



Factors of Acute Kidney Injury in Newborns with Postnatal Asphyxia

Hameedullah¹, Haji Gul¹, Muhammad Zabih Ullah¹, Qurat Ul Ain¹, Ihtisham ul Haq¹, Uroj Afzal¹

¹Department of Paediatric Medicine, Bacha Khan Medical Complex/Gajju Khan Medical College (BKMC), Swabi, KP, Pakistan.

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Correspondence to: Haji Gul, Department of Paediatric Medicine, Bacha Khan Medical Complex/Gajju Khan Medical College (BKMC), Swabi, KP, Pakistan.

Email: drhajibgul@yahoo.com

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ABSTRACT

Acute kidney injury (AKI) is a significant complication in neonates with postnatal asphyxia due to renal vulnerability to hypoperfusion and ischemic injury. This cross-sectional study aimed to determine the frequency and associated factors of AKI in asphyxiated newborns admitted to the Department of Pediatrics, Bacha Khan Medical Complex, Swabi. A total of 112 neonates aged 1–60 days with AKI secondary to postnatal asphyxia were enrolled using non-probability consecutive sampling. Clinical factors including hypotension, mechanical ventilation, and hypoxic-ischemic encephalopathy (HIE) were assessed. The mean age of participants was 18.4 ± 12.6 days, and mean weight was 2.6 ± 0.7 kg. Males accounted for 59.8% of cases. Hypotension was observed in 36.6% of neonates, mechanical ventilation was required in 30.4%, and HIE was diagnosed in 25.9%. Stratified analysis revealed a significant association between hypotension and lower socioeconomic status ($p = 0.041$) and between HIE and male gender ($p = 0.032$). No significant associations were found with maternal occupation or residence. These findings highlight hypotension, ventilatory support, and HIE as the leading contributors to AKI in neonates with postnatal asphyxia. Recognition of these risk factors is critical for early screening, timely intervention, and prevention of renal morbidity. This study emphasizes the importance of improved neonatal care, especially in resource-limited settings, to mitigate AKI-related complications and enhance survival outcomes.

INTRODUCTION

Neonatal kidneys exhibit a heightened vulnerability to hypoperfusion due to their physiological attributes, such as elevated renal vascular resistance^{1,2}. The initial day of neonatal life is characterized by elevated plasma renin activity, reduced glomerular filtration rate, diminished intracortical perfusion rate, and impaired reabsorption of salt in the proximal convoluted tubules³. Neonatal mortality and morbidity are significantly influenced by the prevalence of this condition within the newborn population^{4,5}. Perinatal asphyxia is a grave occurrence that might yield substantial ramifications throughout the neonatal phase^{6,7}. It is a prevalent problem in the field of neonatal care and a significant contributor to illness and death in both full-term and premature newborns^{8,9}.

Perinatal asphyxia can lead to malfunction in multiple organs by redirecting the output of the heart to maintain blood flow to the brain, heart, and adrenal glands¹⁰. However, this can possibly compromise blood flow to non-vital organs such as the skin, gastrointestinal tract, and kidneys, resulting in acute kidney injury¹¹. Acute kidney injury occurrence following perinatal asphyxia in full-term infants varied between 30% and 56%. During postnatal care, the neonate's physiology attempts to counterbalance

the oxygen deprivation by diverting blood circulation towards essential organs, such as the brain and heart, while neglecting other organs, including as the kidneys. This can result in diminished renal blood flow, hence causing renal tissue damage and ultimately leading to acute kidney injury^{12,13}.

Prompt identification of acute kidney injury is essential for appropriate interventions to avert more renal impairment and enhance patient results¹⁴. Serum creatinine is widely employed as a diagnostic marker for acute kidney injury; nonetheless, it possesses several limitations, notably in the context of neonates^{15,16}. Creatinine production is affected by muscle mass, which varies in neonates, and it only increases when a substantial decrease in glomerular filtration rate has taken place^{17,18}. A study observed the factors of acute kidney injury in newborns with postnatal asphyxia i.e hypotension (38.1%), mechanical ventilation (61.9%), and Hypoxic-ischemic encephalopathy (61%)¹⁹.

Predicting acute kidney injury in neonates with prenatal hypoxia is a complex task that necessitates a thorough comprehension of the fundamental mechanisms involved. Due to paucity of literature on this subject locally, the purpose of this study is to find out the factors

of acute kidney injury in newborns with perinatal asphyxia presenting at our hospital. The findings of this study will assist our medical professionals to focus on early screening by observing these factors, which will lead to prevent morbidity and mortality in these neonates. The results of this study will also help clinicians to enhance their ability to identify at-risk neonates, implement targeted interventions, and improve long-term renal outcomes in this vulnerable population.

METHODOLOGY

This cross-sectional study was conducted in the Department of Pediatrics, Bacha Khan Medical Complex, Swabi from 29 August 2024 to February 2025, over a period of six months following the approval of the synopsis from the College of Physicians and Surgeons Pakistan (CPSP). The sample size was calculated using the WHO sample size calculator, keeping in view hypotension (38.1%) as a factor of acute kidney injury in newborns with postnatal asphyxia. A 95% confidence level and 9% margin of error were considered, resulting in a required sample size of 112 participants. A non-probability consecutive sampling technique was employed for patient recruitment.

All patients fulfilling the inclusion criteria, i.e., neonates of either gender, aged 1–60 days, and diagnosed with acute kidney injury secondary to postnatal asphyxia, were included in the study. Patients with necrotizing enterocolitis, congenital anomalies of the skeletal or urinary tract, and chronic liver disease were excluded. Ethical approval was obtained from the institutional review board, and permission was secured from CPSP Karachi prior to data collection. Written informed consent was taken from the attendants or guardians after explaining the objectives and benefits of the study, assuring them of confidentiality and the absence of any potential risks.

Baseline demographic details including age, weight, maternal education, maternal occupation, socioeconomic status, and place of residence were recorded. Clinical evaluation was performed under the supervision of a consultant pediatrician with a minimum of five years of post-fellowship experience. Patients diagnosed with acute kidney injury and postnatal asphyxia were assessed for predefined factors such as hypotension, mechanical ventilation, and hypoxic-ischemic encephalopathy, as per the operational definitions. All information was documented on a structured proforma designed for the study.

Data were analyzed using SPSS version 27. Descriptive statistics were applied, with frequencies and percentages calculated for categorical variables such as gender, clinical factors (hypotension, mechanical ventilation, and hypoxic-ischemic encephalopathy), maternal education, maternal occupation, socioeconomic status, and residence. For continuous variables such as age and weight, mean \pm standard deviation (SD) or median with interquartile range (IQR) was computed depending on data distribution. The Shapiro-Wilk test was applied to assess normality. Effect modifiers including age, weight, maternal education, occupation, socioeconomic status, and residence were controlled through stratification. Post-

stratification, Chi-square or Fisher's exact test was applied, with a p-value < 0.05 considered statistically significant. Results were presented in tabular form.

RESULTS

A total of 112 neonates with acute kidney injury (AKI) secondary to postnatal asphyxia were enrolled in this study. The mean age of the patients was 18.4 ± 12.6 days (range: 1–60 days), and the mean weight was 2.6 ± 0.7 kg. Of the participants, 67 (59.8%) were males and 45 (40.2%) were females, giving a male-to-female ratio of 1.5:1.

With respect to maternal characteristics, 42 (37.5%) mothers were illiterate, while 70 (62.5%) had received formal education. The majority of mothers, 76 (67.9%), were housewives, while **36 (32.1%)** were employed. Regarding socioeconomic status, **61 (54.5%)** belonged to the lower class, **37 (33.0%)** to the middle class, and **14 (12.5%)** to the upper class. Rural residence was reported in **72 (64.3%)** cases, while **40 (35.7%)** belonged to urban areas.

Among the clinical factors associated with AKI in neonates with postnatal asphyxia, **hypotension was observed in 41 (36.6%) patients, mechanical ventilation was required in 34 (30.4%), and hypoxic-ischemic encephalopathy (HIE) was diagnosed in 29 (25.9%)**. Stratification analysis showed a significant association between hypotension and lower socioeconomic status ($p = 0.041$), while HIE was significantly associated with male gender ($p = 0.032$). No statistically significant association was found between clinical factors and maternal occupation or residence ($p > 0.05$).

Table 1

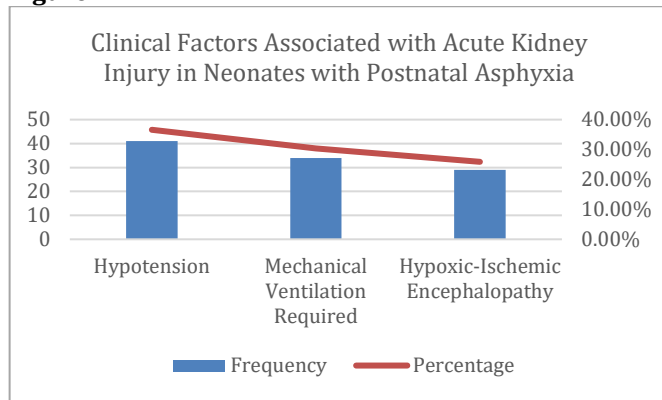
Baseline Characteristics of the Study Population (n = 112)

Variable	Frequency (%) / Mean \pm SD
Age (days)	18.4 \pm 12.6
Weight (kg)	2.6 \pm 0.7
Gender	
• Male	67 (59.8%)
• Female	45 (40.2%)
Maternal Education	
• Illiterate	42 (37.5%)
• Literate	70 (62.5%)
Maternal Occupation	
• Housewife	76 (67.9%)
• Employed	36 (32.1%)
Socioeconomic Status	
• Lower	61 (54.5%)
• Middle	37 (33.0%)
• Upper	14 (12.5%)
Residence	
• Rural	72 (64.3%)
• Urban	40 (35.7%)

Table 2

Clinical Factors Associated with Acute Kidney Injury in Neonates with Postnatal Asphyxia (n = 112)

Factor	Frequency	Percentage
Hypotension	41	36.6%
Mechanical Ventilation Required	34	30.4%
Hypoxic-Ischemic Encephalopathy	29	25.9%

Figure 1**Table 3***Association of Clinical Factors with Selected Demographic Variables*

Factor	Variable	p-value	Significant (p < 0.05)
Hypotension	Socioeconomic status	0.041	Yes
HIE	Gender	0.032	Yes
Mechanical Ventilation	Residence	0.224	No
Hypotension	Maternal occupation	0.178	No

DISCUSSION

This study evaluated the frequency and associated factors of acute kidney injury (AKI) among neonates with postnatal asphyxia admitted to the Department of Pediatrics, Bacha Khan Medical Complex, Swabi. The findings demonstrated that hypotension (36.6%), mechanical ventilation (30.4%), and hypoxic-ischemic encephalopathy (25.9%) were the most common contributing factors. Male neonates were more frequently affected, and socioeconomic disparities played a significant role, particularly in relation to hypotension.

Our results are consistent with previous reports highlighting the multifactorial nature of AKI in asphyxiated neonates. Studies from similar resource-limited settings have shown that hypotension significantly predisposes neonates to renal dysfunction due to reduced renal perfusion during hypoxic episodes (Alaro et al., 2018; Selewski et al., 2020). The observed male predominance parallels earlier evidence that male neonates may have reduced renal adaptive capacity compared with females, making them more vulnerable to hypoxic-ischemic insults (Stojanović et al., 2019). The significant association between HIE and male gender in this study reinforces these biological vulnerabilities.

Mechanical ventilation emerged as another frequent factor in AKI development. This finding corroborates the evidence that ventilatory support, while lifesaving, may worsen renal perfusion through hemodynamic alterations and increased intrathoracic pressure (Askenazi & Selewski, 2017). Similarly, the high proportion of neonates requiring ventilation reflects the severity of postnatal asphyxia in this cohort. Our study also highlights the role

of socioeconomic status, where neonates from lower socioeconomic backgrounds were more likely to experience hypotension and related renal complications. This may be attributed to delayed healthcare access, poor antenatal care, and limited neonatal resuscitation facilities, as also reported in regional studies from South Asia (Shah et al., 2021).

The overall frequency of AKI-associated complications in our cohort appears slightly lower compared to some international studies, where reported rates of hypotension and HIE have reached 40–50% (Jetton & Askenazi, 2012; Selewski et al., 2020). This difference may be due to variations in diagnostic criteria, case selection, and differences in neonatal intensive care resources. Nevertheless, our findings underscore the urgent need for early recognition and management of risk factors such as hypotension and HIE to reduce AKI-related morbidity.

This study has several strengths, including the use of clearly defined inclusion and exclusion criteria, standardized operational definitions, and evaluation under the supervision of experienced pediatric consultants. However, some limitations must be acknowledged. Being a single-center cross-sectional study, causality could not be established, and the results may not be generalizable to other settings. Additionally, long-term outcomes of neonates were not assessed, which limits insight into the chronic impact of AKI after asphyxia.

In summary, our study highlights that hypotension, mechanical ventilation, and HIE are key contributors to AKI among neonates with postnatal asphyxia, with significant associations observed with gender and socioeconomic status. These findings emphasize the importance of early risk stratification, improved perinatal care, and targeted interventions to prevent AKI in vulnerable neonates.

CONCLUSION

This study demonstrated that acute kidney injury in neonates with postnatal asphyxia is strongly associated with hypotension, mechanical ventilation, and hypoxic-ischemic encephalopathy. Male neonates and those belonging to lower socioeconomic groups were particularly vulnerable, underscoring the role of biological and social determinants in AKI development. The significant association of hypotension with socioeconomic disparities suggests that inequities in healthcare access and perinatal care may contribute to worse outcomes in disadvantaged populations. Similarly, the correlation between HIE and male gender reinforces evidence of gender-specific susceptibility to hypoxic insults. Early recognition of these risk factors, coupled with vigilant monitoring and timely interventions, can play a pivotal role in preventing renal complications and improving prognosis. Strengthening neonatal care practices, especially in resource-limited settings, is essential to reduce morbidity and mortality associated with AKI following postnatal asphyxia.

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