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A Hospital-Based Study on the Clinical and Demographic Profile of Hemodialysis at a Tertiary Care Institute

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Abstract:

Background: Hemodialysis (HD) is a vital intervention in the intensive care unit (ICU), particularly for patients with acute kidney injury (AKI), chronic kidney disease (CKD), or end-stage renal disease (ESRD) with superimposed complications.

Aim: This study aims to evaluate the clinical characteristics, causes of AKI, dialysis modalities, complications, and outcomes in ICU patients undergoing hemodialysis.

Methods: A retrospective analysis was conducted at Father Muller Medical College from January 2018 to December 2023. Medical records of 1245 patients who underwent hemodialysis in the ICU were reviewed. Data on demographics, comorbidities, laboratory parameters, dialysis modality,

vascular access, complications, and outcomes were analyzed.
Results: The mean age of patients was 36.7 ± 14.5 years, with a slight male predominance (50.3%). Hypovolemia (22.5%), acute glomerulonephritis (21.9%), and pregnancy-related complications (18.5%) were the leading causes of dialysis-requiring AKI. Of the total, 16.9% had AKI superimposed on CKD, primarily due to hypertension. Intermittent hemodialysis (IHD) and continuous renal replacement therapy (CRRT) were used based on hemodynamic status. The most common indication for dialysis was refractory fluid overload (89.4%). Complications included hemodynamic instability, infections, bleeding, and electrolyte imbalances. Overall mortality was 29.1%, while 53% were discharged improved.
Conclusion: Hemodialysis in the ICU is associated with significant morbidity and mortality. Tailored dialysis modality selection, early identification of AKI causes, and optimized vascular access strategies are crucial for improving patient outcomes.
Keywords: Hemodialysis, ICU, Acute Kidney Injury, CRRT, Dialysis Complications, Central Venous Catheter

Introduction

Acute kidney injury (AKI) and chronic kidney disease (CKD) with acute exacerbation are common and life-threatening complications among critically ill patients admitted to intensive care units (ICUs). Hemodialysis (HD) is an essential therapeutic intervention in such patients, aimed at restoring fluid and electrolyte balance, removing metabolic toxins, and managing acid-base disturbances. The advent of advanced dialysis technologies has made it possible to tailor renal replacement therapy (RRT) to the specific needs of critically ill patients. However, the choice of dialysis modality—intermittent hemodialysis (IHD), continuous renal replacement therapy (CRRT), or hybrid techniques—remains a critical decision based on individual patient hemodynamics, comorbidities, and resource availability [1].

The burden of AKI in ICU settings is significant. Global epidemiological data indicate that AKI occurs in up to 57% of critically ill patients, and approximately 23% of these patients require renal replacement therapy [2]. The pathophysiology of AKI in the ICU is multifactorial, involving hypovolemia, sepsis, nephrotoxic agents, and systemic inflammatory responses. In resource-limited settings like many parts of India, AKI is often community-acquired and presents late, frequently requiring urgent dialysis [3].

Intermittent hemodialysis (IHD) is often used for patients with stable cardiovascular profiles, while CRRT is better suited for hemodynamically unstable patients as it allows gradual fluid and solute removal. Hybrid therapies such as sustained low-efficiency dialysis (SLED) aim to provide the hemodynamic stability of CRRT and the efficiency of IHD [4]. Choosing the optimal modality involves balancing the need for solute clearance, volume control, and resource limitations, particularly in developing nations [5].

Vascular access remains a pivotal element in the delivery of hemodialysis. Arteriovenous fistulas (AVFs) are preferred for their durability and low infection rates, but central venous catheters (CVCs) are often used in acute settings due to ease of placement and immediate availability [6]. The widespread use of temporary CVCs in ICUs is associated with an increased risk of complications, including catheter-related bloodstream infections (CRBSIs), thrombosis, and stenosis [7].

Complications of dialysis in critically ill patients are not uncommon. Hemodynamic instability, infections, electrolyte disturbances, and access-related issues can significantly influence patient outcomes [8]. Mortality rates in ICU patients undergoing dialysis vary widely, influenced by the underlying cause of renal failure, presence of multiorgan dysfunction, and the timing of intervention. Studies suggest that prompt identification of AKI and early initiation of dialysis may improve outcomes [9].

India faces unique challenges in the management of dialysis in ICU settings. Late presentation, high burden of infectious diseases, lack of widespread nephrology expertise, and resource constraints contribute to delayed diagnosis and suboptimal outcomes. Additionally, the epidemiology of AKI in India is skewed towards younger populations with reversible causes such as obstetric complications, tropical infections, and trauma, which contrasts with patterns observed in developed countries [10].

This retrospective observational study was conducted to analyze the clinical profile, indications, modalities, complications, and outcomes of ICU patients undergoing hemodialysis in a tertiary care hospital in South India. By identifying the most common etiologies, risk factors, and treatment outcomes, this study aims to provide data that can guide clinical decision-making and resource allocation in similar settings.

The study also highlights the need for strengthening early diagnostic frameworks for AKI, improving infection control practices for catheter care, and enhancing access to advanced modalities like CRRT and hybrid therapies. This is particularly important in a country where tertiary care hospitals often serve as referral centers for a vast catchment population and where dialysis resources must be optimized for maximum impact.

To the best of our knowledge, this is one of the largest single-center studies in South India to assess ICU-based hemodialysis practices over a 5-year period. The findings offer valuable insights for intensivists, nephrologists, and hospital administrators aiming to improve renal care in critical settings.

Materials and Methods

Study Design and Setting

This was a retrospective observational study conducted at the Father Muller Medical College Hospital, a tertiary care academic center located in Mangalore, Karnataka. The hospital has a multidisciplinary ICU equipped with nephrology support and dialysis facilities, including IHD, CRRT, and hybrid modalities.

Study Period

The study covered a period of five years, from January 1, 2018, to December 31, 2023.

Study Population

Inclusion criteria:

All adult patients (age ≥18 years) admitted to the ICU and who underwent at least one session of hemodialysis during their stay.

Exclusion criteria:

Pediatric patients (<18 years)

Patients dialyzed for drug overdose or toxic ingestion

Patients with chronic dialysis for end-stage renal disease (ESRD) prior to ICU admission

Records with incomplete or missing data

A total of 1245 patient records were reviewed and analyzed.

Data Collection

Data were collected retrospectively from electronic medical records and dialysis logs. The following variables were extracted:

Demographic data: age, sex, residence, referral origin

Clinical characteristics: comorbidities (HIV, HTN, DM, CVD, etc.), presenting symptoms, ICU admission diagnoses

Etiology of AKI: hypovolemia, AGN, pregnancy-related causes, nephrotoxins, sepsis, obstructive uropathy

Laboratory parameters: serum creatinine, BUN, potassium, hemoglobin, inflammatory markers (CRP, PCT)

Dialysis details: modality used (IHD, CRRT, SLED), number of sessions, type of vascular access, anticoagulation strategy

Outcomes: recovery, mortality, dialysis dependence at discharge, complications (CRBSIs, thrombosis, hemodynamic instability)

Definitions

AKI was defined according to KDIGO criteria.

Refractory fluid overload was defined as fluid retention unresponsive to diuretics with respiratory compromise.

Uremic symptoms included encephalopathy, pericarditis, nausea, and pruritus.

Dialysis dependence was defined as requiring maintenance dialysis at hospital discharge.

Ethical Considerations

Patient confidentiality was maintained through anonymized data entry and secure storage.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Descriptive statistics were used to summarize categorical variables (frequencies, percentages) and continuous variables (mean, standard deviation). Chi-square tests and independent t-tests were used for bivariate analysis.

A p-value <0.05 was considered statistically significant.

General Demographics and ICU Admission

Out of 1,245 adult ICU patients who received hemodialysis during the study period (2018–2023), the mean age was 36.7 ± 14.5 years (range: 18–82 years). Age distribution revealed that 67.5% of patients were between 21–40 years, 18.1% between 41–60, 9.2% under 20, and 5.2% over 60. The female-to-male ratio was nearly equal (49.7% female, 50.3% male). Geographically, 67.5% of patients were urban residents, of whom 38.4% hailed from Mangalore city.

Table 1 Patient Demographics and Baseline Characteristics

Characteristic	n = 1,245 (%)
Age (mean ± SD, years)	36.7 ± 14.5
Age group	
< 20	114 (9.2)
21–40	840 (67.5)
41–60	225 (18.1)
> 60	65 (5.2)
Sex distribution	
Male	627 (50.3)
Female	618 (49.7)
Residence	
Urban	841 (67.5)
Rural	404 (32.5)
In-hospital referrals	
Direct from home	498 (40.0)
Referred from other centers	747 (60.0)

Comorbidities and Predisposing Conditions

Approximately 15.9% of patients had HIV infection, 14.1% had hypertension, 3.3% had a history of cerebrovascular accident, and 2.6% had diabetes mellitus. No other major comorbidities were documented in more than 1% of the study population.

Clinical Presentation and Causes of AKI

Presenting Features

The predominant symptoms at presentation included:

Oliguria: 86.1% (n = 1,073)

Generalized edema: 58.9% (n = 734)

Encephalopathy or altered sensorium: 49.0% (n = 610)

Convulsions: 11.3% (n = 141)

Etiology of AKI

Primary causes of AKI triggering hemodialysis initiation included:

Hypovolemia (from GI losses or hemorrhage): 22.5%

Acute glomerulonephritis (AGN): 21.9%

Pregnancy-associated causes: 18.5%

- Preeclampsia/eclampsia – 12.5%
- Puerperal sepsis – 3.3%
- Postpartum hemorrhage – 1.3%

Nephrotoxin exposure: 12.6% (gentamycin, tenofovir, chemotherapeutics)

Obstructive uropathy: 8.4% (e.g., stones, prostate)

Sepsis (without AGN or volume loss): 6.7%

Rhabdomyolysis/interstitial nephritis/malignant hypertension: 3.4%

Additionally, 16.9% (n = 210) had AKI on CKD (stage 3+), primarily arising in patients with background hypertension (51.9%) and diabetes.

Laboratory Parameters

Laboratory values at ICU admission and pre-discharge are shown in Table 2, highlighting significant improvements post-dialysis.

Table 2. Laboratory Parameters at Admission vs Discharge

Parameter	Admission (mean ± SD)	Discharge (mean ± SD)
Hemoglobin (g/dL)	10.2 ± 2.1	8.2 ± 1.8
Creatinine (mg/dL)	10.18 ± 5.19	4.97 ± 3.54
Blood Urea Nitrogen (mg/dL)	103 ± 45	52 ± 26
Serum Potassium (mEq/L)	5.03 ± 1.35	4.06 ± 1.02
CRP (mg/L)	68.4 ± 25.7	27.1 ± 12.9

Dialysis Modalities, Access, and Frequency

Modalities Utilized

Intermittent hemodialysis (IHD): 50.4% (n = 628)

Continuous renal replacement therapy (CRRT): 29.8% (n = 372)

Hybrid therapy (SLED/EDD): 19.8% (n = 245)

Vascular Access Types

Vascular access was:

Central venous catheter (CVC): 72.6% (n = 904)

Among those, multilumen catheters were used in 68% for additional infusions/monitoring.

Arteriovenous fistula (AVF): 14.3% (n = 178)

Arteriovenous graft (AVG): 5.8% (n = 72)

Temporary tunneled or femoral line: 7.3% (n = 91)

Dialysis Sessions and Duration

The average number of sessions per patient was 4.8 (range 1–31). Total dialysis sessions across the cohort were 5,976.

Complications during Dialysis

Hemodynamic instability requiring vasopressors occurred in 35% (n = 436) of sessions. Other complications included:

Catheter-related bloodstream infections (CRBSI): 19.4% (n = 241)

Thrombosis or access malfunction: 11.2% (n = 140)

Bleeding events: 7.9% (n = 98)

Severe electrolyte disturbances: 6.1% (n = 76) — mainly hypokalemia, hypocalcemia

Clinical Outcomes and ICU Metrics

Table 3. Outcomes and Length of Hospital Stay

Outcome	n = 1,245 (%)
Discharged improved	661 (53.1)
Mortality	362 (29.1)
Absconded	132 (10.6)
Progressed to ESRD	90 (7.3)
Mean ICU length of stay (days)	20.7 ± 14.2
Death attributable to:	
• Sudden cardiac arrest	146 (40.3 of deaths)
• Sepsis and multiorgan failure	104 (28.7%)
• Fluid overload complications or pulmonary edema	58 (16.0%)
• Other (bleeding, electrolyte crisis)	54 (14.9%)

Subgroup Outcomes: AKI vs AKI-on-CKD

Among the 210 patients with AKI-on-CKD:

Discharged improved: 86 (40.9%)

Mortality: 94 (44.8%)

Dialysis-dependent at discharge: 30 (14.3%)

Comparatively, the purely AKI cohort (n=1,035) had:

Discharged improved: 575 (55.6%)

Mortality: 268 (25.9%)

Dialysis-dependent: 60 (5.8%)

. Association Analysis

Bivariate analysis revealed:

Hemodynamic instability (vasopressor use) was associated with higher mortality (45% vs. 20%, $p < 0.001$).

CRBSI increased risk of mortality (OR 1.8, 95% CI 1.3–2.4, p = 0.02).
CRRT/SLED usage correlated with improved outcomes in unstable patients (p = 0.03).
Background CKD, especially when diabetogenic or hypertensive, predicted poorer survival (p = 0.01).

Summary of Key Findings

Table 4. Key Drivers of Mortality (Multivariate Logistic Regression)

Predictor	Adjusted OR (95% CI)	p-value
Age ≥ 60 years	2.1 (1.5–2.9)	<0.001
Vasopressor requirement	3.4 (2.6–4.5)	<0.001
CRBSI	1.8 (1.3–2.4)	0.02
AKI-on-CKD	1.9 (1.4–2.6)	0.01
Mode of dialysis (CRRT vs IHD)	0.7 (0.5–0.9)	0.03

In a diverse sample of 1,245 ICU patients undergoing hemodialysis at a tertiary centre over five years, younger adults predominated with reversible AKI etiologies. While dialysis resulted in significant laboratory improvement, complication rates were high and mortality remained considerable at nearly 30%. Unstable patients, CRBSI, and preexisting CKD emerged as predictors of poor prognosis. These findings highlight critical opportunities for intervention: better infection control, prompt modality selection—especially CRRT/SLED for unstable patients—and close monitoring in those with CKD to improve survival and functional recovery.

Discussion

The current study presents a comprehensive overview of critically ill patients requiring hemodialysis in the ICU at Father Muller Medical College Hospital over a period of five years. It investigates demographics, etiologies, dialysis modalities, complications, and outcomes in a cohort comprising 1,245 patients. In this discussion, we place our findings within the broader context of ICU-based renal replacement therapy, compare them with existing literature, analyze pathophysiologic mechanisms, and explore the implications for clinical practice in resource-limited settings.

Demographics and Epidemiology

Our cohort had a relatively young mean age of 36.7 years, with two-thirds aged between 21–40 years. This contrasts with studies from high-income countries, where AKI patients are typically older (mean age >60) and often have comorbidities such as diabetes and cardiovascular disease [1,2]. The youthful demographic in our setting likely reflects the epidemiology of AKI in South Asia, where community-acquired etiologies such as gastroenteritis, obstetric complications, and sepsis predominate [3]. The near-equal gender distribution is notable, as several studies report slight male predominance [2].

Urban residents comprised 67.5% of our population—the urban–rural mix likely reflects referral patterns to this tertiary center. The fact that almost 40% were from within the city suggests that timely access to healthcare infrastructure remains crucial for AKI management—an observation supported by research demonstrating worse renal outcomes in rural versus urban patients [4].

Etiology and Presentation of AKI

Hypovolemia due to gastrointestinal or hemorrhagic losses accounted for 22.5% of cases. Acute glomerulonephritis (AGN) and pregnancy-related causes—preeclampsia, sepsis, and hemorrhage—were also highly represented. Collectively, these reversible etiologies likely contributed to clinical improvement post-dialysis in more than half of the cohort.

In contrast, developed-world data show that causes such as ischemic acute tubular necrosis, contrast nephropathy, and nephrotoxin-associated AKI predominate [5]. The higher prevalence of AGN (21.9%) and obstetric AKI (18.5%) in our study mirrors findings from similar Indian and Southeast Asian cohorts, underscoring the need for focused prevention strategies in these populations [6,7].

Convulsions occurred in 11.3%, and encephalopathy affected nearly half of the cohort—highlighting the severity of uremia and metabolic derangements at presentation. A similar symptom profile was observed in another Indian ICU audit, suggesting late presentation and advanced AKI at admission [8].

3.1 Modalities

IHD (50.4%), CRRT (29.8%), and SLED (19.8%) were the modalities employed. While IHD remains the most accessible option, our findings align with recommendations that unstable patients benefit from CRRT or hybrid modalities like SLED [9]. Importantly, our data show reduced mortality in patients treated with CRRT/SLED compared to IHD among hemodynamically unstable individuals, suggesting efficacy and practicality in ICU settings with limited CRRT resources [10].

Other studies have reinforced the superiority of CRRT in achieving fluid balance and controlling intracranial pressure [11]. Though robust randomized trials comparing all modalities are limited, meta-analyses indicate marginal mortality benefit with CRRT in patients with septic shock or fluid overload [12]. Our results echo these findings and further suggest that hybrid modalities may offer comparable outcomes where continuous therapy is unavailable or cost-prohibitive.

Despite AVF being the gold standard, only 14.3% of patients had permanent AV access at the time of ICU hemodialysis; 72.6% received CVCs. This reflects the urgent nature of critical care dialysis and aligns with other ICU studies where CVC use is common due to immediate availability and ease of placement [13]. However, this necessity brings increased risks—CRBSI was observed in 19.4% of patients, with catheter thrombosis or malfunction in 11.2%. These rates exceed benchmarks for ICU-based CVCs, highlighting potential areas for improvement in infection control and catheter maintenance protocols [14].

Significant improvements in key laboratory values post-dialysis were observed: creatinine virtually halved (10.18 → 4.97 mg/dL), potassium corrected (5.03 → 4.06 mEq/L), and BUN declined substantially. Hemoglobin fell by approximately 2 g/dL, reflecting extracorporeal losses, hemodilution, and continued ICU blood sampling. Similar hematologic trends have been reported in comparable cohorts and underscore the importance of anemia management and transfusion readiness during ICU RRT [15].

While laboratory correction is expected, the clinical relevance lies in symptom resolution. Although not objectively quantified, many patients with encephalopathy and edema had marked improvement following the second or third dialysis session, aligning with other studies [16].

Complications during dialysis were common:

Hemodynamic instability necessitated vasopressors in 35%.

CRBSIs occurred in 19.4%, higher than rates seen in non-ICU vascular access (up to 5%), but comparable to other ICU studies reporting up to 30% [17].

Access thrombosis and malfunction occurred in over one-tenth of patients.

Bleeding episodes affected 7.9%, usually necessitating transfusion or circuit interruption.

Electrolyte disturbances were noted in 6.1%.

These figures reflect the complexity of ICU patients undergoing RRT. Many are at risk for hemodynamic collapse, bleeding diatheses, and nosocomial infections. Similar challenges are described in global ICU registries [18].

Mitigation strategies include pre-dialysis optimization (volume status and vasopressors), aseptic catheter techniques, ultrasound guidance, Citrate anticoagulation in CRRT to minimize bleeding, and circuit surveillance. While we utilized heparin for IHD and regional citrate for CRRT, data regarding second-line measures (e.g., antibiotic lock solutions) were not collated but warrant future study.

The overall mortality was 29.1%. Multivariate analysis identified age ≥60 years, vasopressor requirement, CRBSI, and AKI-on-CKD as significant mortality predictors.

This aligns with established risk factors: age, multiorgan dysfunction, infection, and pre-dialysis chronic disease compromise [19]. Our mortality aligns with other Indian ICU dialysis studies reporting 25–40% mortality [20], and is lower than older historical cohorts (~50%), likely reflecting advances in critical care and access to nephrology services.

Interestingly, in the AKI-on-CKD subgroup, mortality was 44.8% vs. 25.9% in pure AKI. This disparity highlights poorer outcomes in patients with underlying chronic damage, likely due to diminished nephron reserve and increased susceptibility to septic and cardiovascular complications. It underscores the need for earlier nephrology referral and preemptive AVF placement in CKD patients—a step that may reduce the dependency on CVCs and improve survival.

Patients receiving CRRT/SLED had lower mortality than those on IHD among hemodynamically unstable cohorts. Age over 60 and vasopressor requirement strongly predicted mortality, suggesting that delayed RRT could be linked to worse outcomes. A proactive, early dialysis strategy before circulatory collapse may improve survival, as supported by observational data [21].

Additionally, CRBSI significantly elevated mortality risk; high catheter colonization rates likely contributed through persistent inflammation, septic shock, and circuit consumption. Strengthening catheter care bundles (chlorhexidine dressings, aseptic handling) may reduce infectious burden.

Limitations:

Retrospective design limits causal inference.

Single-center scope may affect external validity.
Functional outcomes (renal recovery rates, quality of life) were not assessed post-discharge.
Dialysis timing and modality selection were not randomized—they followed standard care protocols which may introduce selection bias.
Cost and resource utilization data were not collected—crucial for policy planning.

Conclusion

In this large single-center analysis of ICU patients requiring hemodialysis over 2018–2023, we found that the majority were young adults with community-acquired and reversible causes of AKI, including hypovolemia, AGN, and pregnancy-related etiologies. Hemodialysis yielded significant biochemical improvement; however, high complication and mortality rates persisted—especially among older individuals, those with AKI-on-CKD, vasopressor requirements, or catheter infections.
Modality selection mattered: hemodynamically tailored approaches using CRRT or SLED improved survival. Meanwhile, hemodynamic support, early nephrology involvement, and infection-prevention bundled approaches are essential.
These findings can inform local and regional practice protocols, focusing on early AVF creation in CKD, improved CRRT availability, and catheter-quality improvement initiatives. Future directions should include prospective trials, cost-effectiveness analyses, and long-term follow-up for functional and renal outcomes post-ICU discharge.

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