Breastfeeding-Associated Hypernatremia: Are We Missing the Diagnosis?

Michael L. Moritz, MD*; Mioara D. Manole, MD†; Debra L. Bogen, MD§; and J. Carlos Ayus, MD∥

ABSTRACT. Objectives. To assess the incidence and complications of breastfeeding-associated hypernatremic dehydration among hospitalized neonates.

Study Design. A retrospective study was conducted at Children’s Hospital of Pittsburgh over a 5-year period, to identify otherwise healthy term and near-term (≥35 weeks of gestation) breastfed neonates (<29 days of age) who were admitted with serum sodium concentrations of ≥150 mEq/L and no explanation for hypernatremia other than inadequate milk intake.

Results. The incidence of breastfeeding-associated hypernatremic dehydration among 3718 consecutive term and near-term hospitalized neonates was 1.9%, occurring for 70 infants. These infants were born primarily to primiparous women (87%) who were discharged within 48 hours after birth (90%). The most common presenting symptom was jaundice (81%). Sixty-three percent of infants underwent sepsis evaluations with lumbar puncture. No infants had bacteremia or meningitis. Infants had hypernatremia of moderate severity (median: 153 mEq/L; range: 150–177 mEq/L), with a mean weight loss of 13.7%. Nonmetabolic complications occurred for 17% of infants, with the most common being apnea and/or bradycardia. There were no deaths.

Conclusion. Hypernatremic dehydration requiring hospitalization is common among breastfed neonates. Increased efforts are required to establish successful breastfeeding.

Methods

Children’s Hospital of Pittsburgh is a 235-bed freestanding hospital with ~12,000 admissions per year. After approval was obtained from the institutional review board, a retrospective study was conducted to identify otherwise healthy term and near-term (gestation of ≥35 weeks) neonates admitted during a 5-year period with serum sodium concentrations of ≥150 mEq/L. A total of 3718 term and near-term infants <29 days of age were discharged from Children’s Hospital of Pittsburgh between January 1997 and December 2001; 406 preterm infants were excluded from review with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge diagnosis codes indicating prematurity (codes 765.00–765.19). The charts of neonates with the following ICD-9-CM discharge diagnosis codes were reviewed: hyperosmolality (code 276.0; n = 22), neonatal dehydration (code 775.5; n = 247), fetal/neonatal jaundice (code 774.6; n = 598), or newborn feeding problems (code 774.7; n = 202). Some children had >1 of the ICD-9-CM codes. Patients were evaluated for an explanation for hypernatremia other than inadequate milk intake could be identified, such as an acute or chronic illness that could affect feeding. Seventy singleton infants fulfilled the study criteria, all of whom were breastfed and 16 (23%) of whom were near term (35–37 weeks of gestation). No formula-fed infants fulfilled the study inclusion criteria.

For demographic purposes, the study group was compared with a historical control group composed of 21,158 infants (≥35 weeks of gestation) who were born at Magee-Womens Hospital (MWH) in Pittsburgh between 1999 and 2001. MWH is representative of the catchment area, accounting for 83% of live births in Allegheny County. The control group data were obtained from the Magee Obstetrics, Maternal, and Infant database, which is an ongoing data collection project at MWH. The database includes data on all women who deliver at MWH and their infants and is an electronic version of a structured, closed-format, medical record abstraction.

Data were reported as the mean ± SD or median (range) as appropriate. Ordinal data were analyzed with the Mann-Whitney rank-sum test, unpaired t test, or comparison of overlapping and nonoverlapping confidence intervals, as appropriate. Nominal data were analyzed with the χ² test. Correlations were determined with the Spearman rank correlation coefficient. P values of <.05 were considered significant.
RESULTS

Between January 1997 and December 2001, the incidence of breastfeeding-associated hypernatremic dehydration among hospitalized term and near-term neonates (n = 3718) was 1.9%, occurring for 70 breastfed infants who met the inclusion criteria and were admitted with serum sodium concentrations of ≥150 mEq/L (Table 1). Compared with historical control data, maternal and infant characteristics were similar with respect to maternal age, gestational age, gender, and delivery method. Hypernatremic infants were significantly more likely to be born to primiparous mothers than were infants in the control group (87% vs 43%; P < .001). Hypernatremic infants had lower birth weights than control subjects (Table 1) but similar birth weights in comparison with primiparous control infants (3245 g [95% confidence interval: 3146–3362 g] vs 3345 g [95% confidence interval: 3336–3355 g]). Ninety percent of mothers (60 of 66 mothers) were discharged with their infants within 48 hours after birth; discharge data were not available for 4 infants. Five of the 9 multiparous mothers had had difficulty breastfeeding previous children. Of these, 1 mother had an infant from a previous pregnancy admitted with dehydration resulting from insufficient lactation. Seasonal occurrence was not a risk factor.

The main reasons recorded in the medical records for seeking medical attention were poor oral intake (47.1%) and jaundice (34.2%). Although 73% of infants had >10% weight loss, only 4 (5.7%) neonates were referred to the hospital by their doctors because of excessive weight loss. Signs or symptoms on presentation to the hospital (Table 2) prompted a full sepsis evaluation with a lumbar puncture for 44 (63%) neonates and parenteral antibiotic treatment for 36 (51%). None of the infants was found subsequently to have bacteremia or meningitis.

Metabolic complications occurred with breastfeeding-associated hypernatremia (Table 3). Significant hyperbilirubinemia (≥15 mg/dL) was the most common metabolic complication, occurring for 50 (71%) neonates, with bilirubin levels exceeding 20, 25, and 30 mg/dL for 26 (37%), 14 (20%), and 3 (4%) neonates, respectively. There was no correlation between the bilirubin level and either weight loss or peak serum sodium concentration. Other commonly occurring metabolic abnormalities were hypoglycemia (glucose concentration of <60 mg/dL) for 14 (20%) neonates and hyperkalemia (potassium concentration of >6 mEq/L) for 10 (14%). The median peak serum sodium concentration was 153 mEq/L (range: 150–177 mEq/L). Higher peak serum sodium concentrations were strongly correlated with greater percent weight loss at admission (r = 0.7, P < .001). Hypernatremia was treated with intravenously administered fluids for all except 1 infant. The median time to correction of hypernatremia, defined as the time from the institution of therapy until the time the serum sodium concentration was 150 mEq/L, was 18 hours (range: 1–80 hours). The median duration of hospitalization was 3 days (range: 1–10 days).

Nonmetabolic complications such as apnea and bradycardia (heart rate of <80 beats per minute) occurred for 12 (17%) infants (Table 4). Infants with nonmetabolic complications had significantly greater...
weight loss at admission (20% vs 12%; \( P < .001 \)) and presented at a later age (8.4 vs 4.7 days; \( P < .001 \)) than did infants without complications, but there was not a significant difference in peak serum sodium concentrations. One patient developed a myoclonic seizure of <1-minute duration after the serum sodium concentration was corrected from 160 mEq/L to 140 mEq/L over 4 days. Only 4 children underwent neuroradiologic imaging; 1 was noted to have left subependymal hemorrhage.

**DISCUSSION**

In this study, we report on 70 children who developed hypernatremia attributable to insufficient or inadequate breastfeeding during a 5-year period. To our knowledge, this is the largest report of its kind. Affected infants were born primarily through vaginal delivery to primiparous mothers. The majority of infants were evaluated and treated for sepsis at presentation. Nonfatal complications were frequent, the most common being severe hyperbilirubinemia, apnea, and bradycardia (Tables 2 and 3). One of 4 children who underwent neuroimaging had subependymal hemorrhage. These data suggest that hypernatremia is a common complication of inadequate milk transfer during breastfeeding in the United States.

In the present study, the 5-year incidence of breastfeeding-associated hypernatremia among all hospitalized term and near-term neonates was 1.9% (70 cases per 3718 admissions), significantly higher than the reported incidence of hypernatremia attributable to all causes among hospitalized children, adults, and elderly subjects (1.1%). The incidence of breastfeeding-associated hypernatremia requiring readmission would be 21 cases per 10 000 live births for infants at \( \geq 35 \) weeks of gestation (44 cases per 21 158 births from 1999 to 2001), assuming that the catchment area for Children’s Hospital of Pittsburgh is similar to that of MWH. The incidence for breastfed newborns would be 47 cases per 10 000 live births, assuming a breastfeeding initiation rate of 44%. Our data are consistent with those of others who have noted a high incidence of breastfeeding-associated hypernatremia.

There is reason to think that the incidence of breastfeeding-associated hypernatremia will increase and that currently the condition is underrecognized. The number of women who initiate breastfeeding will likely increase, because the American Academy of Pediatrics advocates strongly that nearly every infant should be breastfed and the Surgeon General has set a goal of 75% of mothers initiating breastfeeding by 2010. Findings from a recent study revealed that 16% of exclusively breastfed infants born to primiparous women had >10% weight loss by day 3 of life, despite education and support provided by a lactation consultant. It is estimated that 10% of breastfed infants develop hypernatremia and that \( \sim 33\% \) of breastfed infants with weight loss exceeding 10% have hypernatremia. This suggests that breastfeeding-associated hypernatremia is much more common than thought previously, with a higher rate than reported in our study.

Breastfeeding-associated hypernatremia can be difficult to recognize clinically. Most infants in our study presented with either jaundice or symptoms consistent with sepsis, such as fever and lethargy. Most of these patients were admitted for presumed sepsis and underwent a full sepsis evaluation, including lumbar puncture and treatment with antibiotics. Although 73% of infants had >10% weight loss, dehydration was noted rarely in the medical records before laboratory evaluation. This is not surprising, because infants with hypernatremic dehydration have better-preserved extracellular volume and therefore have less-pronounced clinical signs of dehydration. However, weight loss and inadequate stooling are sensitive indicators of dehydration among breastfed infants and should be included in the history of all infants presenting for evaluation of jaundice, fever, weight loss, and lethargy.

Many breastfed infants with hypernatremic dehydration in this study had short-term complications. Because of the retrospective nature of this study, long-term follow-up data were not evaluated. There is good reason to think that breastfeeding-associated hypernatremia can have serious deleterious consequences. Recent prospective data revealed that more than one half of infants admitted with breastfeeding-associated hypernatremia exhibited abnormal devel-

**TABLE 4.** Nonmetabolic Complications Among Neonates With Breastfeeding-Associated Hypernatremia

<table>
<thead>
<tr>
<th>Weight Loss, %</th>
<th>Birth Weight, kg</th>
<th>Age at Admission, d</th>
<th>Gestational Age, wk</th>
<th>Maximal Sodium Concentration, mEq/L</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>9</td>
<td>38</td>
<td>173</td>
<td>Apnea, bradycardia, intubation</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>13</td>
<td>40</td>
<td>164</td>
<td>Apnea, bradycardia</td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>13</td>
<td>41</td>
<td>172</td>
<td>Acute renal failure (BUN: 114 mg/dL; creatinine: 2.0 mg/dL), central line</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>16</td>
<td>40</td>
<td>156</td>
<td>Apnea, liver dysfunction</td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>13</td>
<td>NA</td>
<td>153</td>
<td>Apnea, intubation, liver dysfunction</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>7</td>
<td>37</td>
<td>160</td>
<td>Seizures</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>6</td>
<td>38</td>
<td>163</td>
<td>Bradycardia, hypothermia</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>4</td>
<td>39</td>
<td>156</td>
<td>Bradycardia</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>6</td>
<td>37</td>
<td>152</td>
<td>Apnea</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>5</td>
<td>37</td>
<td>150</td>
<td>Bradycardia</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>6</td>
<td>35</td>
<td>150</td>
<td>Apnea, bradycardia, hypothermia</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>3</td>
<td>40</td>
<td>153</td>
<td>Left subependymal hemorrhage</td>
<td></td>
</tr>
</tbody>
</table>

NA indicates not available; BUN, blood urea nitrogen.
opment with long-term follow-up monitoring. This is consistent with previous data that revealed long-term neurologic sequelae among children with hypernatremia. Hypernatremic dehydration among infants has been associated historically with high mortality rates. Serious vascular complications and death were reported in previous studies of breastfeeding-associated hypernatremia and in a our institution. The number of central nervous system complications in this study was likely underestimated, because only 4 patients underwent neuroimaging studies.

The association of hypernatremia with severe hyperbilirubinemia (bilirubin concentrations of >25 mg/dL), which occurred for 20% of our patients, might contribute to long-term neurologic sequelae. Hypernatremia can cause disruption in the blood-brain barrier, which facilitates the diffusion of bilirubin across the blood-brain barrier and thereby may enhance the risk of bilirubin encephalopathy. Hypernatremia and hyperbilirubinemia each cause central nervous system depression among infants with lethargy, poor suck, and anorexia. These factors can lead to a cycle of worsening dehydration, jaundice, and hypernatremia, which in combination can lead to brain injury.

Because of the retrospective nature of this study, there were some variables that we were unable to assess. First, this study probably underestimated the true incidence of breastfeeding-associated hypernatremia, because we queried charts only on the basis of ICD-9-CM codes and not on the basis of serum sodium concentrations. Serum sodium levels were not determined for all breastfed infants requiring readmission. Second, because of the incomplete nature of the feeding histories recorded in the medical records, we were unable to assess the possible reasons for lactation failure, such as inadequate latch, poor breastfeeding technique, low milk supply, inadequate feeding frequency, or maternal illness. The failure of physicians to record adequate feeding and elimination histories suggests the need for better physician training in breastfeeding management. We were not able to assess the adequacy of follow-up monitoring and breastfeeding education and support that were provided. Third, given the nature of the study design, there were important maternal characteristics that we were unable to assess, such as maternal education, socioeconomic status, marital status, and social support.

It is unclear why the incidence of breastfeeding-associated hypernatremia may be increasing, but it does not seem to be attributable to early discharge from the hospital or to a higher incidence of breastfeeding. Studies indicated that early discharge was not associated with increased readmission rates. The breastfeeding initiation rate in Western Pennsylvania is among the lowest in the nation at only 44%. The high incidence of breastfeeding-associated hypernatremia among infants born to first-time mothers may be related to the fact that primiparous women produce significantly less milk than multiparous women during the first postpartum week, with a subset of primiparous women having very low milk production during the first postpartum week. The increasing incidence of hypernatremia could also be attributable to less-stringent criteria for treating neonatal hyperbilirubinemia. Less-stringent guidelines for the treatment of neonatal jaundice would result predictably in a later presentation of insufficient lactation. Jaundice is a common clinical sign of insufficient lactation. Perhaps measurement of serum sodium concentrations should be added to the practice guidelines for the management of hyperbilirubinemia.

Breastfeeding-associated hypernatremia should be completely preventable. Unfortunately, physicians receive limited residency training to deal with breastfeeding complications, and there is general reluctance to provide supplemental formula to breastfed infants with insufficient lactation. Most pediatric texts do not give clear recommendations regarding how to treat breastfed infants with excessive weight loss or when to intervene with supplemental feeding. Obviously, the goal is to prevent dehydration, which must begin with adequate breastfeeding assistance in the newborn nursery that continues after discharge. To this end, breastfed infants should be evaluated by an experienced health care professional at no more than 3 to 5 days of age, as recommended in the most recent American Academy of Pediatrics guidelines. Infants should be evaluated with a weight check, physical assessment of hydration and jaundice, and evaluation of breastfeeding and infant elimination patterns. Most breastfeeding-associated hypernatremia could be prevented if infants with excessive weight loss or inadequate breast milk transfer were judiciously given expressed breast milk if available and formula if necessary until breast milk production increased and breastfeeding difficulties were addressed by a health care provider well trained in lactation support.

CONCLUSIONS

Breastfeeding is the most complete and perfect form of nurture and nourishment for infants, and all efforts should be made to promote successful breastfeeding. Breastfeeding-associated hypernatremia is a completely preventable complication that seems to be relatively common. Pediatric health care providers should be aware of this potentially serious complication of insufficient breastfeeding. Primiparous women in particular need additional support, education, and follow-up monitoring to ensure successful breastfeeding and to avoid complications of insufficient lactation. The judicious use of expressed breast milk or formula could prevent most cases of breastfeeding-associated hypernatremia. Both physicians and parents need better education and clearer guidelines on preventing, recognizing, and treating breastfeeding-associated dehydration. A comprehensive approach to the prevention and treatment of dehydration, hypernatremia, and hyperbilirubinemia should be part of any breastfeeding promotion campaign by the American Academy of Pediatrics or the US Department of Health.
We thank Karen Branstetter for editorial assistance, Dr Carol Gilmour for providing a preliminary control dataset, and Tara Straw for providing data from the Magee Obstetrics, Maternal, and Infant database at MWH.

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