Feto-maternal outcome of pregnancy-related acute kidney injury in a North Indian population

Rekha Sachan, Savita Shukla, Radhey Shyam¹, Pushp L. Sachan², Munna L. Patel³

Abstract:
BACKGROUND: Acute kidney injury (AKI) is a serious complication in pregnancy, resulting in significant maternal and fetal morbidity/mortality. The aim of this study was to evaluate the magnitude of pregnancy-related AKI (PRAKI) in a North Indian population, and its contributing factors.

MATERIALS AND METHODS: This prospective study was carried out at the department of obstetrics and gynecology in collaboration with the nephrology unit and internal medicine department at King George Medical University from June 2019 to October 2020. After informed consent and ethical clearance, a total of 150 PRAKI women were enrolled, and 98 women were subjected to renal replacement therapy as per Kidney Disease Improving Global Outcomes 2012 guideline and were followed for 3 months for renal and fetomaternal outcome.

RESULTS: There was a high incidence (1.02%) of AKI during pregnancy and puerperium. Majority (57.3%) of the women were aged 26–30 years, and 93.3% had institutional deliveries. About 49% of the women suffering from PRAKI were multipara, and most were identified in the postpartum period (82%). Hypertensive disorder of pregnancy (48%), puerperal sepsis (45%), and hemorrhage (34%) were the associated causes for PRAKI. Stillbirth/intrauterine death (IUD) was higher in Stage II (53.8%) and Stage III AKI (37.7%) (none in Stage I AKI). The majority of the neonates were born with a birth weight of ≤2500 g irrespective of the stages of AKI. Preterm deliveries were significantly higher in Stage II AKI (53.8%) than in Stage I (33.3%) and Stage III (20.0%). Thirty-seven cases of PRAKI were managed conservatively, while 98 required dialysis. Complete recovery occurred in 27.3% and partial renal recovery in 31.3%. However, 3.3% progressed to chronic kidney disease, 34% expired, and 4% were lost to follow-up. High maternal mortality of 30.1% was observed in those dialyzed.

CONCLUSION: AKI is associated with fetal growth restriction and preterm deliveries. Stillbirth/IUD is higher in Stage II and Stage III AKI.

Keywords:
Fetomaternal outcome, pregnancy-related acute kidney injury, renal replacement therapy

Introduction

Pregnancy-related acute kidney injury (PRAKI) observed during antenatal, intrapartum, and postpartum period is a life-threatening complication of pregnancy that usually occurs as a result of obstetric complications, such as septic abortion, hyperemesis gravidarum, preeclampsia/ eclampsia, hemolysis, elevated liver enzymes, and low platelets syndrome, placental abruption, intrauterine death (IUD), uterine hemorrhage, and puerperal sepsis in women with previous healthy kidneys.¹ ² Acute kidney injury (AKI) is characterized by sudden decline in glomerular filtration rate, leading to decreased excretion of nitrogenous waste products, such as urea, creatinine, and uremic products.³ Dialysis is one of the most commonly used Renal...
Replacement therapy (RRTs) in the present era. In the past 50 years, the incidence of PRAKI has fallen worldwide from 20% to 40% in 1960 to <10%, probably due to the improvement of obstetric and prenatal care, as well as legalization of abortion.[4] Currently, the incidence of PRAKI has decreased in developed countries to only 1%–2.8%. However, it is still frequent in developing countries with an incidence of around 4.2%–15%.[6]

In India, PRAKI requiring dialysis fell from 15% in 1982–1991 to 10% in 1992–2002, with a concurrent decrease in maternal mortality from 20% to 6.4%, respectively.[6] This marked decline might be due to the reduction in sepsis associated with abortion and childbirth, as well as improved management of postpartum hemorrhage and placental abruption.[6,7]

In normal pregnancies, the serum concentration of creatinine falls as a result of the increase in glomerular filtration rate (hyperfiltration), and as such, low reference limits have been advocated for pregnant women. Elevation of the Serum creatinine levels >0.9 mg/dl or 75 µmol in pregnancy considered outside the normal range for pregnancy and calls for critical evaluation of renal function.[8] Late recognition of AKI may result in delayed referral for dialysis.

This study included the women of PRAKI defined on the basis of the Kidney Disease Improving Global Outcomes (KDIGO) guidelines 2012.[9] Serum creatinine level of 0.8 mg/dl or >72 µmol in pregnancy considered as a higher reference limit because this level is considered a borderline in pregnancy for normal renal function. Beyond this level, further evaluation of renal function is required.

Even though the incidence of PRAKI has been declining, it still remains a serious problem because of significant adverse maternal and fetal outcomes.[10–12] According to some studies, the rates of maternal and perinatal mortality in patients with PRAKI have risen to 30% and 60%, respectively.[10] Thus, there is a need for further evaluation of AKI in pregnancy to improve obstetric outcomes, as well as practices. The aim of this study was to evaluate the factors that contribute to PRAKI, renal recovery, and fetomaternal outcome.

**Materials and Methods**

A prospective, observational study was carried out at the department of obstetrics and gynecology, in collaboration with the nephrology unit, department of medicine, over a period of 16 months from June 2019 to October 2020. A total of 14,702 obstetric women were admitted for delivery; 150 women with PRAKI were recruited for this study. Most of the patients included in our study were near-term gestational age (37–40 weeks of gestation) and post delivered. Out of 150 women suffering from PRAKI, 98 women (Group A) PRAKI were subjected to RRT fulfilling the criteria for dialysis as per KDIGO 2012 guideline. 37 PRAKI (Group B) not requiring dialysis were managed conservatively, and 15 unfortunate patients suffering from PRAKI (Group C) who were hemodynamically unstable were kept on supportive treatment. Those women who were either in stage III AKI or had indications for dialysis were subjected to hemodialysis (RRT). Women suffering from PRAKI (Group B) subjected for conservative management. Steroid coverage was given to achieve fetal lung maturity in women having gestation age less than 37 weeks. In HDP group, 4 hourly blood pressure monitoring and MgSO₄ (Pretichard)/Zuspan regimen was given in severe preeclampsia and eclampsia to prevent convulsion and input/output monitoring was done. In cases of uncontrolled blood pressure, early delivery was conducted to avoid further kidney damage. In patients with sepsis, there were culture and sensitivity and broad-spectrum antibiotic initiation at an early stage to avoid further damage. In hemorrhage, hypotension was managed by supplementation of fluid and blood as per requirement. Strict input–output, vitals monitoring was done. Proper evaluation of renal function was carried out. Group C patients were hemodynamically unstable, so they were kept on vasopressor and inotropic supports, and maximum patient were kept on ventilator supports, but survival was very poor till the time of study since continuous RRT machines were not available in our department. Maternal and fetal outcomes of these PRAKI cases were evaluated. Maternal outcome was assessed in terms of morbidity, mortality, and renal recovery after replacement therapy (RRT). Perinatal outcomes included still birth, intrauterine fetal demise, admission to neonatal intensive care unit, and the survival of newborn of mothers who had PRAKI. These patients were followed up for the next 3 months for outcomes. Of the 98 cases, 6 patients left against medical advice. Ethical approval was obtained from the Institutional Review Board vide Letter No. 96th ECM II B-Thesis/P68 dated 22/05/2019, and informed written consent was taken from all participants. The sample size for this study was calculated using the standard formula.

\[ n = \frac{Z^2 \times P(1-P)}{d^2} \]

where

- \( n \) = sample size,
- \( Z = Z \) statistic for a level of confidence, for the level of confidence of 95%, which is conventional, \( Z = 1.96 \)
- \( P = \) expected prevalence or proportion (in proportion of one; if 7%, \( P = 0.07 \))
- \( d = \) precision (in proportion of one; if 5%, \( d = 0.05 \)).

\[ n = 1.96 \times 1.96 \times 0.076 \times 0.93/0.05^2. \]
Information was gathered from the patients with a structured questionnaire consisting of patient age, complete postal address, registration number, contact number, religion, symptoms, and signs. Subjects were recruited after a detailed history was taken; a thorough physical examination including obstetric and pelvic examination was done. Specific investigations including complete blood count testing, (automated blood cell analyzer (Abbott CELL-DYN Ruby Hematology Analyzer), random blood sugar, coagulation profile, ABG, liver function test, kidney function test, and renal ultrasound was carried out before enrolment. Blood samples were obtained within the 1st 24 h of ICU admission and then every other day for 3 days from all patients, and a biochemical analysis was done. Some special investigations including blood culture, high vaginal swab culture sensitivity, and urine routine microscopy and culture sensitivity were sent and reports were evaluated.

Women with PRAKI requiring RRT as per the KDIGO guidelines 2012 were included in this study. Women with known case of end-stage kidney disease, hypertension, diabetes mellitus, history of renal stone, and small size echogenic kidneys and women with a recent history of urological intervention were excluded from this study.

Data were collected in terms of fixed variables such as age, gender, race, place, and socioeconomic status, as well as in terms of continuous variables such as blood urea, serum creatinine, input, output, and improvement in clinical symptoms and signs. These continuous variables were measured 6 h after each hemodialysis and after 24 h every day for 7 days in each group. Simple t-test and Chi-square test were used for quantitative and qualitative analysis, respectively, and an analysis of variance was used to estimate the improvement in parameter.

Results

The women’s age ranged from 20 to 35 years. The majority (57.3%) suffering from PRAKI were aged 26–30 years; 56% of these women had Stage III AKI, 53.3% of PRAKI women were illiterate, 77.3% were Hindu, 51.3% were from urban areas, and 70.0% belonged to the upper-middle socioeconomic class [Table 1].

HDP is associated with vascular endothelial damage even much earlier than the appearance of symptoms, and this vascular endothelial damage is a prime feature of preeclampsia and might affect the renal glomerular endothelial. The association of HDP with Stage II chronic kidney disease (CKD) is therefore more common. HDP was found to be the most common risk factor (48%). It was observed that the highest number of Stage III AKI (81.94%) was found in HDP group. Out of 13 cases of AKI Stage II, 12 (92.3%) belonged to the HDP group. The worst outcome with Stage III CKD might be the result of dialysis-associated complications including infections and electrolyte imbalance and hypotension. Differences between all stages of AKI were also statistically significant for overall HDP (Stage II, 92.3% vs. Stage I, 33.3% and Stage III, 44.0%) (P = 0.003). On subgroup analysis, the differences in all three stages of AKI were significant for eclampsia (61.5% Stage II vs. 25.4% Stage III and 0.0% Stage I) (P = 0.012). The second most common risk factor was sepsis (45%), and the third was obstetric hemorrhage (34%). Medical disorders were associated with AKI in 26% cases [Table 2].

All the Stage I AKI and the majority of Stage II AKI (92.3%) were managed conservatively (i.e., Group B); while the majority of Stage III AKI (73.1%) received hemodialysis (RRT) (i.e., Group A), only 16.4% of Stage III AKI were managed conservatively. 7.7% of Stage II and 10.4% of Stage III PRAKI were managed with supportive treatment as they were hemodynamic unstable (Group C) although they required dialysis [Table 3].

None of the women from Stage I and Stage II AKI had an abortion, but 4 women (3.0%) of Stage III AKI aborted. The majority of women delivered vaginally irrespective of the stages of PRAKI (in Stage I - 66.7%, in Stage II - 69.2%, and in Stage III - 54.5%). The association between mode of delivery and stages of PRAKI was nonsignificant. Although the number of women who suffered stillbirth/IUD was higher in Stage II AKI (53.8%) and Stage III AKI (37.7%) compared to Stage I AKI (0.0%), this difference was not significant.

The majority of the neonates born with birth weight of ≤2500 g, irrespective of Stages of AKI (in Stage I, II, and III: 100% 69.2%, and 83.1%, respectively), showed that AKI was associated with fetal growth restriction. Association between birth weight of new-born and stages of PRAKI was not significant. Preterm deliveries were significantly higher in Stage II AKI (53.8% women) compared to Stage I AKI (33.3%) and Stage III AKI (20.0% women) [Table 4].

After 3 months of follow-up, the rate of complete recovery was significantly higher in Stage I AKI (100%) and in Stage II AKI (84.6%) compared to Stage III AKI (20.1%), with the rate of death of these patients significantly higher (37.3%). Differences at 3-month follow-up were statistically significant (χ² = 32.986 (df = 8); P < 0.001) [Table 5].

Out of 150 patients, only 144 were evaluated for outcome in terms of recovery and mortality because 6 patients went Leave against medical advice (LAMA). In 51.2% of patients with eclampsia, there was complete recovery, and an overall recovery of 75.6% in patients with HDP, 24.4% in patients with hemorrhage, and 39.0% in patients with sepsis, and 31.7% in the group with medical...
Table 1: Demographic profile of women with pregnancy related acute kidney injury

| Stage I (n=3) | Stage II (n=13) | Stage III (n=134) | Total (n=150) | P-value |
|--------------|----------------|------------------|---------------|---------|
| N (% )       | N (% )         | N (%)            | N (%)         |         |
| Age group (years) |         |                 |               |         |
| 20-25        | 1 (33.3)       | 4 (30.8)         | 48 (35.8)     | 53 (35.3) | 0.770 |
| 26-30        | 2 (66.7)       | 9 (69.2)         | 75 (56.0)     | 86 (57.3) |         |
| 31-35        | 0              | 0                | 11 (8.2)      | 11 (7.3)  |         |
| Education    |                |                 |               |         |
| Illiterate   | 2 (66.7)       | 10 (76.9)        | 68 (50.7)     | 80 (53.3) | 0.595 |
| Up to 8th standard | 0         | 0                | 6 (4.5)       | 6 (4.0)   |         |
| High school  | 0              | 2 (15.4)         | 15 (11.2)     | 17 (11.3) |         |
| Intermediate | 1 (33.3)       | 0                | 28 (20.9)     | 29 (19.3) |         |
| Graduate     | 0              | 1 (7.7)          | 17 (12.7)     | 18 (12.0) |         |
| Religion     |                |                 |               |         |
| Hindu        | 3 (100.0)      | 7 (53.8)         | 106 (79.1)    | 116 (77.3) | 0.074 |
| Muslim       | 0              | 6 (46.2)         | 28 (20.9)     | 34 (22.7) |         |
| Residence    |                |                 |               |         |
| Rural        | 2 (66.7)       | 9 (69.2)         | 62 (46.3)     | 73 (48.7) | 0.235 |
| Urban        | 1 (33.3)       | 4 (30.8)         | 72 (53.7)     | 77 (51.3) |         |
| Socioeconomic status |         |                 |               |         |
| Upper        | 0              | 0                | 2 (1.5)       | 2 (1.3)   | 0.287 |
| Upper middle | 3 (100.0)      | 7 (53.8)         | 95 (70.9)     | 105 (70.0) |         |
| Lower middle | 0              | 0                | 18 (13.4)     | 18 (12.0) |         |
| Lower        | 0              | 6 (46.2)         | 19 (14.2)     | 25 (16.7) |         |

Table 2: Association between stages of acute kidney injury and various risk factors

| Risk factors                  | Total (n=150) | Stage I (n=3) | Stage II (n=13) | Stage III (n=134) | P-value |
|-------------------------------|---------------|---------------|-----------------|-------------------|---------|
| Hypertensive disorders of pregnancy (n=72) |               |               |                 |                   |         |
| NSPE                          | 3             | 0             | 1 (7.7)         | 2 (1.5)           | 0.303   |
| SPE                           | 27            | 1 (33.3)      | 3 (23.1)        | 23 (17.2)         | 0.681   |
| Eclampsia                     | 42            | 0             | 8 (61.5)        | 34 (25.4)         | 0.012   |
| Total                         | 72            | 1 (33.3)      | 12 (92.3)       | 59 (44.0)         | 0.003   |
| Hemorrhage (n=52)             |               |               |                 |                   |         |
| Abruptio placenta             | 15            | 0             | 1 (7.7)         | 14 (10.4)         | 0.802   |
| Placenta previa               | 1             | 0             | 0               | 1 (0.7)           | 0.942   |
| Atonic and traumatic PPH      | 39            | 0             | 3 (23.1)        | 36 (26.9)         | 0.559   |
| Retained placenta             | 7             | 0             | 1 (7.7)         | 6 (4.5)           | 0.809   |
| Uterine inversion             | 1             | 0             | 1 (7.7)         | 0                 | 0.005   |
| Total                         | 52            | 0             | 4 (30.8)        | 48 (35.8)         | 0.415   |
| Sepsis (n=68)                 |               |               |                 |                   |         |
| Puerperal sepsis              | 64            | 1 (33.3)      | 3 (23.1)        | 60 (44.8)         | 0.303   |
| Septic abortions              | 4             | 0             | 0               | 4 (3.0)           | 0.782   |
| Total                         | 68            | 1 (33.3)      | 3 (23.1)        | 64 (47.8)         | 0.213   |
| Medical disorders (n=40)       |               |               |                 |                   |         |
| Gastroenteritis               | 2             | 0             | 0               | 2 (1.5)           | 0.886   |
| Jaundice                      | 11            | 0             | 1 (7.7)         | 10 (7.5)          | 0.886   |
| Heart disease                 | 2             | 0             | 0               | 2 (1.5)           | 0.886   |
| Deranged coagulation profile  | 25            | 1 (0.0)       | 2 (15.4)        | 23 (17.2)         | 0.726   |
| Total                         | 40            | 1 (33.3)      | 3 (23.1)        | 36 (26.9)         | 0.925   |

NPSE=Nonsevere preeclampsia, SPE=Severe preeclampsia, PPH=Postpartum hemorrhage

A disorder showed complete recovery. 40% had partial recovery in patients with hemorrhage, 36.2% in HDP, and 17.0% in medical disorder had partial recovery. CKD occurred in 60% of patients with hemorrhage and 40% of those with sepsis. There was maternal death of 49% of those who had sepsis, 41.2% in HDP group, there was hemorrhage mortality of 35.3% and 31.4% of those with medical disorders [Table 6].
Discussion

In our study, the incidence of PRAKI was 1.02%, various other studies reported an incidence of 1.56%, 0.81%, and 0.66%, respectively. However, other Indian studies have reported a much higher incidence of PRAKI, i.e., 11.5%, 9.06%, and 12.8%, respectively. Western studies have reported a considerable rise in the incidence of AKI in Canada and the USA. This rise is mainly due to the upsurge in cases of HDP and hemorrhage.

In our study, the majority of PRAKI women were aged 26–30 years with a mean age of 26.65 ± 3.18 years. Various other authors had reported mean age 24.16 ± 5.024 years, 26.5 ± 4.3 years, and 25.00 ± 00 years.

In the study, the majority of patients were belonged to urban areas and from upper middle socioeconomic class, while other authors reported that the rural population was more than the urban population, (61.1% and 70%, respectively). The study results showed that socioeconomic factors including poverty, poor obstetrics care, lack of proper healthcare facilities, inadequate antenatal care (ANC) visit and lack of awareness of the condition, and delayed referral practices contribute to the increase in numbers of PRAKI in developing countries. In the present study, the etiology of PRAKI was multifactorial. It included hypertensive disorders of pregnancy, hemorrhage, sepsis, and medical disorders including gastroenteritis, jaundice, heart disease, and deranged coagulation profile. Deranged coagulation

Table 3: Stage-wise distribution of treatment modalities (n=150)

| Treatment group     | Stage I (n=3) | Stage II (n=13) | Stage III (n=134) | Total (n=150) |
|---------------------|---------------|-----------------|-------------------|---------------|
|                     | N(%)          | N(%)            | N(%)              | N(%)          |
| Group A (RRT)       | 0             | 0               | 98 (73.1)         | 98 (65.3)     |
| Group B (conservative management) | 3 (100.0) | 12 (92.3) | 22 (16.4) | 37 (24.7) |
| Group C (hemodynamically unstable) | 0        | 1 (7.7)        | 14 (10.4)         | 15 (10.0)     |

χ² (df); P = 46.809 (4); <0.001

RRT=Renal replacement therapy

Table 4: Renal replacement therapy with fetomaternal outcomes

| Mode of delivery | Stage I (n=3) | Stage II (n=13) | Stage III (n=134) | Total (n=150) |
|------------------|---------------|-----------------|-------------------|---------------|
|                  | N(%)          | N(%)            | N(%)              | N(%)          |
| Vaginal          | 2 (66.7)      | 9 (69.2)        | 73 (54.5)         | 84 (56.0)     |
| LSCS             | 1 (33.3)      | 3 (23.1)        | 56 (41.8)         | 60 (40.0)     |
| Hysterectomy     | 0             | 1 (7.7)         | 1 (0.7)           | 2 (1.3)       |
| Aborted          | 0             | 0               | 4 (3.0)           | 4 (2.7)       |

χ² (df); P = 6.401 (6); 0.380 (NS)

Table 5: Renal outcome in various stages of pregnancy-related acute kidney injury patients from admission to follow-up up to 3 months (n=150)

| Outcome          | Stage I (n=3) | Stage II (n=13) | Stage III (n=134) | Total (n=150) |
|------------------|---------------|-----------------|-------------------|---------------|
|                  | N(%)          | N(%)            | N(%)              | N(%)          |
| Complete recovery| 3 (100.0)     | 11 (84.6)       | 27 (20.1)         | 41 (27.3)     |
| Partial recovery | 0             | 1 (7.7)         | 46 (34.3)         | 47 (31.3)     |
| CKD              | 0             | 0               | 5 (3.7)           | 5 (3.3)       |
| Expired          | 0             | 1 (7.7)         | 50 (37.3)         | 51 (34.0)     |
| Loss to follow-up| 0             | 0               | 6 (4.5)           | 6 (4.0)       |

χ²=32.986, (df=8); P<0.001. CKD=Chronic kidney disease
profile can lead to microembolism which can damage glomerular endothelium, causing AKI (disseminated intravascular coagulation due to sepsis and hemorrhage leading to hypovolemia).

Of the etiological factors, HDP (48%) was the most commonly associated risk factor; the second most common was sepsis (45%) followed by hemorrhage in 34% and medical disorders in 26%. Prakash and Ganiger reported the most common cause of AKI as HDP (51.8%) followed by puerperal sepsis in 15% and hemorrhage in 9.65%.[23]

In this study, 48% developed AKI as a result of HDP. Of those with HDP, the significant risk factors for the development of PRAKI were severe preeclampsia and eclampsia. It was also found that the association of both overall HDP and eclampsia for the development of AKI was statistically significant with Stage II AKI compared to Stage III AKI and Stage I AKI. Other authors have also reported a high incidence of HDP, 66.6%, 66%, and 56%, respectively.[13,15,19]

The recent increase in the incidence of PRAKI in Canada and the United States was mainly due to increased rates of HDP and hemorrhage. One Chinese study reported that HDP was the cause of AKI in 77.2%.[24]

Sepsis was the second most common contributing factor for PRAKI in our study. Puerperal sepsis, the most common, contributed around 33.3%, 23.1%, and 44.8% in Stage I, II, and Stage III AKI, respectively. Various studies have reported sepsis as a leading cause of AKI, 92%, 61.6%, 55.1%, and 46.9%.[16,19,23,25] The reason for the lower incidence of septic AKI in our study is the increase in institutional delivery and better obstetric care. Hemorrhage was associated with 34% of patients of PRAKI. Atonic and traumatic PPH (75%) was the most common of overall hemorrhagic disorders in Stage II and III patients of PRAKI, constituting 23.1% and 26.9%, respectively. However, various studies have revealed it as the leading cause of PRAKI, 57%,[21] 55.8%,[38] and 60%.[19]

In the present study, 56.0% delivered vaginally, 40% of women underwent cesarean section, 1.3% of patients required laparotomy or hysterectomy, and 4 (2.7%) patients had an abortion. The association between mode of delivery and stages of PRAKI was nonsignificant. One study reported 42% normal vaginal delivery and 48% cesarean delivery, and another study reported 61% vaginal deliveries and 34% cesarean sections.[20,22]

There were a total of 61.6% live births and 38.4% still born in our study. Stillbirth/IUD was observed in a higher proportion of those with Stage II AKI and Stage III AKI (53.8% and 37.7%, respectively) compared to Stage I AKI (0.0%). Gopalakrishnan reported 54% adverse fetal outcome (still birth/IUD).[27]

The majority of neonates (82.2%) had a birth weight of ≤2500 g, irrespective of stages of AKI. The association...
of neonatal birth weight and stages of PRAKI was not significant because the majority of patients registered in the late third trimester or were admitted postpartum, so fetuses had gained weight. Williams reported that fetal growth restriction might be due to placental etiology, poor nutrition, and chronic disease.

In the present study, preterm deliveries were significantly higher in Stage II AKI (53.8%), than Stage I AKI (3.3%) and Stage III AKI (20.0%). After correlation with etiological factors, it was found that most of the Stage II AKIs (92.3%) were from the HDP group. However, the total preterm (23.3%) deliveries were fewer than the term (76.7%) deliveries. This is in contrast to various other studies that reported 53% and 40.9% preterm deliveries. Williams stated that in cases of renal insufficiency and eclampsia, the frequency of preterm labor is high possibly because of the action of metabolic poisons. The center for uterine contraction in the medulla is stimulated by the excess of carbon dioxide in blood caused by metabolic acidosis.

Complete recovery was 28.5% in the present study. In contrast, a much higher recovery rate has been reported by various authors, 60%, 86%, 75%, 86%; and 89.4% respectively.

In our study, after 3 months of follow-up, 27.3% of cases recovered completely, 31.3% recovered partially, 3.39% progressed to CKD, and 34% expired. On stage-wise comparison of outcome in PRAKI at 3-month follow-up, the rate of complete recovery was significantly higher in Stage I (100%) and Stage II AKI (84.6%). The rate of maternal death was significantly higher in Stage III AKI (37.3%).

In this study, 34% died directly or indirectly as a result of AKI. The main cause of mortality was sepsis which accounted for 49%, preeclampsia/eclampsia in 41% and hemorrhage in 35.3%. Other studies reported a high maternal mortality of 37.6%,18,19,20,23 and 15%. In our study, 65% of patients in Group A (n = 98) required hemodialysis, but the study by Tanwar et al., reported that dialysis was required in 82%.19

In our study, all Stage I cases, who were managed conservatively, completely recovered maternal renal function, while of the 12 women in Stage II AKI who were managed conservatively (Group B), 91.66 recovered completely and 8.33% partially. One patient (Group C) of Stage II AKI expired as a result of associated risk factors (multiple organ dysfunction with hepatic encephalopathy and unstable vitals) without dialysis. There was no mortality in the conservative group (Group B).

The majority of Stage III AKI cases in Group A (73.1%) received dialysis, but only 62% after 3 months of follow-up were available for evaluation of maternal renal outcome. Of the remaining 92, 39.1% had expired. Similarly the Eswarappa had reported 31% deaths and Krishna et al., had reported 36% mortality in the dialysis group.

After 3 months of follow-up, 5.4% in our study had progressed to CKD, while Eswarappa reported 3% and Prakash and Ganiger had reported 4.6% progression to CKD.

In the present study, 46.7% recovered partially while Gopalakrishnan et al., reported partial recovery in 35%. Only 8% had complete recovery in our study.

The complete recovery in patients with eclampsia was 51.2%; in overall HDP was 75.6%; in patients with sepsis was 39%; in those with medical disorders was 31.7%, and in those with hemorrhage was 24.4%. Partial recovery occurred in 44.7% of patients with sepsis AKI, 40.4% in those with hemorrhage, 36.2% in HDP AKI, and 17% in medical disorder patients with AKI. There were 60% cases of CKD in patients with hemorrhage and 40% in sepsis patients.

49% of women in the sepsis group alone expired and 41.2%, 35.3%, and 31.4% in HDP, hemorrhage, and medical disorders group, respectively, also expired. The high rate of maternal mortality at our institution could be because most cases were referred to our institution in a very serious condition. Unfortunately, efforts to save lives in some cases failed.

Our study was conducted at a tertiary care hospital, so it does not truly reflect the etiological spectrum of AKI prevalent in the country. Second, long-term outcome could not be studied in our patients owing to inability to follow-up long term. Nevertheless, our study provides important data for obstetricians, nephrologists, and the government to make the necessary provision for healthcare improvement.

Although the current incidence of increased PRAKI might be because of the rise in the incidence of HDP, this high incidence was hitherto caused by sepsis. At present, an improvement in obstetric care and sepsis and the coverage of broad-spectrum antibiotics has reduced the severity of AKI and the need for dialysis by many of the patients. Proper ANC and early diagnosis of AKI would promote better management of pregnancy-related hypertension and timely delivery.
Conclusion

AKI is associated with restriction in fetal growth and preterm deliveries. Stillbirth/IUD is comparatively higher in women with Stage II and Stage III AKI. High mortality is associated with PRAKI women requiring dialysis. According to our study, the number of institutional deliveries has not risen though HDP still continues to be a major cause of PRAKI. This is mainly due to the lack of education, awareness, inadequate ANC and postnatal care in remote rural areas. Although the high incidence of HDP was responsible for AKI in pregnancy, sepsis was the second leading cause of PRAKI, which underlines the need for better ANC and institutional aseptic deliveries.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Beaufils MB. Pregnancy. In: Davidson AM, Cameron JS, Grunfeld JP, et al., editors. Clinical nephrology. 3rd ed. New York: Oxford University Press; 2005. p. 1704-28.
2. Prakash J, Tripathi K, Pandey LK, Gadela SR, Usha. Renal cortical necrosis in pregnancy-related acute renal failure. J Indian Med Assoc 1996;94:227-9.
3. Jefferson A, Thurman JM, Schrier RW. Pathophysiology andetiology of acute kidney injury. In: Floege J, Johnson RJ, Feehally J, editors. Comprehensive Clinical Nephrology. New York: Elsevier Saunders; 2010. p. 806-7.
4. Kumar KS, Krishna CR, Kuma VS. Pregnancy related acute renal failure. J Obstet Ganecol India 2006;56:308-10.
5. Gopalan KR, Shah PR, Gera DN, Gumber M, Dabhi M, Feroz A, et al. Pregnancy-related acute renal failure: A single-center experience. Indian J Nephrol 2008;18:17-21.
6. Prakash J, Kumar H, Sinha DK, Kapadlaya PG, Pandey LK, Srivastava PK, et al. Acute renal failure in pregnancy in a developing country: Twenty years of experience. Ren Fail 2006;28:309-13.
7. Prakash J. The kidney in pregnancy: A journey of three decades. Indian J Nephrol 2012;22:159-67.
8. Lindheimer MD, Katz AI. Kidney function in the pregnant rat. J Lab Clin Med 1971;78:633-41.
9. Kellum JA, Lameire N, Aspelin P, Barsoum RS, Burdman EA, Goldstein SL, et al. Kidney disease: Improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. Kidney International Supplements 2012;2:1-138. https://doi.org/10.1038/kisup.2012.1.
10. Patel ML, Sachan R, Radheshyam, Sachan P. Acute renal failure in pregnancy: Tertiary centre experience from north Indian population. Niger Med J 2013;54:191-5.
11. Godara SM, Kute VB, Trivedi HL, Vanikar AV, Shah PR, Gumber MR, et al. Clinical profile and outcome of acute kidney injury related to pregnancy in developing countries: A single-center study from India. Saudi J Kidney Dis Transpl 2014;25:906-11.
12. Hildebrand AM, Liu K, Shariff SZ, Ray JG, Sontrop JM, Clark WF, et al. Characteristics and outcomes of AKI treated with dialysis during pregnancy and the postpartum period. J Am Soc Nephrol 2015;26:3085-91.
13. Mahesh E, Puri S, Varma V, Madhyastha PR, Bande S, Gurudev KC. Pregnancy related acute kidney injury: An analysis of 165 cases. Indian J Nephrol 2017;27:113-7.
14. Huang C, Chen S Acute kidney injury during pregnancy and puerperium: A retrospective study in a single center. BMC Nephrol 2017;18:146.
15. Arrayhani M, El Youbi R, Sqalli T. Pregnancy-related acute kidney injury: Experience of the Nephrology Unit at the University Hospital of Fez, Morocco. ISRN Nephrol 2012;2013:109034.
16. Tanwar RS, Agarwal D, Gupta RK, Rathore V, Beniwal P, Joshi P, et al. Characteristics and outcome of postpartum acute kidney injury requiring dialysis: A single-center experience from North India. Saudi J Kidney Dis Transpl 2018;29:837-45.
17. Mehrabadi A, Liu SL, Bartholomew S, Hutcheon JA, Magee LA, Kramer MS, et al. Hypertensive disorders of pregnancy and the recent increase in obstetric acute renal failure in Canada: Population based retrospective cohort study. BMJ 2014;349:g731.
18. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol 2012;120:1029-36.
19. Alakananda, Dutta BK, Das S. A study of etiological factors of pregnancy related acute kidney injury. Int J Res Rev 2018;5:9-12.
20. Esvarappa M, Madhyastha PR, Puri S, Varma V, Bhandari A, Chennabassappa G. Postpartum acute kidney injury: A review of 99 cases. Ren Fail 2016;38:889-93.
21. Papegowda SH, Devi PK, Singh RL, Muruganadam A, Tochhawng ZL. Acute kidney injury in obstetrics: A five-year study in a tertiary centre. Int J Reprod Contracept Obstet Gynecol 2020;9:113-9.
22. Saini S, Chaudhury AR, Divyaveer S, Maurya P, Sircar D, Dasgupta S, et al. The changing face of pregnancy-related acute kidney injury from eastern part of India: A hospital-based, prospective, observational study. Saudi J Kidney Dis Transpl 2020;31:493-502.
23. Prakash J, Ganiger VC. Acute kidney injury in pregnancy-specific disorders. Indian J Nephrol 2017;27:258-70.
24. Huang C, Chen S. Acute kidney injury during pregnancy and puerperium: A retrospective study in a single centre. BMC Nephrol 2017;18:146.
25. Krishna A, Singh R, Prasad N, Gupta A, Bhadauria D, Kaul A, et al. Maternal, fetal and renal outcomes of pregnancy-associated acute kidney injury requiring dialysis. Indian J Nephrol 2015;25:77-81.
26. Haroon F, Dhroila MF, Qureshi R, Imtiaz S, Ahmed A. A frequency of pregnancy-related complications causing acute kidney injury in pregnant patients at a tertiary care hospital. Saudi J Kidney Dis Transpl 2019;30:194-201.
27. Gopalakrishnan N, Dhanapriya J, Muthukumar P, Sakthirajan R, Dineshkumar T, Thirumurugan S, Balasubramanayan T. Acute kidney injury in pregnancy-A single center experience. Ren Fail 2015;37:1476-80.
28. Esvarappa M, Gireesh MS, Ravi V, Kumar D, Dev G. Spectrum of acute kidney injury in critically ill patients: A single center study from South India. Indian J Nephrol 2014;24:280-5.