogeneity of the protocols and strategies for treatment in ICUs in different regions further complicates direct comparisons. Moreover, a number of studies did not provide detailed data on AKI staging and long-term renal outcomes, limiting complete assessment of disease progression.

CONCLUSION

AKI is one of the major challenges during trauma management in the ICU, contributing to prolonged hospitalization, increased mortality, and complex clinical courses. Among the risk factors underlined in this review, trauma severity, obesity, and hemodynamic instability require careful monitoring and specific intervention. Management of AKI in trauma requires early diagnosis, optimization of fluid management, and reduction of nephrotoxic risk. Future studies should be directed toward establishing standardized AKI prevention protocols and examining long-term renal outcomes in trauma survivors.

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