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Incidence, Risk Factors and Outcomes of Sodium Imbalance in Neonates: A Prospective Observational Study in a Neonatal Intensive Care Unit

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ABSTRACT
Sodium imbalance, including hyponatremic and hypernatremia, is a significant concern in neonates admitted to the Neonatal Intensive Care Unit (NICU). This study aims to assess the incidence, risk factors, clinical presentations and outcomes of neonates with sodium imbalances. A prospective observational study was conducted at Dhiraj General Hospital, Pipariya, from April 2018 to September 2019. Neonates with serum sodium levels <130mEq/L (hyponatremia) or >150mEq/L (hypernatremia) were included. Data were collected on demographic details, clinical presentation, risk factors, complications and outcomes. Descriptive statistics, Pearson's Chi-square test and relative risk were used to analyze the data. Of 825 NICU admissions, the incidence of hyponatremia was 26.6 per 1000 and hypernatremia was 33.9 per 1000. Hyponatremia was more common in extramural admissions (46.5 per 1000). Risk factors included sepsis (86.36%) and prematurity (40.90%) for hyponatremia and delayed breast-feeding initiation (89.28%) and reduced feeding frequency (82.14%) for hypernatremia. The mean sodium levels were 124.11mEq/L in hyponatremic and 160.64mEq/L in hypernatremia. Complications such as acute renal failure were seen in all hypernatremia neonates (100%). Mortality rates were 22.73% in hyponatremic neonates and 10.71% in hypernatremia neonates. Sodium imbalances are associated with significant morbidity and mortality in neonates. Early identification and appropriate management are critical to improving outcomes, particularly in neonates with associated complications such as sepsis and acute renal failure.

INTRODUCTION

Sodium is a critical electrolyte in maintaining cellular function, fluid balance and acid-base homeostasis, especially in neonates[1]. The regulation of sodium is particularly important in newborns, as they are vulnerable to electrolyte imbalances due to immature renal function and various perinatal factors. Hyponatremia (serum sodium <130mEq/L) and hypernatremia (serum sodium >150mEq/L) are two common types of sodium imbalances that can significantly impact neonatal outcomes, particularly in critically ill neonates admitted to the Neonatal Intensive Care Unit[2,3] (NICU). Hyponatremic can result from fluid overload, sepsis, or renal immaturity, and is associated with increased morbidity, including neurological complications[4]. Hypernatremia, often related to dehydration, inadequate breast-feeding, or excessive sodium intake, is equally dangerous, potentially leading to seizures, cerebral edema, or acute renal failure[5]. Both conditions demand prompt diagnosis and intervention to prevent life-threatening complications[6]. The prevalence of these conditions varies across different settings, with extramural admissions often showing higher rates due to delayed presentation and lack of early neonatal care[7]. Despite the known risks, there is a scarcity of large-scale studies addressing the incidence and outcomes of sodium imbalances in neonates in resource-limited settings such as India. This study aims to investigate the incidence, risk factors and clinical outcomes of neonates with hyponatremia and hypernatremia admitted to the NICU at Dhiraj General Hospital, Pipariya. By understanding the patterns of these electrolyte imbalances and their associated comorbidities, the study seeks to highlight the importance of early detection and appropriate management to improve neonatal survival and reduce morbidity.

MATERIALS AND METHODS

Study Design: This study was a prospective observational study conducted at the Neonatal Intensive Care Unit (NICU) of Dhiraj General Hospital, Pipariya. The study was designed to observe and analyze cases of sodium imbalance, specifically hyponatremia and hypernatremia, in neonates.

Study Period: The enrollment of participants took place over a period of one and a half years, from April 2018 to September 2019.

Study Population: The study included neonates admitted to the NICU with serum sodium levels less than 130mEq/L (hyponatremic) or greater than 150mEq/L (hypernatremia). Neonates were included based on their serum sodium levels, as per the inclusion criteria. Parental consent was obtained prior to participation.

Inclusion Criteria: Neonates admitted to the NICU during the study period with sodium levels <130mEq/L (hyponatremia) or >150mEq/L (hypernatremia).

Exclusion Criteria:

- Neonates older than 28 days of life.
- Neonates whose parents were unwilling to participate in the study.

Sample Size: Due to the rarity of the condition, the sample size consisted of all neonates who met the inclusion criteria during the study period.

Data Collection and Variables: Data were collected using a standardized proforma, including detailed demographic information, clinical presentation, risk factors and outcomes. The neonates were assessed through history-taking, clinical examination and relevant investigations. Risk factors such as prematurity, sepsis, feeding practices and associated comorbidities were recorded. Serum sodium levels were monitored and electrolyte imbalances were identified.

Statistical Analysis: Descriptive statistics, including frequency, percentages, mean and standard deviation (SD), were used to summarize the data. Pearson's Chi-Square test, relative risk and p-values were calculated to determine associations between variables and outcomes.

Ethical Considerations: The study was conducted after receiving approval from the Institutional Ethics Committee. Informed consent was obtained from the parents or legal guardians of all enrolled neonates.

RESULTS AND DISCUSSIONS

This study evaluated the incidence, demographic characteristics, clinical presentations, and outcomes of neonates with sodium imbalances (hyponatremia and hypernatremia) admitted to the Neonatal Intensive Care Unit (NICU) at Dhiraj General Hospital, Pipariya. The data is summarized in seven tables.

Incidence of Hyponatremic and Hypernatremia: Out of the 825 neonates admitted during the study period, the incidence of hyponatremia was 26.6 per 1000 NICU admissions. The incidence was notably higher among extramural admissions (46.5 per 1000) compared to intramural admissions (9.1 per 1000). Hypernatremia was diagnosed in 28 neonates, resulting in an overall

Table 1: Incidence of Hyponatremia and Hypernatremia

Parameter	Total Admissions (n=825)	Number of Cases	Incidence (per 1000 admissions)
Hyponatremia	825	22	26.6
Hyponatremia (Extramural)	387	18	46.5
Hyponatremia (Intramural)	438	4	9.1
Hypernatremia	825	28	33.9
Hypernatremia (Extramural)	387	27	69.8
Hypernatremia (Intramural)	438	1	2.3

Table 2: Demographic Characteristics of Hyponatremic and Hypernatremic Neonates

Parameter	Hyponatremia (n=22)	Hypernatremia (n=28)
Male (%)	63.64%	53.57%
Female (%)	36.36%	46.43%
Primipara mothers (%)	81.82%	67.86%
Multipara mothers (%)	18.18%	32.14%
Mean Gestational Age (weeks)	34.9	37.1

Table 3: Clinical Presentation and Risk Factors

Risk Factors	Hyponatremia (n=22)	Hypernatremia (n=28)
Sepsis (%)	86.36%	71.42%
Prematurity <34 weeks (%)	40.90%	10.71%
Very Low Birth Weight (VLBW) (%)	31.81%	7.14%
Delayed breastfeeding initiation (%)	-	89.28%
Reduced feeding frequency <8/day (%)	-	82.14%
Hot climate conditions (%)	-	78.57%

Table 4: Presenting Features

Presenting Features	Hyponatremia (n=22)	Hypernatremia (n=28)
Poor feeding (%)	90.90%	92.30%
Poor activity (%)	77.27%	-
Lethargy/coma (%)	77.27%	50%
Excess weight loss >10% (%)	-	75%
Signs of dehydration (%)	54.54%	71.43%
Vomiting (%)	22.72%	50%

Table 5: Sodium and Electrolyte Imbalance

Parameter	Hyponatremia (n=22)	Hypernatremia (n=28)
Mean Sodium Level (mEq/L)	124.11 (110-129)	160.64 (151-186)
Sodium Range 121-130mEq/L (%)	72.72%	-
Sodium Range 151-160mEq/L (%)	-	60.71%
Hyperkalemia (K+ >6mEq/L) (%)	36.36%	25%

Table 6: Complications and Comorbidities

Complications/Comorbidities	Hyponatremia (n=22)	Hypernatremia (n=28)
Sepsis (%)	86.36%	71.42%
Thrombocytopenia (%)	68.18%	-
Convulsions (%)	45.45%	32.14%
Acute Renal Failure (ARF) (%)	4.54%	100%
Hyperglycemia (%)	4.54%	28.57%
Hypocalcemia (%)	31.81%	25%

Table 7: Outcome and Mortality

Parameter	Hyponatremia (n=22)	Hypernatremia (n=28)
Discharged (%)	40.91%	57.14%
LAMA - Moribund (%)	36.36%	28.57%
Expired (%)	22.73%	10.71%
Mean Duration of Stay (days)	13.59 (Range 1-47)	9.0 (Range 2-23)

incidence of 33.9 per 1000 NICU admissions, with extramural neonates exhibiting a much higher incidence (69.8 per 1000) compared to intramural neonates (2.3 per 1000) (Table 1).

Demographic Characteristics: In both hyponatremia and hypernatremia groups, there was a male predominance, with the male-to-female ratio being 1.75:1 and 1.15:1, respectively. The majority of mothers of both hyponatremic (81.82%) and hypernatremic (67.86%) neonates were primipara. The mean gestational age was lower for hyponatremic neonates (34.9 weeks) compared to hypernatremic neonates (37.1 weeks) (Table 2).

Clinical Presentation and Risk Factors: The most common risk factors in hyponatremic neonates were sepsis (86.36%), prematurity (<34 weeks, 40.90%) and very low birth weight (31.81%). In hypernatremic neonates, delayed initiation of breastfeeding (89.28%), reduced feeding frequency (<8/day, 82.14%) and hot climate conditions (78.57%) were significant risk factors (Table 3).

Presenting Features: Poor feeding was a predominant presenting feature in both hyponatremic (90.90%) and hypernatremic (92.30%) neonates. Other common symptoms in the hyponatremic group included poor activity (77.27%), lethargy/coma (77.27%) and signs of

dehydration (54.54%). Hypernatremic neonates exhibited excess weight loss (>10%, 75%) and signs of dehydration (71.43%) (Table 4).

Sodium and Electrolyte Imbalance: The mean sodium level in hyponatremic neonates was 124.11mEq/L, with most neonates (72.72%) having sodium levels in the range of 121-130mEq/L. In hypernatremic neonates, the mean sodium level was 160.64mEq/L, with 60.71% of neonates presenting sodium levels in the range of 151-160mEq/L. Hyperkalemia (K+>6mEq/L) was present in 36.36% of hyponatremic neonates and 25% of hypernatremic neonates (Table 5).

Complications and Comorbidities: Sepsis was a major complication observed in both hyponatremic (86.36%) and hypernatremic (71.42%) neonates. Thrombocytopenia (68.18%) and convulsions (45.45%) were more common in hyponatremic neonates, while all hypernatremic neonates experienced acute renal failure (ARF). Other complications included hyperglycemia (28.57%) and hypocalcemia (25%) in hypernatremic neonates (Table 6).

Outcome and Mortality: In the hyponatremic group, 40.91% of neonates were discharged, while 36.36% left against medical advice (LAMA) in a moribund state, and 22.73% expired. Among hypernatremic neonates, 57.14% were discharged, 28.57% left LAMA in a moribund state and 10.71% expired. The mean duration of hospital stay was longer for hyponatremic neonates (13.59 days) compared to hypernatremic neonates (9.0 days) (Table 7).

This study investigated the incidence, risk factors, clinical presentations and outcomes of sodium imbalances (hyponatremia and hypernatremia) in neonates admitted to the NICU at Dhiraj General Hospital, Pipariya. The results emphasize the significant morbidity and mortality associated with sodium disturbances, particularly in neonates with underlying risk factors such as sepsis and prematurity, as noted by Hao[8]. The incidence of hyponatremia in this study was 26.6 per 1000 NICU admissions, similar to other findings that report hyponatremia as a common electrolyte disturbance in critically ill neonates (Hassan[6]). The incidence was particularly higher in extramural admissions (46.5 per 1000), which could be attributed to delayed referrals and inadequate neonatal care in peripheral settings, echoing observations made by Basalely[9]. This emphasizes the importance of early recognition and management of electrolyte disturbances, particularly in resource -limited settings where access to specialized care may be delayed. Similarly, hypernatremia was prevalent with an incidence of 33.9 per 1000 NICU admissions. The incidence was much higher in extramural neonates (69.8 per 1000), suggesting that improper feeding practices, particularly delayed initiation of breastfeeding and inadequate feeding frequency, contribute significantly to hypernatremia, as also highlighted by Kim[10]. This finding is consistent with existing literature linking neonatal hypernatremia to dehydration and insufficient breast milk intake, particularly during the early neonatal period (Asfour[11]). Environmental factors, such as the hot climate during the study period, may have exacerbated the dehydration and sodium imbalance, as suggested by Corsello[12]). Sepsis emerged as a major risk factor in both hyponatremic (86.36%) and hypernatremic (71.42%) neonates, consistent with findings from Basalely[9] that show sepsis disrupts electrolyte balance by altering renal function and triggering inappropriate antidiuretic hormone secretion. Prematurity and low birth weight were additional risk factors in the hyponatremic group, supporting the findings of Kim[10] that associate these conditions with impaired renal sodium handling. The clinical presentations of both hyponatremia and hypernatremia were characterized by poor feeding, lethargy and signs of dehydration, which is consistent with previous studies (Hassan[6]). In hypernatremic neonates, there was a higher frequency of excess weight loss (>10%) and dehydration, hallmark signs of hypernatremia caused by inadequate breast-feeding, as similarly reported by Araya[13]. Poor neonatal feeding practices, coupled with warm climate conditions, likely exacerbated dehydration and sodium imbalances. The outcomes were notably poor in neonates with sodium imbalances, with 22.73% of hyponatremic neonates and 10.71% of hypernatremic neonates succumbing to their conditions. Mortality was particularly high in neonates with severe electrolyte imbalances and associated complications such as acute renal failure and convulsions. The mean duration of stay was longer for hyponatremic neonates (13.59 days) compared to hypernatremic neonates (9.0 days), suggesting the prolonged management often required for severe sodium imbalances, as also discussed by Becker[14]. This study underscores the importance of early identification and management of sodium imbalances in neonates, particularly in high-risk groups such as those with sepsis and prematurity. The findings align with Basalely[9] in suggesting that improving neonatal feeding practices, particularly promoting early and exclusive breast-feeding, could prevent a significant proportion of hypernatremic cases. Additionally, timely intervention for sepsis and other comorbidities could reduce the risk of hyponatremia and improve overall neonatal outcomes.

Limitations: The study's sample size was limited due to the rarity of sodium imbalances, which may affect the generalizability of the results to all NICU populations.

The single-center design may not capture variations in care practices across different NICUs, which can influence outcomes. Future multicenter studies with larger sample sizes, as recommended by Basalely[9], are needed to validate these findings and explore strategies to reduce the burden of sodium imbalances in neonates.

CONCLUSION

This study highlights the significant incidence of sodium imbalances in neonates, particularly hyponatremia (26.6 per 1000 NICU admissions) and hypernatremia (33.9 per 1000 NICU admissions), with extramural neonates being at higher risk. Sepsis, prematurity and inadequate breast-feeding practices were major risk factors. Mortality was notable, with 22.73% of hyponatremic and 10.71% of hypernatremic neonates succumbing to their conditions. Early detection, timely management of sepsis and promoting appropriate breast-feeding practices are essential to reduce the burden of sodium imbalances and improve neonatal survival outcomes in resource-limited settings.

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