Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/mjafi

Original Article

Correction of hypernatremic dehydration in neonates with supervised breast-feeding: A cross-sectional observational study

Apoorv Saxena ^a, Suprita Kalra ^{b,*}, Subhash Chandra Shaw ^c,
K. Venkatnarayan ^d, Amit Sood ^e, V.V. Tewari ^f, Rakesh Gupta ^g

^a Clinical Tutor, Department of Pediatrics, Armed Forces Medical College, Pune 411040, India

^b Classified Specialist (Pediatrics & Pediatric Nephrology), Army Hospital (R&R), New Delhi, India

^c Associate Professor (Pediatrics & Neonatology), Armed Forces Medical College, Pune 411040, India

^d Officer on Special Duty, National Institute For Transforming India, NITI Aayog, New Delhi, India

^e Classified Specialist (Pediatrics), Command Hospital (Western Command), C/o 56 APO, India

^f Senior Advisor (Pediatrics & Neonatology), Command Hospital (Southern Command), Pune 411040, India

^g Director, Govt Institute of Medical Sciences, Noida, UP, India

ARTICLE INFO

Article history:

Received 15 February 2019

Accepted 8 May 2019

Available online 11 July 2019

Keywords:

Hypernatremic dehydration

Acute kidney injury

Exclusive breast-feed

Arterial blood gas

Central nervous system

ABSTRACT

Background: Hypernatremic dehydration is an uncommon but a serious cause of readmission in neonates especially in the ones on exclusive breast-feeding. The management of such neonates is challenging as serious complications can occur both because of hypernatremic dehydration and its rapid correction. The aim was to study the clinical profile of neonates with hypernatremic dehydration and determine the outcome of these neonates after appropriate management.

Methods: This is a prospective cross-sectional observational study of neonates readmitted with hypernatremic dehydration in a tertiary care hospital in a 12-month period from March 2017 to February 2018. The inclusion criterion was as follows: all neonates with serum sodium >145 mEq/l. The exclusion criteria were as follows: neonates with hypoglycemia, positive sepsis screen and any other congenital diseases. Neonates with serum sodium between 145 and 160 mEq/l were treated with supervised quantified oral feeds at 150 ml/kg/day, unless they had features of shock. Neonates who had serum sodium ≥ 160 mEq/l were given intravenous (IV) fluids initially.

Results: A total of 2412 deliveries took place during the study period. Hypernatremic dehydration was reported in 46 (1.9%) of them, which required admission. We found that all these neonates were exclusively breast-fed, with 81.3% neonates born to primigravidae. One neonate presented with seizures, and one, with metabolic acidosis. More than 50% neonates had acute kidney injury (AKI) on admission. No neonates in our study developed central nervous system (CNS) complications such as cerebral venous thrombosis, convulsions or intracranial haemorrhage, and complete recovery from AKI was documented in all neonates.

* Corresponding author.

E-mail address: kalrasuprita@gmail.com (S. Kalra).

<https://doi.org/10.1016/j.mjafi.2019.05.002>

0377-1237/© 2019 Director General, Armed Forces Medical Services. Published by Elsevier, a division of RELX India Pvt. Ltd. All rights reserved.

Conclusion: Hyponatremic dehydration can be a serious problem even in term healthy neonates especially in exclusively breast-fed neonates born to primiparous women. Our study shows that quantified oral feeding is effective in successful management of hyponatremic dehydration and not associated with the dreaded CNS complications due to rapid correction.

© 2019 Director General, Armed Forces Medical Services. Published by Elsevier, a division of RELX India Pvt. Ltd. All rights reserved.

Introduction

Normal neonatal feeding is essentially advocated as on-demand feeding with a minimum of 10–12 feeds per day. Adequate feeding depends on multiple factors such as lactogenesis, milk ejection reflex, effective suck by the neonate coupled with maternal and infant breast-feeding techniques and duration and frequency of feeds.¹ On an average, a term neonate loses about 3% of birth weight everyday through diuresis in the 1st week of life up to a maximum of 8–10%.² Any weight loss more than this is significant. Decreased urine output is usually the first marker of dehydration in neonates.

Term appropriate-for-gestational age neonates who are otherwise healthy and discharged from the hospital in 48–72 h of life are sometimes brought back by the caregivers with signs of dehydration. This is chiefly due to inadequate feeding because of numerous reasons leading to hyponatremic dehydration, warranting readmission.³ Hyponatraemia was believed to be unusual in breast-fed babies. It is however being increasingly reported nowadays in breast-fed babies also.^{4,5} Although it may be mild in most babies, it can cause significant morbidity and mortality because of the dreaded central nervous system complications such as intracranial haemorrhage, cerebral venous thrombosis, cerebral oedema, shock, acute kidney injury (AKI) and even death.^{6,7}

The aim of our study was to determine the various risk factors associated with hyponatremic dehydration in term neonates and to determine the outcomes following the management with supervised oral feeding at 150 ml/kg with breast milk and reconstituted milk (if breast-feeding was not sufficient in quantity) instead of use of intravenous fluids as has been conventionally carried out in otherwise well neonates.

Material and methods

Our study is a cross-sectional study that was conducted at a tertiary care centre in western India between March 2017 and February 2018.

Setting

Our hospital is a tertiary care hospital with approximately 2500 deliveries in a year. Routine postnatal counselling is given by the neonatologist/pediatrician for the mothers with special attention on breast-feeding. Babies in the postnatal ward are monitored as per the unit check list. Primiparous mothers are discharged after 48–72 h of delivery once the breast-feeding is established and mother is confident of handling the baby, whereas multiparous mothers are discharged after 24–48 h. All

the neonates are called for follow-up 48–72 h after the discharge for the assessment of weight gain and jaundice.

Hyponatraemia was defined as serum sodium levels >145 mEq/L for the purpose of this study. Table 1 gives the standard operational definitions used for neonates. Babies who were found to have positive sepsis screen and those with any coexisting congenital anomalies were excluded. Neonates with suspected or proven metabolic disorders other than hyponatraemia such as hypoglycemia/hypocalcemia or any other inborn error of metabolism were excluded. Data were collected in a predesigned proforma by the first author.

Bhutani nomogram and American Academy of Pediatrics (AAP) guidelines were used for management of neonatal hyperbilirubinaemia.¹² Daily weight was recorded. The main outcome was complete recovery defined as serum sodium <145 mEq/L with no features of dehydration¹³ as seen clinically (weight gain, good breast-feeding, good suck and no seizures/jitteriness) and by laboratory parameters (serum sodium, serum creatinine and serum urea).

Management

Neonates with hyponatremic dehydration with serum sodium between 145 and 160 mEq/l were treated with supervised quantified oral feeds at 1.5 times the maintenance with breast milk and/or reconstituted milk if the mother's feed was not seen to be sufficient in quantity. Neonates who had serum sodium ≥ 160

Table 1 – Important definitions used in the study.

1.	Hyponatraemia in neonates ⁸	Serum Na level (mEq/L)
	Definition	
	Normal	130–145
	Mild hyponatraemia	145–159
	Moderate hyponatraemia	160–170
	Severe hyponatraemia	>170
2.	Hypoglycemia ⁹	
	Plasma blood glucose <50 mg/dl	
3.	Neonatal AKI ¹⁰	
	Increase of serum creatinine ≥ 0.3 mg/dl within 48 h	
4.	Reduced urine output	
	Urine output ≤ 3 times in 24 h	
5.	Metabolic acidosis ¹¹	
	pH < 7.25 or less with HCO ₃ 16 or less or base excess – 10 or less with normal pCO ₂ levels	
6.	Dehydration	
	Weight loss >3% per day or $\geq 10\%$ or clinical findings of dehydration with hyponatraemia	

Weight loss was calculated from the birth weight using the following formula: % weight loss = (birth weight – present weight)/birth weight $\times 100$.

mEq/l were given intravenous (IV) fluids (N/2 in 5% dextrose) initially at 1.5 times the maintenance.¹⁴ IV fluid boluses and/or inotropes were given for neonates who presented with shock, as warranted by their clinical condition. Serum sodium, urea, creatinine and bilirubin along with blood glucose were measured. Severely dehydrated neonates who were suspected to have metabolic acidosis were also subjected to arterial blood gas (ABG) analysis. Sepsis screening was performed for all neonates at the time of admission. Vital signs were recorded every 2 hours. Serum sodium, urea and creatinine were measured every 12 hours to prevent the rapid fall of sodium. One neonate presented with seizures, and one, with metabolic acidosis; they were managed accordingly. All neonates were discharged when complete recovery from hypernatremic dehydration was documented. A detailed neurological examination of all the babies was conducted before discharge. Furthermore, all babies with Serum sodium (S. Na) > 170 mEq/dl and neonates who presented with seizure were subjected to transcranial Ultrasonography (USG) before discharge. No further neuroimaging was carried out if it was normal. However, all babies were followed up with clinical examination in outpatient department (OPD).

Statistical analysis

Statistical analysis was carried out using the SPSS 20.0 statistical programme.

Results

A total of 2412 deliveries took place during the study period. Hypernatremic dehydration was reported in 46 (1.9%) of them, which required follow-up. Three neonates were excluded from the study because of positive sepsis screen (Fig. 1). The incidence was slightly higher in the summer season. Table 2 summarises the clinical characteristics and important investigations of neonates admitted with hypernatraemia. We found that all these neonates were exclusively breast-fed, with 35 (81.3%) neonates born to primiparous mothers. History of poor feeding for the neonates was given by 35 (81.3%) of the mothers. Eleven neonates were administered IV fluids in initial resuscitation, whereas 32 were given only supervised oral feeds after admission. More than 50% neonates had AKI on admission. The rate of correction of hypernatraemia was achieved in 2.59 ± 1.36 days with quantified breast-feeding (Table 2). Four babies who had serum sodium >160 mEq/L but were accepting orally were managed with quantified feeds without any adverse outcome. No baby in our study developed CNS complications such as cerebral venous thrombosis, convulsions or intracranial haemorrhage during the management, irrespective of the sodium levels. Complete recovery from AKI was documented in all neonates.

Fig. 1 – Patient flow diagram.

Table 2 – Clinical characteristics and important investigations of neonates admitted with hypernatraemia (n = 43).

Age at presentation (days)	5.6 (2–16)
Primiparous mothers, n (%)	35 (81.3%)
Male, n (%)	26 (60.4%)
Vaginal delivery, n (%)	33 (76.7%)
Term neonates, n (%)	38 (88.3%)
Exclusive breast-feeding, n (%)	43 (100%)
Poor feeding, n (%)	35 (81.3%)
Reduced urine output, n (%)	20 (46.5%)
Mean birth weight (kg)	2.93 ± 0.40
Mean weight at presentation (kg)	2.55 ± 0.42
Mean % weight loss on admission	13.4 ± 6.0
Jaundice at presentation, n (%)	26 (60.4%)
Mean serum Na level at presentation, mEq/L	158.1 ± 8.6
Mean serum urea	81.7 (7–304)
Mean serum creatinine	0.99 (0.18–5.6)
Acute kidney injury, n (%)	23 (53.4%)
Mean recovery time (days)	2.76 ± 1.4
Mean recovery time on quantified feeds (days) (n = 32)	2.59 ± 1.36
Mean recovery time on IV fluids (days) (n = 11)	3.27 ± 1.48

Discussion

Hypernatremic dehydration is one of the most common problems encountered in the healthy term appropriate-for-gestational age neonates in the first week of life. Our study as the previous studies^{15,16} has shown this condition to be more common in neonates born to primiparous mothers. This may be because of ineffective galactopoiesis in primiparous mothers during the initial 48 h that can lead to infrequent suckling by the baby, further compounding the problem because of infrequent stimulation. Ineffective feeding is primarily related to poor breast-feeding techniques, that is, incorrect positioning and latching along with lack of education about breast-feeding. This can sometimes be compounded by other factors such as flat nipple, sore nipple and so on⁶ that interfere with breast-feeding.

Other factors associated with hypernatremic dehydration are low-birth weight babies, intra-uterine growth restriction (IUGR) babies, low maternal education, early discharge from the hospital and low socioeconomic status.⁶ One interesting point to note in our study is babies who are delivered by caesarean section are more likely to be fed under supervision till the time the mother is confident of handling the baby, which may reduce the risk of hypernatremic dehydration.

Weight loss is a significant marker of dehydration in the early neonatal period. Research studies have shown that a weight loss of 3% per day during the first week up to a maximum of 8–10% is acceptable.⁷ Babies with weight loss more than the expected should be screened for hypernatraemia. Other clinical pointers towards hypernatremic dehydration are history of lethargy, poor feeding, decreased urine output, irritability and tachycardia.

Neonatal hyperbilirubinaemia is often present in neonates with hypernatremic dehydration. In our study, 41% of neonates had coexistent neonatal hyperbilirubinaemia requiring

phototherapy. Jaundice in these neonates is aggravated because of dehydration and decreased urine output, thereby decreased removal of bilirubin. Treatment of hyperbilirubinaemia with phototherapy further adds to the dehydration because of increased insensible water loss creating a vicious cycle.

Acute kidney injury (AKI) has been reported to be the most common complication of hypernatremic dehydration, which at least in the initial stages is due to hypovolaemia in these neonates.¹⁷ In our study, 20 (46.5%) patients had a history of decreased urine output, and 23 (53.4%) babies had AKI. Thus, decreased urine output can be a reliable clue in the history that can be used for early identification of hypernatremic dehydration.

The goals of management in neonates with hypernatremic dehydration are the appropriate treatment of the condition in a protocolised manner to avoid the catastrophic consequences of the condition as well as due to its rapid correction. This is however difficult to achieve because of the presence of various factors requiring consideration, and therefore, no standard guidelines have been formulated to avoid or treat it.¹⁸

The guiding principle in management of hypernatremic dehydration has always been to correct it slowly. It is always emphasised to correct serum sodium concentration at a rate not more than 0.5 mEq/L per hour to provide better neonatal outcomes.^{19–23} It should be however not be corrected too slowly as it may lead to complications such as sinus venous thrombosis and increased mortality.^{24,25} Alshayeb et al.²⁴ found that neonates with a 24-h correction rate of less than 0.25 mEq/L per hour were associated with significantly higher mortality as also with rapid correction.^{3,7,20} In our study, the average rate of correction of serum sodium concentration was approximately 6 mEq/L per day (0.25 mEq/L/hour), and it was not associated with any complications.

If managed with intravenous fluids, the main challenge is to administer a fluid with just enough sodium concentration to achieve correction albeit slowly as mentioned previously to avoid complications. This entails careful initial choice of intravenous fluids and close monitoring of serum sodium levels thereafter. The recommendations for intravenous fluids range from 0.18% to 0.9% saline solutions, but the fluid containing lower sodium concentrations should be avoided.^{22,23}

Quantified oral feeds allow slow correction of hypernatraemia and thus should be the modality of choice if the baby is accepting orally and has no other comorbidities, as shown in a study on neonates with hypernatremic dehydration by Erdemir et al.²⁶

Our study elegantly brings out the safety of correction of hypernatraemia with supervised and quantified oral feeding without need for use of intravenous fluids, which would require far more frequent investigations and carry a higher risk of complications because of rapid correction. It would also bring down cost of therapy considerably as use of intravenous fluids will be reduced, and in addition, serum sodium can be monitored at a relatively less frequency. This is even more important in smaller centres where frequent investigations and intensive monitoring during intravenous therapy may be difficult.

This however needs to be confirmed in larger studies before we can advocate oral feeding as the optimal mode of correction of hypernatraemia in otherwise healthy neonates.

These neonates also need to be followed up for long-term neurodevelopmental and renal outcomes for which they should undergo six-monthly follow-up to assess neurologic and renal functions.

Conclusion

Hypernatremic dehydration can be a serious problem even in term healthy neonates, especially in exclusively breast-fed neonates born to primiparous women. This condition requires early identification and timely management to prevent complications. Our study shows that quantified oral feeding is effective in successful management of hypernatremic dehydration and not associated with the dreaded CNS complications due to rapid correction.

Conflicts of interest

The authors have none to declare.

REFERENCES

- Escobar G, Gonzales V, Armstrong M, Folck B, Xiong B, Newman T. Rehospitalization for neonatal dehydration. *Archives of Pediatrics & Adolescent Medicine*. 2002;156:155.
- Clarke T, Markarian M, Griswold W, Mendoza S. Hypernatremic dehydration resulting from inadequate breast-feeding. *Pediatrics*. 1979;63:931–932.
- Laing IA. Hypernatremic dehydration in newborn infants. *Acta Pharmacol Sin*. 2002;23:48–51.
- Ng P, Chan H, Fok T, et al. Early onset of hypernatraemic dehydration and fever in exclusively breast-fed infants. *Journal of Paediatrics and Child Health*. 1999;35:585–587.
- Boskabadi H, Maamouri G, Ebrahimi M, et al. Neonatal hypernatremia and dehydration in infants receiving inadequate breastfeeding. *Asia Pacific Journal of Clinical Nutrition*. 2010;19:301–307.
- Mujawar N, Jaiswal A. Hypernatremia in the neonate: neonatal hypernatremia and hypernatremic dehydration in neonates receiving exclusive breastfeeding. *Indian Journal of Critical Care Medicine*. 2017;21:30.
- Sielski L, McKee-Garrett T. *Manual of Neonatal Care*. 7th ed. New Delhi: Wolters Kluwer; 2016:107.
- Hauser GJ, Kulick AF. *Electrolytes disorders in pediatric intensive care unit*. *Pediatric Critical Care Medicine*. 1st ed. USA: Springer; 2007:1161–1163.
- Wilker R. *Manual of Neonatal Care*. 7th ed. New Delhi: Wolters Kluwer (India); 2016:285.
- Ricci Z, Ronco C. Neonatal RIFLE. *Nephrology Dialysis Transplantation*. 2013;28:2211–2214.
- Dell KR. *Fluid, Electrolytes, and Acid-Base Homeostasis*. Fanaroff and Martin's Neonatal-Perinatal Medicine: Diseases of the Fetus and Infant. 9th ed. Philadelphia, PA: Mosby-Elsevier; 2011:669–677.
- American Academy of Pediatrics, Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics*. 2004;114:297–316.
- Konetzny G, Bucher H, Arlettaz R. Prevention of hypernatraemic dehydration in breastfed newborn infants by daily weighing. *European Journal of Pediatrics*. 2008;168:815–818.
- Greenbaum L. *Electrolytes and Acid Base Disorders*. Nelson Textbook of Pediatrics. 20th ed. Philadelphia: Elsevier; 2016:390–391.
- Lavagno C, Camozzi P, Renzi S, et al. Breastfeeding-associated hypernatremia. *Journal of Human Lactation*. 2015;32:67–74.
- Caglar M, Ozer I, Altugan F. Risk factors for excess weight loss and hypernatremia in exclusively breast-fed infants. *Iran Journal of Public Health*. 2005;34:1–11.
- Unal S, Arhan E, Kara N, Aliefendioğlu D. Breast-feeding-associated hypernatremia: retrospective analysis of 169 term newborns. *Pediatrics International*. 2008;50:29–34.
- Bischoff A, Dornelles A, Carvalho C. Treatment of hypernatremia in breastfeeding neonates: a systematic review. *Biomedicine Hub*. 2017;2, 3-3.
- Oddie S. Hypernatraemic dehydration and breast feeding: a population study. *Archives of Disease in Childhood*. 2001;85:318–320.
- Adrogué H, Madias N. Hypernatremia *New England Journal of Medicine*. 2000;342:1493–1499.
- Kozeny G, Murdock D, Euler D, et al. In vivo effects of acute changes in osmolality and sodium concentration on myocardial contractility. *American Heart Journal*. 1985;109:290–296.
- Lien Y, Shapiro J, Chan L. Effects of hypernatremia on organic brain osmoles. *Journal of Clinical Investigation*. 1990;85:1427–1435.
- Coulthard M. Will changing maintenance intravenous fluid from 0.18% to 0.45% saline do more harm than good? *Archives of Disease in Childhood*. 2008;93:335–340.
- Alshayeb H, Showkat A, Babar F, Mangold T, Wall B. Severe hypernatremia correction rate mortality in hospitalized patients. *The American Journal of the Medical Sciences*. 2011;341:356–360.
- Bolat F, Oflaz M, Güven A, et al. What is the safe approach for neonatal hypernatremic dehydration? *Pediatric Emergency Care*. 2013;29:808–813.
- Erdemir A, Kahramaner Z, Cosar H, et al. Comparison of oral and intravenous fluid therapy in newborns with hypernatremic dehydration. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2014;27:491–494.