Iran J Pediatr. 2023 April; 33(2):e129542. https://doi.org/10.5812/ijp-129542.

Published online 2023 March 21.

Case Report

Management of Hypernatremia Dehydration in Three Neonates with Ichthyosis

Razieh Sangsari [1, 2], Maryam Saeedi [1, 2] and Kayvan Mirnia [1, 2, *]

[1] Department of Pediatrics, Tehran University of Medical Sciences, Tehran, Iran
[2] Division of Neonatology, Children's Medical Center, Pediatric Center of Excellence, Tehran, Iran

[*] *Corresponding author*: Division of Neonatology, Faculty of Medicine, Children's Medical Center, Pediatric Center of Excellence, Tehran, Iran. Email: kayvanmirnia@yahoo.com

Received 2022 July 02; **Revised** 2022 September 11; **Accepted** 2023 January 27.

Abstract

Introduction: Ichthyosis is an epidermal disruption that increases insensible water loss. Hypernatremic dehydration is a consequence of skin disruption. This study reviewed the treatment of hypernatremic dehydration in patients with ichthyosis comparing to patients with intact skin.
Case Presentation: We studied five neonates with hypernatremia, including three ichthyosis cases and two normal-skin neonates. This case-series study showed that the sodium correction rate is slower in infants with ichthyosis than in infants with normal skin. The first and second neonates needed less sodium than fluid intake than normal skin infants, although fluid requirement was lower in the third ichthyosis infant than in others due to less skin disruption in this infant.
Conclusions: Fluid therapy in hypernatremic dehydration in ichthyosis patients is different from neonates with intact skin because of excessive insensible water loss in these patients. It may be needed to give more fluid and less sodium depending on the degree of skin disruption, which may not be determined by physical examination.

Keywords: Ichthyosis, Hypernatremia, Dehydration, Fluid Therapy

1. Introduction

Ichthyosis is a Mendelian disorder of skin cornification. It often presents in the neonatal period (1). The disruption of skin cornification disrupts the skin's barrier protection and produces high sensible water loss instead of insensible water loss (IWL) of normal skin, among other complications (2). Sensible water loss in these patients may exceed six-fold the IWL of normal skin (3). It results in hypernatremia dehydration (4), which can be a significant complication. Serum sodium concentration may be very high, producing persistent convulsions and subsequent sequels (5). Death or seizure may proceed if the serum sodium level exceeds 160 mmol/L (6).

Weighing babies during breastfeeding leads to the early recognition of dehydration and prevents hypernatremia in these infants (7). Moreover, skin care in patients with humidification and emollitions decreases sensible water loss, decreasing dehydration and hypernatremia (1). However, if hypernatremia exists, what is the best way of fluid therapy? Is fluid treatment in these patients the same as in normal skin neonates? There are some studies about hypernatremia treatment in neonates, but the survey about treating hypernatremia in ichthyosis infants is limited. This article reviews the treatment of some hypernatremic ichthyosis and hypernatremic normal skin neonates and compares them. We hypothesized a high-water loss from disrupted epidermal in ichthyosis, so it might be necessary to treat these patients by increasing water with maintenance sodium intake (8).

2. Method

In this article, we assessed liquid and sodium amounts, sodium correction rate, seizure, consciousness state, and brain edema of five neonates, including three ichthyosis cases and two cases of hypernatremia with normal skin, in the Neonatal Intensive Care Unit (NICU) of the Children's Medical Center from 2017 to 2019 in Tehran, Iran.

Hypernatremia was defined as sodium plasma levels > 150 mmol/L. Dehydration was a weight loss of more than 10% of birth weight at the end of the fifth day of life or more than 2% of birth weight loss every day for the first five days from birth, accompanying clinical findings and lab tests of dehydration. We calculated the percentage of weight loss by (birth weight-admission weight)/birth weight $\times$ 100 (9, 10).

2.1. Criteria for Dehydration Lab Test Were

(Blood urea nitrogen (mg/dL))/ (serum creatinine (mg/dL)) > 20, specific gravidity > 1012, and metabolic acidosis. A pH of less than 7.25 in arterial blood gas (ABG) and a base excess of -10 or lower showed metabolic acidosis. Neonatologists or fellows of neonatology initially examined all patients. In ichthyosis cases, the incubator's temperature was adjusted to 37°C with 40% humidity. The temperature in normal-term neonates was adjusted at 36.5°C, and we did not humidify the incubator in normal-skin neonates. We could not use higher humidity because of the risk of infection. The neonates underwent hypernatremic dehydration treatment after NICU admission. The protocol for treating hypernatremic dehydration in neonates is administrating 1.2 - 1.5 times of the maintenance fluid in cc/ kilogram (11). About 77 meq/L of sodium was added to the serum if the patient's sodium level was less than 165 meq/L, about 155 meq/L if the serum sodium level was between 165 and 175 meq/L, and if the initial sodium level of the neonate is more than 175 meq/L then the amount of sodium added to the fluid, should be 10 meq/L less than the initial level of the patient. For example, if the initial level of sodium in a neonate who arrives to emergency room is 190 meq/L, the fluid what we prepare should contain 180 meq/L sodium (12). Then, fluid and sodium amounts were adjusted by checking sodium, potassium, blood urea nitrogen (BUN), serum creatinine (Cr), and specific gravidity (SG) every 4 - 6 hours. The goal was to reduce the rate of serum sodium level to about 0.5 mmol/L per hour per day. Our secondary outcomes were sodium correction rate, seizure, low consciousness, and brain edema. We performed this study based on the ethical principles of the Helsinki Declaration with the ethics code of No.: IR.TUMS.CHMC.REC.1399.012.

3. Case Presentation

3.1. Case 1

A 10-day-old male neonate with generalized ichthyosis in the physical exam was admitted with a GA of 35 weeks and a birth weight of 2600 g. His weight on admission was 2000 g. Blood gas showed metabolic acidosis with a pH of 7.24 and a base excess of -14.7 mmol/L. Serum sodium and potassium were 185 and 6 mmol/L. BUN, serum Cr, and SG were 65 mg/dL, 1.1 mg/dL, and 1022 respectively. We replaced the fluid therapy with 1.5 times of the maintenance of dextrose water with 170 meq/L sodium in the 24-hour, but the sodium level increased in subsequent lab tests. The sodium level was reduced gradually; when we changed the serum sodium level to 50 meq/L, the correction rate was 0.5 mmol/L per hour per day. The seizures, low consciousness, and brain edema were not seen during treatment. The sodium concentration was corrected within 75 hours (Table 1).

3.2. Case 2

A 12-day-old male neonate with generalized ichthyosis in the physical exam was admitted with a GA of 38 weeks and a birth weight of 2900 g. His weight on admission was 2420 g. During hospitalization, the neonate showed hypernatremic dehydration. His blood gas showed a pH of 7.28 and a base excess of -9 mmol/L. Serum sodium and potassium were 168 and 4.1 mmol/L. BUN, serum Cr, and SG were 36 mg/dL, 1.2 mg/dL, and 1022 respectively. The fluid replacement was 1.3 times the maintenance with 100 meq/L sodium. The sodium correction rate was 0.15 mmol/L per hour. After reducing sodium intake to 50 meq/L and increasing the free water, the correction rate became 0.5 mmol/L per hour per day. The sodium concentration was corrected within 80 hours. The seizures, low consciousness, and brain edema were not seen during treatment (Table 1).

3.3. Case 3

A 2-day-old male neonate with generalized ichthyosis in the physical exam and a GA of 37 weeks weighing 2100 g and birth weight of 2360 g was admitted due to hypernatremic dehydration. His blood gas showed a pH of 7.26 and a base excess of -9 mmol/L. Serum sodium and potassium were 178 and 5.8 mmol/L. BUN, serum Cr, and SG were 47 mg/dL, 1.3 mg/dL, and 1020 respectively. The fluid replacement was 1.4 times the maintenance, which contained 150 meq/L sodium. The sodium correction rate was about 0.40 mmol/L per hour per day. The correction time of sodium was within 72 - 80 hours. The seizures, low consciousness, and brain edema were not seen during treatment (Table 1).

3.4. Case 4

An eight days old female neonate with a gestational age of 40 weeks, normal skin in the physical examination, weighing 2500 g, and birth weight of 3120 g was admitted due to hypernatremia and dehydration. Her blood gas showed a pH of 7.24 and a base excess of -12 mmol/L. Serum

Table 1. Cases Information

Variables	Case 1 (Ichthyosis)	Case 2 (Ichthyosis)	Case 3 (Ichthyosis)	Case 4 (Normal Skin)	Case 5 (Normal Skin)
GA (week)	35	38	37	40	38
Age (day)	10	12	2	8	3
Birth weight (g)	2600	2900	2360	3120	3080
First Na. level (mmol/L)	185	168	178	163	160
Wight loss (g)	600	480	260	620	400
SG	1022	1022	1020	1030	1020
BE	14.7	-9	-9	-12	-10
BUN	65	36	47	60	34
Fluid therapy (M)	1.5	1.3	1.4	1.5	1.3
First Na therapy	170	100	150	77	75
Na. correction rate/24 h	0.1	0.15	0.4	0.45	0.55
Corrected Na therapy (mmol/L)	50	50			
Adjusted Na. correction rate/24 h	0.5	0.5			
Na. correction time (h)	75	80	80	50	40

Abbreviation: M, maintenance.

sodium and potassium were 163 and 4 mmol/L. BUN, serum Cr, and SG were 60 mg/dL, 1.7 mg/dL, and 1030 respectively. Fluid replacement with 1.5 times the maintenance and 77 meq/L sodium was prescribed. The sodium correction rate was about 0.45 mmol/L per hour per day. Sodium correction time was within 48 - 50 hours. The seizures, low consciousness, and brain edema were not seen during treatment (Table 1).

3.5. Case 5

A three days old male neonate with a gestational age of 38 weeks and normal skin in physical examination, weighing 2680 g on admission and birth weight of 3080 g was admitted due to hypernatremica dehydration. His blood gas showed a pH of 7.4 and a base excess of -10 mmol/L. Serum sodium and potassium were 160 and 4.6 mmol/L. Blood urea nitrogen, serum Cr, and SG were 34 mg/dL, 1.2 mg/dL, and 1020 respectively. The fluid replacement was 1.3 times the maintenance with 75 meq/L sodium. The sodium correction rate was about 0.55 mmol/L per hour per day. Sodium correction time was about 40 hours. Seizures, low consciousness, and brain edema were not seen during treatment (Table 1).

In this study, we reviewed five neonates with hypernatremia. First, the fluid and sodium were administered routinely based on the percentage of dehydration and serum sodium level; following all infants, the sodium correction rate was slower in three ichthyosis infants than in normal skin infants. They needed more fluid than sodium intake compared to normal skin infants, although fluid requirement was less in the third ichthyosis infant than in other ichthyosis infants, possibly due to less skin disruption in this infant.

4. Discussion

Hypernatremia is a complication of dehydration, leading to many adverse and lethal events in neonates (10). Adverse and lethal conditions in hypernatremia are seen in sodium levels of more than 160 meq/L (6). Appropriate treatment is to correct sodium levels gradually to prevent brain edema. In contrast, a lower correction rate is associated with prolonged high sodium levels, higher mortality, and complications (10). A correction rate of 0.5 mmol/L per hour is desirable to avoid adverse outcomes (6, 9). Adjusting fluid and sodium infusion is essential for the appropriate correction rate of serum sodium levels (9). A systematic review discussed that the treatment of hypernatremia neonates differs based on the amount of dehydration and renal concentration (13). It is essential to find the etiology of hypernatremia for appropriate treatment (14).

To the best of our knowledge, there are no articles on treating hypernatremia in ichthyosis infants. In ichthyosis infants, water loss from disrupted skin is high, so severe hypernatremia is common in these patients (3, 15). This type of hypernatremia is seen in extremely premature neonates with increased transepidermal free water loss (15). Such cases are treated with an appropriate adjustment of free water. Humidification of the incubators decreases water loss in patients. The treatment route in hypovolemic hypernatremia may differ for patients due to hypernatremia with normal or high total body weight (16, 17). This article shows that when we correct hypernatremia in ichthyosis as in normal skin infants, sodium decrement is lower, and it takes a long time to restore serum sodium levels. Thus, hypernatremia in these patients has to be corrected differently. A delay in sodium correction may be due to increased insensible water loss in ichthyosis infants. That's why we need to prescribe more free water than sodium, so we ordered more than 1.5 times of the maintenance fluid and less sodium in these patients. However, all ichthyosis patients do not have an equal condition; skin disruption and sensible water loss are different in these patients (15). We must consider that ichthyosis can mimic second-degree burns, so we need to design a new way for fluid therapy with more water for treatment. However, gradual reduction of serum sodium level at a rate of 0.5 mmol/L per hour is necessary. We need to design an exact protocol for ichthyosis classification on the severity of skin disturbance to decide on the best amount of fluid to administer.

4.1. Study Limitations

The study number of neonates with hypernatremia in the ichthyosis group compared to dehydration with intact skin group is limited. Therefore, statistical analysis was not possible on this number of neonates. Thus, further studies need to evaluate a suitable type of fluid therapy in these patients. For more accurate results, a clinical trial study is essential. We observed the correction time in both groups and noticed that increasing free water to the ichthyosis group helped decrease the Na amount; although the inference with few cases is impossible, it helps us for future proper study designs.

4.2. Conclusions

We evaluated hypernatremic dehydration patients with ichthyosis comparing to patients with hypernatremic dehydration with intact skin. We believe that hypernatremia in ichthyosis is most due to sensible water loss than cellular dehydration in hypernatremia with intact skin. Treating with more fluid and normal sodium in ichthyosis may be more beneficial than treating with high amounts of fluid and sodium in hypernatremia.

Footnotes

Authors' Contribution: R. S. conceived and designed the evaluation and drafted the manuscript. K. M. participated in designing the evaluation, performed parts of the statistical analysis, and helped to draft the manuscript. M. S. re-evaluated the clinical data, performed the statistical analysis, and revised the manuscript.

Conflict of Interests: Funding or research support: No funding or research support is reported. Employment: No employment is reported. Personal financial interests: No personal financial interests, stocks, or shares in companies are reported. Consultation fees: No consultation fees are reported. Patents: No patents are reported. Personal or professional relations with organizations and individuals (parents and children, wife and husband, family relationships, etc.): No personal or professional relations with organizations and individuals are reported. Unpaid membership in a government or non-governmental organization: No unpaid membership in a government or non-governmental organization is reported. Are you one of the editorial board members or a reviewer of this journal? Yes.

Ethical Approval: We performed this study based on the ethical principles of the Helsinki Declaration and ethics code: IR.TUMS.CHMC.REC.1399.012.

Funding/Support: None is reported.

Informed Consent: Written informed consent was obtained.

References

1. Dyer J, Spraker M, Williams M. Care of the newborn with ichthyosis. *Dermatol Ther*. 2013;**26**(1):1–15.
2. Avril M, Riley C. Management of Epidermolytic Ichthyosis in the Newborn. *Neonatal Netw*. 2016;**35**(1):19–28. [PubMed ID: 26842536]. https://doi.org/10.1891/0730-0832.35.1.19.
3. Nguyen MA, Gelman A, Norton SA. Practical Events in the Management of a Collodion Baby. *JAMA Dermatol*. 2015;**151**(9):1031–2. [PubMed ID: 25992873]. https://doi.org/10.1001/jamadermatol.2015.0694.
4. Glick JB, Craiglow BG, Choate KA, Kato H, Fleming RE, Siegfried E, et al. Improved Management of Harlequin Ichthyosis With Advances in Neonatal Intensive Care. *Pediatrics*. 2017;**139**(1). [PubMed ID: 27999114]. https://doi.org/10.1542/peds.2016-1003.
5. Durrani NUR, Imam AA, Soni N. Hypernatremia in Newborns: A Practical Approach to Management. *Biomed Hub*. 2022;**7**(2):55–69. [PubMed ID: 35950014]. [PubMed Central ID: PMC9247442]. https://doi.org/10.1159/000524637.
6. Bolat F, Oflaz MB, Guven AS, Ozdemir G, Alaygut D, Dogan MT, et al. What is the safe approach for neonatal hypernatremic dehydration? A retrospective study from a neonatal intensive care unit. *Pediatr Emerg Care*. 2013;**29**(7):808–13. [PubMed ID: 23823259]. https://doi.org/10.1097/PEC.0b013e3182983bac.

7. Craiglow BG. Ichthyosis in the newborn. *Semin Perinatol*. 2013;**37**(1):26–31. [PubMed ID: 23419760]. [PubMed Central ID: PMC3758581]. https://doi.org/10.1053/j.semperi.2012.11.001.
8. Garrahy A, Thompson CJ. Management of central diabetes insipidus. *Best Pract Res Clin Endocrinol Metab*. 2020;**34**(5):101385. [PubMed ID: 32169331]. https://doi.org/10.1016/j.beem.2020.101385.
9. Singla M, Malik S, Korday CS, Paldiwal AA. Weight Loss and/or Hypernatraemia in inadequately breastfed term neonates having non-haemolytic unconjugated hyperbilirubinaemia. *J Clin Diagn Res*. 2018;**12**(1).
10. Lavagno C, Camozzi P, Renzi S, Lava SA, Simonetti GD, Bianchetti MG, et al. Breastfeeding-Associated Hypernatremia: A Systematic Review of the Literature. *J Hum Lact*. 2016;**32**(1):67–74. [PubMed ID: 26530059]. https://doi.org/10.1177/0890334415613079.
11. Kliegman R, Stanton B, St Geme JW, Schor NF, Behrman RE. *Nelson Textbook of Pediatrics, Edition 21*. 21th ed. Hunan ke xue ji shu chu ban she; 2020. 431 p.
12. Christine A, Gleason I, Sandra E. *Averys Diseases of the Newborn*. *Elsevier*. 10th ed. Elsevier; 2018. 378 p.
13. Bischoff AR, Dornelles AD, Carvalho CG. Treatment of Hypernatremia in Breastfeeding Neonates: A Systematic Review. *Biomed Hub*. 2017;**2**(1):1–10. [PubMed ID: 31988896]. [PubMed Central ID: PMC6945909]. https://doi.org/10.1159/000454980.
14. Das J. Hypernatremic Dehydration in Newborn Infants: A Review. *Ulutas Med J*. 2015;**1**(2):25–22. https://doi.org/10.5455/umj.201506181158472.
15. Garty BZ, Wiseman Y, Metzker A, Reisner SH, Nitzan M. Hypernatremic dehydration and hypothermia in congenital lamellar ichthyosis. *Pediatr Dermatol*. 1985;**3**(1):65–8. [PubMed ID: 4070089]. https://doi.org/10.1111/j.1525-1470.1985.tb00489.x.
16. Modi N. Management of fluid balance in the very immature neonate. *Arch Dis Child Fetal Neonatal Ed*. 2004;**89**(2):F108–11. [PubMed ID: 14977891]. [PubMed Central ID: PMC1756027]. https://doi.org/10.1136/adc.2001.004275.
17. Rand SE, Kolberg A. Neonatal hypernatremic dehydration secondary to lactation failure. *J Am Board Fam Med*. 2001;**14**(2):155–8.