DOI: 10.7860/IJNMR/2023/64477.2395

Original Article

Paediatrics Section

Clinico-aetiological Profile and Outcome of Hypernatremic Dehydration in Term Neonates Admitted to the NICU at a Tertiary Care Centre in Udaipur, Rajasthan, India

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ABSTRACT

Introduction: Hypernatremic dehydration is commonly found in the first week of neonatal life. Hypernatremia develops when water loss exceeds sodium loss, as in lactational failure with inadequate breastfeeding, or when sodium intake exceeds water intake disproportionately (salt poisoning), such as when neonates receive concentrated formula or top milk. The common presentations include lethargy, irritability, poor feeding, dehydration, reduced urinary frequency, significant weight loss, and fever.

Aim: The aim of this study was to investigate the clinico-etiological profile and outcome of hypernatremic dehydration in term neonates admitted to the Neonatal Intensive Care Unit (NICU) at a tertiary care centre. Additionally, the study aimed to examine the factors contributing to hypernatremic dehydration.

Materials and Methods: This prospective cohort study was conducted at the NICU, Department of Paediatrics, of Geetanjali Medical College, Udaipur, Rajasthan, India from February 2021 to July 2022. A total of 51 term neonates with a history of inadequate breastfeeding, maternal history of lactational failure, significant weight loss (>10% weight loss within a short period of time), or dehydration fever, along with hypernatremia (serum sodium > 145 mEq/L), were enrolled in the study. Data regarding serum sodium level, serum bilirubin level, Kidney Function Test (KFT), Ultrasonography of Kidney, Ureters and Bladder (USG KUB), and neuroimaging were collected for all study subjects and statistically analysed using the Chi-square test.

Results: A total of 51 neonates were admitted to the NICU during the study period, with a mean age of 6.05±2.2 days (range 0-15 days) and a mean birth weight of 2810 grams. The study showed that the mean weight (in %) loss was 13.75±4.1 (range 10.1-21%). The study also revealed that 64.7% of the mothers of neonates experienced lactational failure, with a p-value <0.05. The presenting complaints were poor feeding (92.2%), fever (45.1%), excessive crying (96.1%), and decreased urine output (47%). The mean Standard Deviation (SD) sodium level on admission was 155.3 mEq/L. Two neonates developed neurological complications (intracranial haemorrhage and cerebral oedema), and 62.7% of neonates developed Acute Kidney Injury (AKI).

Conclusion: Hypernatremic dehydration poses a significant threat in early neonatal life and is often underdiagnosed. Common causes include a lack of awareness about exclusive breastfeeding, lactational failure, and improper breastfeeding techniques, as well as feeding problems due to inverted/flat nipples or cracked nipples/breast engorgement. These findings were observed in the present study.

Keywords: Intracranial haemorrhage, Lactational failure, Sodium loss, Weight reduction

INTRODUCTION

Neonatal hypernatremia refers to a blood sodium level that is more than 145 mEq/L [1]. The incidence of hypernatremic dehydration varies from country to country and even within the same country due to variable demographic and environmental features [2]. Escobar GJ et al., found an overall incidence of dehydration was 2.1 per 1000 live births [3]. Lee KS et al., reported a dehydration rate of 0.58 per 1000 live births [4]. Ahmed A et al., found the incidence of breastfeeding-associated hypernatremic dehydration among neonates was 1.38% [5]. This lower incidence was due to their colder geographic regions. Bhat SR et al., found a very high incidence of 31.6% (188 per 1000 live births) [6]. This high incidence may be due to their selection of the study period, which was during warm months, and their centre being in southern India, which is hotter than Northern India [7,8].

Usually, neonates with hypernatremic dehydration present within the first two weeks of birth with complaints of excessive crying, fever, lethargy, decreased frequency of micturition, refusal to feed, dehydration, breathlessness, significant weight loss, and seizures. If timely diagnosis and management are not done, it can lead to complications such as acute renal failure, intracranial haemorrhage with cerebral oedema, and later developmental delay [9-11]. The present study was therefore undertaken at the study centre to investigate its incidence, maternal and neonatal risk factors contributing to this problem, along with presenting clinical symptoms and complications after management. Although signs, symptoms, and complications were discussed in previous studies [12-15], risk factors behind them were not addressed in previous studies. However, in the present study, the authors focused on the risk factors associated with hypernatremic dehydration to spread knowledge among mothers antenatally and postnatally about the methods of breastfeeding and latching through individual counselling and mass camping.

Hence, the present study was conducted to study the clinico-etiological profile and outcome of hypernatremic dehydration in

term neonates admitted to the NICU in a tertiary care centre in Southern Rajasthan.

MATERIALS AND METHODS

This prospective cohort study was conducted in the NICU, Department of Paediatrics, Geetanjali Medical College and Hospital, Udaipur, from February 2021 to July 2022. The study was approved by the Institutional Ethics Committee (IEC No. GU/HREC/EC/2021/893). A total of 51 term neonates who presented to the department with symptoms suggestive of hypernatremia within the study duration were enrolled in the study.

Inclusion criteria: Term (>37 weeks) neonates (up to 28 days of age) admitted to the neonatal intensive care unit, presenting with any of the following clinical conditions: History of inadequate breastfeeding, maternal history of lactational failure, significant weight loss (>10% weight loss within a short period of time), or dehydration fever along with hypernatremia (serum sodium >145 mEq/L) [1], were included in the study.

Exclusion criteria: Neonates with clinically detected obvious congenital malformations, perinatal asphyxia, and those with clinical and laboratory evidence of sepsis among the aforementioned neonates were excluded.

Study Procedure

Informed consent was obtained from parents of all study participants. Detailed history of the neonates, physical examination, and feeding information were collected. Blood samples and other required investigations (serum sodium level, serum bilirubin level, Kidney Function Test (KFT), Ultrasonography of Kidney, Ureters and Bladder (USG KUB), neuroimaging) were performed for all study participants, and the data were collected. The laboratory used the Ion Selective Electrode method (ISE) for serum sodium level estimation, and Turbometry was used for KFT. In the current study, the cutoff range for the following parameters were described as blood urea levels (>3 mg/dL), high serum creatinine levels (>0.3 mg/dL), and serum sodium level (>145 mEq/L) [1,7].

Any complications or morbidities during hospitalisation and post-hospitalisation for a period of one week, six weeks, and 14 weeks (clinical and imaging) were noted.

STATISTICAL ANALYSIS

Data were entered into Microsoft excel software. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0 by IBM Corporation. Statistical analyses for categorical variables were compared using the chi-squared test.

RESULTS

In the current study, out of total 51 neonates with dehydration, 30 (58.8%) were males and 21 (41.2%) were females with hypernatremic dehydration. It was observed that 25 (49%) women were primigravida, and 26 (51%) women were multigravida. Neonates born through normal vaginal delivery were 14 (27.5%), while 37 (72.5%) of the neonates were delivered through Lower Segment Caesarean Section (LSCS) [Table/Fig-1].

The mean age of neonates on admission was 6.05±2.2 days. The mean birth weight and mean admission weight were 2810±282.3 g and 2420±221.4 g, respectively. The mean weight loss after birth due to dehydration was 13.75±4.1. Most of the neonates, 49 (96.1%), were discharged, one patient went Left Against Medical Advice (LAMA) due to financial reasons, and one neonate died due to complications of dehydration [Table/Fig-2].

Parameters		No. of neonates (%)
Gender	Male	30 (58.8%)
	Female	21 (41.2%)
Gravida	Primigravida	25 (49%)
	Multigravida	26 (51%)
Made of delivery	Vaginal	14 (27.5%)
	LCS	37 (72.5%)

[Table/Fig-1]: Parameters assessed in neonates.

Demographic profile	Values
Total number of neonates with hypernatremic dehydration	51
Mean age at admission (days±SD)	6.05±2.2
Mean birth weight (grams±SD)	2810±282.3
Mean weight at admission (grams±SD)	2420±221.4
Mean weight loss after birth (%±SD)	13.75±4.1
Discharged/LAMA/mortality	49/1/1

[Table/Fig-2]: Demographic Profile of all the newborns.

The most common presentations in admitted neonates were excessive crying in 49 (96.1%) cases, jaundice in 22 (43.1%) cases, and fever in 23 (45.1%) cases. Other symptoms included decreased frequency of micturition in 24 (47%) cases, refusal to feed in 47 (92.2%) cases, lethargy in 51 (100%) cases, breathlessness in 7 (13.7%) cases, and seizures in 4 (7.8%) cases. In the present study, 2 (3.9%) patients had intracranial haemorrhage with cerebral oedema on USG Cranium report [Table/Fig-3].

Signs and symptoms	No. of newborns	Percentage (%)
Excessive cry	49	96.1
Poor feeding	47	92.2
Fever	23	45.1
Lethargy	51	100
Breathlessness	7	13.7
Jaundice	22	43.1
Decreased urine output	24	47
Seizure	4	7.8
Neurological complication (Intracranial haemorrhage and cerebral oedema)	2	3.9

[Table/Fig-3]: Clinical features and complication in newborns with hypernatremia.

Out of the 51 neonates, 32 (62.7%) had higher blood urea levels (98.4±6.2 mg/dL) and high serum creatinine levels (1.76±0.62 mg/dL). According to All India Institute of Medical Sciences (AIIMS) NICU protocol guidelines, even an increase in serum creatinine level >0.3 mg/dL is sufficient to diagnose Acute Kidney Injury (AKI) [Table/Fig-4].

Parameters		n (%)	Mean±SD
Blood urea levels	>3 mg/dL	32(62.7%)	98.4±6.2
	>3 mg/dL	19(37.3%)	
Serum creatinine levels	>0.3 mg/dL	32(62.7%)	1.76(±0.62)
	>0.3 mg/dL	19(37.3%)	

[Table/Fig-4]: Renal function test in neonate.

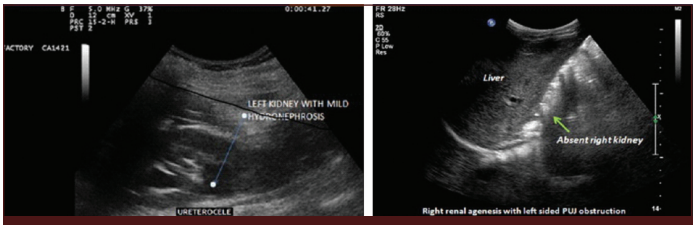
Based on renal ultrasonography, the study showed that 1 (2%) patient had congenital renal malformation, 5 (9.8%) patients had

renal parenchymal abnormalities, and 2 (3.92%) patients had hydronephrosis [Table/Fig-5].

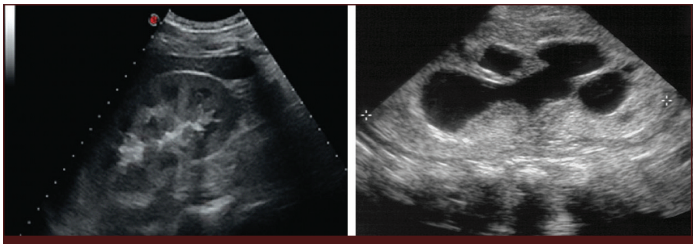
Neonates with USG KUB findings	No. of newborns	Percentage
Congenital renal malformation	1	2
Renal parenchyma abnormalities	5	9.8
Hydronephrosis	2	3.92

[Table/Fig-5]: USG KUB findings.

The renal ultrasonography image of the neonate showed the left kidney with mild hydronephrosis, and the arrow points to a ureterocele [Table/Fig-6]. The renal ultrasonography image of the neonate showed right renal agenesis with left-sided PUJ (Pelvi-Ureteric Junction) obstruction, and the arrow points to the absent right kidney [Table/Fig-7]. The renal ultrasonography image of the neonate showed diffuse renal parenchymal disease [Table/Fig-8]. The renal ultrasonography image of the neonate showed renal insufficiency [Table/Fig-9].



[Table/Fig-6]: Renal ultrasonography showing left kidney with mild hydronephrosis. **[Table/Fig-7]:** Renal ultrasonography showing right renal agenesis with left-sided PUJ obstruction. (Images from left to right)



[Table/Fig-8]: Renal USG showing diffuse renal parenchymal disease. **[Table/Fig-9]:** Renal USG showing renal insufficiency. (Images from left to right)

In the current study, 26 (51.0%) neonates had serum sodium levels between 150-169, while 20 (39.2%) had levels between 145-149, and 5 (9.8%) had levels >170 mg/dL. The mean serum sodium level was 155.3±5.6 mg/dL [Table/Fig-10].

Serum sodium levels	No. of newborns	Percentage (%)
>170 mg/dL	5	9.8%
150-169 mg/dL	26	51%
145-149 mg/dL	20	39.2%

[Table/Fig-10]: Serum sodium level in newborns admitted in NICU.

In the current study, mothers of 37 (72.5%) neonates were not aware of exclusive breastfeeding (p-value <0.05), and 33 (64.7%) mothers experienced lactational failure (p-value <0.05) due to feeding problems such as faulty feeding technique, breast engorgement, inverted nipples, flat nipples, cracked nipples, breast abscess, and improper breast attachment [Table/Fig-11].

Out of the 51 cases, the maximum number of cases, 31 (60.7%), were admitted during the summer months from March to July. Eight (15.6%) cases were seen during the monsoon season, and 12 (23.5%) cases were seen during the winter months. Hypernatremic dehydration was corrected based on water deficit and solute deficit. The goal was to decrease serum (Na+) by

Factors	n (%)
Percentage of neonates whose mother not aware about exclusively breastfeeding	37 (72.5%)
Percentage of neonates whose mother having lactation failure among them Cracked nipple/breast abscess Flat/inverted nipple Improper breast feeding technique/difficulty in latching	33 (64.7%) 2 (3.9%) 18 (35.1%) 13 (25.4%)
Percentage of neonates taking improperly diluted formula milk	8 (15.6%)
Percentage of neonates developed hypernatremic dehydration in summer season	31 (60.7%)

[Table/Fig-11]: Factors contributing hypernatremic dehydration in neonates.

<10 mEq/L every 24 hours. The rehydrating fluid of choice was N/2 D5% with a total fluid requirement of 130-150 mL/kg/day, along with other electrolytes. Frequent monitoring of the serum (Na+) value was the most important component of correcting moderate or severe hypernatremia, to ensure fluid therapy could be adjusted for adequate correction without being too slow or too fast [1]. The formula (Actual Na-Desired Na/150)×1,000×percentage of total body water×weight in kg is used to determine the amount of free water needed to safely lower Na [11].

Mild metabolic acidosis is common in babies with Acute Renal Failure (ARF). If the pH is <7.2 and bicarbonate <18 mEq/L, sodium bicarbonate is given in a dose of 1-2 mEq/kg over 3-4 hours. Routine monitoring of serum sodium levels for fluid overload, hypernatremia, and intracranial haemorrhage is necessary [7].

Neonates presenting with seizures were treated with anticonvulsants like phenytoin/levetiracetam in recommended doses. Neonates with decompensated shock were treated with vasopressors like dopamine and dobutamine. In the present study, feeding was started as soon as possible, and gradually the neonates were weaned off from maintenance fluid.

DISCUSSION

Breastfeeding is considered to be the best and safest way to feed neonates. Lack of maternal knowledge about lactation, early initiation of breastfeeding, proper attachment, and failure of early postnatal follow-up have been associated with neonatal dehydration. Decreased urine frequency may be considered a warning sign of dehydration in neonates. The present study included 51 neonates, with males accounting for 58.8% and females for 41.2%. The mean age of presentation was 6.05 days (range 0-15 days), which is consistent with the findings of previous studies by Livingstone VH et al., (8 days) and Boskabadi H et al., (9 days) [8,9]. In the current study, out of the 51 patients, the mean age was 6.05 days (range 0-15 days). In a study by Bolat F et al., and Bischoff AR et al., neonates were admitted between 2 and 17 days and 1 to 17 days, respectively, with mean ages of 5 days and 4.8±3 days [10,11]. In the current study, the mean weight loss was 13.75%, ranging from 10.1% to 21%. In a study by Livingstone VH et al., the mean weight loss was 19.3% [8]. Oddie SJ reported a mean weight loss of 19.5% (range 10.34%-20.69%) [12].

In the present study, common presentations included refusal to feed (92.2%), lethargy (100%), excessive crying (96.1%), jaundice (43.1%), and fever (45.1%). Other symptoms included decreased frequency of urination (47%), breathlessness (13.7%), and seizures (7.8%). In the current study, 51% of newborns had serum sodium levels between 150 and 169, while 39.2% had levels between 145 and 149. 9.8% had levels >170 mg/dL, and the mean serum sodium level was 155.3 mEq/L. According to a study by Bilgin LK, serum sodium

levels ranged from 155 (150-190) mEq/L [13], while Yaseen H et al., found that serum sodium levels were 155 (150-196) mEq/L [14].

In the current study, out of the 51 neonates, 72.5% had mothers who were not aware of exclusive breastfeeding, with a p-value <0.05. Additionally, 35.1% of neonates had mothers with flat/inverted nipples, while 3.9% had mothers with breast abscesses or cracked nipples. 23.5% of neonates had mothers with improper breastfeeding technique/difficulty in latching, and 15.6% of neonates were being given improperly diluted formula milk.

According to the study by Boskabadi H et al., only 32% of neonates had mothers with improper feeding technique, while 27% had inverted nipples, 5.5% had breast engorgement, and 16.6% had cracked nipples. Additionally, 78.4% of neonates were breastfed with insufficient formula dilution [9]. Livingstone VH et al., found that breastfeeding issues and latching difficulties were present in 52.9% of newborns, with a p-value <0.05 [8]. According to Swathvi Kumar M et al., 75% of neonates had inadequate nutrition based on indicators of appropriate feeding. Furthermore, 16.67% of mothers with a history of insufficient feeding experienced issues with their breasts or nipples, and 4% had serious medical issues [15].

In the present study, out of the 51 neonates, 60.7% were admitted during the summer months from March to July, while 15.6% and 23.5% were admitted during the monsoon and winter seasons, respectively, with a p-value of <0.05. In a study by Kumar MS et al., out of a total of 368 neonates brought to the NICU, 49 had dehydration fever [15]. Bhat SR et al., reported that 28% of all cases occurred during the winter season, while 44.8% occurred during the summer [16].

In the current study, out of the 51 neonates, 62.7% had elevated blood urea nitrogen levels (>3mg/dL) and raised creatinine levels (>0.3 mg/dL). According to AIIMS NICU protocol guidelines, an increase in serum creatinine level >0.3 mg/dL is sufficient to diagnose Acute Kidney Injury (AKI). Renal ultrasonography showed that 2% had congenital renal malformation, 9.8% had renal parenchymal abnormalities, and 3.92% had hydronephrosis. In the study by Swathvik Kumar M et al., 75.51% of patients had elevated creatinine levels and 18.36% had AKI [15]. In the current study, 3.9% of patients had intracranial haemorrhage and cerebral oedema on cranial ultrasonography. Bolat F et al., found that 8.7% of patients had intracranial haemorrhage and cerebral oedema, while Bilgin LK reported that 3.3% had cerebral oedema on cranial ultrasonography [10,13].

Neonates with hypernatremic dehydration who were brought to the NICU were effectively treated, and 49 (96.1%) out of the total 51 neonates were discharged. However, one patient with acute renal failure was improving but had to discontinue treatment due to financial reasons. Unfortunately, one patient with acute renal failure, decompensated shock, and cerebral oedema passed away. Only 3.9% of the 49 neonates who underwent follow-up had long-term issues such as seizures, neurological disabilities, and developmental delays. These neonates exhibited symptoms such as the absence of a social smile, inability to hold their neck, lack of alertness to sound, persistent cortical thumbing, intermittent opisthotonus positioning, increased tone in the lower limbs, and seizures. Follow-up was conducted at intervals of one week, six weeks, and 14 weeks, where an MRI revealed evidence of old intraventricular haemorrhage (IVH) and cerebral oedema.

In a study by Bhat SR et al., out of 67 cases, 54 came for follow-up and developmental delay was observed in six cases (11.1%) [6].

Lactational counselling should be an essential part of antenatal care provided to pregnant women in order to prepare them for the highly beneficial activity of breastfeeding with proper technique and confidence. Efforts should be made to diagnose this condition early, such as through frequent weighing of the baby during the first two weeks of life to monitor excessive weight loss. All mothers should be taught the correct feeding method, including proper positioning and attachment. Mothers should also be educated about the signs and symptoms of dehydration before discharge. Early diagnosis and treatment are crucial for the survival and better prognosis of neonates with hypernatremic dehydration [16].

Limitation(s)

A limitation of the present study was the small sample size, which may limit the generalisability of the findings. Additionally, the study was unable to conduct long-term follow-up and assess the neurodevelopmental outcomes of the patients, as they frequently relocated to new locations every few years. Therefore, further studies are needed from diverse cross-sections of society to determine the long-term outcomes and prognosis of such patients.

CONCLUSION(S)

Within the limitations of the present study, it can be concluded that neonatal hypernatremia is a preventable and treatable condition. The study found a high frequency of hypernatremic dehydration in neonates during the summer months. It is crucial to establish successful nursing interventions in the first week of life, as poor feeding and weight loss in an otherwise healthy neonate may indicate the presence of hypernatremia. Early diagnosis and appropriate treatment are key factors for a better prognosis. While the study highlights the association between inadequate breastfeeding and hypernatremic dehydration, breastfeeding should still be encouraged as the preferred method of feeding newborns. Prior to discharge from the hospital, women should be informed about the warning signs and symptoms of dehydration, adequate urine production, and expected weight loss. Early discharge policies should include follow-up at the well-baby clinic to identify breastfeeding problems that could lead to hypernatremia, and prompt corrective actions should be taken to prevent any adverse consequences.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 08, 2023
- Manual Googling: Jul 10, 2023
- iThenticate Software: Jul 12, 2023 (8%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Apr 05, 2023**
Date of Peer Review: **May 11, 2023**
Date of Acceptance: **Jul 13, 2023**
Date of Publishing: **Dec 31, 2023**