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Original Article

Clinical Predictors of Sodium Disturbance in Children Presenting with Acute Watery Diarrhea in a Tertiary Hospital of Bangladesh

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Abstract

Background: *Sodium disturbances, either hyponatremia or hypernatremia, are the most common electrolyte imbalance encountered in managing children with acute watery diarrhoea. Early diagnosis and prompt management of these conditions by identifying clinical predicting factors in diarrheal children under 5 years of age are critically essential to prevent deaths in such children, especially in resource-limited settings. Our study aimed to evaluate clinical predicting factors associated with sodium disturbance in children hospitalized with acute watery diarrhea.*

Materials and Methods: *In this cross-sectional study, 121 children of 2 months to 5 years of age admitted in the Department of Pediatrics, Chittagong Medical College Hospital, Chattogram for acute watery diarrhea were included. Clinical features and sodium levels on admission were recorded. Children were grouped in hyponatremia (serum sodium <135mmol/l), hypernatremia (serum sodium >145mmol/l) and normonatremia (serum sodium 135–145mmol/l) and compared.*

Results: *Of the 121 children, 18 (14.9%) were hyponatremic, 71 (58.7%) isonatraemic, and 32 (26.4%) hypernatraemic. Logistic regression analysis revealed that children who did not receive ORS before admission, had severe dehydration and lethargy on admission would be more likely to have hyponatremic dehydration. Children who were younger, received concentrated ORS, thirsty and had convulsions on admission would be more likely to have hypernatremic dehydration than children with isonatremia.*

Conclusion: *The type of ORS used and age appears to be good predictors of sodium disturbance in children admitted with AWD.*

Key words: Children; Diarrhea; Hypernatremia; Hyponatremia.

INTRODUCTION

Diarrhea remains one of the major causes of infectious deaths worldwide among children under five.[1,2] Diarrhea is a leading cause of morbidity and mortality among under-five children in Bangladesh, which accounts for 6% of 0.119 million deaths in 2015.[3,4] The prevalence of diarrhea in children under five is accounted for 44.5% and was the highest at age 6-23 months.[5]

The clinical manifestations of acute diarrhea are related to the lack of water and electrolyte imbalance. Because their sodium content determines the osmolality and volume of extracellular fluid, this ion plays a crucial role in regulating water and electrolytes. In this sense, the biochemical change in children suffering from dehydration can be hyponatremic, isonatremic, or hypernatremic.[6] Disorders of sodium level in diarrhea-related dehydration cases can be a medical emergency that requires quick and appropriate diagnosis and treatment.[7,8]As a result, the clinical detection of water and electrolyte disorders, especially hyponatremic dehydration, becomes essential due to their severe neurological consequences.[9]

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Hyponatremia and hypernatremia are often underdiagnosed due to a wide range of overlapping manifestations and delayed timely intervention.[10,11] Different studies have emphasized the importance of early detection of clinical predictors to facilitate appropriate management and prevent potential ramifications of sodium disturbance, especially in resource-poor settings.[12,13] This study aimed to determine the clinical predictors of hyponatremia and hypernatremia in admitted children with acute watery diarrhea with deranged sodium balance.

MATERIALS AND METHODS

This cross sectional study was conducted at the Inpatient Department of the Pediatric Unit, Chittagong Medical College Hospital, Chattogram, from June 2018 to May 2019. Prior approval was obtained from the Ethical and Review Committee of Chittagong Medical College for the study. Written informed consent was obtained from the parents or guardians of the children.

In the study, a sample size of 121 cases was calculated with a 95% confidence level and 9.0% margin of error with the expected frequency of sodium disturbance in AWD of 43.3%.[12] The sampling technique was non-probability convenient sampling. Admitted children with AWD aged between 2 months to 5 years were included in the study. Children with other systemic infections, persistent diarrhea, dysentery, chronic diarrhea, severe acute malnutrition, and non-consenting caregivers were excluded.

After consenting, each child was assessed by taking a history from the mother/caregiver and performing the physical examination. Two ml of venous blood sample was obtained with all aseptic precaution before rehydration and sent to a laboratory for analysis of electrolytes. Type of sodium imbalance was assessed as per operational definition.

The severity of dehydration was labeled as per WHO criteria.[14] Hypernatremia was defined as serum sodium level over 145 mEq/L (Normal range: 135-145 meq/L) and hyponatremia was defined as serum sodium concentration below 135 mEq/l.[15] Mild, moderate, and severe hypernatraemic dehydration was defined as serum sodium between 146–159mmol/L, 160–169 mmol/L, and greater than 169 mmol/L, respectively.[16] Mild, moderate, and severe hyponatremic dehydration was defined as serum sodium between 130–135 mmol/L, 125–129 mmol/L, and less than 125 mmol/L.[17]

The data were analyzed statistically through SPSS version 23.0. Qualitative variables were expressed as frequency and percentage, and quantitative variables were defined as the median and interquartile range (25% to 75%). Test of significance was performed by Mann–Whitney U test (For data that were not normally distributed) for quantitative variables. The Chi-square test or Fisher's exact test was performed for categorical variables. Multiple logistic regression analyses were performed to identify characteristics associated with hyponatremia or hypernatremia after adjusting for other singly significant variables. An alpha of 0.05 was considered the threshold for statistical significance (p 0.05), and the strength of association was determined by estimating relative risks and corresponding 95% confidence intervals.

RESULTS

Out of 121 admitted cases majority were male, and the median age was 12 months (IQR: 2-54). Clinical characteristics of the patients on admission were presented in Table I. It depicted that, majority of the child had diarrhea for 3 days, with motion frequency >6 times/day and severe dehydration. In addition to loose motion, the other most prevalent symptom was vomiting presented in 88%, followed by sunken eye, lethargy, fever, increased thirst, irritability, convulsion and unconsciousness. Regarding ORS preparation, though 57.4% of them received properly prepared ORS, one-third of them (29.6%) received concentrated ORS. Most of the children, 71(58.7%), were normonatremic, followed by 32(26.4%) hypernatremic and 18(14.9%) hyponatremic patients. Out of 18 hyponatremic patients, 14 (77.8%) had mild hyponatremia, and the rest, 4 (22.2%) had moderate hyponatremia. Among 32 hypernatremic children, 20 (62.4%) had mild hypernatremia, and 6 (18.8%) had severe hypernatremia.

Table I Demographic and clinical characteristics of the patient on admission (n=121)

Variables		Frequency (%)/Median (IQR)
Age, in month	Median (IQR)	12 (9-16)
Sex	Male	75 (62.0%)
Diarrhea Duration (At admission)	≤3 days	79 (65.3%)
	>3 days	42 (34.7%)
Frequency of Diarrhoea in 24 hours	≤6 times	15 (12.4%)
	>6 times	106 (87.6%)
Severity of dehydration	Moderate	45 (38.0%)
	Severe	75 (62.0%)
ORS gave before admission		115 (95.0%)
Preparation of ORS (n=115)	Appropriate	66 (57.4%)
	Haphazard	14 (12.2%)
	Concentrated	34 (29.6%)
	Diluted	1 (0.9%)
Received pre-hospital medication		108 (89.3%)
Received pre-hospital IV fluid		34 (28.1%)
Clinical findings		
Abdominal distension		2 (1.7%)
Abdominal doughy feelings		8 (6.6%)
Decreased muscle tone		10 (8.3%)
Increased muscle tone		13 (10.7%)
Diminished reflex		4 (3.3%)
Exaggerated reflexes		9 (7.4%)
Pulse,/minute		96 (90-100)
SBP, mmHg		76 (70-80)
DBP, mmHg		40 (35-50)
Temperature, ^{0}F		100 (98-101)
Nutritional Status (WHZ-score)	>-2 SD	81 (66.9%)
≤-2SD	40 (33.1%)	
Types of sodium disturbance		
Normonatremia		71(58.7%)
Hyponatremia		18(14.9%)
	Mild	14 (77.8%)
	Moderate	4 (22.2%)
Hypernatremia		32(26.4%)
	Mild	20 (62.4%)
	Moderate	6 (18.8%)
	Severe	6 (18.8%)

When serum sodium was studied in univariate analyses (Table II) with selected clinical parameters, a statistically significant association was found between hyponatremia and shorter duration of onset, history of no ORS before admission, lethargic and severe dehydration on arrival. In univariate analyses, children with hypernatremia were younger, had H/O concentrated ORS intake more often presented with fever, convulsion, unconsciousness, increased thirst, absent sunken eye, normal skin turgor and doughy feeling of abdominal skin. Most of the normonatremic and hyponatremic children had a history of receiving appropriately prepared ORS. On the other hand, most of the children with hypernatremia had a history of receiving concentrated ORS.

Table II Comparison of demographic and clinical characteristics among the children with normonatremia and hyponatremia and normonatremia and hypernatremia

Characteristics	Normonatremia (n=71)	Hyponatremia (n=18)	Hypernatremia (n=32)	p value[a]	p value[b]
Age in months	12 (10-17)	11 (8-18)	10 (8-13)	0.343*	0.006*
Male sex	41 (57.7%)	14 (77.8%)	20 (62.5%)	0.118†	0.65†
Duration of diarrhea, days	3 (1-4)	2 (1-2.25)	3 (1.5-3.5)	0.05*	0.841*
Frequency of motion /day	15 (8-20)	15 (11-20)	15 (9-19)	0.658*	0.617*
Fever during admission	36 (50.7%)	9 (50.0%)	23 (71.9%)	1.0†	0.044†
No ORS before admission	2 (2.8%)	4 (22.2%)	0 (0%)	0.014‡	0.174‡
H/O concentrated ORS	13 (18.3%)	0 (0%)	21 (65.6%)	NA	<0.001†
Convulsion	0 (0%)	0 (0%)	12 (37.5%)	NA	<0.001
Unconsciousness	0 (0%)	0 (0%)	5 (15.6%)	NA	0.002
Skin pinch goes normally	27 (38.0%)	2 (11.1%)	25 (78.1%)	0.054‡	<0.001†
Doughy abdominal feeling	0 (0%)	0 (0%)	8 (25%)	NA	<0.001
Absent sunken eye	11 (15.5%)	0 (0%)	17 (53.1%)	NA	<0.001
Increased thirst	31 (43.7%)	5 (27.8%)	24 (75.0%)	0.087‡	0.003†
Severe dehydration	43 (60.6%)	16 (88.9%)	16 (50.0%)	0.023†	0.32†
Lethargic on admission	43 (60.9%)	16 (88.9%)	14 (43.8%)	0.023†	0.112†
Malnutrition <-2WHZ	22 (31.0%)	9 (50.0%)	9 (28.1%)	0.130†	0.770†

Data were expressed as frequency (percentage) or Median (Interquartile range). [a]Between Normotremia and hyponatremia,[b] Between Normotremia and hypernatremia, *Mann-Whitney U test, †Chi-square test, ‡Fisher's exact test, NA: Not Applicable.

In logistic regression analyses, after adjusting for likely covariates (Table III) children with a history of receiving no ORS before admission, severe dehydration and lethargy during admission were more likely to have hyponatremic dehydration during hospital admission.

Table III Independent predictors of hyponatremia in study patients

Predictors	Unadjusted RR (95% CI of RR)	p-value	Adjusted RR (95% CI of RR)	p-value
Duration of diarrhea, days	0.73 (0.52-1.03)	0.05	0.54 (0.02-1.03)	0.124
No ORS before hospitalization	9.86 (2.64-59.2)	0.014	5.2 (1.82-33.25)	0.041
Severe dehydration	5.21 (2.1-24.4)	0.023	2.42 (2.03-87.66)	0.031
Lethargy	5.69 (3.1-24.4)	0.021	1.64 (1.01-12.8)	0.041

RR: Relative Risk, CI: Confidence Interval.

In logistic regression analyses, after adjusting for likely covariates (Table IV) children with younger age, history of receiving concentrated ORS before admission, convulsion and increased thirst during admission were more likely to have hypernatremic dehydration during hospitalization.

Table IV Independent predictors of hypernatremia in study patients

Predictors	Unadjusted RR (95% CI of RR)	p-value	Adjusted RR (95% CI of RR)	p-value
Age	0.49 (0.24-0.97)	0.006	0.65 (0.25-0.89)	0.037
Use concentrated ORS	8.52 (3.31-21.92)	<0.001	1.85 (0.53-6.48)	0.038
Fever during admission	2.48 (1.01-6.1)	0.044	1.01 (0.34-11.1)	0.845
Convulsion during admission	4.55 (3.1-6.7)	<0.001	2.45 (1.12-4.32)	0.034
Unconsciousness	3.63 (2.6-5.0)	0.002	3.42 (0.03-11.4)	0.99
Skin pinch goes normally	5.28 (2.22-15.28)	<0.001	2.89 (0.25-3.12)	0.89
Absent sunken eye	6.18 (2.4-15.9)	<0.001	1.45 (0.56-4.5)	0.94
Doughy abdominal feeling	3.97 (1.18-6.29)	<0.001	1.21 (0.89-5.6)	0.56
Increased thirst	3.87 (1.53-9.79)	0.003	7.9 (1.5-41.6)	0.015

RR: Relative Risk, CI: Confidence Interval.

DISCUSSION

This study found sodium disturbance is common in children admitted with AWD. 41.3% of the study population had sodium disturbance (Hyponatremia and hypernatremia) similar to other previous studies, where disturbance of sodium ranges from 27.2%-64.8%.[12,18,19] Isonatremic dehydration was the most typical type in the present study, similar to other studies.[12,20]

In univariate analysis of the present series, similar to Shahrin et al. and Samadi et al. the incidences of hypernatraemia were related to age.[12,18] The incidence of hypernatraemia decreased with increasing age. These trends in hypernatraemic and hyponatraemic dehydration to age are due to older children being often given fluids with low sodium content such as water, juice, ginger ale, sodas, or tea. Moreover, in response to loss, receptor cells in the hypothalamus shrink resulting in increased thirst leading to increased water intake by older children. On the other hand, infants and young children are more prone to hypernatremia because they cannot relate their thirst to

caregivers or access fluid independently.[21] But another study found no significant association between age and type of electrolyte abnormality.[20]

In the present study, moderate malnutrition was more in hyponatremic children in comparison to normonatremic children, and conversely, it was less common in hypernatremic children than normonatremic children. The poor nutritional state is a risk factor for the development of hyponatremia, and different studies observed a significant relation between serum sodium concentration and nutritional state.[12,18,22,23] The explanation for these findings may be that the poor reserves of electrolytes and other nutrients in malnourished children cannot compensate for accumulated losses of sodium.[18]

Preparation of home-prepared ORS had a vital role to play in the electrolyte disturbances occurring in AWD. In the present study, children who received concentrated ORS were more likely to present with hypernatremia than those who received appropriately prepared ORS at home.In this study, 65.6% of children with hypernatremic dehydration received concentrated ORS before admission. Dastidar and Konar observed a significant association between type of ORS and sodium status. Significantly more children who were suffering from Hyponatremic dehydration were given diluted ORS.[20]

On the other hand, all the children who suffered from Hypernatremic dehydration had concentrated ORS in their study. Afroz et al. also found 67% of hypernatremic patients had a history of concentrated ORS intake. Intake of concentrated ORS and diarrhea during the winter were the most important causes of hypernatremia.[24].

Similar to Shahrin et al.we observed a significant association between serum sodium concentration and abnormal mental status, including lethargy, irritability or convulsions.[12] However, in the present study, no children with hyponatremia presented with convulsion. This can be explained by the fact that all hyponatremic cases were mild or moderate severity without any cases with sodium level <125 mmol/L.

We observed the association of increased thirst with hypernatremia. Clinical signs such as restlessness and thirst are common signs of dehydration and hypernatremia.[12,25] Other signs of dehydration like sunken eyes and slow skin turgor were significantly absent in the present study among patients with hypernatremia.Diagnosis of hypernatremia is still underestimated by clinicians owing to the lack of overt clinical signs of dehydration. Typical clinical signs (Sunken eyes, decreased skin turgor, hypotension) are less evident in hypertonic than in isotonic and hypotonic dehydration of the same severity because the extracellular fluid volume is compensated and less affected.[26]

Children with a history of receiving no ORS before admission presented with severe dehydration and lethargy during admission were an independent predictive factor for hyponatremia revealed in logistic regression analysis in the present study. Shahrin et al. found a significant association between older age, convulsion and SAM. Dastidar & Konar found an association of diluted ORS and convulsion and Okposio et al. found a statistically significant association with age more than 12 month, male gender and vomiting with hyponatremia.[12,20,19] On the other hand, children with a younger age with a history of receiving concentrated ORS before admission presented with convulsion and increased thirst were more likely to have hypernatremic dehydration in the present study. Other studies also found an association of concentrated ORS with hypernatremia.[20,24]

LIMITATIONS

The present study was based on a small sample size with a non-random sampling method. This study reflects the experience of just one urban tertiary care government hospital, so this may not be generalizable to all patients admitted elsewhere. Confounding variables could not be addressed rigorously in this study.

CONCLUSION

Children admitted with AWD who did not take ORS for rehydration were more prone to develop hyponatremia manifested as lethargy and severe dehydration. On the other hand, younger children and those who had a history of concentrated ORS intake were more prone to develop hypernatremia manifestedas increased thirst and convulsion. The findings of our study have significant clinical importance to generate future research hypotheses for targeted identification of hyponatremia and hypernatremia and early interventions to reduce diarrhea-related deaths in a resource-limited setting.

RECOMMENDATIONS

Serum electrolyte measurement should be done in admitted children with AWD to identify and managesodium disturbances. Strengthening awareness programs for appropriate ORS preparation among caregivers would be helpful in reducing diarrhea-related complications.

DISCLOSURE

All the authors declared no competing interest.

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