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A Study on Short-Term Outcome of Acute Kidney Injury Based on Clinical and Urinary Sediment Scoring Indices

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Abstract

Background: Acute kidney injury is a common and serious clinical condition associated with significant morbidity and mortality among hospitalised patients. Early identification of patients at risk for adverse outcomes is essential for timely intervention. Conventional markers such as serum creatinine often detect renal injury late, highlighting the need for simple and reliable prognostic tools. Clinical risk indices and urinary sediment scoring systems, particularly the CSI (Cast Scoring Index), have been proposed as useful bedside methods for assessing the severity of tubular injury and predicting outcomes in AKI (Acute Kidney Injury). ***Methods:*** This prospective observational cohort study was conducted in the Department of General Medicine at Karnataka Institute of Medical Sciences (KIMS), Hubballi, from June 2024 to January 2026. A total of 183 adult patients (>18 years) diagnosed with AKI according to KDIGO criteria were included. Clinical data, laboratory parameters, and urinary sediment findings were recorded. Urine microscopy was used to determine the CSI, and each patient was also assessed using the Advanced CKD-after-AKI Risk Score. Short-term outcomes evaluated included renal recovery, requirement of RRT (Renal Replacement Therapy), length of hospital stay, mortality, and development of CKD (Chronic Kidney Disease) at 3-month follow-up. Statistical analysis included correlation testing, group comparisons, and ROC-based predictive evaluation. ***Results:*** The mean age of the study population was 50.73 ± 15.13 years, with a male predominance (65%). Acute gastroenteritis (48.6%) and sepsis (37.2%) were the most common causes of AKI. RRT was required in 17.5% of patients. Most patients achieved partial renal recovery (81.4%) at discharge, while 10.9% had complete recovery and 7.7% showed no recovery. The CSI was significantly higher in patients requiring RRT (3.31 ± 0.93 vs. 1.35 ± 1.08; $p < 0.0001$). Both CSI and Advanced CKD Risk Score showed strong positive correlations with peak serum creatinine and hospital length of stay. At follow-up, CKD developed in 8.2% of patients. ***Conclusion:*** The Cast Scoring Index and Advanced CKD-after-AKI Risk Score are valuable tools for assessing AKI severity and predicting short-term outcomes. Urinary sediment examination provides a simple, inexpensive, and effective bedside method for early risk stratification, particularly in resource-limited settings.

Keywords: Acute Kidney Injury, Urinary Sediment, Cast Scoring Index, Renal Replacement Therapy, Chronic Kidney Disease Risk, AKI Outcomes.

INTRODUCTION

Acute kidney injury is a common and serious clinical syndrome characterized by a sudden decline in renal function occurring over hours to days. It is frequently encountered in both community and hospital settings and often develops in patients with underlying comorbidities such as diabetes mellitus, hypertension, and chronic kidney disease. The incidence of AKI varies widely depending on the clinical setting, ranging from about 5% in general hospital wards to nearly 50% in

critically ill patients admitted to intensive care units. In regions with a high burden of systemic illnesses and limited access to early nephrology care, AKI represents a significant proportion of acute medical admissions and contributes substantially to healthcare utilization.[1]

AKI is associated with significant short-term morbidity and mortality. Even small increases in serum creatinine are linked to complications such as fluid overload, electrolyte disturbances, respiratory failure, and multi-organ dysfunction. In severe cases, mortality rates can approach 60%, particularly among patients requiring intensive care or RRT (Renal Replacement Therapy). The need for RRT further increases the complexity and cost of care and requires specialized infrastructure and trained personnel, which may be limited in many healthcare settings. Additionally, AKI often prolongs hospital and intensive care stays, increasing the risk of nosocomial infections and other complications.[2,3] The consequences of AKI extend beyond the acute episode. Patients who survive AKI are at increased risk of persistent reduction in kidney function, development of CKD (Chronic Kidney Disease), and progression to end-stage renal disease. Structural changes such as tubular atrophy, interstitial fibrosis, and nephron loss contribute to long-term renal impairment. Studies have shown that individuals with a history of AKI have higher rates of CKD progression and cardiovascular morbidity compared with those without AKI.[4]

Current diagnostic approaches rely mainly on serum creatinine levels and urine output, which have important limitations as early indicators of kidney injury. Serum creatinine often rises only after substantial loss of renal function, and urine output may be influenced by several non-renal factors. Consequently, AKI is frequently detected late, limiting opportunities for early intervention.[5]

AIMS AND OBJECTIVES

The present study aims to evaluate the role of clinical and urinary sediment scoring indices in patients with acute kidney injury. It seeks to assess the short-term outcomes of patients diagnosed with AKI, including recovery patterns and associated clinical implications. Additionally, the study intends to predict the risk of progression to CKD in patients with AKI by utilizing the Advanced CKD-after-AKI Risk Index Score along with the urinary Cast Scoring Index, thereby helping in early risk stratification and prognosis assessment.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective observational cohort study in the Department of General Medicine, including the medicine wards and Medical Intensive Care Unit (MICU), at Karnataka Institute of Medical Sciences (KIMS), Hubballi, Karnataka. The study was carried out over a period of two years, from June 2024 to January 2026. The study population comprised adult patients admitted to the medicine wards and MICU who were diagnosed with AKI and met the predefined eligibility criteria. These patients were prospectively observed and evaluated to assess clinical parameters, urinary sediment scoring indices, and short-term outcomes.

Inclusion and Exclusion Criteria

Adult patients aged >18 years diagnosed with AKI of any KDIGO stage and admitted to the medicine wards or MICU who were willing and feasible for at least 3 months of follow-up after discharge were included in the study. Patients were excluded if they had conditions that could independently affect renal outcomes, including vasculitis, hemolytic uremic syndrome, acute interstitial nephritis, acute glomerulonephritis, clinically significant urinary tract obstruction, prior chronic dialysis (>3 months), known chronic kidney disease, history of nephrectomy, multiple myeloma, metastatic cancer under active treatment, solid organ or hematopoietic transplant, NYHA class IV heart failure, or a history of NSAID or other nephrotoxic drug use. Patients unable to complete the required 3-month follow-up were also excluded.

Sample Size Calculation

Sample size was estimated using the method for precision (confidence interval width) around the area under the ROC curve (AUC) for a diagnostic/prognostic model.

Formula used:

$n \geq (Z1-\alpha/2)^2 \times VF / L^2$

Where:

N = required sample size

$Z1-\alpha/2$ = standard normal deviate for desired confidence level (for 95% confidence, $Z1-\alpha/2 = 1.96$)

L = desired half-width of confidence interval (absolute error) = 0.05

VF = variance factor computed from expected AUC

AUC = anticipated area under the ROC curve = 0.8

$\Phi-1(AUC)$ = inverse of standard cumulative normal distribution corresponding to AUC

$A=\Phi-1(AUC) \times 1.414$

Calculations

For AUC = 0.8, $\Phi^{-1}(AUC)=0.84$

$A = 0.84 \times 1.414 = 1.19$

$VF = (0.0099 \times e^{-(A \times A/2)}) \times (6A^2 + 16) = 0.119$

Thus:

$n \geq (1.96)^2 \times 0.119 / (0.05)^2$

$n \geq 183$

Accordingly, the minimum required sample size was 183 participants.

Data Collection Procedure

All eligible patients underwent a detailed clinical evaluation, which included demographic details, relevant medical history, presenting complaints, comorbidities, risk factors for AKI, medication and exposure history related to renal injury, and a thorough general and systemic examination. All information was recorded in a predesigned proforma. Laboratory and imaging investigations were performed according to the study protocol and clinical requirements, including a complete hemogram with peripheral smear and reticulocyte count, renal function tests, serum electrolytes, liver function tests, urine albumin by dipstick, urine routine examination, urine microscopy, serum LDH, random blood sugar, HbA1c, and ultrasonography of the abdomen and pelvis. A fresh urine sample was collected for microscopic examination to identify granular and renal tubular epithelial casts, which were graded using the Urinary Cast Scoring Index (CSI). Each participant was also assessed using the Advanced CKD after AKI Risk Index based on predefined clinical parameters for prognostic evaluation. Outcomes assessed included recovery of kidney function, need for renal replacement therapy, length of hospital stay, development of CKD at follow-up, and mortality. Patients were followed for a minimum period of three months after discharge to evaluate renal function status and clinical outcomes. All collected data were entered into a structured Microsoft Excel database from the predesigned proforma, and data accuracy was ensured through periodic verification with clinical records and laboratory reports.

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median (interquartile range) based on data distribution, while categorical variables were expressed as frequencies and percentages. Associations between scoring indices (clinical risk index and Cast Scoring Index) and outcomes such as renal recovery, need for RRT (Renal Replacement Therapy), mortality, CKD development, and hospital stay were analyzed using appropriate statistical tests (chi-square/Fisher's exact test for categorical variables and t-test/Mann–Whitney U test for continuous variables). Predictive performance of the Advanced CKD after AKI Risk Index and CSI was evaluated using ROC (Receiver Operating Characteristic) curve analysis with estimation of AUC (Area under the Curve), sensitivity, and specificity. Multivariable regression analysis was used to adjust for confounders and identify independent predictors of adverse outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Demographic Characteristics of Study Population (n = 183)

Variable	Category	n	%
Age (in years)	Mean ± SD	50.73 ± 15.13	
	Range	18 – 85	
Age Group	<30	13	7.1
	30–39	27	14.8
	40–49	45	24.6
	50–59	60	32.8
	60–69	14	7.7
	≥70	24	13.1
Gender	Male	119	65.0
	Female	64	35.0

Table 1 shows the demographic profile of the study population. The mean age of patients was 50.73 ± 15.13 years, with the majority belonging to the 50–59-year age group. Males constituted 65% of the study population.

Table 2. Baseline Clinical Characteristics and Comorbidities

Variable	n	%	
Diabetes Mellitus	81	44.3	
Hypertension	90	49.2	
Baseline Serum Creatinine (mg/dL)	**N**	**Mean ± SD**	**Range**

Baseline SCr	183	1.02 ± 0.17	0.70 – 1.30

Table 2 illustrates the baseline clinical characteristics of patients with acute kidney injury. Hypertension and diabetes mellitus were common comorbidities, and the mean baseline serum creatinine was 1.02 ± 0.17 mg/dL.

Table 3. AKI Severity and Etiology

Variable	Category	n	%
KDIGO Stage	Stage 1	73	39.9
	Stage 2	60	32.8
	Stage 3	50	27.3
Etiology of AKI	**n**	**%**	
Acute gastroenteritis	89	48.6	
Sepsis	68	37.2	
Snake bite	15	8.2	

Table 3 illustrates the distribution of AKI severity and underlying etiologies. KDIGO Stage 1 AKI was most common. Acute gastroenteritis and sepsis were the leading causes of AKI in this cohort.

Table 4. Laboratory Parameters and Urine Findings

Variable	N	Mean ± SD	Range
Admission serum creatinine (mg/dL)	183	2.73 ± 1.17	1.12 – 6.11
Peak serum creatinine (mg/dL)	183	3.08 ± 1.34	1.17 – 6.64
Urine Protein (Dipstick)	**n**	**%**	
2+	60	32.8	
1+	48	26.2	
Trace	46	25.1	

Table 4 shows laboratory parameters among the study participants. The mean admission serum creatinine was 2.73 mg/dL, and most patients demonstrated mild to moderate proteinuria on urine dipstick examination.

Table 5. Distribution of Clinical and Urinary Sediment Scoring Indices

Score	N	Mean ± SD	Range
Cast Scoring Index (CSI)	183	1.69 ± 1.29	0 – 4
Advanced CKD after AKI Risk Score	183	5.67 ± 3.33	0 – 12
CSI Score		**Number of Patients**	
0		38	
1		48	
2		51	
3		32	
4		14	

Table 5 illustrates the distribution of urinary sediment and clinical scoring indices. The mean CSI score was 1.69, while the mean Advanced CKD after AKI risk score was 5.67.

Table 6. Clinical Outcomes during Hospitalization

Outcome	n	%
RRT Required	32	17.5
No RRT	151	82.5
Discharge Status	**n**	**%**
Alive	181	98.9
Death	2	1.1
Renal Recovery at Discharge	**N**	**%**
Partial recovery	149	81.4
Complete recovery	20	10.9
No recovery	14	7.7
Variable	**Mean ± SD**	
Hospital stay (days)	9.10 ± 4.12	
Dialysis sessions	0.69 ± 2.16	

Table 6 shows the clinical outcomes of AKI patients during hospitalization. Approximately 17.5% required renal replacement therapy, and most patients achieved partial renal recovery at discharge.

Table 7. Follow-up Outcomes and CKD Development

Variable	n	%
Follow-up completed	134	73.2
Lost to follow-up	34	18.6
Death before follow-up	15	8.2
CKD Status at Follow-up	**n**	**%**
No CKD	123	91.8
CKD G3b	4	3.0
CKD G4–5	6	4.5
Follow-up	**Mean ± SD**	
Serum Creatinine	1.22 ± 0.59 mg/dL	

Table 7 illustrates the follow-up outcomes of patients after AKI. At three months, most patients did not develop CKD, while a small proportion progressed to CKD stages G3b–G5.

DISCUSSION

Acute kidney injury remains a significant clinical problem associated with considerable morbidity, mortality, and long-term renal complications. Early identification of patients at higher risk of adverse outcomes is essential for timely intervention and appropriate monitoring. The present study evaluated the role of clinical risk scoring and urinary sediment scoring indices, particularly the Advanced CKD-after-AKI Risk Score and the CSI, in predicting short-term outcomes and the risk of CKD following AKI.

In this study, 183 patients with AKI were evaluated. The mean age was 50.73 ± 15.13 years, and the majority of patients belonged to the 50–59-year age group, indicating that AKI was more common in middle-aged and older individuals. Males constituted 65% of the study population, demonstrating a clear male predominance. These findings are comparable with previous studies evaluating AKI epidemiology. Gupta et al., (2023) reported a mean age of 42.3 ± 16.4 years with male predominance among patients with AKI. However, their study population was relatively younger, which may be attributed to the higher prevalence of snake bite-associated AKI in rural areas included in their study.[6] Differences in age distribution across studies may reflect variations in geographic location, etiological factors, and healthcare accessibility.

In the present study, the most common causes of AKI were acute gastroenteritis (48.6%) and sepsis (37.2%), followed by snake bites and tropical infections. These findings highlight the continued importance of infectious diseases and volume depletion as major contributors to AKI in developing countries. In contrast, studies conducted in intensive care settings frequently identify sepsis as the leading cause of AKI. For example, Elsayed et al., (2025) evaluated patients with sepsis-associated AKI and demonstrated that urinary sediment findings were significantly associated with the progression and severity of renal injury. Their study emphasised the importance of early identification of tubular injury through urine microscopy.[7]

Comorbid conditions were frequently observed in the present study. Hypertension (49.2%) and diabetes mellitus (44.3%) were the most common comorbidities. These metabolic conditions are well-known risk factors for both AKI and CKD and may contribute to increased susceptibility to renal injury. The presence of comorbidities can also influence the severity of AKI and delay renal recovery, thereby increasing the risk of long-term renal impairment.[8]

Urinary sediment analysis plays an important role in evaluating the underlying pathology of AKI. In the present study, the Cast Scoring Index ranged from 0 to 4 with a mean value of 1.69 ± 1.29, while the Advanced CKD-after-AKI Risk Score ranged from 0 to 12 with a mean of 5.67 ± 3.33. A strong positive correlation was observed between the two scoring indices, indicating that both reflect the severity of renal injury and may provide complementary prognostic information. Urine microscopy has long been recognised as a valuable bedside diagnostic tool in AKI. Varghese et al., (2022) demonstrated that the presence of muddy brown granular casts and renal tubular epithelial casts is strongly associated with acute tubular injury and worsening renal function. These findings support the clinical utility of urinary sediment examination as a simple and cost-effective method for assessing kidney injury.[9]

In the present study, higher CSI scores were significantly associated with higher peak serum creatinine levels, increased requirement for RRT, and longer duration of hospital stay. These findings indicate that urinary sediment scoring may serve as an indicator of AKI severity. Patients with more severe tubular injury are more likely to develop complications requiring dialysis support. These observations are consistent with previous studies demonstrating the prognostic value of urinary sediment scoring in AKI. With respect to short-term outcomes, 17.5% of patients required renal replacement therapy, indicating moderate severity of AKI in the study population. The majority of patients achieved partial renal recovery at discharge, suggesting that early recognition and management of AKI can improve outcomes. The mean hospital stay was 9.10 ± 4.12 days, reflecting the clinical burden associated with AKI.

During follow-up, 8.2% of patients developed CKD, highlighting the potential long-term consequences of AKI. Although patients who developed CKD tended to have higher CSI and clinical risk scores, the association did not reach statistical significance. This may be attributed to the relatively small number of CKD cases and the limited duration of follow-up. Nevertheless, several studies have demonstrated that AKI is an important risk factor for the development of CKD and long-term renal dysfunction.

The findings of the present study suggest that urinary sediment examinationcombined with clinical risk scoring provides valuable prognostic information in patients with AKI. The Cast Scoring Index and Advanced CKD-after-AKI Risk Score may help identify patients at higher risk of adverse outcomes and CKD progression. These tools are particularly useful in resource-limited healthcare settings, where access to advanced biomarkers may be limited. Early risk stratification using simple bedside methods can facilitate timely intervention and improve patient outcomes.

Limitations

The present study has certain limitations that should be acknowledged. Being an observational and single-centre study, causal relationships between scoring indices and outcomes cannot be firmly established and the findings may have limited generalisability. In addition, a loss to follow-up of 18.6% may have introduced potential bias in the assessment of CKD outcomes. The small number of patients who developed CKD (n = 11) also limited the statistical power to detect significant differences between groups. Furthermore, serial urinary sediment examinations were not performed, which might have provided additional prognostic information as reported by Varghese et al. Finally, novel urinary biomarkers such as TIMP-2*IGFBP7 and KIM-1 were not evaluated, which could have allowed comparison with the clinical and urinary scoring indices used in this study.

CONCLUSION

This study demonstrates that the Cast Scoring Index and the Advanced CKD-after-AKI Risk Score are useful tools for assessing the severity of acute kidney injury and predicting short-term clinical outcomes. Higher scores were associated with increased need for renal replacement therapy, higher peak serum creatinine levels, prolonged hospital stay, and poorer renal recovery. The strong correlation between the two scoring systems suggests that urinary sediment findings and clinical risk factors provide complementary information in evaluating AKI severity. Given that urinary sediment examination is simple, non-invasive, and cost-effective, these scoring indices can serve as practical bedside tools for early risk stratification and prognostication, particularly in resource-limited settings. Further large multicentre studies with longer follow-up are required to validate their role in predicting long-term outcomes such as progression to chronic kidney disease.

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