

Review

Hypertonaemic Dehydration in Children with Acute Diarrhoea: It's Clinical Profile and Renal Involvement

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Abstract**Background**

Diarrhea is a leading cause of illness & death among children in developing countries. Hypertonaemia is a serious complication in acute diarrhea, when associated with acute kidney injury (AKI) resulting increased mortality.

Objective

This study, was undertaken to measure the frequency of hypertonaemia in acute diarrhoea, its clinical presentation and renal involvement.

Methods

This was cross sectional observational study. A total of hundred and seven children with acute diarrhea aged between 2 months to 60 months of both sex admitted in the inpatient department of Dhaka Shishu Hospital and ICH and SSF Hospital, Mirpur-2, over a period of 6 months from August 2011 to February 2012 were included randomly in the study. Serum electrolytes, creatinine was checked in all the study children just after admission before starting any treatment and at 24 and 72 hours after admission. A total 12 hypertonaemic patients were evaluated for clinical profile and AKI staging was done by pRIFLE criteria. Hypertonaemia was classified into mild, moderate and severe grading. All patients were treated conservatively and with Intermittent Peritoneal Dialysis (IPD) as needed. Fluid management was done according to serum sodium level and water deficit.

Results

Among 107 children, hypertonaemia found in 12 (11.2%) children. Patients who developed hypertonaemia 4(33.3%) were mild, 5(41.7%) moderate and 3(25%) severely hypertonaemic. The proportion of children with consciousness at baseline and after 24 hours was staggeringly lower in severe hypertonaemic children than that in mild and moderate children. Intact sensory function was found in all mild & severe hypertonaemic children at baseline. Twenty percent of moderate hypertonaemic children

had paresthesia at baseline and another 20% after 72 hours, while 33.3% of severe hypertonaemic patients exhibited paresthesia after 24 hours. All of the patients had signs of severe dehydration at baseline in the three groups. Forty percent of moderate and 33.3% of severe hypertonaemic children had some signs of dehydration after 24 hours and 50% of mild, 40% of moderate and 66.7% of severe hypertonaemic patients after 72 hours. Among 12 hypertonaemic patient total 7 patients develop oliguria. Out of 7 oliguric patient 5 patient need dialysis for acute kidney injury. All 3 (100%) severe hypertonaemic patient and 2 (40%) moderate hypertonaemic patients underwent peritoneal dialysis.

All of the mild and moderate and 1(33.3%) in severe hypertonaemic children improve after treatment and 2(66.7%) of 3 severe hypertonaemic children died during treatment.

Conclusion

Hypertonaemia is a serious complication of acute diarrhea in children, severe hypertonaemia has increased mortality and morbidity than that of mild and moderate hypertonaemia.

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Keywords: Hypernatraemia; Acute Diarrhoea; AKI

Introduction

Acute diarrhea is defined as the abrupt onset of abnormally high fluid content in the stool: more than the normal value of approximately 10 mL/kg/d in the infant and young child. Dehydration as a result of diarrhea continues to be a leading cause of death in children especially in developing countries [1]. It is usually associated with high case fatality rate [2]. Hypernatraemia (serum sodium concentration of 150 mmol/L or more) is most likely to occur in a child suffering from diarrhoea with inadequate intake of fluid, repeated vomiting, intake of concentrated ORS or undiluted cow's milk. Most children with hypernatraemia are dehydrated, but do not show typical signs and symptoms of dehydration [3]. Patients with hypernatraemia are usually irritable, restless, weak and lethargic. Alert patients are very thirsty, they may have fever. Seizure & coma are possible sequelae of brain hemorrhage [4]. However, little is known about its magnitude and associated morbidity and mortality, particularly from developing countries [5]. Two different studies from ICDDR,B showed the incidence of hypernatraemia to be 6.4% and 5.1%, respectively [6]. No such data is available from other Specialized Pediatric Hospitals in the country. WHO estimates that there are >700 million episodes of diarrhea annually in children <5yrs of age in developing countries. While global mortality may be declining the overall incidence of diarrhoea remains unchanged at least 3.2 episodes/child/ year. The decline in diarrhoeal mortality, despite the lack of significant changes in incidence, is the result of improved case management of diarrhea, as well as improved nutrition of infants and children. These interventions have included widespread home and hospital based oral rehydration therapy, as well as improved nutritional management of children with diarrhoea. Persistently high rates of diarrhoea among young children despite intensive efforts at control are of particular concern [7]. The objective of the study is to find out the frequency of hypernatraemia, its clinical presentation and the immediate outcome in two different specialist paediatric hospital settings.

Methodology

This prospective comparative study was conducted in inpatient departments of Dhaka Shishu Hospital, Sher-e-Bangla Nagar, Shyamoli and ICH & Shishu Sasthya Foundation Hospital, Mirpur-2, Dhaka over a period of 6 months from 10th August, 2011 to 10th February 2012. Total 107 children aged 2 months to 5 years admitted for acute watery diarrhoea were selected consecutively for the study. Written consents were obtained from the accompanying persons. They were then assessed for clinical conditions following the inpatient pediatric protocol at the selected hospital. Structured questionnaire including clinical and laboratory data were completed for all cases. Blood samples were collected just after clinical examination and the treatment was started according to standard protocol of the hospital. All the patients were then followed up for 72 hours to see the treatment outcome. Investigation results were obtained within 4 hours of admission and once there was hypernatraemia, the

serum electrolytes were repeated at 24 and 72 hours. The outcomes were cautiously recorded and later analyzed. For data analysis, SPSS statistical package was used and analyzed using Chi-square (χ^2) Test, One-Way ANOVA Test and Repeated Measure ANOVA statistics. Children who had persistent diarrhoea, acute diarrhoea with associated problems, blood mixed stool, parents of children unwilling to give consent were excluded from the study.

Results

A total of 107 patients age ranging from 2 months to 5 years were enrolled for the study, of which 12(11.2%) were found hypernatraemic. Among them, 4 patients had mild ($\text{Na}^+ < 160$ mmol/L); 5 had moderate ($\text{Na}^+ : 160-170$ mmol/L) and 3 had severe ($\text{Na}^+ : > 170$ mmol/L)

Table I: Demographic Characteristics Among the Three Groups

Demographic characteristics	Hypernatraemia			p-value
	Mild (n = 4)	Moderate (n = 5)	Severe (n = 3)	
Age (years)*				
0.2 – 1	4(100.0)	4(80.0)	1(33.3)	
2 – 5	00	1(20.0)	2(66.7)	
Mean \pm SD	3.4 \pm 1.5	1.0 \pm 0.6	0.6 \pm 0.3	0.114
Sex*				
Male	2(50.0)	3(60.0)	1(33.3)	0.766
kFemale	2(50.0)	2(40.0)	2(66.7)	
Weight*	5.2 \pm 0.7	6.5 \pm 1.8	15.3 \pm 4.6	0.046

ANOVA statistics was used to analyses the data and presented as mean \pm SD;* Data were analyzed using Chi-square (χ^2) Test.

Hypernatraemia all 4 children with mild and 4 out of 5 with moderate and 1 out of 3 severe hypernatraemic children were between 2 months to 23 months, while 2 out of 3 (66.7%) of severe and 1 out of 5 (20%) moderate hypernatraemic children were between 24-60 months. Eight out of 12 children with mild, moderate and severe hypernatraemia were suffering for diarrhea for 3 days, while 2 out of 3 (66.7%) with severe, and 1 out of 5 with moderate(20%) suffered for 4 days. Vomiting was present in all 3 groups but vomiting for >3 days was present in 20% moderate and 100% severe hypernatraemic group. Other signs and symptoms like convulsion, irritability, seizures, increased muscle tone and oliguria were higher in severe hypernatraemic patients than mild and moderate patients (0% vs. 40% vs. 100%, $p = 0.029$; 75% vs. 80% vs. 100%, $p = 0.657$; 50% vs. 60% vs. 66.7%, $p = 0.902$; 25% vs. 60% vs. 100%, $p = 0.137$ respectively) (Table II).

Table II: Sign & symptoms among the three groups

Sign & symptoms	Hypernatraemia			p-value
	Mild (n = 4)	Moderate (n = 5)	Severe (n = 3)	
Suffering from diarrhea				
2 days	00	1(20.0)	00	0.220
3 days	4(100.0)	3(60.0)	1(33.3)	
4 days	00	1(20.0)	2(66.7)	
Passes loose stool				
8 times	1(25.0)	00	00	0.315
10 times	3(75.0)	3(60.0)	1(33.3)	
15 times	00	2(40.0)	2(66.7)	
Vomiting	3(75.0)	5(100.0)	3(100.0)	0.336
Duration of vomiting				
1 Day	2(66.7)	1(20.0)	00	0.359
2 Days	1(33.3)	3(60.0)	00	
≥3 Days	00	1(20.0)	3(100.0)	
				-
Convulsion	00	2(40.0)	3(100.0)	0.029
Irritability	3(75.0)	4(80.0)	3(100.0)	0.657
High-pitched cry or wail	1(25.0)	5(100.0)	00	0.011
Altered sensorium	1(25.0)	1(20.0)	00	0.657
Seizures	00	2(40.0)	3(100.0)	0.029
Increased muscle tone	2(50.0)	3(60.0)	2(66.7)	0.902
Oliguria	1(25.0)	3(60.0)	3(100.0)	0.137
Excessive diuresis	1(25.0)	1(20.0)	00	0.657

*Data were analyzed using Chi-square (χ^2) Test.

The proportion of patients with intact consciousness at baseline and after 24 hours was lower in the severe hypernatraemic patients than that in the mild and moderate groups. However, the percentage of intact consciousness after 72 hours was less in moderate hypernatraemic patients compared to other counterparts.

Fifty percent (50%) of patients in mild and 60% moderate hypernatraemic patients had normal motor function, while all severe hypernatraemic patients had abnormal motor functions. The improvement of motor function reached to 100% in mild and moderate hypernatraemic patients within 3 days of treatment, but not in the severe group. In all of them motor functions took more than 3 days to return to normal. Intact sensory function was available in mild, moderate and severe hypernatraemic patients at baseline. Twenty percent of moderate hypernatraemic patients had paresthesia at baseline and it continued up to 72 hours, while 33.3% of severe hypernatraemic patients developed paresthesia after 24 hours and returned to normal at 72 hours. All of the patients had signs of severe dehydration at baseline in all three groups. After 24 hours, 40% of moderate and 33.3% of severe hypernatraemic patients still had some signs of dehydration (p = 0.360) (Table III).

Table III: Monitoring of clinical examination throughout observation period

Consciousness	Hypernatraemia			p-value
	Mild (n = 4)	Moderate (n = 5)	Severe (n = 3)	
Intact Consciousness*				
At baseline	4(100.0)	5(100.0)	1(33.3)	0.027
After 24 hours	4(100.0)	5(100.0)	2(66.7)	0.195
After 72 hours	4(100.0)	4(80.0)	3(100.0)	0.466
Motor function (Normal)*				
At baseline	2(50.0)	3(60.0)	00	0.016
After 24 hours	4(100.0)	4(80.0)	1(33.3)	0.195
After 72 hours	4(100.0)	5(100.0)	1(33.3)	0.466
Sensory function# at baseline				
Intact	4(100.0)	4(80.0)	3(100.0)	0.466
Parasthesia	00	1(20.0)	00	
After 24 hours				
Intact	4(100.0)	5(100.0)	2(66.7)	0.195
Parasthesia	00	00	1(33.3)	
After 72 hours				
Intact	4(100.0)	4(80.0)	3(100.0)	0.466
Parasthesia	00	1(20.0)	00	
Dehydration status*				
At baseline				
Severe sign	4(100.0)	5(100.0)	3(100.0)	
After 24 hours				
No sign	4(100.0)	3(60.0)	2(66.7)	0.360
Some sign	00	2(40.0)	1(33.3)	
After 72 hours				
No sign	3(50.0)	3(60.0)	1(33.3)	0.766
Some sign	2(50.5)	2(40.0)	2(66.7)	

Repeated measure ANOVA statistics was employed to analyse the data and 'p' refers to overall differences between groups * Data were analyzed using Chi-square (χ^2) Test.

Three (75%) mild hypertreanaemic, 3 (60%) moderate and 1 (33.3%) severe hypertreanaemic patients received oral rehydration solutions (ORS). Two (50%) mild, 4 (60%) moderate and 1 (33.3%) hypertreanaemic patient had a history of medication before hospitalization. Every one of the hypertreanaemic patients was given IV fluid immediately to replace fluid deficit. Two (40%) out of 5 moderate and 3 (100%) of severe hypertreanaemic patients needed dialysis for acute disease ($p = 0.029$) (Table IV). All of the mild and moderate and 1 (33.3%) severe hypertreanaemic patients improved, while 2 (66.7%) of 3 severe hypertreanaemic patients died during treatment (Figure 1).

Table-IV: Treatment history throughout observation period

Treatment history	Hypertreanaemia			p-value
	Mild (n = 4)	Moderate (n = 5)	Severe (n = 3)	
Given ORS	3(75.0)	3(60.0)	1(33.3)	0.539
Amount of ORS				0.449
10 – 20	2(66.7)	2(66.7)	1(100.0)	
21 – 30	1(33.3)	1(33.3)	00	
Medication before hospitalization	2(50.0)	4(60.0)	1(33.3)	0.396
Intravenous fluid administration	4(10.0)	5(100.0)	3(100.0)	-
Dialysis	00	2(40.0)	3(100.0)	0.029

* Data were analysed using Chi-square (χ^2) Test.

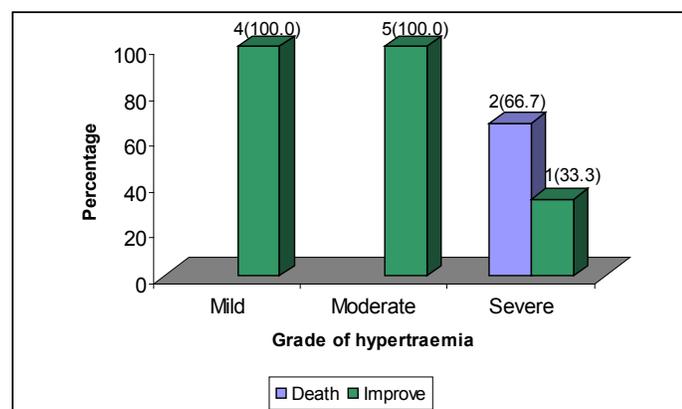


Fig. 1: Comparison of outcome among grade of hypertreanaemia

Discussion

The present study highlights the prevalence of hypertreanaemia (serum $Na^+ > 150mEq/L$) in hospitalized patient, which was approximately 11.2%. Anderson et al [8,9] found a prevalence of 10.4% when defining hypertreanaemia as serum sodium concentration $>150 mEq/L$; our results using this definition is similar. Findings of current study showed mean age and weight of severe hypertreanaemic patients was higher than those of mild and moderate and male was higher in moderate compared to those in mild and severe hypertreanaemic patients. All (100%) of mild hypertreanaemic patients were suffering from acute diarrhea for three days. In case of moderate hypertreanaemia, 20% patients were suffering from diarrhoea for two days, 60% for three days and another 20% for four days. One-third (33.3%) of severe hypertreanaemic patients were suffering from diarrhea for three days and rest 66.7% for four days. Three (75%) mild hypertreanaemic patients exhibited vomiting (66.7% for one day and 33.3% for two days). All (100%) moderate hypertreanaemic patients had vomiting (20% for one day, 60% for two days and 20% > three days) and all (100%) severe hypertreanaemic patients had vomiting for >3 days.

The patients with other signs and symptoms like convulsion, irritability, seizures, increased in muscle tone were higher in severe hypertreanaemic patients than mild and moderate patients. As has been stressed in these studies, Tierney et al [10] reported that 11 (10.7%) of 103 patients developed hypertreanaemia during hospitalization. Patients who developed hypertreanaemia during hospitalization were younger in case of mild hypertreanaemia than moderate and severe patients (mean age \pm SD, 1.9 ± 0.2 years compared with 2.6 ± 1.7 years and 3.7 ± 0.9 years; $P < 0.01$). Fifty-five percent of severe hypertreanaemic patients had increased insensible water losses and 35% had convulsion, 76% high-pitched cry or wail. However, previous study conducted by Long et al [11]. observed that vomiting and increased muscle tone varied widely among different grade of hypertreanaemic patients.

Consciousness at baseline was intact in all patients in mild and moderate hypertreanaemic pt, but significantly worse in patients with severe hypertreanaemia (66%) than with moderate and mild hypertreanaemia. At 72 hours, consciousness improved in all patients. Surprisingly, however, it was still somehow altered in patients with moderate hypertreanaemia, although it returned to almost normal in patients with mild and severe hypertreanaemia. The reason for this discrepancy remained unclear.

Abnormal motor function (hypo or hypertonic) was observed in all the patients with severe hypertreanaemia, while the same was observed in 50% in mild and 40% in moderate hypertreanaemic patients. Twenty percent of moderate hypertreanaemic patients had complaint of paresthesia at baseline, and another 20% developed the same at 72 hours, while only 33.3% of severe hypertreanaemic patients exhibited the same at 24 hours. On the other hand, none of the patients with mild hypertreanaemia had any complaint of altered sensory function. Almost similar results of paresthesia were also reported by others [12]. Snyder & Merson, however,

found that some residual weakness was still persisting in some patients even after 72 hours who had both motor and sensory function altered. They, therefore, emphasized that long time follow up would be essential in these patients [13].

Our study reveals that all the patients with mild and moderate and 1 (33.3%) of severe hypernatraemic patients improved after treatment. Two (66.7%) of 3 severe hypernatraemic children died during treatment. Alshayeb and associates [14] demonstrated that mean admission serum Na⁺ level was 159 ± 3 mEq/L. Ninety percent of their patients received the recommended <0.5 mEq/L/hr serum Na⁺ correction rate; however, hypernatremia was corrected only in 27% of patients after 72 hours of treatment. On third-day, patient mortality rate was 37%. The mortality rate in our study (66.7%) in severe hypernatraemia was almost similar with other studies (66%) [15-16]. The mortality we also observed is similar to that reported in other studies of hypernatremia [7,15,17,18,19,20].

Conclusion

Hypernatraemia is not uncommon in our hospitalized population. There are important differences in the prognostic significance of hypernatraemia across clinical settings. Hypernatraemic dehydration remains an important, serious complication in this study and resulted high mortality in patients with severe hypernatraemia. Early identification, proper medical examination and management may be helpful for the solution of the problem and can provide the exact estimate of the burden.

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