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ACUTE KIDNEY INJURY IN THE ICU: INCIDENCE, DIALYSIS TRIGGERS, MORTALITY, AND 90-DAY RENAL OUTCOMES

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ABSTRACT

Introduction: Acute kidney injury (AKI) is a consequential complication of critical illness associated with prolonged intensive care, renal replacement therapy (RRT), death, and incomplete recovery. Its Indian burden is amplified by sepsis, delayed referral, nephrotoxic exposure, variable dialysis access, and limited post-discharge follow-up. Contemporary Indian data integrating AKI incidence, RRT indications, mortality, and 90-day renal outcomes remain limited. **Aim:** To determine the incidence, indications for RRT, mortality, and 90-day renal outcomes of AKI among adults admitted to a multidisciplinary ICU. **Methodology:** Hospital-based prospective observational cohort study screened 184 consecutive adult admissions to a tertiary-care multidisciplinary ICU from January to December 2025; 46 patients developing AKI by Kidney Disease: Improving Global Outcomes (KDIGO) creatinine and/or urine-output criteria constituted the cohort. Adults staying at least 24 hours were eligible; maintenance-dialysis patients, kidney-transplant recipients, stage 5 chronic kidney disease, and incomplete baseline or follow-up records were excluded. Clinical characteristics, comorbidities, organ support, serial renal investigations, urine output, KDIGO stage, APACHE II and SOFA scores, RRT indications and modality, ICU stay, hospital death, and 90-day survival and renal status were recorded prospectively. Follow-up used clinic or telephone assessment supported by creatinine reports. Descriptive statistics, chi-square/Fisher's exact tests, and Welch's t-test were used; $p<0.05$ was significant. **Results:** AKI occurred in 46 of 184 screened ICU admissions (25.0%). Mean age was 56.8 ± 15.1 years; 29 (63.0%) patients were male, sepsis/septic shock accounted for 31 (67.4%), and 20 (43.5%) reached KDIGO stage 3. RRT was required in 19 (41.3%) patients; refractory metabolic acidosis (9/19, 47.4%) and persistent oliguria/anuria (6/19, 31.6%) were the principal triggers. In-hospital mortality was 15/46 (32.6%) and was higher with RRT than without RRT (10/19, 52.6% vs 5/27, 18.5%; p=0.025). By day 90, cumulative mortality was 19/46 (41.3%), again higher in the RRT group (12/19, 63.2% vs 7/27, 25.9%; p=0.016). Among 27 day-90 survivors, complete renal recovery occurred in 16 (59.3%), persistent non-dialysis kidney dysfunction in 9 (33.3%), and dialysis dependence in 2 (7.4%). **Conclusion:** AKI affected one-quarter of adult ICU admissions and frequently followed sepsis; two-fifths required RRT, most often for acidosis or persistent oliguria. RRT requirement identified a severely ill subgroup with greater hospital and 90-day mortality, supporting early detection and structured post-AKI follow-up.

KEYWORDS

Acute Kidney Injury; Intensive Care Unit; Renal Replacement Therapy; Mortality; Renal Recovery

INTRODUCTION

Acute kidney injury (AKI) is a heterogeneous clinical syndrome defined by an abrupt reduction in kidney function, manifested by a rise in serum creatinine, diminished urine output, or both. The resulting failure of solute, acid–base, electrolyte, and volume regulation can rapidly destabilize a critically ill patient. Even modest creatinine increases are associated with longer hospitalization, greater cost, and excess mortality, making AKI an important quality-of-care and patient-safety problem rather than an isolated biochemical abnormality [1]. The Kidney Disease: Improving Global Outcomes (KDIGO) framework standardized diagnosis and severity staging and thereby improved comparability across clinical settings; nevertheless, creatinine remains a delayed functional marker and urine-output measurement is vulnerable to documentation error, diuretic exposure, and hemodynamic confounding [2].

The burden of AKI is greatest in intensive care units (ICUs), where sepsis, shock, mechanical ventilation, major surgery, contrast exposure, and nephrotoxic drugs frequently coexist. The multinational BEST Kidney study established the global scale of severe acute renal failure in critical illness and demonstrated its close relationship with sepsis, organ failure, and death [3]. Subsequently, the AKI-EPI investigation found that more than half of assessed ICU patients fulfilled AKI criteria and that mortality increased progressively with KDIGO stage [4]. Reported incidence varies substantially because of differences in case mix, baseline creatinine ascertainment, observation windows, and inclusion of urine-output criteria. This heterogeneity makes locally generated estimates essential for service planning, particularly where ICU beds and dialysis resources are constrained [5].

Indian ICUs encounter a distinctive intersection of community-acquired and hospital-acquired kidney insults. Alongside diabetes, hypertension, cardiovascular disease, and an ageing population, clinicians manage severe bacterial sepsis, tropical infections, gastroenteritis, poisoning, snake envenomation, obstetric emergencies, delayed surgical presentation, and unregulated medication exposure. In a prospective Indian ICU study, Korula et al. reported AKI in 16.1% of critically ill patients, with substantial dialysis use and 28-day mortality [6]. Other Indian cohorts have documented sepsis as a dominant precipitant and have highlighted vasopressor dependence, mechanical ventilation, multiorgan failure, and higher AKI stage as markers of adverse prognosis [7]. Such variability reflects referral pathways and institutional capacity and cautions against uncritical transfer of estimates from high-income health systems.

Renal replacement therapy is lifesaving when AKI produces complications that cannot be controlled medically. Accepted emergency indications include refractory hyperkalemia, severe metabolic acidosis, pulmonary edema or clinically important fluid overload, and uremic complications; persistent oliguria or anuria and progressive azotemia also influence decisions in the context of the entire clinical trajectory [8]. The choice between intermittent hemodialysis, sustained low-efficiency dialysis (SLED), and continuous kidney replacement therapy depends on hemodynamic stability, catabolic burden, fluid-removal requirements, expertise, and availability. In many Indian tertiary hospitals, intermittent hemodialysis and SLED remain pragmatic modalities because continuous therapy is more resource intensive.

The timing of RRT in the absence of an unequivocal emergency remains controversial. The AKIKI trial did not demonstrate a survival advantage from systematically earlier treatment and showed that a delayed strategy allowed some patients to recover without dialysis [9]. The large STARRT-AKI trial likewise found no reduction in 90-day mortality with accelerated initiation; accelerated treatment exposed more patients to RRT and increased ongoing dialysis dependence among survivors [10]. These trials support an indication-led, patient-centred approach rather than initiation based solely on AKI stage or an isolated biochemical threshold. They also underline that RRT requirement is usually a marker of disease severity and cannot be interpreted as the cause of poor outcome in a descriptive study.

AKI does not end at ICU discharge. Survivors have elevated risks of

recurrent AKI, chronic kidney disease (CKD), cardiovascular events, rehospitalization, and premature death [11]. AKI and CKD are now understood as interconnected syndromes, and incomplete recovery may represent a transition through acute kidney disease toward persistent CKD [12]. However, post-AKI surveillance is inconsistent in routine Indian practice. Patients may return to distant districts, obtain creatinine testing outside the treating hospital, or receive no nephrology review after apparent clinical improvement. Consequently, discharge-only studies underestimate the enduring burden of critical-illness-associated AKI.

Evidence from Indian hospital-based cohorts remains heterogeneous with respect to AKI definitions, denominators, dialysis practices, and duration of follow-up. Some studies describe only patients referred to nephrology, while others omit urine output or exclude early deaths, potentially altering incidence and outcome estimates [13]. Severity scores such as the Sequential Organ Failure Assessment (SOFA) and Acute Physiology and Chronic Health Evaluation II (APACHE II) provide useful contextual measures, but they do not replace serial assessment of kidney trajectory and organ support [14]. A study integrating an ICU admission denominator, standardized KDIGO staging, explicit RRT triggers, hospital mortality, and a predefined 90-day renal assessment can therefore offer clinically relevant baseline information. The present study was undertaken to describe this continuum in an Indian multidisciplinary ICU, with emphasis on incidence, real-world dialysis indications, survival, and renal recovery after discharge [15].

AIM

To determine the incidence, indications for renal replacement therapy, mortality, and 90-day renal outcomes of acute kidney injury among adults admitted to a multidisciplinary intensive care unit.

METHODOLOGY

A hospital-based prospective observational cohort study was conducted in the multidisciplinary adult intensive care unit of a tertiary-care teaching hospital in India from January to December 2025 after obtaining approval from the Institutional Ethics Committee. All consecutive adult ICU admissions during the study period were screened using a prospectively maintained screening log. After applying the predefined eligibility criteria, 184 eligible ICU admissions constituted the denominator for estimating AKI incidence. Of these, 46 patients developed AKI and constituted the final analysed AKI cohort. Thus, the study followed a time-bound consecutive-enrolment approach, and the analysed sample size remained 46 throughout. Patients aged 18 years or older, admitted to the ICU for at least 24 hours, and developing AKI during or immediately before the index ICU admission were eligible. AKI was diagnosed according to Kidney Disease: Improving Global Outcomes criteria as an increase in serum creatinine of ≥0.3 mg/dL within 48 hours, an increase to ≥1.5 times the known or presumed baseline value within the preceding seven days, or urine output <0.5 mL/kg/hour for at least six hours. Patients receiving maintenance dialysis, those with stage 5 chronic kidney disease, previous kidney transplantation, obstructive uropathy requiring primary urological intervention, or readmission after enrolment during the same study period were excluded. Patients with insufficient information for reliable AKI classification were also excluded. Patients who became unavailable during follow-up were retained in the incidence and in-hospital analyses and were to be reported separately for 90-day outcomes; however, the vital status and renal outcome of all 46 enrolled patients were successfully ascertained at day 90. The most recent stable serum creatinine value documented within the preceding three months was considered the baseline. When a previous result was unavailable, baseline kidney function was clinically adjudicated using the admission profile, subsequent creatinine trajectory, previous medical records, and evidence of pre-existing kidney disease, with uncertain cases reviewed jointly by the intensivist and nephrologist. Demographic characteristics, referral source, primary clinical diagnosis, diabetes mellitus, hypertension and other comorbidities, nephrotoxic exposure, hemodynamic variables, cumulative fluid balance, vasopressor requirement, invasive mechanical ventilation, Acute Physiology and Chronic Health Evaluation II score, and Sequential Organ Failure Assessment score during the first 24 hours were recorded in a predesigned case-record form. Laboratory assessment included serial serum creatinine and blood urea, sodium, potassium, bicarbonate, arterial blood gas analysis, complete blood count, liver-function tests, urine microscopy, relevant microbiological cultures, and ultrasonography of the kidneys and urinary tract when clinically indicated. AKI severity was classified according to the worst KDIGO stage reached during the index ICU admission. Sepsis without septic shock and septic shock were recorded as mutually exclusive clinical categories using Sepsis-3 criteria. Renal replacement therapy was initiated jointly by the critical-care and nephrology teams according to the patient's overall clinical condition and prespecified institutional indications. These included refractory metabolic acidosis with persistent severe acidemia despite appropriate medical treatment; life-threatening hyperkalemia, particularly serum potassium ≥6.0 mmol/L, electrocardiographic abnormalities, or failure to respond to medical management; persistent oliguria, defined as urine output <0.3 mL/kg/hour for at least 24 hours, or anuria for at least 12 hours accompanied by worsening biochemical or volume status; pulmonary edema or clinically significant fluid overload unresponsive to medical and diuretic therapy; and uremic complications such as encephalopathy, pericarditis, or clinically significant bleeding. Where multiple indications coexisted, the predominant indication responsible for initiating RRT was recorded for analysis. The choice between intermittent hemodialysis and sustained low-efficiency dialysis was determined by hemodynamic stability, fluid-removal requirements, metabolic abnormalities, and local feasibility. The primary study outcomes were AKI incidence among eligible ICU admissions, RRT requirement and principal indication, in-hospital mortality, cumulative 90-day mortality, and renal status at day 90. Complete renal recovery was defined as survival without dialysis with serum creatinine returning to within 25% of the pre-AKI baseline value. Persistent non-dialysis kidney dysfunction was defined as survival without dialysis with serum creatinine remaining >25% above baseline or a sustained deterioration in estimated glomerular filtration-rate category compared with the pre-AKI baseline. Dialysis dependence was defined as an ongoing requirement for maintenance kidney replacement therapy at day 90. Follow-up was completed through scheduled nephrology or medicine outpatient review or structured telephone contact. Day-90 renal classification was supported by hospital or externally performed serum creatinine reports and dialysis records, while vital status was confirmed directly from the patient or legally authorized representative. Written informed consent was obtained from each patient or legally authorized representative. Participant confidentiality was maintained through coded study identifiers, and participation did not alter routine clinical management. Data were analysed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation after assessing their distribution, while categorical variables were presented as frequency and percentage. Important proportions were additionally reported with 95% confidence intervals. AKI incidence was calculated using the 184 eligible ICU admissions as the denominator. The RRT and non-RRT groups were compared exploratorily using Welch's independent-samples t-test for ICU stay. Two-sided Fisher's exact test was used for 2×2 categorical comparisons, and the Fisher–Freeman–Halton exact test was used to compare RRT requirement across the three KDIGO stages because of small expected cell frequencies. No multivariable modelling was undertaken because of the limited sample size and number of outcome events. A two-sided p-value <0.05 was considered statistically significant. All between-group findings were interpreted as exploratory associations and not as evidence of a causal effect of RRT on mortality or renal recovery.

RESULTS

Table 1. AKI Incidence, Baseline Clinical Profile, and Disease Severity (Analysed AKI Cohort, n=46)

Variable	Category	n	Percentage/ Mean ± SD
Eligible ICU admissions screened	All eligible admissions	184	—
AKI incidence	KDIGO-defined AKI	46	25.0% of 184
Age (years)	Mean ± SD	46	56.8 ± 15.1
Age group	18–40 years	8	17.4
	41–60 years	22	47.8
	>60 years	16	34.8
Sex	Male	29	63.0
	Female	17	37.0
Primary clinical context	Sepsis without septic shock	22	47.8
	Septic shock	9	19.6
	Postoperative complications	7	15.2
	Acute pancreatitis	4	8.7

	Other conditions	4	8.7
KDIGO stage	Stage 1	11	23.9
	Stage 2	15	32.6
	Stage 3	20	43.5
Severity score	SOFA score	46	9.48 ± 2.71
	APACHE II score	46	18.72 ± 4.83
RRT requirement according to KDIGO stage	Stage 1	1/11	9.1
	Stage 2	4/15	26.7
	Stage 3	14/20	70.0
	Exact p-value	—	0.002*

*Fisher–Freeman–Halton exact test.

Interpretation: AKI was identified in 46 of 184 eligible ICU admissions, giving an incidence of 25.0% (95% CI: 19.3%–31.7%). The mean age was 56.8 ± 15.1 years, and 29 patients (63.0%) were male. Sepsis without shock and septic shock together accounted for 31 cases (67.4%). KDIGO stage 3 AKI was observed in 20 patients (43.5%). RRT requirement increased significantly from 9.1% in stage 1 to 70.0% in stage 3 AKI (Fisher–Freeman–Halton exact test, p=0.002).

Table 2. RRT Requirement, Principal Indications, and Modality Among Patients with AKI (n=46)

Variable	Category	n	Percentage (%)
RRT requirement	Required	19	41.3
	Not required	27	58.7
Principal RRT indication*	Refractory metabolic acidosis	9	47.4
	Persistent oliguria/anuria	6	31.6
	Life-threatening hyperkalemia	2	10.5
	Fluid overload/pulmonary edema	2	10.5
RRT modality	Intermittent hemodialysis	14	73.7
	Sustained low-efficiency dialysis	5	26.3

*Percentages for RRT indications and modalities were calculated using the 19 patients receiving RRT as the denominator. Only the predominant indication was counted for each patient, although multiple indications could coexist.

Interpretation: RRT was required in 19 of 46 patients (41.3%; 95% CI: 28.3%–55.7%). Refractory metabolic acidosis was the most frequent principal indication, accounting for nine cases (47.4%), followed by persistent oliguria or anuria in six cases (31.6%). Intermittent hemodialysis was used in 14 of the 19 patients receiving RRT (73.7%), while five patients (26.3%) underwent sustained low-efficiency dialysis.

Table 3. Hospital and 90-day Outcomes According to RRT Requirement (n=46)

Outcome	RRT group (n=19)	Non-RRT group (n=27)	Total	p-value
ICU stay, days, mean ± SD	11.84 ± 3.26	8.30 ± 2.58	9.76 ± 3.35	<0.001†
Mechanical ventilation, n (%)	15 (78.9)	10 (37.0)	25 (54.3)	0.007‡
In-hospital mortality, n (%)	10 (52.6)	5 (18.5)	15 (32.6)	0.025‡
Cumulative mortality by day 90, n (%)	12 (63.2)	7 (25.9)	19 (41.3)	0.016‡
Day-90 survivors, n	7	20	27	—
Complete renal recovery among survivors, n (%)	2 (28.6)	14 (70.0)	16/27 (59.3)	0.084‡
Persistent non-dialysis kidney dysfunction among survivors, n (%)	3 (42.9)	6 (30.0)	9/27 (33.3)	0.653‡
Dialysis dependence among survivors, n (%)	2 (28.6)	0 (0.0)	2/27 (7.4)	0.060‡

†Welch's independent-samples t-test.
‡Two-sided Fisher's exact test.
Percentages for day-90 renal outcomes were calculated among the 27 patients who were alive at day 90.

Interpretation: Patients requiring RRT had a significantly longer ICU stay than patients managed without RRT (11.84 ± 3.26 versus 8.30 ± 2.58 days; p<0.001). Mechanical ventilation was more frequent in the RRT group (78.9% versus 37.0%; p=0.007). In-hospital mortality was significantly higher among patients requiring RRT (52.6% versus 18.5%; p=0.025), as was cumulative 90-day mortality (63.2% versus 25.9%; p=0.016). Among the 27 patients alive at day 90, 16 (59.3%) achieved complete renal recovery, nine (33.3%) had persistent non-dialysis kidney dysfunction, and two (7.4%) remained dialysis dependent. Differences in individual renal-recovery categories did not reach statistical significance.

DISCUSSION

In this prospective descriptive cohort, AKI occurred in 25.0% of 184 adult ICU admissions. The analysed patients were predominantly middle-aged or older, nearly two-thirds were male, and sepsis or septic shock accounted for over two-thirds of AKI. KDIGO stage 3 was the largest severity category, and higher stage was strongly associated with RRT requirement. The incidence lies within the broad range reported in critical care but is lower than the 57.3% prevalence recorded on the AKI-EPI study's assessment day [4]. That difference is clinically plausible because AKI-EPI enrolled a heterogeneous international ICU population and used a point-prevalence strategy, whereas the present single-centre denominator and case mix were narrower. Conversely, Korula et al. reported a 16.1% incidence in an Indian mixed ICU [6], lower than the present 25.0%; differences in admission thresholds, baseline creatinine availability, urine-output capture, and sepsis burden can materially influence ascertainment. The dominance of sepsis is consistent with Gurjar et al., who described septic AKI as common and highly lethal in critically ill Indian patients [16], and with the PICARD experience, in which severe AKI commonly occurred in the context of systemic illness and multiorgan dysfunction [17]. The present Table 1 therefore reflects a credible Indian tertiary-care pattern but should not be treated as a population estimate beyond comparable ICUs.

RRT was used in 19 of 46 patients (41.3%). Refractory metabolic acidosis was the principal trigger in 47.4% of treated patients, followed by persistent oliguria or anuria in 31.6%; intermittent hemodialysis was the most frequently used modality, with SLED reserved largely for patients requiring gentler solute and fluid removal. Korula et al. reported hemodialysis in 39.1% of Indian ICU patients with AKI [6], closely resembling the present overall RRT proportion. In contrast, treatment exposure in international cohorts varies with enrolment severity and local modality access. The AKIKI investigators used conventional complications—including severe hyperkalemia, metabolic acidosis, pulmonary edema, marked azotemia, and prolonged oliguria—as triggers in the delayed arm and found that postponement in the absence of an emergency avoided RRT in a substantial subgroup without increasing mortality [9]. STARRT-AKI similarly found no 90-day survival advantage from accelerated initiation and reported greater dialysis dependence with the accelerated strategy [10]. These comparisons support the indication-led practice shown in Table 2. They do not establish that the observed modality mix was optimal; intermittent dialysis predominance may partly reflect affordability and infrastructure rather than physiology alone. Because each patient was assigned one principal indication, the table also simplifies the frequent coexistence of acidosis, oliguria, hyperkalemia, and fluid overload.

Hospital mortality was 32.6%, rising to 41.3% cumulatively by day 90. Patients receiving RRT had longer ICU stays, more frequent mechanical ventilation, higher in-hospital mortality, and higher 90-day mortality than patients managed without RRT. The two-sided Fisher's exact p-values were derived directly from the displayed counts, but these differences should be interpreted as severity associations. RRT recipients had more stage 3 disease and organ-support needs; the design cannot determine whether dialysis itself changed survival. The BEST Kidney study reported high hospital mortality among critically ill patients with severe acute renal failure, especially when RRT and multiple organ failure were present [3]. In an Indian medical ICU cohort, Saxena et al. observed overall in-hospital mortality of 28.4% among AKI patients and identified sepsis and critical- illness features as adverse prognostic markers [7], reasonably

close to the 32.6% recorded here. Priyamvada et al. described 30-day mortality exceeding 50% in an Indian tertiary-care AKI cohort [13], higher than the present 90-day estimate; their referral population and etiological spectrum likely represented a different severity mix. The present association between ventilation and RRT also accords with the concept that ICU AKI is usually embedded within multiorgan failure rather than occurring in isolation [1,3].

Renal status at day 90 adds information not captured by hospital survival alone. Among 27 survivors, 16 (59.3%) met the prespecified definition of complete recovery, nine (33.3%) had persistent non-dialysis kidney dysfunction, and two (7.4%) remained dialysis dependent; both dialysis-dependent survivors had received RRT during admission. Chawla et al. emphasized that AKI and CKD form an interconnected continuum and that even apparent recovery confers future renal and cardiovascular risk [12]. Bouchard et al. also documented substantial mortality and incomplete recovery in a prospective international ICU cohort, particularly with severe AKI and greater illness burden [18]. In an Indian study of short-term AKI outcomes, Bhattacharya et al. reported complete recovery in 92.9% of survivors at discharge [15], a higher proportion than the present day-90 finding. The contrast may reflect differing recovery definitions, exclusion patterns, and the fact that discharge creatinine can underestimate later persistent dysfunction or loss to follow-up. Table 3 therefore reinforces the need to treat post-AKI care as part of the original critical-care episode rather than an optional add-on. A practical pathway would include medication reconciliation, avoidance of unnecessary nephrotoxins, blood-pressure and glycaemic management, repeat creatinine and urine protein assessment, and nephrology referral for stage 3 AKI, incomplete recovery, or dialysis-treated disease.

The study has strengths relevant to practice: it used a defined ICU denominator, KDIGO criteria incorporating creatinine and urine output, prospectively recorded dialysis triggers, and complete 90-day vital-status ascertainment. It also separated cumulative mortality from renal outcomes among survivors, preventing death from being misclassified as non-recovery. Important limitations remain. The single-centre sample of 46 produced wide uncertainty around percentages and limited statistical power; exploratory p-values were not adjusted for multiple comparisons. The study did not estimate confidence intervals, model confounding, compare RRT modalities, or test early versus delayed dialysis. Baseline creatinine could require clinical adjudication, and a single day-90 creatinine cannot fully characterize renal trajectory or formally establish chronicity in every survivor. Finally, access and clinician preference influenced modality selection. Accordingly, the results generate local descriptive evidence and hypotheses but do not justify causal conclusions or a universal RRT threshold. Larger multicentre Indian cohorts with standardized follow-up at 30 days, 90 days, and one year are required.

CONCLUSION

Acute kidney injury affected one-quarter of adult admissions to this multidisciplinary ICU and was most often associated with sepsis, with a substantial proportion progressing to KDIGO stage 3. Two-fifths of affected patients required renal replacement therapy, principally for refractory metabolic acidosis or persistent oliguria/anuria. RRT requirement marked a subgroup with greater organ-support needs, longer ICU stay, and significantly higher in-hospital and 90-day mortality, although causality cannot be inferred from this descriptive design. Among 90-day survivors, more than one-third had persistent kidney dysfunction or dialysis dependence. These findings support systematic AKI surveillance, indication-based RRT, careful transition from ICU to ward and community care, and structured biochemical and nephrology follow-up after discharge in Indian hospital practice.

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