Section: Nephrology

Original Research Article

OBSERVATIONAL STUDY OF PREDICTORS AND OUTCOME OF ACUTE KIDNEY INJURY IN ACUTE CORONARY SYNDROME IN PATIENTS ADMITTING IN CARDIAC ICU AT A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Acute kidney injury (AKI) is a serious complication of acute coronary syndrome (ACS), particularly among patients requiring cardiac intensive care. It is associated with adverse renal outcomes and increased mortality. Identifying factors associated with AKI severity may help improve risk stratification and clinical management. **Objective:** To determine the incidence, associated clinical and biochemical factors, and outcomes of AKI among patients with ACS admitted to a cardiac intensive care unit (CICU) at a tertiary care hospital.

Materials and Methods: This prospective observational follow-up study was conducted at King George Hospital, Visakhapatnam, over 12 months and included 100 adult patients with ACS admitted to the CICU. Demographic, clinical, laboratory, and procedural data were collected. AKI was classified according to the reported Kidney Disease: Improving Global Outcomes (KDIGO) criteria. Associations between categorical variables were assessed using the chi-square test, and continuous variables were summarized as mean ± standard deviation. Statistical significance was set at $p < 0.05$.

Results: AKI occurred in 64% (64/100) of patients, comprising Stage 1 in 31%, Stage 2 in 16%, and Stage 3 in 17%; 36% had no AKI. AKI stage was significantly associated with age ($p < 0.001$), sex ($p = 0.040$), BMI category ($p < 0.001$), hypertension ($p < 0.001$), prior renal dysfunction ($p = 0.004$), cardiogenic shock ($p < 0.001$), ventilatory support ($p < 0.001$), and heart failure ($p = 0.001$). Diabetes mellitus was not significantly associated with AKI stage ($p = 0.101$). HbA1c and LDL cholesterol differed significantly across AKI stages (both $p < 0.001$). Mean serum creatinine decreased from 2.55 ± 2.05 mg/dL at admission to 1.43 ± 0.78 mg/dL at discharge and 1.16 ± 0.50 mg/dL at three months. Renal replacement therapy was required in 17 patients, all classified as Stage 3 AKI. Overall mortality was 16%, with the highest mortality in Stage 3 AKI (64.7%); mortality differed significantly by AKI stage ($p < 0.001$).

Conclusion: AKI was common among ACS patients admitted to the CICU and was associated with clinical severity, pre-existing renal dysfunction, and adverse outcomes. Stage 3 AKI was associated with the highest mortality and requirement for renal replacement therapy. Early identification of high-risk patients and close monitoring of renal function may support improved clinical management.

Keywords: Acute kidney injury; acute coronary syndrome; cardiac intensive care unit; renal replacement therapy; serum creatinine; mortality; risk factors.

INTRODUCTION

Acute coronary syndrome (ACS), comprising ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina, is a major cause of morbidity and mortality worldwide.[1,2] Management frequently requires coronary angiography and percutaneous coronary intervention (PCI), which may be complicated by acute kidney injury (AKI).[3] AKI is characterized by an abrupt decline in renal function, manifested by increased serum creatinine or reduced urine output, and is diagnosed using established criteria such as Kidney Disease: Improving Global Outcomes (KDIGO).[4] Its development in ACS is multifactorial, involving reduced renal perfusion due to hemodynamic instability, contrast-associated renal injury, systemic inflammation, and underlying comorbidities.[5]

The incidence of AKI among patients with ACS varies according to diagnostic criteria, patient characteristics, and procedural factors, with reported rates ranging from 7% to 30%.[6] A systematic review and meta-analysis involving 114,758 patients reported a pooled incidence of 12.6% (95% CI: 10.5%–14.9%).[6] AKI in ACS is associated with increased in-hospital and long-term mortality, prolonged hospitalization, greater healthcare costs, and an increased risk of CKD.[4-6] Important predictors include advanced age, diabetes mellitus, pre-existing CKD, anemia, hemodynamic instability, severe cardiac dysfunction, emergency PCI, and increased contrast volume.[7] Although preventive measures such as adequate hydration, judicious contrast use, and avoidance of nephrotoxic medications are recommended, AKI remains a significant clinical challenge. Early identification of high-risk patients is therefore essential for timely intervention and improved outcomes.

Despite the substantial burden of cardiovascular disease and associated comorbidities in India, region-specific evidence regarding AKI predictors and outcomes among critically ill ACS patients remains limited. King George Hospital (KGH), Visakhapatnam, is a tertiary care centre serving a diverse population from Andhra Pradesh, Odisha, and neighboring regions. Its cardiac intensive care facilities provide an appropriate setting to investigate this complication.

The present observational study aims to determine the incidence, clinical and biochemical predictors, and outcomes of AKI among ACS patients admitted to the cardiac intensive care unit at KGH, using KDIGO criteria. The findings may facilitate early risk stratification, guide preventive strategies, and improve the management of AKI in ACS patients in Indian tertiary care settings.

MATERIALS AND METHODS

This prospective observational follow-up study was conducted at King George Hospital (KGH), Visakhapatnam, a tertiary care centre with dedicated cardiac and nephrology services. The study was planned over a period of 12 months.

The study population comprised adult patients diagnosed with acute coronary syndrome (ACS), including ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina, who were admitted to the Cardiac Intensive Care Unit (CICU) during the study period. All eligible patients were enrolled using convenient sampling. The final sample size was determined by the number of eligible patients recruited during the study period.

Eligibility criteria: Adult patients admitted to the CICU with ACS were considered eligible. Patients with comorbidities such as diabetes mellitus, hypertension, and metabolic syndrome; a history of acute kidney injury (AKI) or chronic kidney disease (CKD) stages 1–4; and hemodynamic compromise or respiratory failure secondary to ACS were included. Patients unwilling to provide informed consent, those with cardiac arrhythmias attributable to structural heart disease unrelated to ACS or electrolyte abnormalities, those with secondary cardiorenal syndromes, and those with end-stage renal disease or CKD stage 5 requiring maintenance renal replacement therapy were excluded.

Following approval from the Institutional Ethics Committee and obtaining informed consent from participants, data were collected using a structured proforma. Demographic variables included age, sex, socioeconomic status, height, weight, body mass index (BMI), and history of addictions. Clinical information included comorbidities such as coronary artery disease (CAD), cerebrovascular accident (CVA), and chronic obstructive pulmonary disease (COPD), family history, previous episodes of AKI, medication history, including angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), and non-steroidal anti-inflammatory drugs (NSAIDs), and the presence of potential postrenal causes of kidney injury.

Laboratory investigations included complete blood count, renal function tests, liver function tests, serum uric acid, lipid profile, thyroid profile, and urinalysis. Urinary protein excretion was assessed using 24-hour urinary protein estimation and the urine albumin-to-creatinine ratio, as applicable. Diagnostic evaluations included chest radiography, electrocardiography (ECG), and two-dimensional echocardiography. For patients undergoing coronary angiography or other interventional procedures, the type and volume of contrast agent administered were documented.

Patients were assessed for the development and severity of AKI using the Kidney Disease: Improving Global Outcomes (KDIGO) criteria and classification. The requirement for renal replacement

therapy, supportive management, and other relevant interventions was recorded. The study outcomes included the incidence and severity of AKI among patients with ACS, identification of clinical and biochemical predictors, renal outcomes at hospital discharge, and the association between early intervention and renal prognosis.

Statistical Analysis: Data were analysed using IBM SPSS Statistics version 25.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Distribution of patients according to AKI stage

AKI stage	Frequency (n)	Percentage (%)
Stage 0 (No AKI)	36	36.0
Stage 1	31	31.0
Stage 2	16	16.0
Stage 3	17	17.0
Total	100	100.0

Of the 100 patients with acute coronary syndrome (ACS), 64 (64%) had AKI, while 36 (36%) had no AKI. Stage 1 was the most common AKI category (31%), followed by Stage 3 (17%) and Stage 2 (16%). AKI stage was significantly associated with age, sex, BMI category, hypertension, prior renal dysfunction, cardiogenic shock, ventilatory support, and heart failure. Diabetes mellitus was not significantly associated with AKI stage. The association with prior cardiac dysfunction was borderline using the Pearson chi-square test; Fisher's exact test was significant ($p = 0.024$). The BMI association should be interpreted cautiously because no significant linear trend was observed ($p = 0.246$). HbA1c differed significantly across AKI stages, with the highest mean in Stage 3 (8.12 ± 1.27%). LDL cholesterol also showed significant differences, with lower mean levels in Stages 2 and 3 than in Stages 0 and 1. Serum uric acid, total cholesterol, and triglyceride levels did not differ significantly across AKI stages.

Table 2: Clinical severity and requirement for renal replacement therapy

Clinical outcome	Stage 0 (n = 36)	Stage 1 (n = 31)	Stage 2 (n = 16)	Stage 3 (n = 17)	Total
Cardiogenic shock, n	0	11	5	11	27
Ventilatory support, n	0	11	0	11	22
Heart failure, n	16	26	11	5	58
Renal replacement therapy, n	0	0	0	17	17

Type of renal replacement therapy	Frequency (n)	Percentage of total cohort (%)
Hemodialysis	12	12.0
Peritoneal dialysis	5	5.0
Total receiving RRT	17	17.0

Cardiogenic shock and ventilatory support were significantly associated with AKI stage (both $p < 0.001$). Heart failure was also significantly associated with AKI stage ($p = 0.001$), although the pattern was non-linear. All 17 patients classified as Stage 3 received renal replacement therapy, comprising 12 patients undergoing hemodialysis and five undergoing peritoneal dialysis. The supplied results report a significant association between AKI stage and RRT requirement ($p < 0.001$).

Table 3: Serum creatinine at admission, discharge, and 3-month follow-up

AKI stage	n	Admission (mg/dL)	Discharge (mg/dL)	3-month follow-up (mg/dL)
Stage 0	36	1.25 ± 0.70	1.00 ± 0.32	0.94 ± 0.30
Stage 1	31	1.82 ± 0.63	1.27 ± 0.42	1.14 ± 0.41
Stage 2	16	2.50 ± 0.70	2.28 ± 0.21	1.69 ± 0.26
Stage 3	17	6.65 ± 1.03	1.84 ± 1.33	1.16 ± 0.78
Overall	100	2.55 ± 2.05	1.43 ± 0.78	1.16 ± 0.50

Mean serum creatinine decreased from 2.55 ± 2.05 mg/dL at admission to 1.43 ± 0.78 mg/dL at discharge and 1.16 ± 0.50 mg/dL at three months. Differences between AKI stages were statistically significant at all three time points ($p < 0.001$). Stage 3 patients had the highest admission creatinine (6.65 ± 1.03 mg/dL), whereas Stage 2 patients had the highest mean creatinine at three months (1.69 ± 0.26 mg/dL), suggesting persistent renal dysfunction in some patients.

Table 4: Association between AKI stage and mortality

AKI stage	Survived, n (%)	Died, n (%)	Total
Stage 0	36 (100.0)	0 (0.0)	36
Stage 1	26 (83.9)	5 (16.1)	31
Stage 2	16 (100.0)	0 (0.0)	16
Stage 3	6 (35.3)	11 (64.7)	17
Total	84 (84.0)	16 (16.0)	100

Pearson chi-square = 39.911; df = 3; $p < 0.001$.

Overall mortality was 16%. Mortality differed significantly across AKI stages ($p < 0.001$). Stage 3 had the highest mortality, with 11 of 17 patients (64.7%) dying, compared with five deaths among 31 patients (16.1%) in Stage 1. No deaths were reported in Stages 0 and 2. These findings indicate an association between severe AKI and mortality in the study cohort.

DISCUSSION

Acute kidney injury (AKI) is an important complication of acute coronary syndrome (ACS), particularly among patients admitted to the cardiac intensive care unit (CICU), owing to the close interaction between cardiac dysfunction and renal hypoperfusion.[4,5] In the present study of 100 patients with ACS, 64% developed AKI, comprising 31% with Stage 1, 16% with Stage 2, and 17% with Stage 3 disease. This incidence was higher than the 17.5% reported by Neves et al,[8] and may reflect the critical care setting, severity of illness, and associated comorbidities.

Age was significantly associated with AKI stage ($p < 0.001$), consistent with previous studies identifying age-related decline in renal reserve and associated comorbidities as important contributors to AKI risk.[7,8] Sex was also significantly associated with AKI stage ($p = 0.040$), with females more frequently represented in Stage 1 and males in Stages 2 and 3. This pattern differs from some previous reports and should be interpreted cautiously because of the limited sample size.[8,9]

BMI category was significantly associated with AKI stage by Fisher's exact test ($p < 0.001$); however, the linear trend was not significant ($p = 0.246$), indicating a non-linear relationship. Further studies are needed to clarify this finding. Hypertension showed a strong association with AKI stage ($p < 0.001$), supporting previous evidence that vascular changes and impaired renal autoregulation may increase susceptibility to renal injury.[8,9] In contrast, diabetes mellitus was not significantly associated with AKI stage ($p = 0.101$), although other studies have identified diabetes as a risk factor for AKI following percutaneous coronary intervention (PCI).[10]

Prior renal dysfunction was significantly associated with AKI stage ($p = 0.004$), consistent with evidence that pre-existing renal impairment increases vulnerability to acute renal insults.[8,10] The association between prior cardiac dysfunction was borderline by Pearson's chi-square test ($p = 0.052$), although Fisher's exact test showed statistical significance ($p = 0.024$). This discrepancy warrants cautious interpretation. Cardiogenic shock, ventilatory support, and heart failure were also significantly associated with AKI stage, highlighting the importance of hemodynamic instability and severe cardiac illness in renal dysfunction.[8,11,12]

Patients with prior renal dysfunction received significantly lower contrast volumes than those without prior renal dysfunction (7.81 ± 11.97 mL versus 36.07 ± 51.44 mL; $p < 0.001$). This difference suggests that contrast administration was tailored to baseline renal risk. Despite this difference, serum creatinine at discharge and at three months did not differ significantly between the groups ($p = 0.462$ and $p = 0.151$, respectively). These findings are consistent with the rationale for judicious contrast use in high-risk patients.[3,11,12] However, because this was an observational study, the results cannot establish that contrast reduction caused the comparable renal outcomes.

Serum creatinine differed significantly across AKI stages at admission, discharge, and three-month follow-up ($p < 0.001$ at each time point). Stage 3 patients had the highest admission creatinine, reflecting more severe renal dysfunction, while subsequent reductions suggested partial recovery. Stage 2 patients also showed improvement, although renal function remained comparatively impaired. These findings are consistent with evidence that AKI may be followed by persistent renal dysfunction and an increased risk of chronic kidney disease.[7,8] Interpretation of follow-up results should account for patient survival and completeness of follow-up.

Among the biochemical parameters, HbA1c was significantly higher in Stage 3 AKI ($p < 0.001$), suggesting a possible relationship between poor glycemic control and severe renal dysfunction. LDL cholesterol also differed significantly across AKI stages ($p < 0.001$), with lower mean levels in Stages 2 and 3; this may reflect treatment differences or the acute illness response and requires cautious interpretation. Serum uric acid, total cholesterol, and triglycerides were not significantly associated with AKI stage.

Renal replacement therapy (RRT) was required in 17 patients, all classified as Stage 3 AKI. This reflects the greater clinical severity of advanced AKI, although the study design does not permit conclusions regarding the independent effect of RRT on recovery or survival. The optimal timing of RRT in severe AKI remains debated.[13,14]

Mortality was significantly associated with AKI stage ($p < 0.001$). Overall, 16 patients died; 11 of the

17 patients with Stage 3 AKI died (64.7%), compared with five deaths among 31 patients with Stage 1 AKI and none in Stages 0 and 2. This pattern indicates that severe AKI was associated with the poorest observed outcome and is consistent with previous studies reporting increased mortality among ACS patients who develop AKI.[6,13,14] Admission serum creatinine was also higher among non-survivors than survivors, further emphasizing the prognostic importance of renal dysfunction.

Limitations

The study was limited by its relatively small sample size, single-centre observational design, and limited follow-up. Subgroup analyses may have lacked statistical power, and unadjusted associations cannot establish independent predictors or causal relationships.

CONCLUSION

Our study highlights the high incidence of AKI (64%) in ACS patients in a CICU, driven by critical illness and comorbidities, compared to lower rates (5–55%) in broader ACS populations. Key predictors, including age, sex, BMI, hypertension, prior renal dysfunction, and severe clinical conditions, align with the literature, suggest context-specific factors. Severe AKI was associated with high mortality (64.7% in Stage 3) and persistent renal dysfunction, consistent with increased risks of death and CKD. These findings underscore the need for vigilant monitoring, risk stratification, and tailored interventions in CICU patients to improve outcomes.

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