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Outcomes of obstetric versus non-obstetric acute kidney injury: insights from an Indian tertiary care centre

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Abstract

Background Pregnancy-related Acute kidney injury (PR-AKI) accounts for approximately 15% of maternal mortality, with 10–30% progressing to end stage renal disease (ESRD). However, there are no comparative studies of obstetric and non-obstetric AKI. This study compares the outcomes of both groups with short-term follow-up to day 90.

Materials and methods This prospective observational study was conducted over 1.5 years, enrolling 260 cases divided into non-obstetric and obstetric AKI groups. Inclusion criteria: Non-obstetric group - patients > 18 years with AKI; Obstetric group - pregnant or up to 42 days postpartum with AKI, as per KDIGO criteria. Patients with known Chronic kidney disease (CKD) or transplant were excluded. Demographics, clinical profiles and relevant investigations (including renal biopsy) were analysed. Outcomes assessed at days 7, 30, and 90 for complete recovery, dialysis dependency, CKD progression, and mortality.

Results Of 260 patients, 83.4% were in non-obstetric group while 16.6% were in the obstetric group. Sepsis was leading cause of AKI (51.5%), affecting 47.7% of non-obstetric and 74.4% of obstetric patients. Renal biopsies (12.3% of cases) predominantly showed acute tubular injury, lupus nephritis, Minimal change disease, Focal segmental glomerulosclerosis, ANCA-associated Glomerulonephritis (GN), IgA nephropathy, and Membranoproliferative GN. In Obstetric AKI, acute cortical necrosis and thrombotic microangiopathy (TMA) were common biopsy findings. At 3-months follow-up, complete recovery was higher in the non-obstetric group (40.5% vs. 33.3%), with the obstetric group having more progression to CKD and dialysis dependency. Mortality was higher in non-obstetric AKI (50.4% vs. 33.3%), likely due to underlying comorbidities.

Conclusion Non-obstetric AKI showed higher early mortality but better long-term recovery, while obstetric AKI had poorer renal outcomes and a higher risk of progression to CKD. Early detection and intervention are critical for improving outcomes.

Keywords Acute kidney injury, Pregnancy related AKI, CKD progression, Complete recovery, KDIGO

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Introduction

Acute kidney injury (AKI) is significant public health issue, associated with high mortality, morbidity, and long-term progression to chronic kidney disease (CKD). AKI occurs in 20–200 per million population in the community, 7–18% of hospitalized patients, and up to 50% of intensive care unit (ICU) patients [1, 2]. Despite advances in treatment, in-hospital mortality remains high [3]. Risk factors associated include extremes of age, comorbidities like diabetes, hypertension, cardiovascular and chronic liver disease, nephrotoxins, surgeries, and sepsis. Obstetric AKI contributes to 3–7% of overall cases in Indian subcontinent [4]. It can result from pre-eclampsia, HELLP (hemolysis, elevated liver enzymes and low platelet count) syndrome, hyperemesis gravidarum, atypical hemolytic uremic syndrome (HUS) in postpartum period, pregnancy related thrombotic microangiopathy (TMA) and other causes like acute gastroenteritis, malaria, dengue, pyelonephritis, lupus nephritis [5]. Significant differences exist in the epidemiology and outcomes of obstetric and non-obstetric AKI. Although adaptations following nephron loss after an AKI event may support short-term survival, but often have detrimental effects on long-term outcomes [6, 7]. Severe AKI can result in incomplete recovery or non-recovery, with a substantial risk of CKD within a year of hospitalization, even in less severe forms of AKI [8, 9].

Understanding the pathophysiology, clinical course, and outcomes of AKI in both groups remains incomplete, potentially affecting recovery. This study aims to compare AKI outcomes in obstetric and non-obstetric groups, assessing complete recovery, dialysis dependency, CKD progression and mortality with follow-up at days 7, 30, and 90. Additionally, it explores the spectrum of AKI in a tertiary care centre.

Materials and methods

This prospective observational study was conducted at Atal Bihari Vajpayee Institute of Medical Sciences (ABVIMS) and Dr Ram Manohar Lohia (Dr RML) Hospital, tertiary care hospital in New Delhi, India, after institutional ethics committee approval and patient consent was obtained, between November 2022 and February 2024.

Inclusion and exclusion criteria.

Adult patients ≥ 18 years of age with AKI as defined by the kidney disease: Improving Global Outcomes (KDIGO) admitted either primarily in the nephrology unit or various other units seeking nephrology referral were included and divided in two groups: Obstetric and non-obstetric AKI group. Staging was done as per KDIGO classification [10]: Stage 1 (creatinine increase ≥ 0.3 mg/dL within past 48 h or an increase of 1.5–1.9 times the baseline or a urine output < 0.5 mL/kg/hour for 6–12 h), Stage 2 (creatinine increase of 2.0–2.9 × baseline value or a urine output < 0.5 mL/kg/hour for ≥ 12 h), and Stage 3 (creatinine increase of 3 × baseline value or serum creatinine ≥ 4 mg/dL or Renal replacement therapy (RRT) initiation or a urine output < 0.3 mL/kg/hour for ≥ 24 h or anuria for ≥ 12 h). Obstetric group included all pregnant patients and patients till day 42 of delivery, presenting with AKI as per KDIGO criteria [10]. Those with preexisting CKD or prior renal transplant were excluded from the study.

Sample size calculation

As per the study by Goswami S et al. [11], taking mortality rate in non-obstetric AKI patients as 25.96% and 10% in obstetric AKI patients the minimum sample size was calculated to be 103 in each group. Considering the dropout rate of 10% at each follow up at day 7, 1 month, and 3 months, respectively, with a total dropout rate of 30%, the minimum sample size required was 282 (141 in each group).

Data collection

The recruitment of patients for the study involved receiving referrals for nephrology consultations from various departments. The inclusion criteria encompassed both out- and in-patient cases within the nephrology department, as well as individuals referred from other wards. Data on demographic characteristics, aetiology, clinical features, comorbidities, biochemical parameters, histopathology, treatment, vasopressor use, RRT, and outcomes were recorded in a proforma. All patients underwent an ultrasonogram of the kidney to note the size and structural abnormalities. Other additional investigations were done as warranted by clinical presentation. Conditions where glomerular diseases were suspected, additional immunological investigations were done. Renal biopsy was performed when AKI did not improve by 14 days or earlier if there was a suspicion of a different disease process as per treating physician's discretion. Baseline CKD was identified from serum creatinine measurement available within the preceding year from patients' records, finding of contracted kidneys on imaging. All eGFR measures were calculated using the Chronic Kidney Disease Epidemiology Collaboration 2009 creatinine equation.

Follow up and outcome measures.

Patients were then followed up at day 7, day 30 and day 90 for following outcomes: complete recovery, dialysis dependency, progression to CKD, and mortality. The following were considered outcome variables:

(i) Complete recovery (CR)– a patient whose serum creatinine decreased and reached their baseline

values, if available. If baseline value was unavailable, serum creatinine cut-off of < 1.4 mg/dL and urine output > 1 ml/kg/hr was taken [12].

(ii) Dialysis dependency– Need for any form of dialysis for > 1month [12].

(iii) Chronic kidney disease- AKD persisting for > 3 months is referred to as chronic kidney disease (CKD) [13].

(iv) Death of patient.

Baseline creatinine was the value of creatinine in mg/dl available from 8 days to 12 months before the current presentation with AKI. In the absence of studies demonstrating the validity of serum creatinine or GFR imputation in the Indian population, an empirical cut-off value of serum creatinine was used.

Statistical analysis

The data entry was done in the Microsoft EXCEL spreadsheet, and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 21.0. The Kolmogorov-Smirnov test was used to test the normality of data distribution. The presentation of the Categorical variables was done in the form of number and percentage (%). Quantitative data were presented as the means ± SD. The association of the variables which were qualitative in nature as mentioned above, were analysed using Chi-Square test. If any cell had an expected value of less than 5 then Fisher's exact test was used. Independent t test was used for comparison of quantitative variables. Student's t test was used to compare parametric mean values between the two groups. The Kruskal-Wallis test was used to compare non-parametric values between > 2 groups. Chi- square and Fisher's exact test were used to compare proportions between the two groups according to application required. Univariate and multivariate logistic regression was used to find out risk factors of mortality. Kaplan Meier survival analysis curve was used to calculate overall survival.

Results

A total of 278 AKI patients were admitted in the hospital during the study period. Of them, 18 patients did not meet the inclusion criteria and thus, 260 patients were enrolled in the study. Out of these, 43 were obstetric AKI cases and 217 were non-obstetric AKI cases (Fig. 1). During follow up at day 7, day 30 and day 90, a total of 6 patients lost to follow up so, 254 patients were analysed at the end of 3 months.

Table 1 displays the baseline and clinical characteristics of study participants. In obstetric group, the mean age was 28.67 ± 4.69 years, whereas in non-obstetric group, it was 47.2 ± 17.53 years. Baseline creatinine was available for 54 cases only: 21 in obstetric group and 33 in non-obstetric group. Most common comorbidity in non-obstetric group was hypertension (24.8%), followed by diabetes mellitus (14.7%), chronic liver disease (9.2%), and cardiovascular disease (8.2%). Most patients (80.7%) were oligo-anuric at presentation in both groups. Ionotropic support was required in 122 patients (56.2%) in the non-obstetric group compared to 15 patients (34.9%) in the obstetric group. In both groups majority cases had Stage 3 AKI at presentation (Fig. 2).

The etiology was multifactorial in most cases, with medical causes accounting for 188 cases (72.3%) and surgical causes for 72 cases (27.6%). Sepsis was the most common cause in both groups. Table 2 displays various possible causes of AKI and source of sepsis in both groups (Supplementary Table S1). Other common causes included gastrointestinal loss due to acute diarrhea (15.8%), third space fluid loss (9.6%), cardiorenal syndrome (8.4%), hepatorenal syndrome (7.7%), glomerular diseases (6.1%), hemorrhage (2.6%), and drug-induced AKI (1.2%). Among nephrotoxins causing AKI, endogenous toxins included myoglobin cast, bile casts, and light chains cast nephropathy. In the obstetric group, hemorrhage was the second most common cause of AKI after puerperal sepsis. Need for various modality of RRT in both group at admission is displayed in Fig. 3.

Renal biopsy was performed in 32 cases (12.3%). Table 3 displays various biopsy findings in both groups. The most common being acute tubular necrosis (ATN) (31.25%) followed by proliferative glomerulonephritis (28.12%), TMA (12.5%), Acute cortical necrosis (12.5%), non-proliferative glomerulonephritis (9.3%). Glomerular diseases included lupus nephritis, nephrotic syndrome, membranoproliferative glomerulonephritis, antineutrophilic cytoplasmic antibody-associated glomerulonephritis, anti-glomerular basement membrane disease, and IgA nephropathy.

Outcome analysis

Table 4 presents a comparative outcome analysis of both group at day 7, 1 month and 3 months.

At the initial assessment on day seven, 16.2% of patients in the non-obstetric AKI group had achieved complete recovery, compared to 11.6% in the obstetric AKI group. By the three-month follow-up, recovery rates had increased to 40.5% in the non-obstetric group and 33.3% in the obstetric group. The need for dialysis on day seven was significantly higher in the obstetric group (67.4%) compared to the non-obstetric group (28.2%). Mortality at day seven was 33.3% in the non-obstetric group, markedly higher than the 13.9% observed in the obstetric group. Although dialysis requirements were more common in the obstetric group, the non-obstetric

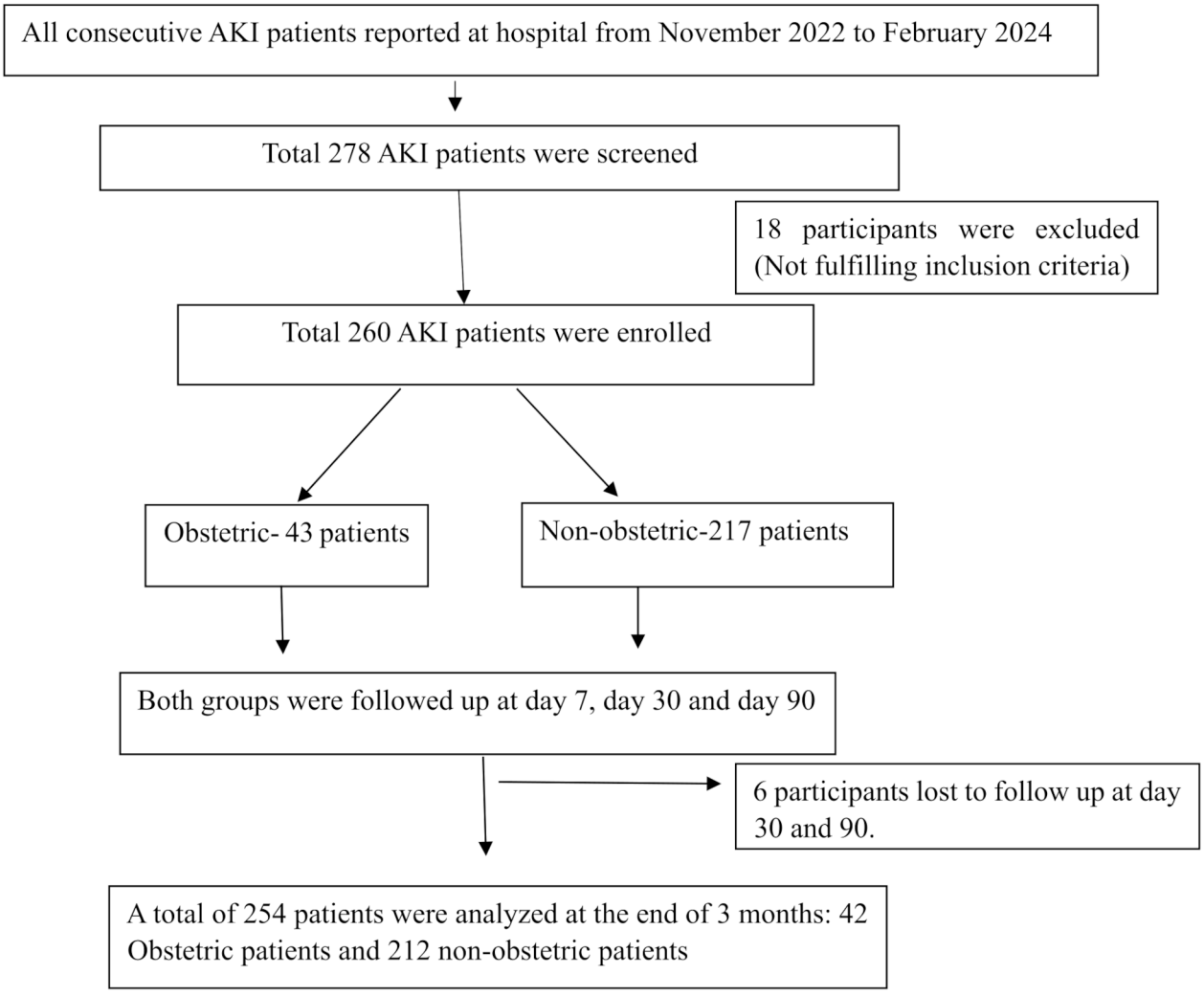


Fig. 1 Study flowchart

group experienced a substantially higher mortality rate during the same period.

At the 30-day follow-up, dialysis dependency was observed in 23.2% of obstetric AKI patients, compared to just 3.3% of non-obstetric AKI patients. Mortality rates also increased by this point, reaching 49.05% in the non-obstetric group and 25.5% in the obstetric group. By the three-month mark, 8.4% of patients in the non-obstetric group had progressed to chronic kidney disease, with 1.8% remaining dialysis-dependent, and a mortality rate of 50.4%. In contrast, the obstetric group demonstrated CKD progression in 33.3% of patients, dialysis dependency in 9.5%, and a mortality rate of 33.3%.

In the non-obstetric group, univariate logistic regression analysis identified several factors that were significantly associated with an increased risk of mortality. These included oliguric presentation, chronic liver disease, vasopressor requirement, mechanical ventilation, hemoglobin levels < 10 g/dL, total leukocyte count (TLC) > 11,000/μL, platelet count < 1.5 lakh/μL, SGOT > 45 U/L, SGPT > 45 U/L, and albumin levels < 3.5 g/dL. After adjusting for these variables in the multivariate analysis, only chronic liver disease (AOR: 4.13, 95% CI: 1.50–11.20, $p = 0.006$), mechanical ventilation (AOR: 12.7, 95% CI: 4.80–33.40, $p < 0.001$), albumin levels < 3.5 g/dL (AOR: 5.36, 95% CI: 2.10–13.40, $p < 0.001$), TLC > 11,000/μL (AOR: 3.02, 95% CI: 1.30–7.00, $p = 0.009$), and hemoglobin levels < 10 g/dL (AOR: 2.32, 95% CI: 1.20–4.40, $p = 0.01$) remained significant predictors of mortality. In the obstetric group, univariate analysis revealed significant associations with mortality for the need for vasopressors, mechanical ventilation, hemoglobin levels < 10 g/dL, platelet count < 1.5 lakh/μL, SGOT levels > 45 U/L, and SGPT levels > 45 U/L. However, in the multivariate logistic regression analysis, only mechanical ventilation (AOR: 40.3, 95% CI: 7.80–207.20,

Table 1 Baseline demographics

Baseline characteristic	Non-Obstetric Number, *n* (%)/ Mean ± SD	Obstetric Number, *n* (%)/ Mean ± SD	*P* value*
Mean age	47.12 ± 17.53	28.67 ± 4.69	**< 0.001**
Female Gender	70(32.2%)	43(100%)	**< 0.001**
Diabetes mellitus *n*(%)	32(14.7%)	1(2.3%)	0.02
Hypertension *n*(%)	54(24.8%)	0(0%)	**< 0.001**
Cardiovascular disease *n*(%)	18(8.2%)	3(6.9%)	1.0
Hypothyroidism *n*(%)	2(0.9%)	1(2.3%)	0.42
Cerebrovascular disease *n*(%)	4(1.8%)	0(0%)	1.0
Chronic liver disease *n*(%)	20(9.2%)	0(0%)	**0.05**
Malignancy n*n*(%)	6(2.7%)	0(0%)	0.59
Smoking *n*(%)	57(26.3%)	0(0%)	**< 0.001**
Alcohol *n*(%)	46(21.2%)	0(0%)	**< 0.001**
Oligo-anuric *n*(%)	173(79.8%)	37(86%)	**< 0.001**
Hypovolemic *n*(%)	52(24%)	2(4.6%)	**< 0.001**
Hypervolemic *n*(%)	120(55.3%)	38(88.3%)	**0.000**
Vasopressors need *n*(%)	122(56.2%)	15(34.9%)	**< 0.002**
Mechanical ventilation *n*(%)	67(30.9%)	17(39.5%)	0.28
eGFR at presentation (ml/min/1.73m2)	19.2 ± 12.96	16.65 ± 13.12	0.23
ICU requirement *n*(%)	68(31.3%)	19(44.1%)	0.10
KDIGO Stage 1	17(7.8%)	5(11.6%)	
KDIGO Stage 2	30(13.8%)	1(2.3%)	< 0.08
KDIGO Stage 3	170(78.3%)	37(86%)	
TLC ($*10^3$), per cu.mm	17264.06 ± 10584.12	18926.51 ± 9338.74	0.11
Platelets (lakhs/cu.mm)	1.88 ± 1.17	1.68 ± 1.40	0.07
Creatinine (mg %)	5.13 ± 3.45	5.53 ± 4.28	0.62
Sodium (mmol/L)	135.05 ± 7.73	135.37 ± 6.37	0.08
Albumin (g%)	2.74 ± 0.77	2.63 ± 0.68	0.70
Uric Acid (mg%)	9.10 ± 3.39	9.06 ± 3.74	0.51
LDH (U/L)	268 (150.5–488)	605 (290–2235)	**< 0.001**
CPK (U/L)	50 (20-260.5)	76 (23–193)	0.39
Proteinuria (> 30 mg/dl)	142(65.4%)	36(83.27%)	**< 0.02**

* Chi square for nominal data mentioned in percentage, independent t-test for continuous data mentioned in mean ± SD (Standard deviation); MAP-mean arterial pressure, KDIGO kidney disease improving global outcome, AKI- Acute kidney injury, eGFR: Estimated Glomerularfiltrationrate TLC-Total leukocyte count, AST-Aspartate amino transferase, ALT-Alanine aminotransferase, LDH-Lactate dehydrogenase, CPK-Creatinine phosphokinase

$p < 0.001$) remained a significant predictor of mortality (Supplementary S2-5)

The Kaplan-Meier survival analysis revealed a significant difference in mean survival times between non-obstetric and obstetric AKI cases. The mean survival time for non-obstetric cases was 20.32 ± 2.64 units, with a 95% confidence interval (CI) of 15.15–25.48. In contrast, obstetric cases demonstrated a considerably longer mean survival of 43.36 ± 6.07 units, with a CI of 31.46–55.25. Overall, the cohort's mean survival was 26.35 ± 2.73 units (CI: 21.01–31.69) (Fig. 4). The longer survival in the obstetric group highlights potential differences in disease progression or management, necessitating further investigation into contributory factors.

Discussion

This study uniquely compares the outcomes between obstetric and non-obstetric AKI, highlighting the short-term impact of acute kidney disease in patients admitted to a tertiary care centre. We observed better outcomes in obstetric AKI compared to non-obstetric AKI, with lower 30 day and 90-day mortality in the former. This disparity may be due to late referrals to tertiary centres and a limited awareness about community-acquired acute kidney injury (CAAKI) in non-obstetric group. Long-term follow-up is essential to identify risk factors for mortality, aiding early detection and management.

Most Indian studies report a mean age of 40 to 60 years for CAAKI patients [14–16]. In our study, the mean age for non-obstetric AKI was (47.12 ± 17.53) while for obstetric group, it was (28.67 ± 4.69) years showing a trend toward younger patients in developing countries. This aligns with M. Mir et al. (2022) finding of a mean age of 26.10 ± 4.3 years for patients with PRAKI [17]. A significant proportion of non-obstetric AKI patients had comorbidities, such as diabetes and hypertension. This global association between AKI, Hypertension and diabetes is also noted in ISN AKI registry data [12]. In our study, most non-obstetric AKI patients presented with stage 3 AKI (79.6%), with 80.7% oliguric at presentation. Furthermore, 52.7% required vasopressor support, 32.3% required mechanical ventilation, and 33.4% needed ICU care, similar to findings of Vasanth et al. (2018) and ISN AKI registry data [12, 18]. Late presentations in our study could be due to delayed recognition, inadequate management of precipitating factor, limited access to health care, and delayed referral to tertiary care or in hospital nephrology referral. The need for dialysis was higher in our study, with 25.4% of patients undergoing sustained low-efficiency dialysis (SLED) and 30.4% receiving intermittent hemodialysis (IHD). Vikrant et al. (2018) reported similar rates [17]. The high rate of dialysis likely reflects the severity of cases due to late referrals. While in obstetric AKI group, 86% patients had oliguria/anuria with majority having hypervolemia at presentation. Most of these cases were referred after initial management at peripheral centres, where fluid resuscitation was likely initiated before nephrology referral. There might be

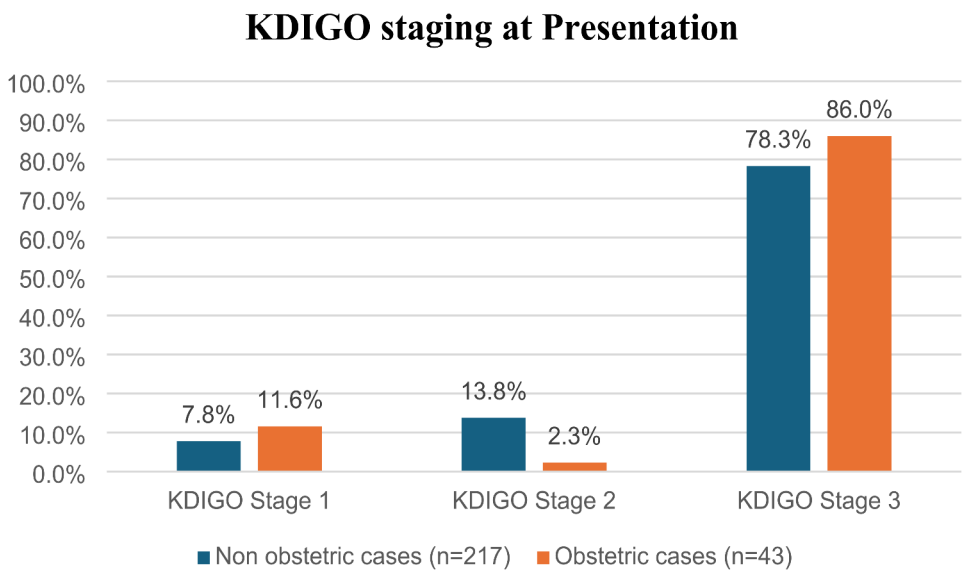


Fig. 2 Distribution of patients among various KDIGO staging

Table 2 Etiology of AKI in obstetric and non-obstetric group

Causes of AKI	Total *N* (%)	Non-Obstetric *N* (%)	Obstetric *N* (%)
GI loss	41(15.8)	39 (18)	2(4.6)
Third space fluid loss#	20(9.6)	20(11.5)	0(0)
Haemorrhage	7(2.6)	1(0.4)	6(13.9)
CRS	22(8.4)	21(9.6)	1(2.3)
HRS	20(7.7)	20(9.2)	0(0)
Sepsis related	134(51.5)	102(47.7)	32(74.4)
Glomerular disease	12(4.6)	12(5.5)	0
Drugs$	3(1.2)	3(1.4)	0(0)
Nephrotoxins	6(2.3)	6(2.7)	0(0)
Obstructive*	4(1.5)	4(1.8)	0(0)
Tropical infection**	13(5)	10(4.6)	3(6.9)

Categorical variables have been displayed in frequency and percentage

Acute pancreatitis- 13 cases, Burns- 3 cases, Nephrotic syndrome-4cases; *Obstructive: malignancy causing obstruction-2 cases, bladder outlet obstruction-2cases; ** Malaria-5 cases (all non-obstetric group); Dengue-5 cases in non-obstetric and 3 cases in obstetric group; GI-Gastrointestinal, TMA-Thrombotic microangiopathy; CRS-Cardiorenal syndrome, HRS-Hepatorenal syndrome, $ Drugs include one case due to vancomycin and 2 cases due to rifampicin;

overhydration due to excessive iv fluids in presence of acute renal shut down.

Sepsis was the most common cause of AKI in both groups. The main source of infection was intra-abdominal infection and lung infections. In epidemiological studies conducted after 2010 at various centres in our country showed that major etiological factor was sepsis contributing between 22% and 53% [16, 19, 20]. In non-obstetric group, the most common medical cause after sepsis was acute diarrhoea, Cardiorenal syndrome, Hepatorenal syndrome, third space fluid loss, glomerular disease, tropical infections i.e. malaria and dengue, drugs and nephrotoxins and obstructive cause. In a study by Kaul A et al. (2012) and Narayan prasad et al. [21] showed that AKI occurred in medical, surgical, and obstetrical settings [12]. Tropical infections like malaria and dengue contributed to about 5% of cases, which was similar to that reported by Eswarappa et al. (6.4%) and Umesh et al. (7.6%) [16, 22], whereas tropical infection was the most common etiology in studies by Vikrant et al. and Bhadade et al. [20, 23]. Acute pancreatitis contributed to about 5% of cases in our study. It occurs due to increased vascular permeability, renal vasoconstriction, abdominal compartment syndrome, thrombotic microangiopathy and is poor prognostic factors. In obstetric AKI, sepsis contributed to 74.4% of cases, followed by hemorrhage and GI loss, consistent with findings from Saini et al. (2020) [24]. Most of these septic cases developed acute kidney disease requiring dialysis and high mortality due to multiorgan failure [24]. In present study there were 12 cases of obstetric AKI having pre-eclampsia/eclampsia at presentation. In another study by Berhe et al., preeclampsia, sepsis and pre-renal causes due to dehydration and hemorrhage were the common causes of pregnancy-related acute kidney injury [25].

Atypical hemolytic uremic syndrome emerged as significant causes in obstetric AKI. In our study, 17 obstetric AKI cases with TMA like picture (15 cases had systemic laboratory evidence of TMA, and 2 were biopsy-proven) were suspected to have post-partum atypical HUS. In our study genetic testing was available for three patients of which one patient was detected to have heterozygous CFHR5 mutation. Fakhouri et al. (2017), noted similar findings, with pregnancy-associated aHUS (P-aHUS) comprising 79% of cases [26]. Further genetic studies are essential to deepen our understanding of complement

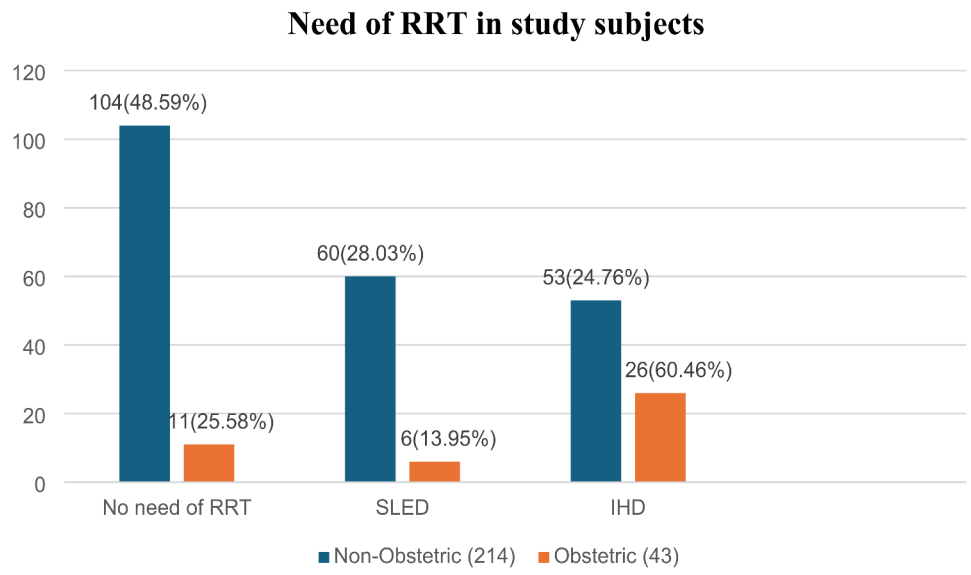


Fig. 3 Distribution various modality of RRT in both groups at the index admission

Table 3 Renal biopsy findings

Biopsy findings	Total *n* (%)	Non-Obstetric *n* (%)	Obstetric *n* (%)
Proliferative GN*	9(28.12)	9(37.5)	0(0)
Non-Proliferative GN	3(9.3)	3(12.5)	0(0)
AIN	2(6.2)	2(8.3)	0(0)
ATI/ATN**	10(31.25)	8(33.3)	2(25)
Acute cortical necrosis	4(12.5)	0(0)	4(50)
TMA	4(12.5)	2(8.3)	2(25)

* Proliferative GN: Lupus nephritis-2 cases, Membranoproliferative GN-one case, ANCA associated GN-2 cases, Anti-GBM-2 cases, Ig A nephropathy-2 cases

**ATN/ATI- includes one case of light chain cast nephropathy, three cases of pigment nephropathy

GN-Glomerulonephritis, ATIN- Acute tubulointerstitial nephritis, ATI-Acute tubular injury, ATN-Acute tubular necrosis, ACN -Acute cortical necrosis, TMA-Thrombotic microangiopathy GBM: Glomerular basement membrane

Categorical variables have been displayed in frequency and percentage

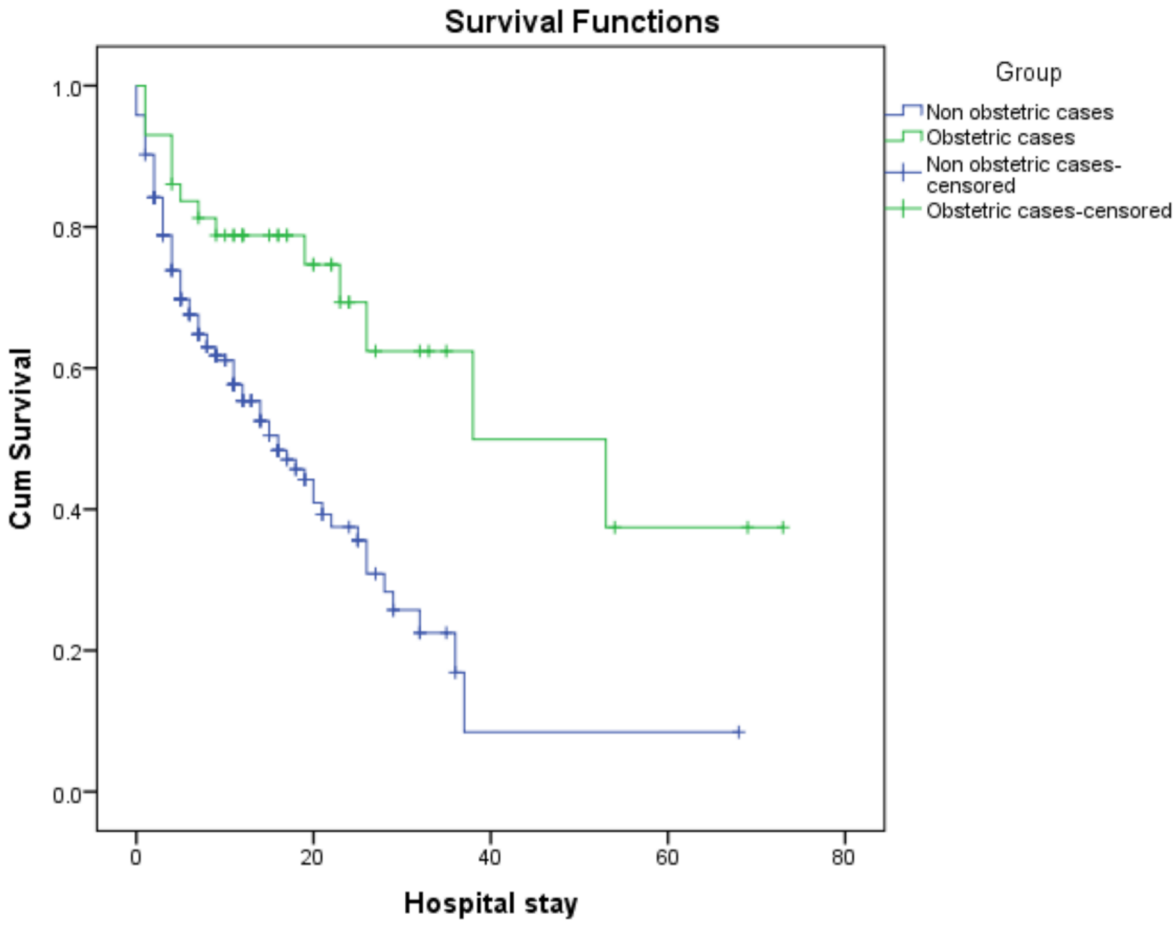
dysregulation and its implications for early detection and prevention.

Renal biopsy was performed in 12.3% of our patients. Study by Vikrant et al. (2018) and Kaul et al. (2018) also had 6.8% and 20% renal biopsy in their cohort of CAAKI patients [20, 21]. The most common finding was acute tubular necrosis followed by glomerular diseases. Data from ISN registry of AKI showed that renal biopsy was done in 15.6% of the patients [12] in which acute tubular necrosis was the most common finding, followed by acute interstitial nephritis [12]. In obstetric AKI, 18.6% of patients underwent biopsy, with findings were acute cortical necrosis, acute tubular necrosis and thrombotic microangiopathy (TMA). Studies by Saini et al. and Vineet et al., TMA corroborate these findings [24, 27]. A total of 11 cases were diagnosed to have acute cortical necrosis (ACN), of which seven cases were CT proven ACN and four had ACN on renal biopsy. Two patients having biopsy proven TMA had pre-eclampsia also. Pre-eclampsia is one of the common cause of TMA in pregnancy-related acute kidney injury [28]. In the study

Table 4 Comparison of outcomes at follow up at day 7, 1month and 3 months

Duration		At Day 7	At 1month		At 3 months		*P** value	*P*** Value	*P**** Value
Outcome parameter	Non-Obstetric *n* (%) + 1LFU	Obstetric *n* (%)	Non-Obstetric *n* (%) + 4LFU	Obstetric *n* (%)	Non-Obstetric *n* (%)	Obstetric *n* (%) + 1LFU	At day 7	At 1mo	At 3mo
CR	35(16.2)	5(11.6)	68(32.07)	9(20.9)	86(40.5)	14(33.3)	**0.01**	**< 0.001**	**< 0.001**
Dialysis requiring	61(28.2)	29(67.4)	7(3.3)	10(23.2)	4(1.8)	4(9.5)	**< 0.01**	**< 0.001**	**< 0.001**
AKD	-	-	43(20.2)	23(53.5)	-	-	**--**	**< 0.001**	**-**
CKD	-	-	-	-	18(8.49)	14(33.3)	**-**	**-**	**< 0.001**
Mortality	72(33.3)	6 (13.9)	104(49.05)	11(25.5)	107(50.4)	14(33.3)	**0.01**	**< 0.001**	**< 0.001**

*P** value: Between obstetric and non-obstetric at day 7; *P*** value: Between obstetric and non-obstetric at 1 month; *P**** value: Between obstetric and non-obstetric at 3 months; CR-Complete recovery, AKD-Acute kidney disease, CKD-Chronic kidney disease, LFU-Lost to follow up



Group	Mean survival			
	Mean	Std Error	95% CI	
			Lower	Upper
Non obstetric cases	20.316	2.637	15.147	25.484
Obstetric cases	43.357	6.070	31.460	55.254
Overall	26.348	2.725	21.007	31.689

Fig. 4 Kaplan meir survival analysis at 90 days

by Sahay et al. [29] 39% of Renal cortical necrosis cases were due to obstetric AKI, but HUS was reported only in 7.3%. Most of the cases in present study had a history of hemorrhage (antepartum/postpartum), indicating that hemodynamic instability has contributed to the poor outcomes. These patients might have inherited defects of the complement pathway that are unmasked during peripartum period, especially in the presence of complications, which acted as trigger. However, confirmation of this hypothesis will need further studies to evaluate

variations in genes regulating the complement pathway. So, further analysis, including genetic studies and detailed exploration of other contributing factors, would be needed to fully elucidate the differences between ACN and non-ACN cases.

Indications for initiation of dialysis differed in the obstetric population due to concerns over fetotoxicity from elevated urea, leading to earlier initiation in pregnant patients. Most cases were postpartum, and the dialysis indications aligned with those for non-obstetric AKI. Our study revealed significant differences in recovery, dialysis dependency and mortality in obstetric and non-obstetric AKI patients across various follow up periods. At the one week, one month and three month follow ups, complete recovery was more frequent in the non-obstetric AKI group compared to the obstetric group. At day 7, mortality in the non-obstetric group was 33.3%, compared to 13.9% in the obstetric group, which required a higher rate of dialysis at this stage. Comparatively, Abebe et al. (2021) reported a lower day 7 mortality rate of 6.8%, which could be attributed to earlier diagnosis and intervention [3]. In contrast, in our cohort, the mortality rate was notably higher in non-obstetric AKI group possibly due to underlying comorbidities. A similar dialysis dependency in 71.7% of obstetric AKI patients was noted by Bantewad et al. [30] reflecting a higher degree of renal involvement in obstetric AKI. In Berhe et al.'s study, 7.5% mortality and 8.6% dialysis requirement in PRAKI patients underscore that dialysis needs were significant in this group [25].

By the three-month follow-up, the non-obstetric group showed a higher rate of complete recovery but also, 8.49% cases progressed to CKD, while 33.3% of the obstetric AKI group progressed to CKD. This highlights that while non-obstetric AKI patients initially had higher mortality, those who survived had better long-term renal recovery. As a tertiary care referral centre, we receive a significant number of cases managed initially at peripheral centres, often presenting in advanced stages of AKI (Stage 3). This delayed presentation contributes to suboptimal recovery rates, which emphasizes the critical need for early identification and timely referral to specialized care for better management. Similar finding has been reported in another study by Costa A Silva et al. [31].On the other hand, obstetric AKI survivors had a greater tendency to progress to chronic kidney disease, which might be due to the more severe acute injury initially masked by higher survival rates in early stage. Sachan et al.'s study (2021) showed similar outcomes in PRAKI patients, where after three months of follow-up, 27.3% recovered completely, 31.3% partially recovered, 3.39% progressed to CKD, and 34% expired [32], aligning with our findings. This suggests that long-term renal recovery in obstetric AKI patients may be more challenging due to factors like sepsis, atypical HUS, or other pregnancy-related complications. In obstetric AKI group, eight out of 11 patients having renal cortical necrosis progressed to CKD at 90 days follow up, of which three cases remained dialysis dependent.

Understanding these divergent trajectories emphasizes the importance of early identification and intervention, particularly in non-obstetric AKI cases where late-stage referral contributed to higher mortality. In contrast, the high CKD progression in obstetric AKI survivors calls for careful post-recovery monitoring and management to mitigate long-term renal deterioration.

The present study identified several risk factors linked to mortality in the non-obstetric group, including oliguria at presentation, need of vasopressors, need for mechanical ventilation, higher KDIGO stage on admission, anemia, sepsis and hypoalbuminemia. Similarly, Chetlapalli et al. [33] found hypotension, anemia and the need for RRT associated with mortality, while Abebe et al. [3] reported hyperkalemia, sepsis, anemia, need for RRT, and age over 60 years as contributing factors. In the obstetric group, only mechanical ventilation requirement was found to have significant association with mortality. Univariate analysis by Teo et al. (2019) and Trongtrakul et al. (2019) both identified need of vasopressor as a predictor of all-cause mortality [34, 35].

Our study's strength lies in its detailed comparison of short-term outcomes between non-obstetric and obstetric AKI cases, offering valuable insights into risk factors and progression to CKD. The findings highlight the critical role of early recognition, management of comorbidities, and timely referrals, especially in non-obstetric AKI, which had a higher mortality rate. Despite these strengths, the study had limitations, including being a single-center study with a short follow-up period, which limits generalizability. Additionally, incomplete baseline creatinine data and the absence of proteinuria assessment during follow-up may have influenced the accuracy of recovery and progression patterns. Also, there is no standard definition of AKI in obstetric group. The KDIGO definition of AKI is standard, but its validation in pregnant patients is an area of research. We also acknowledge that precise data on urine output were not consistently documented. Instead, patients were categorized as oliguric, non-oliguric, or anuric at presentation. Also, the calculated sample size for both groups was 141 to ensure sufficient statistical power. However, due to the rarity of obstetric AKI, achieving this number within a reasonable time frame was not feasible. While this reduces the statistical power for comparisons involving the obstetric group, the findings still provide valuable insights. Number of cases in obstetric AKI group is naturally lower as it reflects actual incidence within population. This decreasing incidence of PRAKI has also been observed in

a study by Prakash et al. [36],10.4% in 1992–2002, from 15.2% in 1982–1991, with declining trend continuing in 2003–2014 (4.68%).However, a multicentric study with long-term follow-up would provide more comprehensive insights into AKI outcomes across different settings.

Conclusion

Our study provides insights into the short-term outcomes of AKI in obstetric and non-obstetric groups. While non-obstetric AKI patients had higher early mortality, survivors had better long-term recovery, whereas obstetric AKI patients had poorer long-term renal outcomes, with a greater risk of CKD progression. It highlights the need for early recognition, better management of comorbidities, and timely referrals to improve outcomes. Further prospective, multicentric studies with longer follow-up periods are necessary to validate these observations.

Supplementary Information

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Supplementary Material 1

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Author contributions
Dr. Beauty Suman contributed to data collection, manuscript preparation, statistical analysis, and interpretation of the results. Dr Himansu Sekhar Mahapatra,Dr Lalit K pursnani and Dr B Muthukumar conceptualized and designed the study, supervised this project, critically reviewed the manuscript for intellectual content, and provided key revisions. Other authors assisted in the literature review, drafting specific sections of the manuscript, and formatting the figures and tables. All authors reviewed and approved the final manuscript.

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Data availability
Any additional data if required, will be available at request from the corresponding author (hsmnephrology@gmail.com).

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the ethical standards. Ethical approval was obtained from institutional ethic committee at ABVIMS and RML Hospital (Approval Number: IEC/ABVIMS/RMLH/1103, dated 12/11/2022). Written informed consent was obtained from all participants before enrolment in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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