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Characteristics of AKI in Pregnancy and Identification of Factors Associated with Poor Outcomes

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Abstract: ***Background:*** Acute Kidney Injury (AKI) in pregnancy is a significant medical concern, particularly in low- and middle-income countries (LMICs), where access to healthcare is limited. ***Objective:*** This study aims to characterize the clinical presentation of AKI in pregnancy and identify factors associated with poor maternal and fetal outcomes in a tertiary hospital in Dhaka, Bangladesh. ***Methodology:*** A retrospective facility-based study was conducted at a tertiary care hospital in Dhaka, Bangladesh, from June 2022 to June 2023. Medical records of 187 women diagnosed with pregnancy-related AKI were reviewed. Patients were identified from maternity ward logbooks, emergency department records, and ICU admission registers. AKI was diagnosed based on serum creatinine levels (≥1.2 mg/dL or an increase of ≥0.3 mg/dL within 48 hours), reduced urine output, or dialysis requirement. Data were collected using a structured questionnaire and analyzed using Stata 16. Statistical analyses included chi-square tests, Fisher's exact tests, and multivariate logistic regression. ***Results:*** Antenatal care was significantly lower in patients experiencing adverse outcomes (59.1% vs. 77.6%, p = 0.015). Vaginal delivery was more common in the composite endpoint group (70.5% vs. 48.2%, p = 0.022). Hypertensive disorders, particularly preeclampsia, were more frequent in the non-composite endpoint group (79.0% vs. 63.6%, p = 0.038). Sepsis (59.1% vs. 46.1%) and pre-renal AKI (50.0% vs. 37.8%) were more prevalent in the composite endpoint group. Anemia (72.7% vs. 46.1%, p = 0.008) and elevated serum creatinine (≥3.0 mg/dL: 40.9% vs. 6.3%, p < 0.001) were significantly associated with worse outcomes. Patients with preexisting chronic kidney disease (CKD) had a significantly higher risk of adverse outcomes (22.7% vs. 0.7%, p < 0.001). ***Conclusion:*** Pregnancy-related AKI remains a critical challenge in Bangladesh, with inadequate antenatal care, hypertensive disorders, and sepsis contributing to poor maternal outcomes.

Keywords: Acute Kidney Injury, Pregnancy, Maternal Mortality, Hypertensive Disorders, Sepsis, Antenatal Care, Bangladesh, Renal Dysfunction.

Original Research Article

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Article at a glance:

Study Purpose: *To identify clinical features and risk factors for poor outcomes in pregnancy-related AKI at a Dhaka hospital.*
Key findings: *Inadequate antenatal care, hypertensive disorders, CKD, sepsis, anemia, and elevated serum creatinine were linked to worse outcomes.*
Newer findings: *CKD, anemia, and high serum creatinine levels were identified as key factors worsening outcomes in pregnancy-related AKI.*
Abbreviations: *AKI - Acute Kidney Injury, CKD - Chronic Kidney Disease, ICU - Intensive Care Unit.*

INTRODUCTION

Acute Kidney Injury (AKI) in pregnancy is a critical condition that poses significant risks to both maternal and fetal health. AKI is characterized by a sudden decline in kidney function, leading to an accumulation of metabolic waste products, electrolyte imbalances, and fluid disturbances. While the incidence of pregnancy-related AKI has declined in developed countries due to improved antenatal care, it remains a major concern in low- and middle-income countries (LMICs), where access to healthcare is often limited. Identifying the characteristics of AKI in pregnancy and

the factors associated with poor outcomes is crucial for improving maternal and neonatal prognosis.[1-3] The etiology of AKI in pregnancy is multifactorial and varies depending on the trimester. In early pregnancy, complications such as hyperemesis gravidarum, septic abortion, and acute pyelonephritis can contribute to kidney injury. In the later stages, hypertensive disorders of pregnancy (including preeclampsia and eclampsia), hemorrhage, and obstetric sepsis are leading causes. The physiological changes during pregnancy, including increased renal blood flow and glomerular filtration rate, may initially mask early kidney dysfunction, delaying diagnosis and management.[4-6]

Pregnancy-related AKI has been associated with increased maternal morbidity and mortality. Women with AKI are at higher risk of developing complications such as pulmonary edema, disseminated intravascular coagulation (DIC), and multi-organ failure. Additionally, AKI is linked to adverse perinatal outcomes, including intrauterine growth restriction, preterm birth, and stillbirth. Given these risks, timely identification of high-risk patients and early intervention are essential to improving outcomes. Several factors contribute to poor prognosis in pregnancy-associated AKI. Delayed diagnosis, inadequate antenatal care, and lack of access to specialized nephrology or critical care services often lead to severe complications. Socioeconomic factors, such as malnutrition and limited healthcare infrastructure, further exacerbate these risks. Understanding these determinants can help in the development of targeted strategies for prevention and management.[7-9] Despite advancements in nephrology and maternal-fetal medicine, significant knowledge gaps remain in the optimal management of AKI in pregnancy. Current research efforts focus on improving diagnostic markers, enhancing early detection strategies, and developing standardized treatment protocols. A multidisciplinary approach involving obstetricians, nephrologists, and critical care specialists is essential to reducing the burden of AKI in pregnancy.

OBJECTIVE

This study aims to characterize the clinical presentation of AKI in pregnancy and identify factors associated with poor maternal and fetal outcomes.

METHODOLOGY

Study Design

A facility-based retrospective study was conducted at a tertiary hospital in Dhaka, Bangladesh, to assess the causes, outcomes, and factors associated with severe maternal outcomes in pregnancy-related acute kidney injury (AKI).

Study Period

The study period spanned from June 2022 to June 2023. Medical records of all women diagnosed with pregnancy-related AKI during this timeframe were reviewed.

Study Setting

The study was carried out at a tertiary care and teaching hospital in Dhaka, Bangladesh. This hospital is a major referral center, serving a large population from Dhaka and surrounding districts. It provides comprehensive obstetric and gynecological services, staffed by a multidisciplinary team of specialists, including nephrologists, obstetricians, and midwives. The hospital also has a dedicated hemodialysis unit equipped with modern dialysis machines, catering to patients with both acute and chronic kidney diseases.

Study Population

The study included the medical records of all women who developed AKI and required dialysis during pregnancy, childbirth, the post-abortion period, and/or the puerperium within the study period.

Sample Size and Power

All cases of pregnancy-related AKI during the study period were included due to the rarity of the condition. The patient list was compiled from maternity ward logbooks, operating theater records, emergency department records, and ICU admission registers. A total of 187 medical charts were reviewed. Using the single population proportion formula with a significance level of $\alpha = 0.05$ and a minimum effect size of 0.2, the statistical power was determined to be 0.87.

Data Collection Tool and Procedures

AKI cases were identified by cross-referencing medical record numbers with a separate logbook for maternal near misses. Data were extracted using a structured questionnaire developed based on existing literature and pilot-tested for reliability. The Open Data Kit (ODK) tool was used for data collection. Extracted data included sociodemographic characteristics, obstetric profiles, comorbidities, clinical presentation, investigations, management, and outcomes. Data collection was conducted by trained medical professionals.

Inclusion criteria for AKI diagnosis included

Absolute serum creatinine ≥1.2 mg/dL
Elevation of serum creatinine by 0.3 mg/dL within 48 hours from baseline
Decreased urine output for ≥6 hours
Requirement for dialysis

Data Analysis

Data were entered into the Open Data Kit (ODK) tool and analyzed using Stata version 16. Descriptive statistics were presented as frequencies and percentages. The normality of continuous data was assessed, and measures of central tendency and dispersion were reported as mean ± standard deviation (SD) or median with interquartile range (IQR). Categorical variables were compared using the chi-square test or Fisher's exact test, while continuous variables were analyzed using an independent t-test.

Bivariate analysis examined the association between independent variables and the composite endpoint (serum creatinine >1.5 mg/dL or death). Variables with a p-value <0.25 were included in multivariate logistic regression analysis. A p-value <0.05 was considered statistically significant. Multicollinearity diagnostics were performed, and collinear variables were excluded from the final model. The model's goodness-of-fit was tested using the Hosmer-Lemeshow test, and receiver operating characteristic (ROC) analysis was performed to estimate predictive power.

RESULTS

The demographic analysis of the study group revealed no significant differences in age distribution, gravidity, or trimester at admission between the composite endpoint and non-composite endpoint groups. However, antenatal care was significantly less frequent in the composite endpoint group (59.1% vs. 77.6%, *p* = 0.015), indicating a possible link between inadequate prenatal monitoring and worse outcomes. Vaginal delivery was more common in the composite endpoint group (70.5% vs. 48.2%, *p* = 0.022), while cesarean deliveries were more frequent in the non-composite group (43.4% vs. 18.2%). There were no significant differences in spontaneous abortion rates, pulse rate, or temperature at diagnosis, suggesting that acute clinical presentations were comparable across groups. These findings highlight the potential impact of antenatal care on pregnancy-related AKI outcomes and suggest that mode of delivery may influence maternal prognosis.

Table 1: Demographic Characteristics of The Study Group

Characteristic	Total (n=187) %	Composite Endpoint Yes (n=44) %	Composite Endpoint No (n=143) %	P-value
Age Group				
18–39	94.6	95.5	94.4	0.787
≥ 40	5.4	4.5	5.6	
Gravidity				
Gravida 1	41.7	27.3	46.1	0.077
Gravida 2–4	36.4	43.2	34.3	
Gravida ≥5	21.9	29.5	19.6	
Trimester at Admission				
First	2.7	6.7	2.1	0.455
Second	14.4	20.0	13.5	
Third	82.9	73.3	84.4	
Antenatal Care	73.3	59.1	77.6	0.015
Spontaneous Abortion	23.5	29.5	21.7	0.282
Pregnancy Outcome				
Vaginal Delivery	53.5	70.5	48.2	0.022
Caesarean Delivery	37.4	18.2	43.4	
Evacuation	8.0	9.1	7.7	
Dead/Discharged Pregnant	1.1	2.3	0.7	
Pulse Rate at Diagnosis				
≤100	55.6	50.0	57.3	0.391
>100	44.4	50.0	42.7	
Temperature at Diagnosis				
≤37.7	82.9	86.4	81.8	0.484
>37.7	17.1	13.6	18.2	

The causes and comorbidities associated with pregnancy-related acute kidney injury (AKI) differed significantly between the composite endpoint and non-composite endpoint groups. Hypertensive disorders of pregnancy were more prevalent in the non-composite group (79.0% vs. 63.6%, *p* = 0.038), with preeclampsia showing a particularly significant difference (76.2% vs. 54.6%, *p* = 0.006). Conversely, the composite endpoint group had a higher proportion of pre-renal AKI (50.0% vs. 37.8%), sepsis (59.1% vs. 46.1%), and acute glomerulonephritis (6.8% vs. 0.0%, *p* = 0.002). Comorbidities were notably more common in the composite endpoint group, including preexisting chronic kidney disease (22.7% vs. 0.7%, *p* < 0.001) and overall comorbid conditions (36.4% vs. 19.6%, *p* = 0.022). Medication exposure rates were similar, though vancomycin use was significantly higher in the composite endpoint group (31.2% vs. 12.7%, *p* = 0.014). These findings suggest that patients experiencing worse outcomes had a greater burden of underlying renal disease, sepsis, and severe AKI-related complications.

Table 2: Causes and Co-Morbidities of Pregnancy Related Acute Kidney Injury

Characteristic	Total (%)	Composite Endpoint Yes (%)	Composite Endpoint No (%)	P-value
Hypertensive Disorders of Pregnancy	75.4	63.6	79.0	0.038
Pre-eclampsia	71.1	54.6	76.2	0.006
Eclampsia	22.5	27.3	21.0	0.382
Gestational Hypertension	21.4	18.2	22.4	0.553
Superimposed Preeclampsia	4.3	2.3	4.9	0.452
Sepsis	49.2	59.1	46.1	0.133
Focus of Sepsis				0.052
Puerperium	20.6	15.4	22.8	
Gastrointestinal	7.6	19.2	3.0	
Chest/Pulmonary	28.3	38.5	24.2	
Urinary Tract	4.3	3.8	4.6	
Central Nervous System	2.2	0.0	3.0	
Pelvic	37.0	23.1	42.4	
Pre-renal AKI	40.6	50.0	37.8	0.148
HELLP Syndrome	26.7	34.1	24.5	0.208
HUS	0.5	0.0	0.7	0.309
AFLP	1.6	2.3	1.4	0.687
Acute Glomerulonephritis	1.6	6.8	0.0	0.002
Comorbidity	23.5	36.4	19.6	0.022
Heart Disease	4.8	2.3	5.6	0.368
Diabetes Mellitus	2.1	4.5	1.4	0.207
HIV	1.1	2.3	0.7	0.375
Chronic Hypertension	4.3	2.3	4.9	0.452
Preexisting CKD	5.9	22.7	0.7	<0.001
Chronic Liver Disease	8.0	9.1	7.7	0.765
Medication Exposure	75.9	72.7	76.9	0.569
Vancomycin	16.9	31.2	12.7	0.014
NSAIDs	23.2	25.0	22.7	0.789
ACE Inhibitors	2.1	3.1	1.8	0.651
Magnesium Sulfate	82.4	75.0	84.5	0.212
Radiographic Contrast	2.1	3.1	1.8	0.651
Tenofovir	1.4	3.1	0.9	0.349

The laboratory findings revealed significant differences between the composite endpoint and non-composite endpoint groups. Patients in the composite endpoint group had a higher prevalence of anemia, with 72.7% having hemoglobin ≤ 11 g/dL compared to 46.1% in the non-composite group (*p* = 0.008). Markedly elevated serum creatinine levels at diagnosis were observed in the composite endpoint group, with 40.9% having levels ≥ 3.0 mg/dL versus only 6.3% in the non-composite group (*p* < 0.001). Additionally, significantly reduced urine output was noted, as 36.0% had oliguria (100–400 mL/24h) and 12.0% had severe oliguria (<100 mL/24h) compared to 8.3% and 1.4%, respectively, in the non-composite group (*p* < 0.001). Although white blood cell counts and platelet levels did not show statistically significant differences, the composite endpoint group had a higher proportion of leukocytosis (>10,000/µL, 47.7% vs. 30.8%) and thrombocytopenia (<50,000/µL, 27.3% vs. 18.2%). These findings suggest that patients with poor outcomes were more likely to have severe renal dysfunction, anemia, and oliguria, which may contribute to their critical condition.

Table 3: Laboratory Findings of The Study Group

Characteristic	Total (%)	Composite Endpoint Yes (%)	Composite Endpoint No (%)	P-value
White Blood Cells (/µL)				0.108
4,000–10,000	60.9	47.7	65.0	
< 4,000	4.3	4.5	4.2	
> 10,000	34.8	47.7	30.8	
Hemoglobin (g/dL)				0.008
≤ 11	52.4	72.7	46.1	
11.1–15.9	38.5	20.5	44.1	

≥ 16	9.1	6.8	9.8	
Platelet Count (/µL)				0.354
< 50,000	20.3	27.3	18.2	
50,000–100,000	18.2	13.6	19.6	
100,000–150,000	61.5	59.1	62.2	
Creatinine at Diagnosis (mg/dL)				< 0.001
< 1.5	43.3	18.2	51.0	
1.5–1.9	28.9	25.0	30.1	
2.0–2.9	13.4	15.9	12.6	
≥ 3.0	14.4	40.9	6.3	
Urine Albumin, n = 154				0.847
Positive	69.5	68.3	69.9	
Negative	30.5	31.7	30.1	
Urine Output in 24h (mL/hour)				< 0.001
< 100	4.1	12.0	1.4	
100–400	15.5	36.0	8.3	
> 400	80.4	52.0	90.3	

In this study, the composite endpoint group exhibited significantly worse clinical outcomes compared to those without the composite endpoint. ICU admission was notably higher (52.3% vs. 18.9%, *p* < 0.001), along with increased use of vasoactive agents (29.5% vs. 9.1%, *p* = 0.001), parenteral antibiotics (77.3% vs. 52.4%, *p* = 0.003), and hemodialysis (22.7% vs. 4.2%, *p* < 0.001). Acute kidney injury (AKI)-related complications, including hyperkalemia (48.3% vs. 17.6%, *p* = 0.009) and altered mentation (58.6% vs. 26.5%, *p* = 0.01), were significantly more prevalent. Renal recovery at Day 7 was worse in the composite endpoint group, with a lower proportion achieving KDIGO Stage 0 (79.5% vs. 90.9%, *p* = 0.041) and higher proportions progressing to Stage 2 (6.8% vs. 0%, *p* = 0.002) and Stage 3 (11.4% vs. 3.5%, *p* = 0.0043). Fetal outcomes were comparable, but birth weight was significantly higher in the composite endpoint group (2800g vs. 2300g, *p* = 0.035). These findings indicate a substantial burden of critical illness and AKI severity in the composite endpoint group.

Table 4: Outcome of the Study Group

Characteristic	Total (%)	Composite Endpoint Yes (%)	Composite Endpoint No (%)	P-value
ICU Admission	26.7	52.3	18.9	< 0.001
Duration of ICU stay [median (IQR)]	5 [5]	5 [6]	6 [8]	0.792
Use of Mechanical Ventilation	48.0	52.2	44.4	0.586
Use of Vasoactive Agents	13.9	29.5	9.1	0.001
Use of Parenteral Antibiotics	58.3	77.3	52.4	0.003
Hemodialysis	8.6	22.7	4.2	< 0.001
Length of Hospital Stay [median (IQR)]	8 [10]	10 (9.5)	8 [9]	0.529
KDIGO Recovery Stages and Serum Creatinine at Day 7				
Stage 0 (Serum Cr < 1.5x baseline)	88.2	79.5	90.9	0.041
Stage 1 (Serum Cr 1.5-1.9x baseline)	4.8	2.3	5.6	0.368
Stage 2 (Serum Cr 2.0-2.9x baseline)	1.6	6.8	0.0	0.002
Stage 3 (Serum Cr ≥ 3.0x baseline)	5.35	11.4	3.5	0.0043
AKI-Related Complications	33.7	65.9	34.1	< 0.001
Hypertension	30.2	34.5	26.5	0.490
Pulmonary Edema	19.0	27.6	11.8	0.111
Anemia	71.4	72.4	70.6	0.873
Hyperkalemia	31.7	48.3	17.6	0.009
Metabolic Acidosis	20.6	27.6	14.7	0.208
Altered Mentation	41.3	58.6	26.5	0.01
Fetal Outcome				
Born Alive	56.1	50.0	58.0	0.478
Stillbirth	17.7	18.2	17.5	
IUFD	10.7	11.3	10.5	
ENND	1.6	0.0	2.1	
Abortus	10.7	18.2	8.4	

Unknown	3.2	2.3	3.5	
If Alive				
1st Minute APGAR Score [mean (SD)]	7.1 (1.2)	7.1 (0.8)	7.1 (1.3)	0.894
5th Minute APGAR Score [mean (SD)]	8.3 (1.0)	8.2 (0.5)	8.3 (1.1)	0.602
Birthweight in grams [mean (SD)], n = 95	2379 (848)	2800 (733)	2300 (849)	0.035

DISCUSSION

The findings of this study align with existing literature on pregnancy-related acute kidney injury (AKI) while also highlighting key distinctions. One of the primary observations was the association between inadequate antenatal care and worse outcomes, a trend consistently reported in prior studies. One research emphasized that limited prenatal monitoring increases the risk of complications such as hypertensive disorders and sepsis, leading to AKI.[9] Similarly, our study found significantly lower antenatal care rates in the composite endpoint group (59.1% vs. 77.6%, p = 0.015), underscoring the critical role of early and continuous obstetric care. However, unlike previous studies where advanced maternal age was a significant risk factor, age distribution was not a distinguishing characteristic in our cohort. A notable finding was the difference in delivery modes between groups. Our study found a higher proportion of vaginal deliveries in the composite endpoint group (70.5% vs. 48.2%, p = 0.022), whereas cesarean deliveries were more frequent in the non-composite group. This is in contrast to studies like that which reported higher rates of cesarean deliveries among patients with severe AKI. The discrepancy might be due to variations in obstetric practices across different populations, with some healthcare settings prioritizing vaginal delivery unless medically contraindicated.[10]

Regarding the etiological factors contributing to AKI, our findings revealed that hypertensive disorders, especially preeclampsia, were more prevalent in the non-composite endpoint group (79.0% vs. 63.6%, p = 0.038), whereas pre-renal AKI and sepsis were more common in the composite endpoint group. This contrasts with other research where hypertensive disorders were consistently associated with severe AKI outcomes. Our results suggest that while hypertensive disorders are common in pregnancy-related AKI, other factors such as sepsis and chronic kidney disease play a crucial role in determining prognosis.[11] Laboratory findings also indicated significant differences, particularly in hemoglobin levels and renal function markers. The composite endpoint group had significantly higher rates of anemia (72.7% vs. 46.1%, p = 0.008) and elevated serum creatinine levels (p < 0.001), similar to findings from a large cohort study which demonstrated that anemia and oliguria were strong predictors of AKI severity. However, our study did not find significant differences in leukocytosis and thrombocytopenia between groups, contrasting with previous studies where these hematological abnormalities were more pronounced in severe AKI cases.[12, 13] The outcome analysis revealed a substantial burden of critical illness in the composite endpoint group, with higher ICU admissions (52.3% vs. 18.9%, p < 0.001) and increased need for interventions such as hemodialysis and vasoactive agents. Similar trends were reported in studies who noted that pregnancy-related AKI requiring ICU admission had a higher likelihood of adverse maternal outcomes. However, fetal outcomes were comparable between groups in our study, except for birth weight, which was significantly higher in the composite endpoint group.[14] This differs from prior research, which often associated worse maternal AKI outcomes with higher stillbirth and neonatal mortality rates.

CONCLUSION

In summary, our study underscores the multifaceted nature of pregnancy-related AKI, emphasizing the impact of antenatal care, delivery mode, and underlying etiologies on maternal outcomes. While our findings align with existing literature regarding the role of inadequate prenatal care and anemia in worsening AKI prognosis, they also highlight key variations, such as the differing prevalence of hypertensive disorders and the influence of delivery mode. The higher burden of critical illness in the composite endpoint group further reinforces the need for early risk stratification and targeted management strategies. These findings call for further research to better understand population-specific factors influencing AKI outcomes in pregnancy.

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