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STUDY THE RISK FACTORS, OUTCOME AND FOLLOW-UP OF NEONATES WITH ACUTE KIDNEY INJURY (AKI), ADMITTED IN OUT-BORN NEONATAL INTENSIVE CARE UNIT

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ABSTRACT

Background: Acute kidney injury (AKI) is a clinical syndrome that complicates the course and worsens the outcome in a significant number of hospitalised patients. The concept of Acute Renal Failure (ARF) has undergone significant re-examination in recent years. **Objective:** To study the risk factors, outcome and follow-up of neonates with acute kidney injury (AKI), admitted in out-born neonatal intensive care unit.

Materials and Methods s: This prospective observational study was conducted among all neonates admitted in Outborn Neonatal Intensive Care Unit of Chacha Nehru Bal Chikitasalaya. Duration of study was 1 year (9 months for enrollment and 3 months for follow-up). Ethics approval for the study was obtained from Institutional Ethics Committee, CNBC, Delhi.

Result: Out of 144 neonates enrolled, 60 developed AKI amounting to 42% incidence of AKI in neonates admitted to NICU. Mean age of the neonates with and without AKI were comparable (6.2 vs 7.7 days). Neonates with AKI had significantly lower gestational age and birth weight in comparison to those without AKI (33.6 versus 35.7 weeks and 2105 grams versus 2365 grams respectively). Proportion of neonates diagnosed with AKI by nRIFLE and mKDIGO classification system were 42% and 40% respectively. Whereas, nRIFLE was more sensitive in identifying the neonates with AKI, mKDIGO identified neonates with more severe stages of AKI. Out of 60 neonates with AKI, eight died during hospitalization and one neonate got discharged by parents against medical advice. Out of 51 neonates discharged, 37 achieved complete renal recovery and 14 achieved partial renal recovery at the time of discharge.

Conclusion: Incidence of AKI in neonates are similar irrespective of type of definition of AKI. Sepsis, birth asphyxia, nephrotoxic drug exposure, duration of mechanical ventilation and SNAP score>20 are risk factors for neonatal AKI. Neonates with AKI are at higher risk of mortality and prolonged hospital stay in comparison to those without AKI.

Keywords: Risk factors, outcome, Neonates, acute kidney injury (AKI), Neonatal intensive care unit.

INTRODUCTION

Acute kidney injury (AKI) affects more than 30% of hospitalized neonates with increased rates of mortality and longer hospital admission. Though, research in adult and pediatric AKI has increased over the last few years; advances in clinical recognition, diagnosis, and supportive care for neonatal AKI lags behind advances in pediatric patient age groups.

The lack of a standardized definition of AKI in neonates similar to those used in adult and pediatric patients and in addition, the unique renal physiology of preterm and term infants and dynamic nature of serum creatinine in first few weeks of neonatal life create challenges for the diagnosis, management and even research concerning neonatal AKI. In addition, nutrition as a critical issue in neonatal care, the special precautions regarding drugs use in neonates and renal replacement therapy in neonates which is not only technically difficult, but also associated with high rates of complications all yield AKI management in neonates to be a great challenge.[1]

The incidence of acute kidney injury (AKI) in neonates in neonatal intensive care units (NICU) ranges from 8% to 22% (5). A very high mortality rate has been reported in neonates with AKI ranging from 10–61%.[2]

Neonates who are critically ill are at high risk for acute kidney injury (AKI) as a result of several potential exposures (eg, nephrotoxic medications, sepsis, hypotension, adverse perinatal events such as asphyxia). Recent data suggest an association between AKI and morbidity and mortality in these patients, such as AKI can no longer be viewed as an incidental finding; it is an independent risk factor for poor outcomes.[3] Neonatal sepsis has been found as the commonest cause of AKI followed by perinatal asphyxia, shock, oliguria, need for mechanical ventilation. Presence of DIC has been associated with poor outcome.[4]

In 2004, the Acute Dialysis Quality Initiative (ADQI) proposed an AKI classification system called "risk, injury, failure, loss, end-stage kidney disease" (RIFLE), to obtain a definition of AKI that could be adopted as universally as possible.[5] The criteria, on which RIFLE was based, were represented by an acute and reversible increment in serum creatinine (SCr) levels and whether associated or not with an alteration of urine output (UO): oliguria/anuria. Three years later, RIFLE criteria were modified for application to children, thus originating the pediatric RIFLE criteria (pRIFLE).[6] Once they were incorporated in pRIFLE, it became possible to formulate a neonatal RIFLE classification (nRIFLE).

Recognizing the long-term implications of AKI, the most recent KDIGO practice guidelines recommended that all patients who experience AKI will be evaluated after 3 months for new onset or worsening of CKD (16). They caution that even if CKD is not present at that time, those with AKI are considered to have increased risk for CKD in long-term.

Over the past 15 years, there have been significant advancements in the study of acute kidney injury (AKI) regarding the diagnosis, recognition, intervention, and impact of AKI on morbidity and mortality in critically ill children. It has become apparent that children who survive an episode of AKI are at increased risk for chronic kidney disease (CKD) and warrant long-term follow-up. Even many studies have shown the various risk factors and outcome of AKI in neonates by various definitions of AKI but literature lacks in comparing the incidence and outcome of AKI by using nRIFLE and KDIGO Criteria. We did this study to evaluate the risk factors, outcomes and follow up of the neonates who were admitted to the ICU for AKI using the nRIFLE and KDIGO criteria.

MATERIALS AND METHODS

This prospective observational study was conducted among all neonates admitted in Outborn Neonatal Intensive Care Unit of Chacha Nehru Bal Chikitasalaya. Duration of study was 1 year (9 months for enrollment and 3 months for follow-up). Ethics approval for the study was obtained from Institutional Ethics Committee, CNBC, Delhi.

Sample size: Considering an incidence of AKI in sick neonates as 10% (As per different studies Incidence is from 8 to 30%), precision of 5%, alpha error of 0.05, we get a sample size of 139. Expecting attrition rate of 10%, final sample size was 150.

Inclusion Criteria: All consecutive neonates with age more than 48 hours of life admitted in NICU.

Exclusion Criteria

1. Neoonates with congenital anomalies of kidney diagnosed antenatally or after birth
2. Congenital Malformations of other organs.

Methodology

All consecutive neonates admitted in out born NICU of CNBC were screened for eligibility criteria. Subjects meeting the inclusion criteria were enrolled for the study after taking written informed consent from the parent or guardian. SNAP II scoring was done at the time of admission in NICU. SNAP II quantifies 6 physiological variables (Blood pressure, temperature, ratio of PO2/FiO2, blood pH, seizure and urine output) with high score reflecting more disturbance in neonatal physiology. Severity of illness was graded according to SNAP II score as follows Mild: 1-20, Moderate: 21-40, Severe: >40.

Data regarding anthropometry, demographic parameters, perinatal, natal and postnatal risk factors, admission diagnosis, co-morbidities and vital signs were noted at the time of enrollment. Gestational age was estimated using new Ballard Score. Blood samples were obtained at admission for hemogram, sepsis screen, blood culture, urea, creatinine, total protein, albumin, sodium and potassium with all aseptic precautions. Duration of various risk factors like ventilation, necrotizing enterocolitis, shock, requirement of inotropes and nephrotoxic drug exposure were noted. Acute kidney injury was diagnosed and classified using modified KDIGO and nRIFLE classification.

If initial blood urea and creatinine was found to be high, these were repeated every day along with urine output monitoring. If urea/creatinine was found to be normal at the time of admission then these babies will be followed daily with urine output monitoring.

In case of catheterized patient, urine output was measured by volume, while in case of patients without urinary catheter; urine output was measured by diaper weighing.

During hospital stay if any neonate deteriorates due to some - medical illness, the neonates were investigated and blood urea and serum creatinine was sent again along with other investigations. Repeat blood urea and serum creatinine was done at the time of discharge in all neonates.

Modified KDIGO and nRIFLE were done daily in all neonates and was followed till discharge or death. Course of AKI during hospital stay was studied in terms of progression of AKI from one stage to another, requirement of dialysis and duration of hospital stay. Outcome was measured in terms of clinical as well as renal recovery at the end of stay in NICU. All neonates with AKI were followed till 3 months of age. Neonates, whose blood urea or serum creatinine was abnormal at the time of discharge, were called every fortnightly for repeat blood urea and serum creatinine till 3 months of age. Neonates with normal blood urea and serum creatinine level were followed at three months for clinical assessment and estimation of blood urea and serum creatinine levels. Other investigations were done as per the clinical need of the neonate. Renal recovery during discharge was graded as below.

Complete Recovery of Renal Function- Normal serum creatinine for age.

Partial Recovery of Renal Function- Serum creatinine level above normal for age

Laboratory Method

Serum creatinine (SCr) was estimated by Modified Jaffe's method with instrument model Beckman Coulter AU400 and AU680. Serum electrolytes were measured by the ISE method, urea by enzymatic urease method, serum calcium by ArsenazoIII method and ABG/VBG by NOVA PRIME PLUS machine.

Statistical Analysis: Data were analyzed using SPSS version 23. Normality distribution of data were tested by Kolmogorov- Smirnov and Shaprio-Wilk test. Continuous variables were expressed as mean± standard deviation or median (Interquartile range) based on normality distribution of data. Categorical variables were expressed as number and percentages. Independent student t test and Chi square or Fischer exact tests were used to test the significance of difference between two means and proportions respectively. Mann-Whitney U test was used to test the significance of difference between two medians, where data were skewed. Risk factors for AKI and mortality in neonates with AKI were analyzed by univariate and multivariate logistic regression analysis.

RESULTS

A total of 192 neonates were screened for the study. Out of 192 neonates, 48 were excluded for various reasons. Finally, 144 neonates were included for the study. Out of 144 neonates enrolled, 60 developed AKI amounting to 42% incidence of AKI in neonates admitted to NICU. Eleven neonates were diagnosed as AKI by both serum creatinine and urine output criteria, 49 by serum creatinine criterion alone and none with urine output criterion alone. Out of 60 neonates with AKI, eight died during hospitalization and one neonate got discharged by parents against medical advice. Out of 51 neonates discharged, 37 achieved complete renal recovery and 14 achieved partial renal recovery. Out of forty-four neonates at 3 months follow-up; 34 were in complete renal recovery, 9 in partial renal recovery and one had died at home.

Mean age of the enrolled neonates at the time of admission was 7.1±6.5 days. Out of 144 neonates, 54% were males. Mean gestational age of the study population was 35.1±3.4 weeks, with more than half (54.5%) of the neonates being preterm. More than half (55.5%) of the enrolled neonates were under low birth weight category, with 12.5% fulfilling the criteria of very low birth weight at the time of admission. One fourth of the neonates were asphyxiated at the time of admission. Eleven neonates had severe illness at presentation as defined by SNAP score>40.

Table 1: Baseline laboratory characteristics of all neonates included in the study

Parameters	Value, mean±SD/median (IQR)
Hb (gm %)	16.3±3.6
HCT (%)	49.3±10.9
TLC (cells per cmm)	16474±10982
Platelets (cells per cmm)	385±165
CRP (median, IQR)	3.7 (1-15)
Serum creatinine at admission (mg/dl)	0.5 (0.4-1.4)
eGFR (ml/min/1.73m^2)	35.2±12
RBS (mg/dl)	112±41
Serum bilirubin (mg/dl)	6.9±6.2
Serum ionized calcium (meq/L)	1±0.15
Serum sodium (meq/L)	149±102
Serum potassium (meq/L)	5±4.4

Table 1: depicts the baseline hematological and biochemical parameters of the study neonates at the time of admission.

Table 2: Comparison of baseline demographic characteristics of neonates with AKI and without AKI

Parameters	AKI (n=60)	No AKI (n=84)	P value
Age at admission (days)	6.2±5.9	7.7±6.9	0.19
Gender Male Female	 33 (55) 27 (45)	 45 (53.6) 39 (46.4)	0.86
Gestational age (weeks)	33.6±3.6	35.7±3.3	<0.001*
Gestational age categories 28-32 weeks 33-36 weeks >37 weeks	 20 (33.3) 20 (33.3) 20 (33.3)	 16 (19) 22 (26) 46 (55)	0.03
Weight (gms)	2105.7±685	2365.5±602	0.01*
Weight categories <999 gm 1000-1499 gm 1500-2499 gm >2500 gm	 3 (5) 8 (13) 19 (32) 30 (50)	 4 (5) 10 (12) 36 (43) 34 (40)	0.58
Maternal nephrotoxic drug exposure	1 (1.7)	2 (2.4)	0.76
Home vs institutional delivery	17 (28.3)	10 (12)	0.01*
Length (cm)	46.1±3.9	45.9±3.8	0.75
Head circumference (cm)	32.3±2.3	32.3±2	0.85
SNAP score at admission Mild Moderate Severe	 21 (35) 32 (53) 7 (12)	 55 (65) 25 (30) 4 (5)	0.001*
Birth asphyxia No asphyxia Stage I Stage II Stage III	 39 (65) 8 (13) 7 (12) 6 (10)	 68 (81) 10 (12) 6 (7) 0 (0)	0.03*
Necrotizing enterocolitis (NEC) No NEC Stage I NEC Stage II NEC Stage III NEC	 51 (85) 7 (12) 1 (2) 1 (2)	 77 (92) 7 (0) 0 0	0.33

P value significant

Mean age of the neonates with and without AKI were comparable (6.2 vs 7.7 days). We observed that neonates with AKI had significantly lower gestational age and birth weight in comparison to those without AKI (33.6 versus 35.7 weeks and 2105 versus 2365 grams respectively). Length and head circumference were comparable in two groups. We also observed that a significantly higher proportion of neonates with AKI had higher SNAP score at the time of admission. A significantly higher proportion of neonates with AKI had moderate and severe birth asphyxia at the time of admission. A significantly higher proportion of neonates with AKI were delivered at home in comparison to those without AKI. There was no significant difference for antenatal maternal nephrotoxic drug exposure in those with AKI and without AKI. There was no significant difference in proportion of neonates with NEC in AKI versus non-AKI group.

Table 3: Comparison of baseline laboratory characteristics of neonates with AKI and without AKI

Parameters	AKI (n=60)	No AKI (n=84)	P value
Hb (gm%)	17±3.2	15.8±3.8	0.06
Hematocrit (%)	51±9.2	48.2±11.9	0.13
Total leukocyte count (cells cmm)	18646±10214	14148±7786	0.003*
C-reactive protein (median, IQR)	8.3 (1.1-23)	3 (1.1-10)	0.02*
Blood urea (mg/dl)	81±62	21±16	<0.001*
Creatinine @admission (mg/dl)	1.9±1	0.4±0.1	<0.001*
RBS (mg/dl)	115±45	110±38	0.47
Bilirubuin (mg/dl)	6.3±6.2	7.4±6.2	0.29
Calcium ionic (meq/L)	1±0.09	1±0.1	0.60
Sodium (meq/L)	141.1±10	141.8±6.6	0.60
Potassium (meq/L)	5.1±1	4.8±1	0.05

P value significant

We observed that neonates with AKI had significantly higher leukocyte count and C- reactive protein in comparison to those without AKI. We also observed that neonates with AKI had significantly higher blood urea and serum creatinine value in comparison to those without AKI.

Table 4: Comparison of AKI stage at diagnosis by nRIFLE and mKDIGO classification system

AKI category, n=144	nRIFLE (n=60)	mKDIGO (n=56)
No AKI/stage 0	84 (59)	88 (61)
Risk/ Stage I	22 (15)	12 (8)
Injury/Stage II	19 (13)	15 (11)
Failure/stage III	19 (13)	29 (20)

We observed that nRIFLE identified a relatively higher proportion of neonates with AKI (n=60) in comparison to those identified by mKDIGO (n=56). However, mKDIGO identified relatively higher proportion of neonates with severe AKI (stage II and III) in comparison to nRIFLE.

Table 4: Maximum AKI stage by nRIFLE and mKDIGO

AKI category	nRIFLE, n=60	mKDIGO, n=56
No AKI/stage 0	84 (58)	88 (60)
Risk/ Stage I	15 (10)	6 (4)
Injury/Stage II	18 (13)	13 (10)
Failure/stage III	27 (19)	37 (26)

We observed that, by n RIFLE classification system, out of 22 neonates under "Risk" category, seven progressed to "Failure" category and out of 19 neonates in "Injury" category; one progressed to "Failure" category. Similarly, by mKDIGO classification system, out of 12 neonates in "stage I" AKI, six progressed to "stage III" AKI and out of 15 neonates in "stage II" AKI, two progressed to "stage III" AKI. Finally, 27 and 37 neonates reached maximum AKI stage "Failure" and "stage III" AKI by nRIFLE and mKDIGO classification system respectively. Median time for achieving maximum stage AKI was 1 (1-2) and 1 (1-2.5) day from hospitalization for mKDIGO and n RIFLE criteria respectively. Only two neonates received peritoneal dialysis as renal replacement therapy for 2 and 5 days respectively.

Table 5: Risk factors for AKI by univariate analysis

Parameters, n (%)	AKI, n=60	No AKI, n=84	OR/mean difference, 95% CI	P value
SNAP score>20 (moderate to severe)	39 (65)	29 (34.5)	3.5 (1.7-7)	<0.001*
Sepsis	30 (50)	24 (29)	2.5 (1.2-4.9)	0.009*
Nephrotoxic drug exposure	30 (50)	19 (22.6)	3.4 (1.6-7)	0.001*
Duration of nephrotoxic drugs	7.7±7.1	4±5.8	3.7 (1.5-5.8)	0.001*
Mechanical ventilation	20 (33.3)	18 (21.4)	1.8 (0.8-3.8)	0.08
Use of vasopressors	17 (28.3)	8 (9.5)	3.7 (1.5-9.4)	0.003*
Birth asphyxia	21 (35)	16 (19)	2.2 (1-4.9)	0.03*
Respiratory distress syndrome	17 (28.3)	21(25)	1.1 (0.5-2.5)	0.65
Dehydration	23 (38.3)	23 (27.4)	1.6 (0.8-3.3)	0.16
Prematurity (Gestational age <37 wks)	38 (63)	38 (45)	2 (1.1-4.1)	0.03*
Very low birth weight (<1500 gm)	13 (21.7)	14 (16.7)	0.7 (0.3-1.6)	0.45
Disseminated intravascular coagulation	5 (8.3)	2 (2.4)	3.7 (0.7-20)	0.10
Necrotising enterocolitis	9 (15)	7 (8.3)	1.9 (0.7-5.5)	0.20

P value significant

We found that moderate to severe SNAP score (>20) at the time of admision, sepsis, nephrotoxic drug exposure, duration of nephrotoxic drug exposure, use of vasopressor agent, birth asphyxia and prematurity were significantly associated with increased risk of AKI in neonates admitted in NICU. Amikacin, Vancomycin, Acyclovir and Colistin were nephrotoxic drugs to which neonates were exposed during hospitalization either alone or in combination.

Table 6: Risk factors for AKI by multivariate analysis

Parameters	OR, 95% CI	P value
Sepsis	2.7 (1.2-5.9)	0.01*
Nephrotoxic drug exposure	3.3 (1.6-7.1)	0.003*
Duration of nephrotoxic drug exposure	1 (0.9-1.1)	0.29
Use of vasopressors	2.2 (0.8-6)	0.12
Duration of mechanical ventilation	1 (1.03-1.04)	0.02*
Birth asphyxia	3.2 (1.2-7.1)	0.01*
Prematurity (GA<37 weeks)	2 (0.9-4.4)	0.07
SNAP score >20, moderate to severe	3.3 (1.3-8.5)	0.01*

P value significant

We found that diagnosis of sepsis, nephrotoxic drug exposure, duration of mechanical ventilation, birth asphyxia and moderate to severe SNAP score at the time of admission were independently associated with increased risk of AKI in neonates admitted in NICU. Though, there was a trend towards prematurity being an independent risk factor for AKI, it did not reach the level of statistical significance.

We found that the neonates with AKI had significantly longer duration of hospital stay in comparison to those without AKI (17 days versus 11 days, p<0.001). Also, neonates with AKI had significantly higher mortality rate in comparison to

those without AKI (13.3% versus 3.6%). We also observed that neonates with AKI had four times higher risk of in-hospital mortality in comparison to those without AKI (OR, 4.1 (1-16), p value=0.03). Out of 60 neonates with AKI, eight died during hospital stay and one left against medical advice. Neonates with AKI had higher rate of mortality with increasing severity of AKI, irrespective of classification system for AKI.

Out of 51 neonates discharged from NICU (8 died and one neonate was taken by parents against medical advice); 37 (75%) achieved complete renal recovery with normalization of serum creatinine for age and 14 (25%) showed partial renal recovery with serum creatinine higher than normal for that age. Seven neonates were found lost to follow up at 3 months. Out of 44 neonates seen at 3 months follow-up; 34 were in complete renal recovery and 9 in partial renal recovery. One neonate expired at home, as confirmed by telephonic conversation.

Table 7. Mortality in neonates in different stages of AKI by nRIFLE and mKDIGO criteria

Stage of AKI, n (%)	nRIFLE (n=8)	mKDIGO (n=8)
Risk/Stage I AKI	1/15 (7)	0/6
Injury/Stage II AKI	3/18 (17)	2/13 (15)
Failure/Stage III AKI	4 /27 (15)	6/37 (16)

Mortality rate in neonates with AKI varied from 6% in "Risk" or stage I to 16% in "Injury" or stage III AKI. Mortality rate increased with increase in severity of AKI, irrespective of AKI classification system.

On univariate analysis, we observed that severe SNAP score (>40) at the time of admission in comparison to mild and moderate SNAP score (<20 and 21-40 respectively), mechanical ventilation and use of vasopressors were significantly associated with increased risk of mortality in neonates with AKI. On multivariate logistic regression analysis, severe SNAP score (>40) was the only independent risk factor for mortality in neonantes with AKI. Neonates with AKI with SNAP score >40 at the time of admission were at nine times higher risk of mortality in comparison to those with mild (<20) and moderate (21-40) SNAP score.

DISCUSSION

In our study, proportion of neonates diagnosed with AKI by nRIFLE and mKDIGO classification system were 42% and 40% respectively. Whereas, nRIFLE was more sensitive in identifying the neonates with AKI, mKDIGO identified neonates with more severe stages of AKI. Neonates diagnosed with AKI were of lower gestational age, lower birth weight, asphyxiated and higher SNAP score at admission in comparison to those without AKI. We found that presence of birth asphyxia, sepsis, nephrotoxic drug exposure, duration of mechanical ventilation and SNAP score >20 at the time of admission were independently associated with increased risk of neonatal AKI. Neonates with AKI had significantly higher in-hospital mortality (13% vs 4%) and longer duration of hospital stay (17 days vs 11 days) in comparison to those without AKI. Out of those who recovered from AKI, one fourth of them had residual renal damage at the time of discharge. SNAP score>40 at the time of admission was the only independent risk factor for mortality in neonates with AKI in our study population.

Incidence of AKI has widely varied from 8% to 60% depending on the studied population and definition of AKI.[7,8] Very few studies have utilized urine output and serum creatinine criteria both for diagnosis of neonatal AKI (29,60).[7,9]

There are only few pediatric studies which have compared AKI by different classification systems.[10,11] In one the largest pediatric studies by Sutherland et al comparing incidence of AKI by change in serum creatinine value in critical and non-critical children by pRIFLE, AKIN and KDIGO; incidence of AKI was highest with pRIFLE (51.1%), followed by KDIGO (40.3%) and AKIN (37.3%). This observation was in consistent with our study, where incidence of AKI was 40% by mKDIGO classification system, though neonates were excluded in study by Sutherland et al (46). Similarly, Choudhary et al in a study to find out the prevalence and outcome of AKI in extremely low birth weight neonates by three existing definitions of AKI (pRIFLE, AKIN and mKDIGO) found that incidence of AKI was 56%, 59% and 60% respectively.[11]

More than half (54%) of the neonates enrolled in our study were preterm (<37 weeks gestation) and low birth weight (<2500 grams), with mean gestational age and mean birth weight as 35.1 weeks and 2257 grams respectively. Incidence of AKI in our study using mKDIGO classification system was 40%, which was lower than the incidence of AKI from study by Shalaby et al,[7] where 56% of neonates were diagnosed as AKI using mKDIGO criteria. The higher incidence of AKI by Shalaby et al can be explained by enrollment of neonates with lower gestational age and lower birth weight (33 weeks and 1848 grams respectively), in comparison to our study neonates.[7] In AWAKEN study, one of the largest multi-national multi-centric studies on neonatal AKI, incidence of AKI was 29.9%, with the majority of cases achieving maximum AKI stage I. In contrast, we observed that majority of neonates from our study achieved maximum AKI stage III.[9]

We observed a higher incidence of AKI in neonates with lower gestational age and lower birth weight,

which was in consistent with the findings of Shalaby et al. In contrast, investigators from AWAKEN study observed that incidence of AKI was higher in neonates between 22-29 weeks and >36 weeks gestation in comparison to neonates between 30-35 weeks of gestation.

We observed that birth asphyxia, sepsis, nephrotoxic drug exposure and SNAP score>20 at admission were independent risk factors for AKI in our study. Sepsis, prematurity, very low birth weight, birth asphyxia and use of mechanical ventilation have been consistently associated with AKI in neonates.[3,8] Similar to our study, Shalaby et al and Mazaheri et al also found perinatal asphyxia as an independent risk factor for AKI.[7,8] Though, we found lower gestational age was a risk factor for AKI on univariate analysis, it failed to achieve level of statistical significance on multivariate analysis. In contrast, lower gestational age was observed as an independent risk factor for AKI by Shalaby et al and Mazaheri et al.[7,8] Our findings on risk factor for neonatal AKI were in consistent with the study by El-Badawy et al, where sepsis and nephrotoxic drug exposure were two most common risk factors for AKI, though difference was not statistically significant.[12]

We observed that 8/60 (13%) neonates with AKI died during hospitalization. Neonates with AKI were at four times higher risk of mortality in comparison to those without AKI. Our finding on neonatal mortality with AKI was in consistent with AWAKEN study, where 10% of neonates with AKI died during hospitalization.[9] In contrast to our study, a higher rate of mortality of 28% in neonates with AKI was reported by Shalaby et al, which can be explained by enrollment of neonates with lower gestational age and with lower birth weight. In our study mortality rate ranged from 6% in stage I to 16 % in stage III AKI, which was much lower than mortality rate in Choudhary et al study, where it ranged from 15% in stage I to 50% in stage III.

Out of neonates who survived an episode of AKI, one fourth of them had elevated serum creatinine level at the time of discharge. This was in agreement with finding of Shalaby et al, where 27.5% of neonates had abnormally high serum creatinine level at discharge. There is lack of study on long-term follow up of neonates with AKI after discharge. We observed that at 3 months follow up, 20% of neonates with AKI had higher than normal serum creatinine for age. This necessitates long-term follow up of these neonates after an episode of AKI because of risk of chronic kidney disease.

CONCLUSION

Incidence of AKI in neonates are similar irrespective of type of definition and classification system of AKI. Sepsis, birth asphyxia, nephrotoxic drug exposure, duration of mechanical ventilation and SNAP score>20 are risk factors for neonatal AKI. Neonates with AKI are at higher risk of mortality and prolonged hospital stay in comparison to those without AKI. SNAP score>40 at the time of admission was the only independent risk factor for mortality in neonates with AKI. One fourth of the neonates who survived after an episode of AKI had elevated serum creatinine at discharge. Early diagnosis and management of neonatal AKI is necessary to prevent mortality and morbidity, including long-term risk of chronic kidney disease.

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