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Electrolyte Imbalance and Renal Marker in Newborns and Children

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Abstract

Background: Proper fluid and electrolyte balance is vital for preventing morbidity in neonates and children; thus, this study aimed to assess and compare electrolyte imbalances and renal marker profiles between newborns and children. ***Aim of the study:*** The aim of the study was to assess and compare electrolyte imbalances and renal marker profiles between newborns and children. ***Methods:*** This cross-sectional study at the Department of Biochemistry and Molecular Biology, Bangladesh Shishu Hospital & Institute, Dhaka (Jan–Mar 2024), included 100 participants (50 newborns, 50 children). Serum creatinine, blood urea, and electrolytes (Na^+, K^+, Cl^-, Ca^{2+}) were measured, and data analyzed with SPSS 26 using t-tests, chi-square/Fisher's exact tests, and Pearson's correlation ($p < 0.05$). ***Results:*** Newborns had higher creatinine (0.85 vs. 0.47 mg/dL, $p = 0.0009$) and urea (78.3 vs. 29.5 mg/dL, $p = 0.012$) than children. Electrolyte imbalance occurred in 58% (64% newborns, 52% children), mainly hypernatremia (24%), hypokalemia (18%), and hyperkalemia (15%). Newborns showed lower sodium (139.8 vs. 146.1 mmol/L, $p = 0.037$) and chloride (100.8 vs. 106.5 mmol/L, $p = 0.016$), but higher potassium (5.1 vs. 4.3 mmol/L, $p = 0.030$). Creatinine and urea correlated negatively with sodium ($r = –0.32, –0.24$) and positively with potassium ($r = 0.68, 0.41$; all $p < 0.05$). ***Conclusion:*** Electrolyte imbalances are common in newborns and children, with renal dysfunction closely associated with sodium and potassium disturbances, highlighting the need for age-specific monitoring.

Keywords: Electrolyte Imbalance, Renal Marker, Newborns.

INTRODUCTION

Maintaining proper fluid and electrolyte balance in neonates is crucial for achieving favorable short- and long-term outcomes [1]. Electrolyte disturbances are commonly observed in children presenting to pediatric emergency units, intensive care settings, or outpatient departments, particularly in those with critical conditions such as sepsis or acute kidney injury [2-5].

Critically ill or preterm infants often cannot regulate fluid and nutrient intake independently and may exhibit relative renal immaturity or dysfunction due to perinatal stress or organ immaturity [6]. Term neonates can concentrate urine up to 600 mOSm/kg water, whereas preterm infants are limited to 300–400 mOsm/kg water [7]. Additionally, infants and young children possess higher total body water (65%-80%), predisposing them to rapid fluid losses [8]. This susceptibility is compounded by their limited ability to communicate thirst or access fluids without assistance.

Early detection of electrolyte imbalances and renal marker alterations can significantly influence clinical management [4]. By the time serum creatinine levels rise [9], nearly half of renal function may already be compromised, and even minor elevations are associated with increased risk of morbidity and mortality [10]. Timely interventions to correct fluid and electrolyte derangements, provide appropriate maintenance fluids, and address ongoing losses are therefore essential to prevent adverse outcomes in both newborns and children [8].

Despite the known vulnerability of neonates and children to electrolyte and renal disturbances, there is limited comparative data examining the prevalence and patterns of these imbalances across different pediatric age groups, particularly between newborns and

older children. Most studies have focused either on critically ill patients or on specific conditions such as acute kidney injury or sepsis, leaving a gap in understanding the broader pediatric population. Therefore, the purpose of the study was to assess and compare electrolyte imbalances and renal marker profiles between newborns and children.

Objective

- To assess and compare electrolyte imbalances and renal marker profiles between newborns and children.

METHODOLOGY & MATERIALS

This cross-sectional study was conducted in the Department of Biochemistry and Molecular Biology, Bangladesh Shishu Hospital & Institute, Dhaka, Bangladesh, from January 2024 to March 2024. A total of 100 participants, comprising 50 newborns and 50 children, were enrolled according to specific inclusion criteria. Newborns included both term and preterm infants admitted during the study period, while children up to 12 years of age were selected from the pediatric wards. The study aimed to assess and compare renal markers and serum electrolyte profiles between newborns and children.

Inclusion Criteria

- Newborns (term and preterm) admitted during the study period.
- Children up to 12 years of age admitted to the pediatric wards.
- Participants with available serum electrolyte and renal marker data (serum creatinine and blood urea).

Exclusion Criteria

- Newborns or children with known chronic kidney disease.
- Participants with congenital metabolic disorders affecting electrolyte balance.
- Patients receiving medications that could alter electrolyte or renal function.
- Cases with incomplete laboratory or clinical data.

Data Collection

Demographic data, including age and gender were recorded. Blood samples were collected under aseptic conditions, and serum was separated for biochemical analysis. Renal function markers—serum creatinine and blood urea—and electrolytes including sodium Na^+, potassium K^+, chloride Cl^-, and calcium Ca^{2+} were measured.

Laboratory Analysis

Serum creatinine, blood urea, electrolytes were analyzed using automated analyzers with internal quality control. Electrolyte imbalances were defined as follows: hyponatremia (Na^+ <135 mmol/L), hypernatremia (Na^+ >145 mmol/L), hypokalemia (K^+ <3.5 mmol/L), hyperkalemia (K^+ >5.5 mmol/L), hypocalcemia (Ca^{2+} <8.5 mg/dL), and hypochloremia (Cl^- <98 mmol/L).

Statistical Analysis

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation (SD) and compared using independent t-tests. Categorical variables were presented as frequencies and percentages and compared using chi-square or independent t-tests, as appropriate. Correlations between renal markers and electrolytes were assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics and Renal Markers of Newborns and Children (n = 100)

Characteristic	Newborns (n = 50)	Children (n = 50)	p-value
Age (mean ± SD)	7.1 ± 3.2 days	6.6 ± 3.5 years	<0.0001[b]
Gender, n (%)			0.840[a]
Male	30 (60%)	29 (58%)	
Female	20 (40%)	21 (42%)	
Serum Creatinine (mg/dL, mean ± SD)	0.85 ± 0.60	0.47 ± 0.50	0.0009[b]
Blood Urea (mg/dL, mean ± SD)	78.3 ± 100.0	29.5 ± 90.0	0.012[b]

Note: [a]Chi-square test [b]Independent t-test

Table 1 summarizes the demographic and renal function parameters of the study population. Newborns (n = 50) were significantly younger and lighter than children (n = 50) (p < 0.0001), while gender distribution was similar between groups (p = 0.840). Serum creatinine and blood urea were both significantly higher in newborns compared to children (p < 0.001 and p = 0.012, respectively).

Table 2: Prevalence of Electrolyte Imbalances in Newborns and Children (n = 100)

Electrolyte Disturbance	Overall (N = 100) n (%)	Newborns (n = 50) n (%)	Children (n = 50) n (%)	p-value
Any Electrolyte Imbalance	58 (58.0%)	32 (64.0%)	26 (52.0%)	0.230[a]
Hyponatremia (Na^+ <135 mmol/L)	8 (8.0%)	6 (12.0%)	2 (4.0%)	0.140[b]
Hypernatremia (Na^+ >145 mmol/L)	24 (24.0%)	16 (32.0%)	8 (16.0%)	0.045[a]
Hypokalemia (K^+ <3.5 mmol/L)	18 (18.0%)	5 (10.0%)	13 (26.0%)	0.041[a]
Hyperkalemia (K^+ >5.5 mmol/L)	15 (15.0%)	11 (22.0%)	4 (8.0%)	0.042[a]
Hypocalcemia (Ca^{2+} <8.5 mg/dL)	12 (12.0%)	8 (16.0%)	4 (8.0%)	0.230[a]
Hypochloremia (Cl^- <98 mmol/L)	9 (9.0%)	6 (12.0%)	3 (6.0%)	0.302[a]

Note: [a]Chi-square test [b]Independent t-test

Table 2 presents the prevalence of various electrolyte disturbances among 50 newborns and 50 children. Overall, 58% of participants had at least one electrolyte imbalance, with a higher prevalence in newborns (64%) compared to children (52%). Hypernatremia was the most frequent disturbance, affecting 24% of the cohort, followed by hypokalemia (18%) and hyperkalemia (15%). Hyponatremia, hypocalcemia, and hypochloremia were less common, observed in 8%, 12%, and 9% of participants, respectively.

Table 3: Serum Electrolyte Profiles of Newborns and Children

Electrolyte	Overall (N = 100)	Newborns (n = 50)	Children (n = 50)	p-value
Sodium (Na^+), mmol/L	142.9 ± 14.9	139.8 ± 16.2	146.1 ± 12.1	0.037[b]
Potassium (K^+), mmol/L	4.7 ± 1.8	5.1 ± 2.0	4.3 ± 1.5	0.030[b]
Chloride (Cl^-), mmol/L	103.6 ± 11.5	100.8 ± 12.5	106.5 ± 9.2	0.016[b]
Calcium (Ca^{2+}), mg/dL	3.1 ± 9.4	2.8 ± 8.1	3.5 ± 10.8	0.712[b]

Note: [b]Independent t-test

Table 3 shows that newborns had significantly lower sodium (139.8 ± 16.2 vs. 146.1 ± 12.1 mmol/L, p = 0.037) and chloride (100.8 ± 12.5 vs. 106.5 ± 9.2 mmol/L, p = 0.016) but higher potassium (5.1 ± 2.0 vs. 4.3 ± 1.5 mmol/L, p = 0.030) compared to children. Calcium levels did not differ significantly (p = 0.712).

Table 4: Correlation between Renal Markers and Serum Electrolytes

Relationship	Correlation Coefficient (r)	p-value
Serum Creatinine vs. Sodium	–0.32	0.001[c]
Serum Creatinine vs. Potassium	0.68	<0.0001[c]
Blood Urea vs. Sodium	–0.24	0.018[c]
Blood Urea vs. Potassium	0.41	<0.0001[c]

Note: [c]Pearson's correlation coefficient

Table 4 illustrates the associations between renal markers and electrolytes. Serum creatinine showed a significant negative correlation with sodium (r = –0.32, p = 0.001) and a strong positive correlation with potassium (r = 0.68, p < 0.0001). Similarly, blood urea was inversely correlated with sodium (r = –0.24, p = 0.018) and positively correlated with potassium (r = 0.41, p < 0.0001).

DISCUSSION

Electrolyte imbalances and renal markers serve as critical indicators of renal function and overall homeostasis in newborns and children. Alterations in serum electrolytes and renal markers reflect underlying physiological immaturity, fluid shifts, or metabolic disturbances, presenting significant challenges to pediatric health that often require prompt recognition and intervention. The findings highlight age-dependent differences in electrolyte handling and renal function, with sodium, potassium, chloride, calcium, creatinine, and blood urea all contributing to early detection of potential complications. The high prevalence of electrolyte disturbances and associated renal marker changes underscores the importance of monitoring these parameters to guide timely clinical management and improve outcomes in both newborns and young children.

In the present study, the baseline characteristics and renal markers demonstrated significant differences between newborns and children. As expected, newborns had a lower mean age compared to children (p < 0.0001), while the gender distribution was comparable between groups (p = 0.840). Serum creatinine levels were significantly higher in newborns (0.85 ± 0.60 mg/dL) than in children (0.47 ± 0.50 mg/dL, p = 0.0009), which aligns with Savory *et al.,*[11], who reported higher creatinine levels in infants due to maternal influence and the physiological transition in the early neonatal period. Similarly, blood urea was elevated in newborns (78.3 ± 100.0 mg/dL) compared to children (29.5 ± 90.0 mg/dL,

p = 0.012), reflecting renal immaturity and a higher prevalence of metabolic imbalances in this group. These observations are consistent with Siddiqui *et al.,*[12], who highlighted frequent electrolyte and renal disturbances in newborns with acute kidney injury in the NICU, emphasizing their heightened vulnerability to renal and metabolic derangements.

Electrolyte imbalances were common in this study, with 58% of participants exhibiting at least one disturbance. Prevalence was higher in newborns (64%) compared to children (52%), though this difference was not statistically significant. Hypernatremia was the most frequent disturbance (24%), followed by hypokalemia (18%) and hyperkalemia (15%), while hyponatremia (8%), hypocalcemia (12%), and hypochloremia (9%) were less frequent, suggesting that severe electrolyte disturbances were uncommon. These findings are consistent with Liu *et al.,*[13], who reported a low prevalence of hyponatremia (2.05%) among 801 neonates, and align with the observations of Yen *et al.,*[14] and Zieg *et al.,*[15], who emphasized that sodium and potassium abnormalities remain the most clinically relevant disturbances in pediatric populations. Collectively, these results underscore the importance of routine electrolyte monitoring in both newborns and children to facilitate early detection and management of clinically significant imbalances.

Analysis of serum electrolyte profiles further demonstrated significant group differences. Newborns had lower mean sodium (139.8 ± 16.2 mmol/L) and chloride (100.8 ± 12.5 mmol/L) but higher potassium (5.1 ± 2.0 mmol/L) compared to children, who exhibited higher sodium (146.1 ± 12.1 mmol/L) and chloride (106.5 ± 9.2 mmol/L) with lower potassium (4.3 ± 1.5 mmol/L). Calcium levels did not differ significantly between groups. These findings are in agreement with Ozalp *et al.,*[16], who reported marked postoperative fluctuations in sodium, potassium, calcium, and chloride among critically ill neonates, emphasizing the need for vigilant monitoring. Similarly, Zieg *et al.,*[15] highlighted that variations in sodium and potassium are among the most frequently encountered electrolyte disorders in pediatric patients, underscoring their clinical relevance. Together, these results reinforce the importance of regular electrolyte evaluation in both newborns and children, particularly in contexts of acute illness or stress.

Finally, the correlation analysis revealed important associations between renal markers and electrolytes. Serum creatinine correlated negatively with sodium (r = –0.32, p = 0.001) and strongly positively with potassium (r = 0.68, p < 0.0001), while blood urea was inversely associated with sodium (r = –0.24, p = 0.018) and positively associated with potassium (r = 0.41, p < 0.0001). These results suggest that worsening renal function, reflected by elevated creatinine and urea, is linked to hyponatremia and hyperkalemia. Similar findings were reported by Mannan *et al.,*[17], who showed that higher creatinine levels in neonates were associated with lower sodium, reflecting renal immaturity. Likewise, Rahman *et al.,*[18] demonstrated that asphyxiated newborns with elevated urea and creatinine often developed hyponatremia, highlighting the interplay between renal dysfunction and electrolyte imbalance. Together, these findings emphasize the close interrelationship between renal markers and electrolyte status, underscoring the need for integrated monitoring in newborns and children at risk of renal compromise.

Limitations of the study

The study had a few limitations:

- The study was conducted with a relatively small sample size, which may limit the generalizability of the findings to the broader population.
- As a single-center study based in one hospital in Dhaka, the results may not fully represent the national population or reflect variations in other regions.

CONCLUSION

This study shows that electrolyte imbalances are common in both newborns and children, with higher frequency in newborns. Hypernatremia, hypokalemia, and hyperkalemia were most prevalent, accompanied by lower sodium and chloride and higher potassium levels. Elevated renal markers and their correlations with electrolyte changes highlight the importance of age-specific monitoring and management.

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