Abstract:
Hypernatremic dehydration manifests typically in neonates in the first 2 weeks of life. The common risk factors for it include primi-parity, anxious elderly mother with lactation problems, caesarean delivery and early discharge. Most of these babies are seen during the summer months. The common presenting features include excessive weight loss, hyperthermia, jaundice, lethargy and poor feeding. We present herewith the clinical characteristics and the challenges we encountered in managing 27 babies with Hypernatremic dehydration.

Keywords: Hypernatremic dehydration, hyperthermia, free water, peritoneal dialysis

Introduction:
Hypernatremic dehydration often results from inadequate feeding. A mother who is sleep-deprived, exhausted and anxious, may not lactate adequately. These babies are not dehydrated because they are breast fed but because they do not get adequate milk (1). Mothers may be of high intelligence and yet not identify the fact that their infant is poorly hydrated (2). The incidence of hypernatremic dehydration varies widely depending on geographic location. A population-based study found the incidence in UK as 7.1 per 10,000 breastfed infants. It occurs in 1.9% of hospitalised term and near-term neonates in Pittsburg (3). Studies from India have found an incidence of 10.1% among term healthy breastfed babies during summer. Hypernatremia has occurred in 31.8% of the neonates who had significant weight loss (4).

Physiological aspects
With the onset of lactation, the concentrations of sodium and chloride in the mammary secretion decline markedly and lactose concentration and breast milk volume increases (5). An inverse relationship exists between breast milk sodium and lactose content. A failure of lactation doesn’t allow this normal fall in breast milk sodium.
A combination of poor volume of breast milk, high ambient temperature in summer and high breast milk sodium leads to hypernatremic dehydration.

**The challenges in management**

Hypernatremic dehydration poses two main problems which makes the management challenging. One is the hyperosmolar state per se and another problem is central pontine myelinosis which can occur with rapid correction.

**Idiogenic osmoles:**

A rapid increase in serum sodium causes cells to shrink, especially in the brain. The brain subsequently undergoes an adaptation process - a volume regulatory increase (VRI) in solutes. This involves rapid accumulation of inorganic ions (acute adaptation) and slower accumulation of organic osmolytes, traditionally termed “idiogenic osmoles” (chronic adaptation). The major organic osmolytes in the brain are glutamine, glutamate, taurine, and myo-inositol (6). Organic osmolytes begin to accumulate after 9–24 h (7). A rapid lowering of serum sodium while correction, creates an osmolar difference. Consequently the brain cells swell because of the accumulated osmoles. This leads to central pontine myelinosis. Uncertainty surrounds the maximum desirable rate of fall of serum sodium. Although many reported cases have exceeded (even up to 30 mmol/l/day) the recommended rates of fall of 12 mmol/l/day and still have claimed short term success, long term follow up studies are lacking to determine the neurologic effects. It looks safe and prudent to aim for a fall in serum sodium of not more than 12 mmol/l/day (8). A correction rate of > 0.5 mmol/L per hour was also found to be an independent risk factor for death or convulsion (odds ratio, 4.3; 95% confidence interval, 1.2-6.5) (9).

**The hyperosmolar state:**

The hyperosmolar state can cause brain shrinkage, venous thrombosis and subdural capillary hemorrhage. These manifestations are attributed both to the severity of the hypernatremia and the rate at which it develops (10). In a study by Bolat et al, a serum sodium greater than 160 mmol/L at admission was an independent risk factor for death or convulsion (odds ratio, 1.9; 95% confidence interval, 1.3-3.7) (9). Alshayeb et al found that patients with first 24-hour hypernatremia correction rate of less than 0.25 mmol/L per hour had significantly higher mortality (11).

**Materials and methods:**

*Type of study*

Retrospective observational study – a case series

*Study period*

May 2014. This month is chosen as it is the hottest month here where we see clusters of babies with hypernatremic dehydration.

*Setting*
The outborn neonatal unit in a tertiary care centre. Treatment protocol Our protocol for treatment of hypernatremic dehydration consists of an emergency phase (restoration of vascular volume with 10 to 20 mL/kg of isotonic intravenous fluid) followed by a rehydration phase (the sum of the free water deficit and maintenance fluid requirements administered evenly over 48 h) (12). Initially, varied amounts of 3% NaCl may need to be added to normal saline to make the fluid isosmotic with plasma. This ensures that serum sodium will not fall rapidly. During the rehydration phase, the typical initial fluids used are ½ normal saline if sodium <175 mmol/l and normal saline if sodium >175 mmol/l. This cut-off of 175 mmol/l was based on the calculations for free water deficit which suggest that the rate of fall of sodium will be <5 mmol/l/day when normal saline is used for rehydration if serum sodium <175. Normal saline has 12% free water when serum sodium is 175 mmol/l. [(1- 154/175) x 100].

To get a fall in serum sodium of at least 5 mmol/l/day, the minimum amount of free water to be given is 20 ml/kg presuming a total body water of 70%. [0.7 x (1- 170/175) l/kg]. This amounts to >167 ml/kg of total fluids, when the replacement fluid is normal saline. This volume may be inappropriately high as it may exceed 150% maintenance fluids. Giving a lesser amount of fluids won’t achieve the desired fall in serum sodium. The recommended volume of fluids is 125-150% maintenance fluids (13). Subsequently, the fluids are decided based on the fall of serum sodium after 6-8 hours.

Peritoneal dialysis is done if there is no response to fluid therapy. The above mentioned protocol is based on the physiologic principles and to the best of our knowledge, there are no published studies using this protocol. In our experience, we have found this simple protocol to be practically useful.

Results

We did a retrospective analysis of all babies admitted in our Institute during the month of May 2014 with serum sodium >/= 150 mmol/l. Amongst them, 27 had features suggestive of Hypernatremic dehydration. 5 (18%) babies had serum sodium > 160 mmol/l. 78% (21/27) babies were exclusively breastfed. Of the remaining, 2 were predominantly breastfed and 4 were from orphanage who were formula fed. All these 4 babies were from a single orphanage where there was high ambient room temperature. 63% (17/27) were born to mothers inexperienced at breastfeeding. The anxiety component was obviously very high in these mothers. Surprisingly 22% (6/27) had successfully breastfed the previous baby. The sex ratio was 2:1 with predominant males which was same as the usual proportion of males admitted in our unit. The age at presentation is shown in the following figure. The median age at presentation was 6 days (range 3-30 days).
56% (15/27) of the babies were delivered by caesarean section. 66% (15/27) of the babies were small for gestational age, defined as less than 10th centile on sex specific Fenton’s chart. 81% (22/27) of the babies were term babies. Among them, 16 were full term (38-39 weeks) and 6 were early term (37-38 weeks) neonates. We had one 32 week preterm and 4 late preterm neonates. The mean gestational age was 38.2 weeks. 48% (13/27) of the babies presented with hyperthermia. And most of the others (44%) presented with lethargy and poor feeding. Only 2 came primarily for jaundice. Overall 7 (26%) babies had probable breastfeeding jaundice, diagnosed after excluding other causes of jaundice. The mean cumulative weight loss (from birth weight) at presentation was 18% (range 7.2 – 37.5 %). The scatter plot of cumulative weight loss and age at presentation is depicted in the following figure. It shows a linear trend, with more weight loss when presented later. The mean weight loss is 13% if presented in the 1st week of life and 23% if presented later. 22 babies had prerenal azotemia. The maximum blood urea at the time of presentation was 389 mg%. 9 (33%) babies had coexistent culture positive sepsis. 6 (22%) babies had hyperglycemia. 3 babies required initial fluid restoration with normal saline bolus 20 ml/kg. 2 babies had serum sodium > 175 mmol/l and required normal saline (rather than ½ normal saline) as the initial rehydration fluid. Revision of the initial rehydration fluid was needed for 3 babies after 6 hours of initial fluid therapy. The fall of sodium during the first 24 hours of fluid therapy is depicted in the following figure. The rate of fall of sodium on an average is 9 mmol/l/day (range 6-12) in the first 24 hours of fluid therapy. 2 babies required peritoneal dialysis for acute kidney injury refractory to fluid therapy, though the fall in serum sodium was appropriate in both.

Of the 27 babies, we lost 5 (18%) babies. 1 baby died primarily of Hypernatremic dehydration. The remaining 4 died of associated sepsis. (One baby had Staphylococcal Scalded Skin Syndrome).

Discussion:
Most of the babies had the typically described presentation – full term exclusively breastfed babies born to elderly primi mother by caesarean section and discharged early without proper breastfeeding counselling. 48% of our babies presented with hyperthermia. Moritz et al. (3) from Pittsburgh has reported hyperthermia in only 20%. Jain et. al. (14) from north India has reported it in 80%. Geographic...
variations in humidity and temperature might have influenced these variations. Most of our babies with hyperthermia were treated for sepsis prior to referral here despite no risks for sepsis. Differentiating fever from hyperthermia has been a challenge to many. It should be stressed that in fever, there will be peripheral vasoconstriction and extremities may be cool, whereas in hyperthermia it’s hot everywhere. The association with hyperglycemia in 22% of babies is of concern as it adds up to the existing hyperosmolar state contributed by sodium and urea. Treating aggressively with insulin should not be done as it pushes the glucose inside the cells, which will add up to the idiogenic osmoles. Also the extracellular osmolarity will be reduced rapidly. Both these can be problematic. Traditionally free water deficit is estimated by the formula 0.7 x wt x (1- {140/observed serum sodium}). Free water-loss estimates may be more accurate when using the formula 0.7 x wt x (1-{[290/plasma osmolality]}) (15). But we have used the simplified treatment protocol specified above. There were no babies who had a fall in serum sodium of >12 mmol/l/day. More importance was given to revision of fluids after 6 hours, depending on the biochemical values. For babies with <10% cumulative weight loss and serum sodium <155 mmol/l, we have treated successfully with banked donor breast milk along with direct breast feeds. We had 3 such babies. Enteral route for fluid replacement has been found to be safe and effective in earlier studies too and may be an alternative to intravenous fluid therapy in newborns with hypernatremic dehydration when clinical situation is stable (16). Fluid therapy is often successful. Even a blood urea of 389 mg% and creatinine of 4.8 mg% have reversed with fluid therapy alone. Only 2 babies required peritoneal dialysis.

In both the indication was persistent uremia, not responding to fluid therapy. Both had hyperglycemia. We had added varied amounts of 3%NaCl to the peritoneal dialysis fluid to make the sodium content 15 mmol/l less than the serum sodium. This is to ensure a controlled fall in serum sodium. The fall we had was 8-12 mmol/l/day which is the desired fall. Yildiz et. al. has achieved both fluid and the desired sodium removal using standard dialysis solutions with varying amounts of glucose (17). The associated hyperglycemia in our babies prevented us from adding more glucose to PD fluid as a measure to control fluid status. Zaki et. al. has reported a baby with rapid fall of sodium (21 mmol/l/day) using standard peritoneal dialysis fluid (18). Considering these results, our novel approach of adding extra sodium to PD fluid appears prudent.

**Conclusion:**
There should be a high degree of suspicion for diagnosing hypernatremic dehydration in a breastfed baby who presents with excess weight loss around the first week of life. Fluid therapy alone is often successful. For milder cases, oral rehydration can also be used. A simplified treatment protocol as explained may be used for managing such babies. When peritoneal dialysis is required, adding 3% saline to the peritoneal dialysis fluid is essential to avoid a rapid fall in serum sodium.
Reference:
1 Laing IA, Wong CM. Hyponatraemia in the first few days: is the incidence rising? Arch Dis Child Fetal Neonatal Ed. 2002 Nov;87(3):F158-62


