Original Article

HEALTH SCIENCES MEDICINE

DOI: 10.32322/jhsm.1250219

J Health Sci Med 2023; 6(3): 579-585

Retrospective analysis of 102 neonatal cases hospitalized with diagnosis of the ongoing phenomenon of neonatal period: hypernatremic dehydration

Mine Özdil, Gonca Vardar

Division of Neonatology, Department of Pediatrics, Atatürk City Hospital, Balıkesir, Turkey

Cite this article as: Özdil M, Vardar G. Retrospective analysis of 102 neonatal cases hospitalized with diagnosis of the ongoing phenomenon of neonatal period: hypernatremic dehydration. J Health Sci Med 2023; 6(3): 579-585.

Received: 13.02.2023 ◆ **Accepted**: 18.04.2023 ◆ **Published**: 31.05.2023

ABSTRACT

Aim: The aim of this study was to examine the prevalence of hypernatremic dehydration (HD) among term neonates admitted to a tertiary care unit over a three-year period and to identify mother and neonate related risk factors associated with HD.

Material and Method: Medical records of 102 term babies and their mothers were analyzed retrospectively. The gender, weight at birth, type of birth, postnatal day of diagnosis, weight and weight loss percentage at diagnosis, season and presenting complaint upon admission, feeding with human milk/formula/mixed, laboratory findings, usage of antibiotics as well as maternal age, parity, residence, level of education and presence of smoking were recorded. Serum sodium (Na) levels, severity of dehydration, age on admission, and length of stay in the neonatal intensive care unit (NICU) were recorded along with any significant effect of maternal demographic properties, residence, season, gender, and type of birth.

Results: The average Na levels were found to be 152.1±4.2 mEq/L (max:166 mEq/L). Mild, moderate and severe hypernatremia were found in 34 (33%), 62 (61%) and 6 (6%) patients, respectively. More weight loss was observed in neonates born via cesarean section vs. vaginal delivery (12.8±3.0% vs. 11.6±3.5%, p=0.01). Higher serum Na levels (153.9±4.86 mEq/L vs. 151±2.34 mEq/L, p=0.008) and a greater median age at admission (4.5 [IQR4-6]) days vs. 3 [IQR3-4]) days, p=0.03) were reported for neonates born to mothers residing in rural/suburban vs. urban areas. Serum Na levels were not different based on the mother's level of education or parity (p=0.96 and p=0.29, respectively). There was no difference in serum Na levels (p=0.05) but the percentage of weight loss was higher when the mother smoked (14.3±3.8% vs. 11.7±3.1%, p=0.003). Serum Na and glucose levels were lower, antibiotics usage rates, and prevalence of mixed feedings were higher in early term infants (p=0.01, p=0.002, p=0.04 and p=0.04, respectively). Males had higher creatinine levels (0.89±0.27 mg/dl vs. 0.78±0.28 mg/dl, p=0.005), but there was no difference between the sexes in terms of day of admission, percentage of weight loss, or length of stay in NICU.

Conclusion: Hypernatremic dehydration is a significant and increasingly prevalent problem of neonatal period. Serum Na levels and severity of dehydration in neonates may be affected by the type of birth, mother's smoking status, residence and early term birth. Counseling on breastfeeding, education of health professionals and caregivers on the signs and symptoms of dehydration, and monitoring of body weight are essential for the prevention, diagnosis, and treatment of HD.

Keywords: Newborn, dehydration, hypernatremia, breastfeeding, weight loss

INTRODUCTION

Breastfeeding is the best and most accepted way of feeding for all neonates with proven health benefits and neonates should only be breastfed in the first 6 months of life (1). However, insufficient breastfeeding, lactation failure and as a result breastfeeding malnutrition may end with dehydration in some of the neonates (2). literature added

Dehydration can be classified according to the serum osmolality as isotonic, hypotonic and hypertonic, as the latter being most dangerous. Neonatal hypernatremia is defined as serum sodium (Na) levels greater than 145mEq/L (3) and is subdivided as mild (145-149 mEq/L), moderate (150-159 mEq/L) and severe (>160 mEq/L) (4). Hypernatremic dehydration (HD) is a well-known, historical and ongoing entity of the neonatal period, but the incidence is reported to be increasing in last two decades, owing to increased awareness of the disease and its complications and promotion of breastfeeding as the predominant form of newborn feeding in accordance with baby-friendly hospital initiative policies (5).

Corresponding Author: Mine ÖZDİL, mineozdil81@hotmail.com

The body and skin characteristics of newborns make them more susceptible to developing HD. The immaturity of the skin barrier, increased extrarenal losses due to greater surface area and decreased capacity of urinary concentration are the accused mechanisms in development of hypernatremia (6). Causes of HD in neonatal period are low fluid intake (hypoalimentation), increased insensible water loss, gastrointestinal losses and renal free water loss in excess of Na, or combination of these (7).

In the first few days of life, breastfeeding can lead to a mild but tolerable dehydration. However, premature hospital discharges without effective lactation support, education, and adequate follow-up, lactation failure with ineffective milk production, and inadequate or suboptimal breastfeeding may result in HD (8,9). In addition, decreased feeding frequency due to neonatal and/or maternal factors, such as infection, stress, mastitis, or flat/inverted nipples, may be superimposing factors in the development of a more severe dehydration and hypernatremia (10,11). Approximately 35% of exclusively breastfed neonates who lost more than 10% of their birth weight in the first few days were found to have hypernatremia (12).

In HD, the clinical manifestations of dehydration, such as tachycardia, decreased skin turgor, and hypotension, are less common because extracellular fluid and plasma volumes are relatively preserved, but intravascular shrinkage occurs (7). Due to the less pronounced signs of dehydration and the absence of routine screening of serum Na levels in the first days of life, dehydration can be difficult to diagnose and is probably more common than reported (13). If neonatal HD is not diagnosed and treated promptly, it can be fatal. It can lead to transaminitis, metabolic acidosis, seizures, venous sinus thrombosis, pontine myelinolysis, permanent brain damage, disseminated intravascular coagulation, acute kidney injury, and even death (14). Both the condition and its complications, as well as the rapid treatment of hypernatremia, may result in severe injury.

The aim of the present study was to examine the clinical characteristics of neonates diagnosed with HD and hospitalized in the neonatal intensive care unit (NICU), as well as to search for any association between maternal-neonatal risk factors and serum Na levels, severity of dehydration, age at admission, and length of NICU stay.

MATERIAL AND METHOD

Ethics approval for the study was granted by the İstanbul Medipol University Non-Interventional Researches Ethics Committee (Date: 03.06.2021, Decision No: 615). No written informed consent was obtained because of the retrospective design of the study. Permission for the study was obtained from Balıkesir Provincial Health Directorate and Atatürk City Hospital (E-51829602-604.01.02). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Data Collection

This retrospective study was conducted in 102 term neonates who were diagnosed with HD and hospitalized to NICU of Balıkesir Atatürk City Hospital between October 2018- June 2021. Neonates with a Na level above 145 mEq/L and with a weight loss above 7% were included, patients with underlying congenital malformations, chromosomal anomalies or metabolic/neurological diseases such as hypotonia, traumatic birth, hypoxic ischemic encephalopathy, a history of diarrhea and babies with gestational weeks <37 were excluded from the study. Medical files of the neonates and their mothers were evaluated retrospectively. Information regarding the neonates' gender, gestational age (weeks), type of birth (cesarean or normal vaginal delivery), birth weight (gr); postnatal day, season and weight loss percentage on admission; feeding source (human milk/formula/mixed), laboratory findings (Na, potassium, urea, creatinine, transaminases, total and direct bilirubin, uric acid, albumin, glucose levels, complete blood count) and blood gases analyses (acidosis/alkalosis, lactate, base excess, methemoglobin and carboxyhemoglobin levels); duration of intravenous fluids and correction of hypernatremia, presence of C reactive protein (CRP) positivity and antibiotic usage, and the presenting complaint on admission to emergency department, any pathologic findings on abdomen and transfontanelle ultrasound, presence of ABO and/or Rh incompatibility and presence of early term births (i.e. gestational weeks between 37 and 38+6/7) were recorded. Degree of hypernatremia was defined as mild (145-149 mEq/L), moderate (150-159 mEq/L) and severe (≥ 160mEq/L) according to Na levels (3). The risk factors of HD, including maternal age, parity, residence (urban or suburban/rural), level of education, presence of smoking, gender and gestational age of the neonate, type of birth, and any significant effect of these factors on serum Na levels, length of NICU stay, and percentage of weight loss were recorded.

Our NICU's protocol for treating hypernatremic dehydrated neonates entails administering saline solutions with a Na concentration of 0.45–0.9% and initiating breastfeeding as soon as possible. Severely dehydrated infants receive an additional initial bolus of 15-20 ml/kg 0.9% saline.

Statistical Analysis

Data was analysed using SPSS software version 24 (SPSS Inc. Chicago, Illinois, USA) program. Categorical data were presented with n and %, and numerical data with mean ± standard deviation if normally distributed, and median (IQR) if non-normally distributed. Mann-

Whitney U-test was used in comparison of independent two goups. In comparison of independent four groups with non-normally distributed data, Kruskal Wallis test was used. Spearman and Pearson correlation tests were used for the correlation analysis. Statistical significance was set as p<0.05.

RESULTS

The rate of hospitalized infants with a diagnosis of HD was 4.2% among hospitalized newborns. The mean serum Na level was detected as 152.1±4.2 mEq/L, with the highest level being 166 mEq/L. Mild, moderate and severe hypernatremia was found in 34 (33%), 62 (61%) and 6 (6%) patients, respectively. Eighty seven patients (86%) were admitted from home, and the remaining 15 patients (14%) were admitted from the postnatal ward. The mean birth weight was 3336±461g, weight on hospital admission 2932±421g, weight loss percentage was 12±3.3%, median gestational weeks at birth was 39 (IQR 38-40) weeks, postnatal age on admission was 3.2 (IQR 3-5) days, duration of intravenous fluids 48 (IQR 24-48) hours, mean correction of hypernatremia was 36,4±17.89 hours and the average length of NICU stay was 7.2±3.2 days. Maternal demographic features are presented in **Table 1**. Laboratory findings of hypernatremic neonates are shown in detail in **Table 2**.

Table 1. Maternal demographic characteristics of neonates with hypernatremic dehydration

Gestational age (weeks)	39 (38-40)
Maternal age(yrs)	27.4 (±4.29)
Maternal level of education	
None or primary	22 (22%)
Secondary and high school	46 (45%)
University and doctorate	34 (33%)
Residence	
Urban	67 (66%)
Suburban and rural	35 (34%)
Parity	
Primiparous	75 (74%)
Multiparous	27 (26%)
Type of birth	
Vaginal delivery	55 (54%)
Cesarean section	47 (46%)
Maternal smoking	19 (18.6%)
Feeding	
Breastfeeding	92 (90%)
Formula feeding	-
Mixed	10 (10%)
Season on admission	
Winter	34 (33%)
Spring	14 (14%)
Summer	28 (27%)
Autumn	26 (26%)

Values expressed as median (interquartile range), n (%) or mean (± std).

Table 2. Laboratory findings of neonates with hypernatremic dehydration

Parameter	Mean ± standard deviation
WBC (cells/mm3)	12981±3964
Hemoglobin (g/dl)	17.35±2.37
Hematocrite (%)	50.9±6.34
Platelet count (cells/mm3)	298030±94534
Sodium (mEq/L)	152.1±4.2
Potassium (mEq/L)	4.8±0.4
Glucose (mg/dl)	60±16
Urea (mg/dl)	54.2±36.9
Creatinine (mg/dl)	0.83±0.28
AST (IU/L)	52.6±25,3
ALT (IU/L)	21±15.4
Total bilirubin (mg/dl)	13.3±5.3
Direct bilirubin (mg/dl)	0.6±0.23
Albumin (g/dl)	4.1±0.36
Uric acid (mg/dl)	6.5±2.1
pH	7.37±0.6
Lactate	3.4±1.2
Base excess	-5.9±-3.1
Methemoglobin	2.2±1.5
Carboxyhemoglobin	1.25±0.6

WBC: White blood cell count, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase

Males and females made up an equal number of newborns, with each constituting 50% of the total. Thirty seven babies (38%) were born early term. The presenting complaint on admission was poor oral intake in 59 (58%), jaundice in 54 (53%), fever in 37 (36%), irritability in 33 (32%) and red color changes in diapers in 6 (6%) patients. Only 20% of infants tested positive for CRP, whereas 48% of infants were administered antibiotics. Ultrasonographic examination was performed in 61 (60%) neonates, nephrocalcinosis was detected in 10 (9.8%). No anomaly was detected by transfontanelle ultrasound. Cranial magnetic resonance imaging was performed in three patients with severe hypernatremia and no pathology was detected. Major blood group (ABO/Rh) incompatibility was detected in 17 (16.5%) neonates. There was no significant difference between neonates with and without major blood group incompatibility in terms of serum Na concentrations and percentages of weight loss (152.5±3.5mEq/L vs. 152.2±4.3mEq/l and 11.4±1.7% vs. 12.3±3.5%, p=0.52 and p=0.68, respectively), but postnatal day on admission was significantly lower in neonates with major blood group incompatibility (median 3 [IQR 2-3] days vs. 4 [IQR 3-5] days, p=0.003) and methemoglobin levels were significantly higher (2.2±1.5 vs. 1.2±0.25, p=0.006).

Serum Na levels significantly correlated with postnatal day on admission (r=0.433, p<0.001), weight loss percentage (r=0.522, p<0.001), duration of intravenous fluids (r=0.216, p=0.003), urea levels (r=0.380, p<0.001), creatinine levels (r=0.220, p=0.03), albumin levels (r=0.317, p=0.002) and living in rural/suburban areas (r=0.320, p=0.001). There was a significant correlation between percentages of weight loss and thrombocyte levels (r=0.297, p=0.03) and a significant inverse correlation between weight loss percentages and pH levels of blood gases (r=-0.270, p=0.03). Neonates of mothers living in rural/suburban communities had significantly higher serum Na levels (**Table 3**). No significant correlation was found between weight loss percentage and birth type, gender, gestational age, or occupation (**Table 3**). There was no correlation between maternal age and serum Na levels, percentage of weight loss, postnatal day on admission, or length of NICU stay (r=0.044, p=0.67; r=-0.530, p=0.61; r=-0.155, p=0.13; r=0.170, p=0.10, respectively).

Cesarean-delivered infants exhibited greater weight loss (12.83.0% vs. 11.63.5%, p=0.01), were born to mothers with a higher level of education (88.6% non-primary vs. 68.1% mid-high graduate, p=0.02), and had higher bilirubin levels (14.2±5.2 mg/dl vs. 11.2±5.2 mg/dl, p=0.04). The serum Na levels, postnatal day on admission, and hematocrit levels (52.1±6.2% vs. 50.1±6.3%, p=0.04) of rural and suburban newborns were significantly higher than those of urban newborns (**Table 3**). There was no significant difference between maternal education levels and serum Na levels, percentage of weight loss, postnatal day at admission, or length of NICU stay (**Table 3**). In babies born to mothers who smoked, the rate of weight loss was statistically significantly higher and serum sodium levels were higher but not statistically significant (**Table 3**). Blood gas analyses, including carbon monoxide and methemoglobin levels, revealed no significant differences between babies born to smoking vs. non-smoking mothers (1.18±0.64 vs. 1.26±0.63 and 2.0±0.73 vs. 2.0±1.50, p=0.54 and p=0.67, respectively). There was no significant difference in serum Na levels, postnatal day on admission, between primiparous and multiparous mothers. Comparing the percentages of weight loss and length of NICU stays for primiparous and multiparous mothers is presented in **Table 3**.

Early term infants were found to have lower Na levels (151.1±3.4 mEq/L vs. 153.4±4.5 mEq/L, p=0.01), higher methemoglobin levels on blood gases (2.4±2.0 vs. 1.6±0.6, p=0.02), lower blood glucose levels (53±15 mg/dl vs. 64±16 mg/dl, p=0.002), higher antibiotic usage rates (61% vs. 41%, p=0.04) and fed with mixed diet (4/37 vs. 6/65, p=0.04). There were no statistically significant gender differences in percentage of weight loss, postnatal day on admission, or length of NICU stay; however, creatinine was significantly higher in males (0.76±0.28 mg/dl vs. 0.89±0.28 mg/dl, p=0.005 and **Table 3**).

DISCUSSION

American Academy of Pediatrics recommends neonates with weight loss exceeding 7% of their weights evaluated promptly for medical history, physical examination of baby and mothers' breast, observation of breastfeeding and laboratory findings if necessary (15). The exact incidence of neonatal HD is difficult to evaluate due to differences in geographical location, limited availability of hospital and postdischarge data (6). Incidence of

Table 3. The effect of maternal-neonatal risk factors on serum Na levels, weight loss percentages, postnatal day on admission and length of NICU stay.

	Serum Na level mEq/L	Weight loss percentage %	Postnatal day on admission (day)	Length of NICU stay (day)
Parity				
Primiparous	152.2±4.2	12.2±3.3	4 (3-5)	7 (5-8)
Multiparous	152.5±4.0	12.3±3.5	4 (3-5)	7 (5-8)
Type of birth				
Cesarean section	152.1±4.4	12.8±3.0[a]	3.5 (3-5)	6 (5-8)
Vaginal delivery	152.3±4.0	11.6±3.5[a]	4 (3-5)	7 (5-9)
Gender				
Female	152.4±4.0	12.5±3.3	3 (3-5)	7 (5-8)
Male	152.0±4.1	11.9±3.2	4 (3-5)	7 (5-8)
Maternal level of education				
None or primary	152.7±4.8	11.9±37	4 (3-5)	6 (4-7)
Secondary/high school	152.5±5.1	12.8±3.8	4 (3-5)	7 (7-8)
University/doctorate	151.7±2.3	11.8±2.3	3.75 (3-4.25)	7 (5-8)
Maternal smoking				
Yes	154.6±5.8[b]	14.3±3.8[c]	4 (3-5)	7 (5-8)
No	151.7±3.6[b]	11.7±3.1[c]	4 (3-5)	7 (5-9)
Occupation				
Rural/suburban	153.9±4.8[d]	12.9±3.8	4.5 (4-6)[e]	7 (5-8)
Urban	151.2±3.4[d]	11.7±2.9	3 (3-4)[e]	7 (5-9)

Values expressed as median (interquartile range) or mean (± std), [a]Comparison of two yielded a p-value=0.01, [b]Comparison of two yielded a p-value=0.05, [c]Comparison of two yielded a p-value=0.003, [d]Comparison of two yielded a p-value=0.008, [e]Comparison of two yielded a p-value=0.02

neonatal HD in postdischarge neonates may range between 1% to 5.6% (16, 17). A retrospective study including 3718 neonates within 28 days of life hospitalized to a tertiary care center between 1997 and 2001 reported incidence of breastfeeding-associated hypernatremic hypovolemia as 1.9 percent (18). Another retrospective study from a different region of our country reported the frequency of HD in all live, healthy term births and in all hospitalized children as 0.7 and 3.1, respectively (19). The rate of hospitalized infants with the diagnosis of HD was 4.2% of all hospitalized newborns. Our study, similar to majority of literature, gives data of hospitalized children. The true incidence of HD in all live births could not be determined because there is no screening for hypernatremia in the first week of life and not all babies born in our hospital present to our hospital for control visits and/or hospitalization. Therefore the true incidence of HD could be much more than reported due to missing and undiagnosed cases.

Approximately 15% of exclusively breastfed infants exhibit excessive weight loss (>10% of birth weight), resulting in hypernatremia in a third of these infants (20). Multiple studies have demonstrated that approximately 95% to 98% of hypernatremia occurs in exclusively or near-exclusively breastfed infants (21, 22), similar to the findings of the present study in which 92% of infants were exclusively breastfed and only 8% were fed a mixed diet. Bhat et al. (23) also reported that exclusively breastfed neonates could lose more than 10% of their weight per day with a frequency of 6.8% and less than 5% per day with a frequency of 24.7%, respectively. In contrast, the study conducted by Gonzalez et al. (5) found comparable rates of HD in neonates who were exclusively breastfed or mixed-fed.

Multiple studies to date have sought to determine the risk factors for developing hypernatremia. Maternal social and biological risk factors may be involved in lactation and breastfeeding interference, thereby contributing to the development of HD. Age, level of education, and experience with child care can affect the intervention of caregivers (mothers). Primiparity has been cited in the majority of studies as one of the most significant risk factors for the development of HD, reflecting the lack of experience and failure to recognize the symptoms and severity of dehydration (14,20,24). Surprisingly, another study identified multiparity as a risk factor for HD, in contrast to the literature which suggests that primiparity causes delayed and inadequate lactogenesis. The investigators concluded that primiparous mothers were monitored more closely during the first postnatal days (4). In our study, the vast majority of mothers (74%) were primiparous, indicating likely less experience with breastfeeding and recognizing the signs of dehydration. However, there was no correlation between parity and serum Na levels, degree of dehydration, or postnatal day at admission; but bilirubin levels were statistically greater in primiparous mothers.

Regarding the association between the mother's level of education and HD, contradictory results have been reported in the literature. Some studies demonstrated that mothers of dehydrated newborns have a low level of education (25-27). On the other hand, Gonzalez et al. (5). demonstrated that having a mother with a higher level of education increases the risk of hypernatremia, which may be explained by the increased willingness of highly educated mothers to breastfeed exclusively. Several studies have found no correlation between maternal education and the degree of dehydration of their offspring (28, 29). Maternal age has also been considered a significant factor in dehydration and hypernatremia (30). In our study, we did not find any correlation between maternal age, education level, serum Na levels, and weight loss percentages.

Due to the inability to breastfeed, cesarean section has been regarded as a significant risk factor for HD in newborns (4,30). Evans et al. (31) found that during the first six days of life, infants born via cesarean delivery received less milk than those born vaginally. Nonetheless, a number of studies found no correlation between type of delivery and serum Na levels and dehydration (14,28). In our study, babies born via cesarean section had greater weight loss than those born vaginally, but there was no difference in Na levels. Data favoring males for the development of HD predominate in the scientific literature (4,14,26). This difference has been attributed to organ immaturity and greater oxidative stress in male infants by Diaz Castro et al. (32). In our study, we found no difference between males and females in terms of Na levels, percentages of weight loss, or laboratory findings, with the exception of males' statistically higher creatinine levels, which most likely indicated a greater muscle mass.

Akgün et al. (25) reported that HD is more prevalent in warm seasons, whereas another study found that the incidence of significant weight loss, clinical dehydration, hypernatremia, and hyperbilirubinemia was higher in the warm months, but the difference was not statistically significant (23). In contrast, Uras et al. (17) determined that season is not a risk factor for the development of HD. In contrast to the majority of literature, the majority of patients in this study were admitted during cold seasons, and we did not find a correlation between serum levels, dehydration severity, and seasons. There are few data regarding the association between neonatal HD and residence (urban/rural). In our study, neonates whose mothers lived in rural and suburban areas had higher serum Na and hematocrit levels and were admitted to the emergency department later than those whose mothers lived in urban areas, likely indicating a delay in care-seeking for infants with signs and symptoms of dehydration.

Clinical manifestations of HD may include jaundice, fever, poor oral intake, decreased urinary output, irritability, and lethargy; however, these symptoms are nonspecific and may be indicative of a variety of diseases in neonates (12). Being a sleepy, quiet infant can delay the diagnosis of HD. As a result of fluid shift from intracellular to extracellular areas, clinical findings can be sparse and may be more noticeable in the advanced stages of dehydration. In a study involving 159 newborns, fever and jaundice were the most prevalent symptoms upon admission (19). In the study by Akdeniz et al. (33), decreased sucking was the most prevalent symptom. In our study, poor oral intake (58%) was the most prevalent symptom, followed by jaundice (53%) and fever (36%). In the present study, platelet levels were positively correlated with weight loss percentages, while pH levels of blood gases analyses were negatively correlated. However, there was no correlation between thrombocyte levels and serum Na levels. On the other hand, Boskabadi et al. (34) have demonstrated a strong correlation between hypernatremia and thrombocytopenia and a poorer prognosis and significantly more complications in thrombocytopenia patients. Babies born early term were found to have significantly lower serum sodium and glucose levels, higher antimicrobial usage rates, and a higher frequency of mixed feeding. These results could be explained by their low birth weights and feeding difficulties compared to more mature term infants, and the likelihood that their families brought them to the hospital sooner.

In pediatric patients, diarrhea and sepsis are known to cause acquired methemoglobinemia (35). In our study, the methemoglobin levels of CRP-positive patients did not differ from those of CRP-negative patients, but there was a correlation with hospitalization day and weight loss percentages, which may reflect the degree of dehydration, however, there was no correlation between methemoglobin and sodium levels. Maternal exposure to tobacco smoke in pregnancy has been linked to preterm birth, neonatal mortality, fetal growth retardation and sudden infant death syndrome (36), but there are no data about the relationship between maternal smoking and neonatal HD. Present study founded significantly higher percentages of weight loss and non-significant higher serum Na levels in neonates of smoking mothers, but there was no significant difference between carbonmonoxide levels in neonates of smoking and non smoking mothers. Our findings regarding the effects of maternal smoking on neonatal dehydration and hypernatremia are comparable to those of Mennella et al. (37), who found that smoking mothers were less likely to breastfeed and that smoking could have dose-dependent negative effects on lactation.

This study has some limitations. Although the clinical significance of elevated breast milk Na levels is not well explained, they have been linked to lactation failure (38). The inability to test breast milk samples for sodium levels is one of the limitations of the current study. And the study demonstrates the results of hospitalized neonates, probably representing the visible part of the iceberg, because there is no hypernatremia screening policy. Nearly half of infants with hypernatremia >150 mEq/L have abnormal developmental scores at 12 months of age, while 21% of infants have developmental delay at 12 months, 19% at 18 months, and 12% at 24 months (39, 40). Unfortunately, we have no information about the long-term neurological development of HD infants in their most crucial first three years of life.

CONCLUSION

Hypernatremic dehydration, despite its life-threatening complications, is a preventable and treatable disease of previously healthy infants. During the first two to four days, it is vital to assess the infant and observe breastfeeding and mother-infant feeding interaction. Important in the development of dehydration and HD are maternal social-biological and neonatal risk factors such as residence (rural/suburban living), maternal smoking, being an early term baby, and being born via cesarean section. Proper education and sensitization of mothers regarding the signs of dehydration, recognition of problems associated with breast-feeding, and maintenance of early control visits in the 2-4 days after early discharges, before dehydration occurs, are crucial for the identification of potential cases carrying risk factors.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of İstanbul Medipol University Non-Interventional Researches Ethics Committee (Date: 03.06.2021, Decision No: 615).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. World Health Organization. The Optimal Duration of Exclusive Breastfeeding: Report of the Expert Consultation. Geneva: World Health Organization, 2001.
2. Livingstone VH, Willis CE, Abdel-Wareth LO, Thiessen P, Lockitch G. Neonatal hypernatremic dehydration associated with breast-feeding malnutrition: a retrospective survey. CMAJ 2000; 162(5): 647-52.
3. Adrogué HJ, Madias NE. Hypernatremia. N Engl J Med 2000; 342: 1493–9.
4. Konetzny G, Bucher HU, Arlettaz R. Prevention of hypernatraemic dehydration in breastfed newborn infants by daily weighing. Eur J Pediatr 2009; 168: 815-8.
5. Ferrández-González M, Bosch-Giménez V, López-Lozano J, Moreno-López N, Palazón-Bru A, Cortés-Castell E. Weight loss thresholds to detect early hypernatremia in newborns. J Pediatr (Rio J) 2019; 95: 689-5.
6. Tomarelli G, Arriagada D, Donoso A, Diaz F. Extreme Neonatal Hypernatremia and Acute Kidney Injury Associated with Failure of Lactation. J Pediatr Intensive Care 2020; 9: 124-7.
7. Durrani NUR, Imam AA, Soni N. Hypernatremia in Newborns: A Practical Approach to Management. Biomed Hub 2022; 7: 55-69.
8. Dewey KG, Nommsen-Rivers LA, Heinig MJ, Cohen RJ. Risk factors for suboptimal infant breastfeeding behaviour, delayed onset of lactation, and excess neonatal weight loss. Pediatrics 2003; 112: 607–19.
9. Taylor D, Durward A. Pouring salt on troubled waters. Arch Dis Child 2004; 89: 411–4.
10. Sofer S, Ben-Ezer D, Dagan R. Early severe dehydration in young breast-fed newborn infants. Isr J Med Sci 1993; 29: 85–9.
11. Rowland TW, Zori RT, Lafleur WR, Reiter EO. Malnutrition and hypernatremic dehydration in breast-fed infants. JAMA 1982; 247: 1016–7.
12. Manganaro R, Marseglia L, Mamì C et al. Breast milk sodium concentration, sodium intake and weight loss in breast-feeding newborn infants. Br J Nutr 2007; 97: 344–8.
13. Bischoff AR, Dornelles AD, Carvalho CG. Treatment of hypernatremia in breastfeeding neonates: a systematic review. Biomed Hub 2017; 2: 1-10.
14. Unal S, Arhan E, Kara N, Uncu N, Aliefendioğlu D. Breast feeding associated hypernatremia: Retrospective analysis of 169 term newborns. Pediatr Int 2008; 50: 29-34.
15. Zanardo V, Pigozzo A, Wainer G, et al. Early lactation failure and formula adoption after elective caesarean delivery: cohort study. Arch Dis Child Fetal Neonatal Ed 2013; 98: F37.
16. Ergenekon E, Unal S, Gücüyener K, et al. Hypernatremic dehydration in the newborn period and longterm follow up. Pediatr Int 2007; 49: 19–23.
17. Uras N, Karadag A, Dogan G, Tonbul A, Tatli MM. Moderate hypernatremic dehydration in newborn infants: retrospective evaluation of 64 cases. J Matern Fetal Neonatal Med 2007; 20: 449–52.
18. Moritz ML, Manole MD, Bogen DL, Ayus JC. Breastfeeding-associated hypernatremia: are we missing the diagnosis? Pediatrics 2005; 116: e343.
19. Ünver Korğalı E, Cihan MK, Oğuzalp T, Şahinbaş A, Ekici M. Hypernatremic dehydration in breastfed term infants: retrospective evaluation of 159 cases. Breastfeed Med 2016; 12: 1-7.
20. Manganaro R, Mamì C, Marrone T, Marseglia L, Gemelli M. Incidence of dehydration and hypernatremia in exclusively breast-fed infants. J Pediatr 2001; 139: 673–5.
21. Oddie SJ, Craven V, Deakin K, Westman J, Scally A. Severe neonatal hypernatraemia: a population-based study. Arch Dis Child Fetal Neonatal Ed 2013; 98: 384-7.
22. Boskabadi H, Maamouri G, Ebrahimi M, et al. Neonatal hypernatremia and dehydration in infants receiving inadequate breastfeeding. Asia Pac J Clin Nutr 2010; 19: 301-7.
23. Bhat SR, Lewis P, David A, Liza SM. Dehydration and hypernatremia in breast-fed term healthy neonates. Indian J Pediatr 2006; 73: 39-41.
24. Escobar GJ, Gonzales VM, Armstrong MA. Rehospitalization for neonatal dehydration: A nested case-control study. Arch Pediatr Adolesc Med 2002; 156: 155–61.
25. Akgün A, Katar S, Taşkesen M, Obek MN. Yenidoğan döneminde önemli bir sorun: hipernatremik dehidratasyon. Göztepe Med J 2010; 25: 126-31.
26. Bülbül A, Can E, Uslu S, Nuhoglu A. Hypernatremic dehydration in term infants. Turk Arch Ped 2009; 44: 84-8.
27. Yaseen H, Salem M, Darwich M. Clinical presentation of hypernatremic dehydration in exclusively breast-fed neonates. Indian J Pediatr 2004; 71: 1059-62.
28. Tayman C, Tonbul A, Aydemir S, Kösüs A, Tatlı MM. Clinical findings and treatment recommendations of hypernatremic dehydration due to breast milk. Dicle Med J 2010; 37: 254-62.
29. Keleş-Alp E. Retrospective evaluation of newborn cases who were followed up with the diagnosis of hypernatremic dehydration. Genel Tıp Derg 2022; 32: 55-60.
30. van Dommelen P, Boer S, Unal S, van Wouwe JP. Charts for weight loss to detect hypernatremic dehydration and prevent formula supplementing. Birth 2014; 41:153-9.
31. Evans KC, Evans RG, Royal R, Esterman AJ, James SL. Effect of caesarean section on breast milk transfer to the normal term newborn over the first week of life. Arch Dis Child Fetal Neonatal Ed 2003; 88: F380-2.
32. Diaz-Castro J, Pulido-Moran M, Moreno-Fernandez J, et al. Gender specific differences in oxidative stress and inflammatory signaling in healthy term neonates and their mothers. Pediatr Res 2016; 80: 595-601.
33. Akdeniz O, Celik M, Samancı S. Evaluation of term newborn patients with hypernatremic dehydration. Turk Arch Pediatr 2021; 56: 344-9.
34. Boskabadi H, Rakhshanizadeh F. Neonatal hypernatremic dehydration and thrombocytopenia: its prevalence and relationship with prognosis. Iran J Pediatr 2018; 28: e65742.
35. Ash-Bernal R, Wise R, Wright S. Acquired Methemoglobinemia: A Retrospective Series of 138 Cases at 2 Teaching Hospitals. Medicine 2004; 83: 265-73.
36. Banderali G, Martelli A, Landi M, et al. Short and long term health effects of parental tobacco smoking during pregnancy and lactation: a descriptive review. J Transl Med 2015; 13: 327.
37. Mennella JA, Yourshaw LM, Morgan LK. Breastfeeding and smoking: short-term effects on infant feeding and sleep. Pediatrics 2007; 120: 497-502.
38. Humenick SS, Hill PD, Thompson J, Hart AM. Breast-milk sodium as a predictor of breastfeeding patterns. Can J Nurs Res 1998; 30: 67-81.
39. Koklu E, Gunes T, Ozturk MA, Kose M, Kurtoglu S, Yuksel F. A review of 116 cases of breastfeeding-associated hypernatremia in rural area of central Turkey. J Trop Pediatr 2007; 53: 347-50.
40. Boskabadi H, Akhondian J, Afarideh M, et al. Long-term neurodevelopmental outcome of neonates with hypernatremic dehydration. Breastfeed Med 2017; 12: 163-8.