

HYPONATREMIA IN SICK CHILDREN SEEKING PEDIATRIC EMERGENCY CARE

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ABSTRACT

This prospective study evaluated the frequency, clinical characteristics and causes of hyponatremia (serum sodium < 130 mEq/L) in 727 children upto 12 years of age, who were brought for emergency care, and needed hospitalization. Hyponatremia was found in 29.8% and was more frequent in summer (36%; 123/341) than in winter (24%; 94/386) ($p < 0.001$). Acute lower respiratory infections (pneumonia) and acute diarrhea each accounted for 20% cases of hyponatremia; others were accounted for by meningitis/encephalitis (12%) septicemia (8%), and renal, heart and liver diseases (6-7% each). Clinical evaluation and concurrent plasma and urinary osmolality and urine sodium suggested that hyponatremia associated with pneumonia, meningitis/encephalitis, septicemia, seizures and miscellaneous diseases was of hypotonic-euvolemic (dilutional) type in more than 80% patients while in all children with acute diarrhea it was of hypovolemic type. The study has shown that hyponatremia occurs frequently in sick children requiring emergency care, especially in summer months, and should receive appropriate attention in the management plan.

Keywords: *Electrolytes disturbance, Hyponatremia, Sodium.*

The studies on frequency and epidemiologic characteristics of hyponatremia have shown this to be the single most common electrolyte abnormality in hospitalized sick adults(1-7). In them, it is invariably associated with hypo-osmolality and normal hydration and is attributed to syndrome of inappropriate antidiuretic hormone secretion (SIADH) or sick cell syndrome(1,8,9). The information on the frequency of hyponatremia in sick children is confined only to a few specific diseases(10-13).

Acute hyponatremia poses an immediate danger to the central nervous system. The rapid shift of fluids associated with this condition frequently results in brain edema(14-16). Administration of routine maintenance fluids, which are generally hypotonic (such as N/5 saline in 5% glucose), may worsen this edema. Since a decrease in plasma sodium concentration appears to be a common occurrence in hospitalized patients, it is essential that sick children who are at risk of hyponatremia are identified at the earliest. In this prospective study, we have evaluated the frequency and clinical characteristics of hyponatremia in children who sought emergency care and required hospitalization.

Material and Methods

Included in the study were children, upto 12 years, who attended the Pediatric Emergency Service during the summer months

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of May, June, July and August and winter months of November, December, January and February. On each day first 5 children who required hospitalization were included in the study irrespective of their primary diagnosis or severity of the illness. The study was approved by the Institute Ethics Committee.

Venous blood samples were obtained and analysed for serum sodium and potassium by flame photometry, serum creatinine by Jaffe's method, plasma osmolality by freezing point depression method, blood glucose by Folin Wu method and urea by monoxime method. Urine osmolality and sodium estimation were done in children with serum sodium < 130 mEq/L. Age-, sex-, and primary diagnosis were recorded in all the cases.

Analysis of Data

The patients were grouped on the basis of serum sodium concentration into normonatremic (serum sodium > 130 mEq/L) and hyponatremic (serum sodium < 130 mEq/L or less). Serum sodium concentration of 125 mEq/L or less was classified as severe hyponatremia. Hyponatremia was further categorized into five types: euvolemic-hypotonic (normal hydration, plasma osmolality \leq 280 mOsm/kg), hypo-volemic (with dehydration), edematous (with edema), due to renal failure and hyperglycemic (fictitious) hyponatremia(1,17).

Frequency of hyponatremia was calculated for the total sample and in relation to age, sex, season and primary diagnosis and expressed as the percentage. The statistical significance of the difference in the frequency distribution was determined by Chi-square test and of group means by 't'-test.

Results

A total of 727 children were studied; 245 boys and 96 girls in summer months and 286 boys and 100 girls in winter months. The mean \pm SD age of the children was 3.14 ± 3.18 years (<1 year—226, 1 year—122, 2 years—74, 3 years—60, 4 years—50, 5 years—37, 6 years—33, 7 years—26, 8 years—34, 9 years—17, 10 years—25, 11 years—22).

The frequency distribution of serum sodium concentration in 727 study children is depicted in *Fig. 1*. Hyponatremia was present in 217 (29.8%) children, while severe hyponatremia (serum sodium \leq 125 mEq/L) was found in 47 (6.4%). Amongst those with severe hyponatremia in 21 the serum sodium ranged between 121-125 mEq/L, in 17 between 116-120 and in 9 patients it was 115, mEq/L or less.

There was no significant age or sex related difference in the distribution of hyponatremia (*Table I*). The mean \pm SD age of hyponatremic children (39.6 ± 38.1 months) was similar to those who had normal serum sodium levels (36.6 ± 38.1 months). The frequency of hyponatremia in summer (36%) was one and half times of winter (24%) ($p < 0.001$). The frequency of severe hyponatremia was 7.6% in summer and 5.4% in winter ($p > 0.1$).

As shown in *Table II*, pneumonia and diarrheal disease, each accounted for about 20% cases of hyponatremia. The frequency of hyponatremia was 26% in pneumonia and 33% in meningoencephalitic illness, being higher in summer as compared to winter (*Table III*). Though one third of children admitted with gastroenteritis had hyponatremia no seasonal difference was observed in this category.

Clinical assessment, plasma and urine

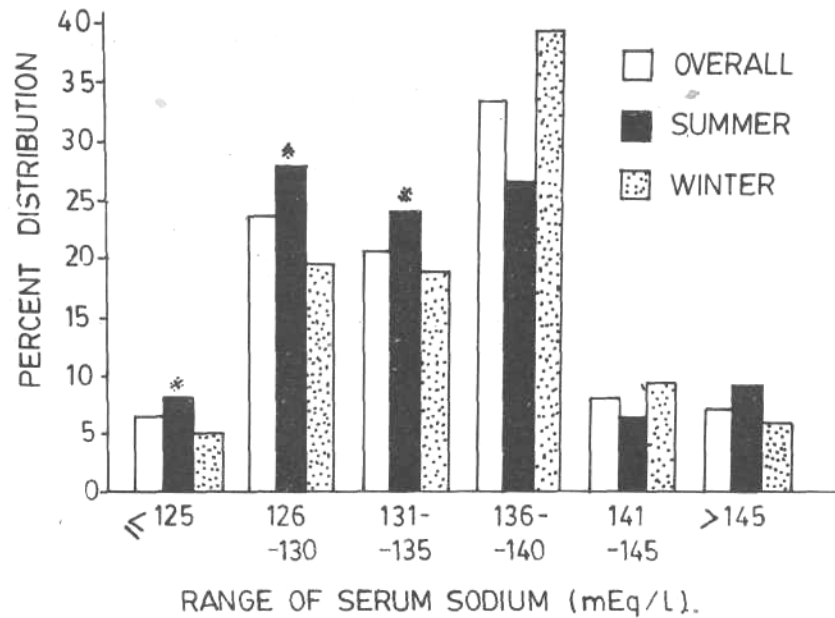


Fig. 1. Frequency distribution of study children with respect to serum sodium levels

TABLE I— Percentage Distribution of Children According to Serum Sodium Concentration (mEq/L) Within Various Age Groups Stratified by Sex of the Children and Season

Age (yrs)	Boys					Girls				
	n	Serum sodium (mcq/L)				n	Serum sodium (mcq/L)			
		≤125	126-130	131-135	≥136		≤125	126-130	131-135	≥136
Summer										
< 1	78	6.4	25.6	21.8	46.1	26	3.8	30.7	23.0	42.3
1- 2	65	9.2	32.3	24.6	33.8	29	3.4	20.7	24.1	51.7
3- 5	44	11.3	20.4	20.4	47.7	18	22.2	22.2	11.1	44.4
6-12	58	6.9	34.4	37.9	20.6	23	0.0	39.1	8.6	52.1
All	245	8.1	28.5*	26.1*	37.1*	96	6.2	28.1*	17.7	47.9
Winter										
< 1	95	4.2	11.5	16.8	67.3	27	3.7	22.2	33.3	40.7
1- 2	79	6.3	22.7	13.9	56.9	23	13.0	21.7	21.7	43.4
3- 5	59	5.0	23.7	18.6	52.5	27	0.0	22.2	18.5	59.2
6-12	53	9.4	22.6	18.8	49.0	23	0.0	4.3	26.0	69.5
All	286	5.9	19.2	16.7	58.0	100	4.0	18.0	25.0	53.0

There was no significant difference between boys and girls at any age group.

* p<0.01 for summer and winter difference.

TABLE II— Primary Diagnosis in 47 Cases of Severe, and 170 Moderate Hyponatremia.

Diagnostic category	Number of children (%)		
	Severe hyponatremia (n=47)	Moderate hyponatremia (n=170)	All (n=217)
Pneumonia	11 (23.4)	31 (18.2)	42 (19.3)
Acute diarrhea	6 (12.7)	39 (22.9)	45 (20.7)
Meningitis/Encephalitis	7 (14.8)	18 (10.5)	25 (11.5)
Septicemia	4 (8.5)	13 (7.6)	17 (7.8)
Heart disease (with and without bronchopneumonia)	3 (6.3)	11 (6.4)	14 (6.4)
Seizures	1 (2.1)	8 (4.7)	9 (4.1)
Renal disease	2 (4.2)	12 (7.0)	14 (6.4)
(i) Renal failure	2 (4.2)	7 (4.1)	9 (4.1)
(ii) Nephrotic syndrome	0	5 (2.9)	5 (2.3)
Liver disease	4 (8.5)	5 (2.9)	9 (4.1)
Miscellaneous	9 (19.1)	33 (19.4)	42 (19.3)*

*This included bronchial asthma 2.3%, anemia 1.9%, neonatal hyperbilirubinemia 1.1%, hematological malignancies 1.6%, malnutrition 1.5% and birth asphyxia 0.8%.

osmolality, and urinary sodium levels suggested that hyponatremia was predominantly of euvolemic (64%) and hypovolemic (27%) types. About 80% of cases of hyponatremia associated with acute respiratory illness, meningitis/encephalitis, septicemia, seizures and miscellaneous diseases were of euvolemic hypotonic (dilutional) type while in all children with hyponatremia associated with acute diarrheal illness it was of hypovolemic type (Table IV). Edematous type of hyponatremia constituted only 5.5% (12/217) of the hyponatremia and was exclusively associated with cardiac, renal and liver disorders (Table IV). Hyperglycemic hyponatremia was seen in one isolated case of diabetic ketoacidosis.

Discussion

The study sample was fairly representative of the type of sick children admitted to our service with respect to their age, sex and the disease entities. The selection was unbiased. Preponderance of males through all age groups, of infants below one year of respiratory illness during winter and acute gastroenteritis during summer is in accordance with the epidemiological pattern observed in our region. The data may therefore, be generalized on a population of sick children seeking emergency care.

We found hyponatremia in 29.8% of sick children who sought emergency care and needed hospitalization. When compared

TABLE III— Frequency (%) of Hyponatremia Among Children with Respect to the Diagnostic Categories and Season

Diagnosis	Summer		Winter	
	Total No.	No. with hyponatremia (%)	Total No.	No. with hyponatremia (%)
Pneumonia	37	16 (43)*	124	26 (21)
Acute diarrhea	67	24 (36)	62	21 (34)
Meningitis/ Encephalitis	39	17 (44)*	36	8 (22)
Septicemia	26	12 (46)	21	5 (24)
Heart disease	28	9 (32)	28	5 (18)
Seizure	22	6 (27)	19	3 (16)
Renal disease	21	10 (47)	14	4 (28)
Liver disease	19	4 (21)	11	5 (25)
Miscellaneous	82	25 (30)	71	17 (24)
All	341	123 (36*)	386	94 (24)

* $p < 0.05$, X^2 test, Between summer and winter.

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to reported data in adult population, the frequency of hyponatremia is much higher in hospitalized sick children.

The frequency was unaffected by the age and the sex of the children but a significant seasonal difference was apparent in the present study. The higher incidence of hyponatremia in summer as compared to winter existed through most of the diagnostic categories except diarrhea. This may be due to an increased salt and water loss through sweating during summer(18). The observation implies that index of suspicion of hyponatremia in summer should be very high and efforts should be made to detect the same.

The most common underlying causes of hyponatremia were diarrhea, pneumonia

and meningoencephalitic illnesses. Thirty four per cent of children with acute diarrhea had hyponatremia. Samadi *et al.*(19) found hyponatremia in 20.8% of 1330 Bangladeshi children below 3 years of age with diarrhea. Similar figures have been reported by other workers from tropics. In contrast to this, the reported frequency of hyponatremic dehydration was only 10% in children with acute diarrhea in the western countries(20). Predictably, hyponatremia in diarrhea was of the hypovolemic type caused by excessive sodium loss in gastro-intestinal secretions; intake of salt free drinks and increased loss of salt through sweating in our climate might have contributed.

The frequency of hyponatremia in children with pneumonia was 26% while in

meningitis/encephalitis it was 33.3%. This is similar to that reported by Shann and Germer(13) and Gonzalez *et al.*(10). The euvolemic-hypotonic type accounted for 80-90% of hyponatremia in these children as also in children with septicemia. Similar observations were made by Gonzalez *et al.* in children with acute infections(10). Apparently, hyponatremia occurs frequently without any major alterations in extracellular fluid volume in children with infectious diseases requiring hospitalization, and should therefore be looked for actively in children with these diagnostic entities, and managed appropriately.

Studies on the mechanism of euvolemic-hypotonic hyponatremia have emphasized a role of syndrome of inappropriate ADH secretion (SIADH) in these patients(1,10-13). By conventional criteria, almost all of our patients with euvolemic-hypotonic hyponatremia could be classified as having SIADH as they had normal hydration, low

plasma osmolality, high urine osmolality and normal renal function. Inappropriately higher concentration of plasma vasopressin than that expected for the degree of hypo-osmolality has been demonstrated in association with euvolemic hyponatremia in children with meningitis(11,12), asthma(21) and hospitalized adults(1). Thus, ADH mediated renal salt loss and water retention could be the cause of hyponatremia in such patients. However, severe hyponatremia may occur in association with eSIADH without unusual loss of sodium from the body or dilution of the plasma sodium. Evidence supporting redistribution and accumulation of sodium within the cells has also been presented(22). Recently, Hannon and Boston(23) have shown significant intracellular shifts of sodium chloride and water in septic animals. They suggested that in these animals hyponatremia and hypo-osmolality was caused by a combination of intracellular shift of sodium and water, and dilution of extracellular space probably as a result of

TABLE IV— Frequency of Various Types of Hyponatremia in Different Diagnostic Categories

	Total number	Type of hyponatremia			
		Euvolemic	Hypovolemic	Renal failure	Edematous
Pneumonia	42	37	5	-	-
Acute diarrhea	45	0	45	-	-
Meningoencephalitis	25	23	1	1	-
Septicemia	17	14	2	1	-
Heart disease	14	9	-	-	5
Seizures	9	9	-	-	-
Renal disease	14	2	-	7	5
Liver disease	9	6	1	-	2
Miscellaneous	42	37	4	-	-
All	217	137	59	9	12

physiological antidiuretic hormone secretion. Data from our ongoing research suggest a significant increase in RBC sodium in the presence of hyponatremia in septicemic children(24). Further studies are needed to clarify the mechanism responsible for hyponatremia in acute infections.

In conclusion, hyponatremia occurs frequently and should be looked for in all sick children. It is of hypotonic-euvolemic type in almost all the acute infections except diarrhea and should be managed accordingly. The causative mechanism and clinical significance of this disturbance in children awaits further studies.

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