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Risk factors and outcomes associated with pregnancy-related acute kidney injury in a high-risk cohort of women in Nigeria

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Abstract

Introduction: Despite a decline in developed countries, pregnancy-related acute kidney injury (PRAKI) remains a significant contributor to maternal mortality and adverse fetal outcomes in resource-constrained settings. Little is known about the impact of pregnancy-related acute kidney injury in Nigeria. Therefore, this study aimed to assess the incidence and maternal-fetal outcomes associated with pregnancy-related acute kidney injury among a cohort of high-risk women in Nigeria.

Methods: This prospective multicenter study included women at high risk of acute kidney injury, who were more than 20 weeks pregnant or within 6 weeks postpartum and admitted to the Obstetrics and Gynecology units of two large public hospitals between September 1, 2019, and July 31, 2022. Acute kidney injury was defined and classified using the Kidney Disease Improving Global Outcomes (KDIGO) criteria.

Results: A total of 433 women, with mean age (± standard deviation) of 28 ± 6 years, were included in the evaluation. Pregnancy-related acute kidney injury occurred in 113 women (26.1%; 95% confidence interval [CI]: 21.1%–30.2%). The leading cause was preeclampsia (n = 57; 50.1%); 19 women died (4.4%), with 17 deaths (15%) occurring in the PRAKI group. Increasing severity of pregnancy-related acute kidney injury was independently associated with maternal

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Disclosure

All the authors declared no competing interests.

Ethical approval

The research protocol was approved by the Health Research and Ethics Committee of Ibrahim Badamasi Babangida Specialist Hospital, Nigeria.

Informed consent

Written informed consent was obtained from each participant prior to enrollment into the study.

mortality: adjusted odds ratio (aOR) for KDIGO stage 2 = 4.40; 95% CI 0.66–29.34, p = 0.13, and KDIGO stage 3 aOR = 6.12; 95% CI 1.09–34.34, p = 0.04. The overall perinatal mortality was 15% (n = 65), with 28 deaths (24.8%) occurring in the PRAKI group. Pregnancy-related acute kidney injury was also associated with an increased risk of perinatal mortality, aOR = 2.23; 95 CI 1.17–4.23, p = 0.02.

Conclusions: The incidence of pregnancy-related acute kidney injury was high, and significantly associated with maternal and perinatal mortality. The leading causes were hypertensive disorders of pregnancy.

Keywords

Acute kidney injury; Hypertensive disorders of pregnancy; Maternal and perinatal mortality; Pregnancy

INTRODUCTION

Acute kidney injury (AKI) is an important cause of increased morbidity and mortality [1] and its impact is particularly devastating during pregnancy, as it adversely affects both mother and infant. The incidence of pregnancy-related acute kidney injury (PRAKI) has been decreasing in developed countries, but it continues to be a significant cause of poor maternal and fetal outcomes in resource-constrained settings [2, 3]. Despite global improvements in antenatal care services, significant reductions in the incidence of PRAKI in resource-constrained settings have yet to be seen. For example, studies have reported the incidence of PRAKI ranging from 5–20% in India [4–6], while data from Africa showed that obstetrical conditions accounted for 5–27% of cases of AKI [7, 8]. The “0 by 25” initiative from the International Society of Nephrology (ISN) has set a goal to eliminate deaths caused by untreated AKI by the year 2025 [9]. However, one of the major obstacles hindering the achievement of this goal is the lack of data on the epidemiology of AKI in low- and middle-income countries (LMICs). In fact, since 1990, only two prospective studies examining AKI in pregnancy have been published from sub-Saharan Africa (SSA) [10, 11]. This is concerning, considering that over 50% of global maternal deaths occur in SSA, and moreover, the contribution of AKI to this significant mortality rate is largely unknown [12].

It is therefore important to investigate the epidemiology of AKI among pregnant women in settings such as Nigeria. By doing so, we can identify potentially modifiable risk factors of PRAKI, enabling prompt intervention and prevention of AKI progression. In addition, we propose to assess maternal and fetal outcomes associated with PRAKI in northern Nigeria, an area known for having one of the highest maternal and child mortality rates in the world. [13]

METHODS

Study design:

Prospective multicenter observational study conducted in Minna, northcentral Nigeria. We recruited adult (≥ 16 years of age) pregnant women (> 20 weeks gestation) and within six

weeks postpartum, admitted to the obstetrics wards of two large public tertiary hospitals, namely, Ibrahim Badamasi Babangida Specialist Hospital (IBBSH) and Jummai Babangida Maternal and Neonatal (JBAMN) Hospital. The study period spanned from September 1st, 2019, to July 31st, 2022. These two hospitals receive tertiary referrals from hospitals in Niger State and its environs. The IBBSH has a hemodialysis unit that is staffed by nephrologists and trained dialysis nurses. The estimated annual delivery rates at IBBSH and JBAMN are 2,000 and 5,000 births, respectively.

We enrolled all women admitted to the obstetric high dependency /maternal intensive care units, post-natal, gynaecology, labour and antenatal wards with likely complications of pregnancy. Some of these complications which may increase the risk of AKI include eclampsia, preeclampsia, pregnancy-induced hypertension, sepsis, antepartum and postpartum hemorrhage.

We excluded women with pre-existing kidney disease, underlying chronic kidney disease (CKD), or known to have any other form of pre-existing kidney condition. Women who did not provide consent to participate in the study were also excluded.

Measurements:

Trained research assistants utilized a standardized data sheet to systematically document patients' sociodemographic information, clinical details, and laboratory measurements. The recorded demographic and clinical parameters included age, marital status, occupation, weight, height, blood pressure readings, temperature, obstetrical history, medication usage, history of consuming local herbs, traditional medicines and other potential nephrotoxins, symptoms indicating renal dysfunction (facial and leg swelling), co-morbid medical conditions, and past medical history. The diagnoses of patients' clinical conditions were made or ascertained by the managing obstetricians.

Ten mL's of whole blood and urine samples were obtained from eligible participants. The collected blood samples were used to assess baseline serum electrolytes, urea, creatinine, complete blood count (CBC), and liver function tests at the time of presentation or upon admission. Follow-up measurements including serum electrolytes, urea, and serum creatinine (SCr) were conducted at 48 hours and 7 days after admission. For patients identified with PRAKI, subsequent monitoring involved serial measurements of serum electrolytes, urea, and creatinine twice weekly for two additional weeks, followed by weekly measurements for the subsequent four weeks. In addition, all patients in patents at risk of AKI had hourly urine output monitoring for the first 24 hours on admission.

Primary and secondary outcomes

Primary outcome measures were incidence and risk factors for PRAKI.

Secondary outcomes included maternal mortality, perinatal mortality, the maternal need for hemodialysis, and kidney recovery.

Study participants that developed AKI were followed up for 3 months to establish short term outcomes such as progression of AKI to chronic kidney disease, kidney failure, kidney recovery, and maternal mortality.

Study Definitions

AKI was defined according to KDIGO criteria [14] and based on changes in serum creatinine levels and urine output as follows:

1. Increase in serum creatinine by 26.5 μmol/L (0.3 mg/dL) within 48 hours, or
2. Increase in serum creatinine to 1.5 times from baseline within 7 days, or
3. Urine output less than 0.5 ml/kg/hour for 6 hours:

AKI was staged for severity according to KDIGO staging criteria as follows: [14].

- KDIGO Stage 1: characterized by an increase in serum creatinine (SCr) to 1.5–1.9 times the baseline creatinine level or an increase in SCr by 26.5 μmol/L (0.3 mg/dL).
- KDIGO Stage 2: an increase in SCr to 2.0–2.9 times the baseline creatinine level.
- KDIGO Stage 3: The most severe stage, where there is an increase in serum creatinine to ≥ 354 μmol/L (≥ 4 mg/dL) or 3 times the baseline creatinine level.

For patients with repeated measurement within seven days on admission, baseline serum creatinine was considered as the lowest serum creatinine on admission. While patients that have documented serum creatinine within a year prior to admission, these serum creatinine values were considered as their baseline.

For patients with no repeated measurements of serum creatinine within seven days on admission and no pre admission creatinine, we estimated baseline creatinine by back calculation with an assumed GFR of 75 ml/min per 1.73 m^2 for age, sex and race[15].

Complete recovery of kidney function was defined as normalization of serum creatinine or serum creatinine returning to <1.5 times the baseline creatinine level.

Hypertensive disorders of pregnancy were defined based on the guidelines of the American College of Obstetricians and Gynecologists as follows:[16]

Gestational hypertension was defined as the development of high blood pressure (systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mm Hg) after 20 weeks of gestation in a woman who previously had normal blood pressure levels.

Preeclampsia was diagnosed when gestational hypertension was accompanied by either proteinuria (urine dipstick for protein ≥ 1+ or a urine protein-to-creatinine ratio (uPCR) of 0.3 or higher) or signs of end-organ damage.[16]

Eclampsia was identified when a woman with preeclampsia experiences new onset grand mal seizures or unexplained loss of consciousness.

Postpartum hemorrhage (PPH) was defined as blood loss ≥ 500mL after delivery.[17]

Antepartum hemorrhage was considered as bleeding from or into the genital tract after 22 weeks of gestational age and prior to delivery.

HELLP syndrome was diagnosed based on evidence of hemolysis, elevated liver enzymes (alanine transaminase (ALT) > twice the upper limit of normal) and low platelet count (<100,000)

Hypoalbuminemia was defined as a serum albumin level of less than 3.5 g/dL.

Ethical considerations

The research protocol was approved by the Health Research and Ethics Committee of Ibrahim Badamasi Babangida Specialist Hospital, Nigeria. Written informed consent was obtained from each participant prior to enrollment into the study.

Statistical analysis

Quantitative data that followed a normal distribution were presented as means ± standard deviations (SDs), while non-normally distributed data were presented as medians and interquartile ranges. Categorical data were expressed as frequencies and percentages (n, %). To compare continuous variables between study participants who developed PRAKI and those who did not, an independent t-test or Wilcoxon rank-sum test was used. Proportion comparisons were conducted using Pearson's or Fisher's exact tests. Logistic regression models were employed to determine independent predictors of PRAKI, and maternal and perinatal mortality. A stepwise regression strategy using a backward selection procedure was applied to fit the multiple regression models. Initially, all potential predictor variables were included, and variables with p-values exceeding the pre-specified threshold of 0.20 were subsequently removed. Covariates that were biologically plausible to be associated with the study outcomes were included in the model, even if their p-values were greater than 0.20. A p-value of less than 0.05 was considered statistically significant with a 95% confidence interval. All analyses were performed using STATA version 13 (STATA Corporation, College Station, TX, USA).

RESULTS

Cohort Description

Table 1 depicts the baseline sociodemographic and clinical characteristics of the study participants, as well as maternal and fetal outcomes, for the AKI and non-AKI groups. The baseline and clinical characteristics were comparable between the two groups. The study included 433 women, with a mean age ± SD of 28 ± 6 years. Among them, 90 (20.8%) were nulliparous, and 96 (22.2%) were grand multiparous (≥ 5 deliveries). Antenatal care service visits were completed by a total of 157 women (36.3%). Most deliveries were vaginal (n=174, 40.2%), although cesarean delivery was also common (n=152, 35.1%). Herbal medicine use was reported by 135 women (31.2 %). The proportion of women with previous history of hypertension was (n=51, 11.8 %).

PRAKI Incidence, Severity and Cause

Pregnancy-related acute kidney injury (PRAKI) was observed in 113 (26.1%) of 433 women (Table 1). Among patients with PRAKI, 43 (38.1%) were classified as KDIGO stage 1, 28 (24.8%) as stage 2, and 42 (37.2%) as stage 3. The incidence rate of PRAKI, based on the number of deliveries (n = 4,200) that occurred during the study period, was 269 per 10,000 deliveries, which was derived from the observed number of PRAKI (n=113).

The causes of pregnancy-related acute kidney injury (PRAKI) included pre-eclampsia (n=57, 50.4%), pregnancy-induced hypertension (n = 14,12.4%), postpartum hemorrhage (n=12, 10.6%), eclampsia (n=8, 7.1%), antepartum hemorrhage (n=7, 6.2%), sepsis (n=5, 4.4%), and HELLP syndrome (n=2, 1.8%) (Figure 1).

In terms of kidney outcomes, 14 patients (12.4%) with PRAKI required hemodialysis.

In addition, 2 patients (1.8%) progressed to chronic kidney disease (CKD stage 4), while 3 patients (2.7%) developed end-stage kidney disease. Full recovery of kidney function within three months of developing AKI was observed in 58 patients (51.3%) who experienced PRAKI (Figure 2). PRAKI patients who required dialysis had significantly lower mean gestational age (32±6.2 versus 35.2±4.2, P=0.02), systolic blood pressure (144±32.4 vs. 167.3±35.6, respectively, P=0.02), diastolic blood pressure (91.1±19.0 versus 107.3 ±22.7, respectively, P=0.01) and experienced higher proportions of maternal death (42.6 % vs. 11.1 %, respectively, P=0.007) and perinatal death (57.1 % vs. 20.2%, respectively, P=0.006) compared to women in the PRAKI group who did not require dialysis (Supplementary Table 1).

Maternal Mortality and fetal outcomes

There was a total of 19 (4.4%) maternal deaths, of which 17 (15.0%) occurred in the PRAKI group and 2 (0.6%) in non -PRAKI group (Table 1). A total of 65 (15.0 %) perinatal deaths were recorded, and 28 (24.8%) of these deaths occurred in the PRAKI group (Table 1). The overall perinatal mortality rate was 150/1000 deliveries.

The occurrence of PRAKI was independently associated with anemia (Hemoglobin < 9 gr/dL), hypoalbuminemia (serum albumin <3.5 g/dL), systolic blood pressure, and use of medications for hypertensive disorders of pregnancy, including magnesium sulfate, labetalol, and methyldopa (Table 2).

Increasing severity of PRAKI was also significantly associated with the risk of maternal mortality, the adjusted odds ratio (aOR) for KDIGO stage 2 was 4.40; 95%CI 0.66–29.34, p= 0.13, and for KDIGO stage 3 it was 6.12; 95%CI 1.09–34.34, p = 0.04 (Table3).

PRAKI was also associated with an increased risk of perinatal mortality, adjusted odds ratio (aOR) = 2.23; 95%CI 1.17–4.23, p=0.02. Other covariates associated with the risk of perinatal death included maternal anemia requiring blood transfusion (aOR = 3.11; 95% CI 1.60–6.02, p= 0.001), and delivery via caesarian section (aOR = 0.42 95 %CI 0.22–0.80, p = 0.008). The use of magnesium sulfate had a protective effect (aOR = 0.36 95%CI 0.19–0.68, p = 0.002) (Table 4).

DISCUSSION

Previously, the comparison of epidemiological data regarding the incidence and prevalence of PRAKI was hindered by the absence of a consensus on how to define AKI during pregnancy. However, with the widespread adoption of the KDIGO, AKIN, and RIFLE classification and staging systems[18], a new opportunity has emerged for making comparisons of PRAKI incidence and outcomes across various studies. In our study, we found a PRAKI incidence rate of 269 per 10,000 deliveries. This rate is significantly higher than the PRAKI incidence rate of 2.68 per 10,000 deliveries reported in a population-based study conducted in Canada [19]. The difference between our findings and the Canadian study can likely be attributed to variations in the study populations. In our study cohort, the majority of study participants had known risk factors for AKI, whereas the Canadian study encompassed both patients with and without risk factors for AKI. In addition, the discrepancy may be influenced by differences in the quality of and access to obstetrical care in the two settings, with Canada's healthcare infrastructure more advanced compared to Nigeria's.

Consistent with this study, other studies conducted in resource-constrained settings have reported high incidence and prevalence rates of PRAKI [4–6]. For example, studies conducted in India showed incidence proportions for PRAKI ranging from 5% to 20% [4–6], while studies from Africa reported that obstetrical conditions accounted for 5–27% of cases of AKI, with incidence rates that were 20–100 times higher than in high income countries [7, 8]. The wide range of reported incidence and prevalence of PRAKI can be due to several factors, including the lack of a standardized definition for AKI across studies, variations in study populations, and differences in study design. For example, while some studies used AKIN or RIFLE criteria to diagnose AKI, our study and others utilized the KDIGO classification system, which incorporates both AKIN and RIFLE criteria.

In this study, the main etiologies of PRAKI were hypertensive disorders of pregnancy, with pre-eclampsia and eclampsia accounting for nearly 60% of cases within our cohort. These findings align with reports from other studies [19–22]. The observed shift from septic abortion as the leading cause of PRAKI in resource-constrained settings can be attributed to global advancements in obstetrical care and improved accessibility to antimicrobial agents for the timely management of sepsis. These improvements likely contributed to a decrease in the incidence of septic abortion-related PRAKI cases, highlighting the positive impact of enhanced healthcare practices and availability of necessary interventions.

The contribution of rare obstetrical complications such as thrombotic thrombocytopenic purpura, acute fatty liver of pregnancy, and atypical hemolytic uremic syndrome as causes of PRAKI could not be determined in this study. These conditions are infrequent, and their underreporting or non-reporting in LMICs may be attributed to both their rarity and limited diagnostic capacity [23]. Therefore, the true prevalence and impact of these rare obstetrical complications on PRAKI cases in these settings remain largely unknown. Furthermore, etiology of AKI during pregnancy can be categorized according to the trimester. While our study included women in their second and third trimesters, it is possible that we failed to

capture causes of PRAKI that are more prevalent during the first trimester, such hyperemesis gravidarum and septic abortion [24].

The occurrence of AKI during pregnancy can have devastating consequences, leading to adverse outcomes for both the mother and the baby. In our study cohort, AKI showed a significant association with increased maternal and perinatal mortality, consistent with findings from other studies[20, 25]. In a recent meta-analysis comprising 11 relevant studies, PRAKI was associated with a 4.5-fold higher risk of maternal death and a 3.4-fold increased risk of stillbirth/perinatal death [25]. In addition, in our study, a maternal mortality rate of 12.8% in the PRAKI group closely aligned with the rates reported in prior published studies by Liu et al. (13.3%) [25], Kabbali et al. (11.4%) [26], and Godara et al. (15.7%) [27]. The association of advanced stages of AKI with increased maternal mortality is also in agreement with other prior studies [3, 28]. The underlying mechanisms of fetal mortality in PRAKI are likely multifactorial and may be attributable to preterm delivery, low birth weight, placental hypoperfusion, and/or fetal distress. Despite advancements in antenatal care services, perinatal mortality rates remain unacceptably high in LMICs. For instance, the overall high perinatal mortality rate of 150 per 1000 deliveries in our report is in agreement with previous findings reported in Nigeria by Adimora et al. (133.94 per 1000)[29] and Fowole et al. (102 per 1000) [30]. However, a systematic review that included studies from Sub-Saharan African countries, though with high heterogeneity, reported an overall lower perinatal mortality rate of 58.35 per 1000 births [31].

We found that the use of magnesium sulfate and caesarean section as a mode of delivery were associated with a reduced risk of perinatal death. These findings can be attributed to the beneficial effects of magnesium sulfate in preventing maternal seizures in preeclampsia, a significant cause of adverse neonatal outcomes. Additionally, magnesium sulfate has a neuroprotective effect on the fetus, further contributing to improved outcomes [32].

Similarly, a systematic review and meta-analysis in acute fatty liver of pregnancy showed a reduction in perinatal mortality rate with Caesarean section (RR, 0.52 [0.38–0.71]) versus vaginal delivery [33]. This observation may be attributed to the expedited intervention aimed at saving both the mother and the child. A previous study from Nigeria also reported that both elective and cesarean sections significantly reduced the odds of perinatal mortality [30].

The use of herbal medicine among pregnant women varies across the globe. For example, an online survey that included 29 European countries reported an overall prevalence of 28.9% for herbal medicine use among 9 459 pregnant women, and higher percentages were reported in Russia (69.0%), Poland (49.8 %) and Australia (43.8 %)[34]. In Africa, a systematic review showed that the average prevalence of herbal medicine use during pregnancy and lactating period was between 30 to 45% [35]. In this study, the prevalence of herbal medicine use was 32%. Although there are various types of medicinal herbs used during pregnancy, studies relating to their safety on both the mother and the fetus are sparse and contradictory [36, 37]. In our study we did not find a statistically significant association between the use of local herbs and an increased risk of AKI or perinatal mortality.

Historically, AKI was viewed as a reversible condition [38]. However, subsequent studies have established a link between AKI and an increased risk of developing CKD and/or progression to end stage kidney disease (ESKD) [38, 39]. In our study, although approximately half of our patients achieved complete recovery of kidney function within three months, which aligns with findings from prior studies [40, 41], we observed that low proportions of patients did progress to CKD and developed kidney failure, 1.8% and 2.7%, respectively. It is important to note that our assessments of CKD and progression to kidney failure may have been underestimated due to challenges in accurately evaluating long-term kidney outcomes in many LMICs, primarily due to loss to follow-up. Nevertheless, it is critical to recognize that PRAKI is a life-threatening condition associated with high maternal and fetal mortality. Therefore, early recognition and prompt management are essential in reducing the occurrence of both short-term and long-term adverse outcomes.

The strengths of this study include the relatively large study sample size and prospective design that allowed for follow-up, as previously published studies from Africa were predominantly retrospective and had relatively small sample sizes. In addition, to our knowledge, this is the first prospective study of PRAKI in Nigeria. Our use of the KDIGO staging criteria to stage severity of AKI is another strength.

Our study has several limitations. First, we utilized an accepted definition of AKI based on serum creatinine levels that has not been specifically validated for use in pregnancy. This approach may have missed mild cases of AKI, as serum creatinine can naturally decrease due to hyper filtration during pregnancy. Second, as mentioned earlier, the long-term outcomes of PRAKI may have been underestimated due to loss to follow-up of patients. To address this limitation, we suggest increasing awareness among healthcare providers and patients about the potential long-term complications of PRAKI and improving the tracking of patients over time. Third, our study was conducted among pregnant women with potential risk factors for PRAKI, in two large urban centers. This may have accounted for the high incidence rate of PRAKI and our inability to tease out the effect of certain established risk factors such age, in addition to potentially limiting the generalizability of our findings. Finally, few women in our study had prenatal care (36%) - it is possible that we may have missed some cases of CKD.

In summary, our study identified a high incidence of PRAKI among pregnant women admitted to obstetrical wards in northcentral Nigeria. PRAKI was found to be significantly associated with increased maternal and perinatal mortality, with hypertensive disorders of pregnancy emerging as the primary contributors. These findings underscore the importance of early identification of risk factors, timely management, and comprehensive monitoring of mothers through a multidisciplinary approach. By identifying the risk factors associated with PRAKI at an early stage and implementing suitable interventions, we can improve outcomes for both mothers and their babies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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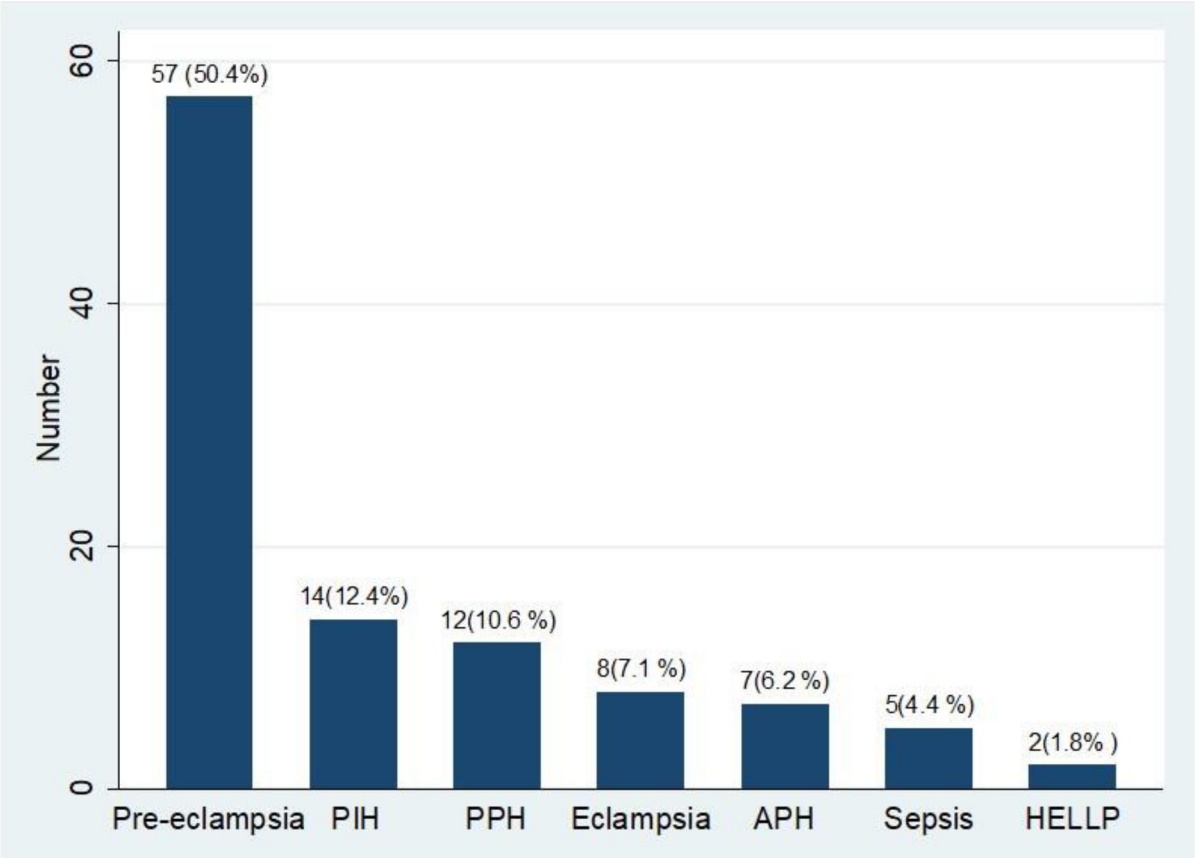

Fig 1.

Etiology of pregnancy related acute kidney injury (PRAKI) among a cohort of high-risk pregnant women, Minna, Nigeria

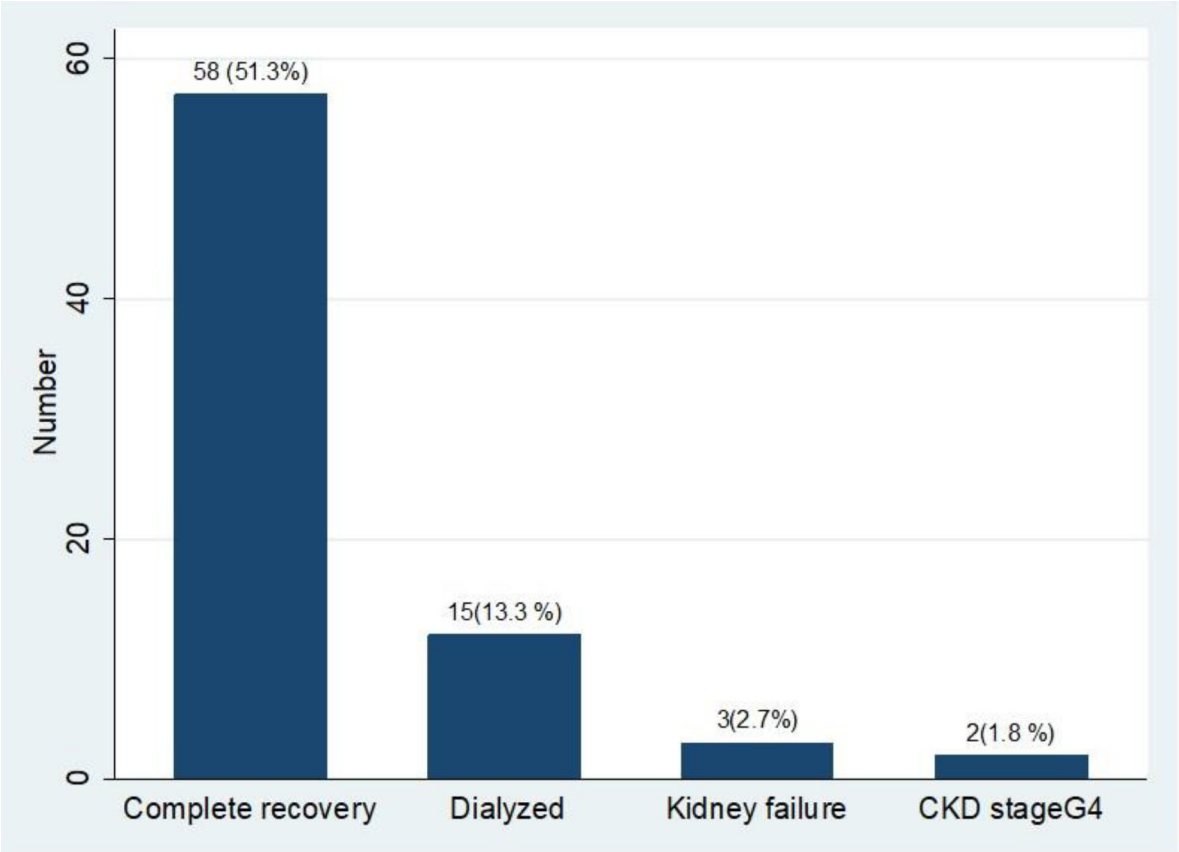

Fig 2.
Kidney outcomes of pregnancy related acute kidney injury in study participants, Minna, Nigeria

Table 1:

Demographics, clinical characteristics, and outcomes of study participants, Minna, Nigeria

Variable	All (N=433)	No AKI (n=320)	AKI (n=113)	P-value
Age (years)	28.0±6.0	28.0±7.0	28.0±6.0	0.72
Systolic BP (mmHg)	161.9±30.3	161.0±28.1	164.5±35.9	0.30
Diastolic BP (mmHg)	104.8±19.8	104.6±18.7	105.3±22.8	0.75
Hemoglobin (g/dL)	10.17±2.37	10.26±2.24	9.90±2.72	0.18
Albumin (g/L)	4.2±1.2	4.3±1.1	3.9±1.3	0.02
Gestational age (weeks)	35.2±4.5	35.4±4.5	34.8±4.6	0.15
Parity n (%)				
Primiparous	90 (20.8)	69 (21.6)	21(18.6)	0.80
Para 1–4	247(57.0)	180(56.3)	67(59.3)	
Grand multiparous	96 (22.2)	71(22.2)	25 (22.1)	
Previous history of HTN	51 (11.8)	40 (12.5)	11(9.7)	0.37
Antenatal care n (%)	157(36.3)	110(34.4)	47 (41.6)	0.23
Mode of delivery n (%)				
Vaginal	174 (40.2)	124 (38.8)	50 (44.2)	0.15
Caesarean	152 (35.1)	117 (36.6)	35 (31.0)	0.17
Use of local herbs	135 (31.2)	98 (30.6)	37 (32.7)	0.73
Use of magnesium sulphate	251 (58.0)	184 (57.5)	67(59.3)	0.41
Blood transfusion	174 (40.2)	121(37.8)	53 (46.9)	0.06
Risk Factors n(%)				
Pre-eclampsia	195 (45.0)	138 (42.9)	57 (50.4)	
Eclampsia	47 (10.9)	39 (12.1)	8 (7.1)	
PIH	82 (18.9)	68 (21.1)	14 (12.4)	
PPH	50 (11.5)	38 (11.8)	12 (10.6)	
APH	28 (6.5)	21(6.5)	7(6.2)	
Sepsis	13 (3.0)	8 (2.5)	5(4.4)	
HELLP	2 (0.5)	0 (0.0)	2(1.8)	
Outcomes n(%)				
Maternal mortality	19 (4.4)	2 (0.6)	17 (15.0)	<0.001
Overall perinatal death	65(15.0)	37(11.5)	28 (24.8)	0.001
Still birth	32 (7.3)	14(4.4)	18(15.9)	<0.001

AKI= acute kidney injury, BP=Blood pressure, PIH =Pregnancy induced hypertension, PPH=Postpartum hemorrhage, APH=Antepartum hemorrhage

Table 2.

Predictors of pregnancy related acute kidney injury (AKI) among a cohort of high-risk pregnant women, Minna, Nigeria

Variable	Crude Odds ratio 95% (CI)	P-value	Adjusted Odds ratio 95% (CI)	P-value
Age (years)	1.01 (0.97–1.04)	0.57	1.02 (0.97–1.06)	0.49
Hemoglobin < 9 g/dL	1.69 (1.05–2.71)	0.03	2.17 (1.21–3.89)	0.009
Hypoalbuminemia	2.15 (1.25–3.70)	0.006	2.40 (1.35–4.27)	0.003
Use of local herbs	1.05 (0.66–1.68)	0.82	1.66 (0.90–3.04)	0.10
Systolic BP (mmHg)	1.004 (0.997–1.01)	0.31	1.02 (1.00–1.02)	0.006
Magnesium sulphate use	1.08 (0.70–1.66)	0.74	1.92 (1.01–3.67)	0.046
Labetalol use	0.72 (0.45–1.16)	0.18	0.52 (0.28–0.99)	0.048
Methyldopa use	0.66 (0.42–1.03)	0.07	0.44 (0.23–0.85)	0.01

BP=Blood pressure, CI=Confidence interval

Table 3.

Predictors of maternal mortality among a cohort of high-risk pregnant women, Minna, Nigeria

Variable	Crude Odds ratio 95% (CI)	P-value	Adjusted Odds ratio 95% (CI)	P-value
AKI Stage 1	1.00(reference)		1.00(Reference)	
AKI stage 2	3.42 (0.58–20.07)	0.17	4.40 (0.66–29.34)	0.13
AKI stage 3	7.27 (1.50–35.22)	0.014	6.12 (1.09–34.34)	0.04
Maternal age	1.09 (0.43–2.74)	0.85	0.97 (0.86–1.09)	0.60
Required blood transfusion	4.45 (1.57–12.58)	0.005	6.94 (1.49–32.22)	0.013
Systolic BP	1.004 (0.99–1.02)	0.65	1.03 (0.99–1.06)	0.15
Diastolic BP	0.99 (0.97–1.02)	0.83	0.97 (0.92–1.03)	0.30
Platelet count	2.31 (0.87–6.13)	0.09	1.76 (0.52–5.96)	0.36
Receipt of magnesium sulfate	0.64 (0.25–1.61)	0.34	1.01 (0.21–4.98)	0.99

AKI= Acute kidney injury, BP=Blood pressure, CI=Confidence interval

Table 4.

Predictors of perinatal death among a cohort of high-risk pregnant women, Minna, Nigeria

Covariate	Crude Odds ratio 95% (CI)	P-value	Adjusted Odds ratio 95% (CI)	P-value
AKI	2.52 (1.46–4.36)	0.001	2.23 (1.17–4.23)	0.02
Maternal age	1.29 (0.76–2.20)	0.33	1.32 (0.71–2.44)	0.38
Caesarean section	0.41 (0.22-.075)	0.004	0.42 (0.22–0.80)	0.008
Use of local herbs	1.47 (0.84–2.53)	0.17	1.65 (0.87–3.13)	0.12
Receipt of Magnesium sulphate	0.31 (0.18–0.54)	<.001	0.36 (0.19–0.68)	0.002
Required blood transfusion	5.42 (3.00–9.82)	<.001	3.11 (1.60–6.02)	0.001

AKI = Acute kidney injury