International Journal of Contemporary Pediatrics
Joseph D et al. Int J Contemp Pediatr. 2023 Feb;10(2):221-226
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20230088

Original Research Article

A study of serum electrolyte imbalances and its impact in children of 4 months to 5 years of age group presenting with acute gastroenteritis

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Received: 14 December 2022
Revised: 09 January 2023
Accepted: 16 January 2023

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ABSTRACT

Background: Fluid and electrolyte derangement are the immediate causes that increases the mortality in diarrhea. The present study was carried out among children of 4 months to 5 years with dehydration due to acute diarrhea to determine the serum electrolyte profile.
Methods: A hospital based cross sectional study was carried out in department of pediatrics, RIMS during a period of two years (sept 2019-Aug 2021).
Results: A total of 195 patients of 4 months to 5 years of age group presented with acute gastroenteritis were included in the study, among them hyponatreamia was the most frequent electrolyte abnormality noted (37.4%). Most (65.5%) of hyponatremic patients in our study took dilute ORS whereas majority (64.2%) of patients who took appropriate ORS had normal serum sodium levels. Frequency and duration of diarrhea, dehydration status and inappropriate ORS were significant risk factors for serum electrolyte and acid base imbalances.
Conclusions: Electrolyte abnormalities were significantly associated with frequency and duration of diarrhea, dehydration status and inappropriate ORS administration. Hence, timely recognition and management of electrolyte abnormalities and appropriate ORS administration improves outcome in acute gastroenteritis related dehydration in children.

Keywords: Acute gastroenteritis, Electrolyte disturbances

INTRODUCTION

Diarrheal disorders in childhood accounts for a large proportion (9%) of childhood deaths, with an estimated 0.71 million deaths worldwide per year. It is the third leading cause of childhood mortality in India, and is responsible for 13% of all deaths/year in children under 5 years of age.[1]

Diarrhoea as a result of gastroenteritis is the most common cause of hypovolemic hyponatremia in children. Emesis causes hyponatremia if the patient takes in hypotonic fluid, either intravenously or enterally. Most patients with emesis have either a normal sodium concentration or hypernatremia.[2]

Similarly, potassium disturbances are also commonly seen in patients with acute gastroenteritis related dehydration. The mechanism by which upper GI losses induce hypokalemia is indirect and stems from the kidney's response to the associated alkalosis. Vomiting and diarrhoea are important causes of hypokalaemia although the mechanisms differ.[3]

Acute gastroenteritis accounts for a major bulk of pediatric patients attending RIMS. However, the exact prevalence of electrolyte disturbances in these patients is not well characterized. Therefore, the present study is taken up to outline the spectrum of electrolyte imbalances in children and to correlate with the clinical manifestations, so as to reduce the morbidity and

mortality associated with diarrheal diseases. The effect of consumption of improperly diluted and concentrated ORS on electrolytes status has also been studied

METHODS

Study design

An institutional based cross-sectional study design was used for the present study.

Study setting

The present study was conducted in 195 children of age 4 months to 5 years with acute gastroenteritis related dehydration admitted in the pediatric ward, regional institute of medical sciences, Imphal, Manipur.

Study duration

The data was collected for a period of 24 months from September 2019 to August 2021.

Inclusion criteria

Children of age 4 months to 5 years with dehydration related to acute gastroenteritis admitted in the pediatric ward, RIMS, Imphal, Manipur were included in the study.

Exclusion criteria

Patients with acute gastroenteritis with no dehydration. Children with persistent diarrhea, dehydration due to other causes were excluded from the study.

Sample size

The calculated sample size was 195 children of 4 months to 5 years age group.

Independent variables

Independent variables-Age, gender, frequency and duration of diarrhea at admission, degree of dehydration at admission.

Outcome variable

Outcome variable-Proportion of children with electrolyte and acid base imbalances at admission and association of electrolyte and acid base imbalances with independent predictors.

Working definitions

Diarrhea: change in consistency and frequency of stools, i.e., liquid or watery stools, that occur >3 times a day.[1]

Hyponatremia: hyponatremia is defined as a serum sodium level <135 mEq/L.[4]

Hypernatremia: hypernatremia is defined as a serum level>145mEq/L.[4] Hypokalemia: hypokalemia is defined as serum potassium level below 3.5 mEq/L.[4]

Hyperkalemia: hyperkalemia is defined as serum potassium level above 5.5 mEq/L.[4]

Sample collection

After all aseptic and antiseptic precaution, 2 ml of blood sample was collected by venipuncture. It was sent immediately to biochemistry department for serum electrolyte analysis. ABG analysis was done among 50 patients presented with severe dehydration by collecting 0.5 ml of arterial sample in heparinized syringe.

RESULTS

Among the study population, 99 (49.7%) were male and 96 (48.2%) were female. Seventy-one (36.4%) were under one year of age, 124 (63.6%) between 1 and 5 years of age. Majority (60%) presented within three days of onset of diarrhea, with most (54.4%) of them having less than 6 episodes per day. Most (50.8%) of the study participants were from middle class family. Most (44.6%) of the study participants presented with some dehydration followed by severe dehydration (38.5%) and no dehydration (16.9%). Even though majority (54.4%) were given appropriate ORS, concentrated ORS were given in 17.4% of patients and dilute ORS in 28.2%. The most common symptom observed was vomiting (65.6%), followed by fever (60.6%). Among 195 enrolled children, overall electrolyte abnormalities were present in majority (70.6%) of the cases.

Isonatreamia was most common followed by hyponatreamia and hypernatreamia. Hypokaleamia was more common than Hyperkaleamia. No statistically significant association between gender and serum electrolytes ($p>0.05$). Similarly, no statistically significant association between age group and serum sodium, potassium and bicarbonate at admission ($p>0.05$). A statistically significant association between frequency of diarrhoea and serum sodium, potassium and chloride at admission ($p<0.01$) was seen, but no significant association ($p=0.135$) between serum bicarbonate and frequency of diarrhoea was found.

Regarding association between duration of diarrhoea and serum electrolytes, It was seen that a statistically significant association ($p<0.05$) between serum sodium and duration of diarrhea was found, with majority (67.9%) of hyponatremic patients had prolonged duration of diarrhea (>3 days). Similarly, majority of patients with hypokaleamia (52.6%) and hypochloreamia (71.8%) had diarrhea for more than three days. Metabolic acidosis was

observed to be more common (29.3%) in those with prolonged diarrhea.

Majority of hyponatremic patients (45.3%) had vomiting during presentation, with a statistically significant association. However no statistically significant association (p=0.975) could be established between hypokaleamia and vomiting. Similarly, there was no significant association (p=0.758) between acid base disturbance and vomiting during admission

Most (82.5%) of those patients presenting with convulsions had hyponatreamic dehydration with a statistically significant association (p<0.01). No significant association between serum potassium (p=0.504) and serum bicarbonate (p<0.432) with seizure was noted. Majority of patients with altered sensorium were hyponatremic (69.0%) and hypochloremic (65.5%) with a significant association (p<0.05). However, there was no significant association between serum potassium (p=0.493), acid base abnormalities (p=0.271) and altered sensorium at presentation.

Regarding association between serum electrolytes and degree of dehydration, most of the patients with severe dehydration had hyponatremia (69.3%), hypokaleamia (53.3%), hypochloreamia (73.3%) at presentation**.** Our study could depict a statistically significant (p=0 .010) association between the type of ORS taken and serum sodium at admission. However, there was neither statistically significant relationship (p=0.167) between the type of ORS taken and serum potassium at admission, nor there was any significant relationship (p=0.617) between acid base disturbances and type of ORS taken.

Table 1: Serum electrolyte changes among the study population.

SE	S. Na, (n=195)			S. K, (n=195)			S. Cl, (n=195)			S. HCO_3, (n=50)		
	≤ 135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Percent (%)	37.4	49.7	12.8	32.3	64.6	3.1	36.9	48.7	14.4	26.0	52.0	22.0
N	73	97	25	63	126	6	7	9	28	13	26	11

Table 2: Association between gender and serum electrolytes.

Sex	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Male	32 (32.3)	54 (54.5)	13 (13.1)	30 (30.3)	64 (64.6)	5 (5.1)	36 (36.4)	53 (53.5)	10 (10.1)	9 (30)	15 (50)	6 (20)
Female	41 (42.7)	43 (44.8)	12 (12.5)	33 (37.5)	62 (43.8)	1 (18.8)	36 (37.5)	42 (43.8)	18 (18.8)	4 (20)	11 (55)	5 (25)
P value	0.309			0.247			0.173			0.7210		

*Chi square test.

Table 3: Association between age group and serum electrolytes.

Age (Years)	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
4 m to 12 m	28 (39.4)	30 (42.3)	13 (18.3)	22 (31)	45 (63.4)	4 (5.6)	35 (49.3)	30 (42.3)	6 (8.5)	9 (32.1)	13 (46.4)	6 (21.4)
12 m to 4	45 (36.3)	67 (54)	12 (9.7)	41 (33.1)	81 (65.3)	2 (1.6)	37 (29.8)	65 (52.4)	22 (17.7)	4 (18.2)	13 (59.1)	5 (22.7)
P value	0.135			0.292			0.016			0.519		

*Chi square test

Table 4: Association between frequency of diarrhea and serum electrolytes.

Frequency	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
≤6 times/ day	17 (16)	72 (67.9)	17 (16)	18 (17)	84 (79.2)	4 (3.8)	15 (14.2)	73 (68.9)	18 (17)	1 (14.3)	6 (85.7)	0 (0)
> 6 times/ day	56 (62.9)	25 (28.1)	8 (9)	45 (50.6)	42 (47.2)	2 (2.2)	57 (64)	22 (24.7)	10 (11.2)	12 (27.9)	20 (46.5)	11 (25.6)
P value	0.010			0.012			0.011			0.135		

*Chi square test

Table 5: Association between duration of diarrhea and serum electrolytes.

Duration (Days)	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
≤3	20 (17.1)	81 (69.2)	16 (13.7)	22 (18.8)	91 (77.8)	4 (3.4)	16 (13.7)	82 (70.1)	19 (16.2)	1 (11.1)	8 (88.9)	0 (0)
>3	53 (67.9)	16 (20.5)	9 (11.5)	41 (52.6)	35 (44.9)	2 (2.6)	56 (71.8)	13 (16.7)	9 (11.5)	12 (29.3)	18 (43.9)	11 (26.8)
P value	0.010			0.014			0.012			0.045		

*Chi square test.

Table 6: Association between symptoms and serum electrolytes.

Symptoms	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Tachycardia	34 (64.2)	15 (28.3)	4 (7.5)	25 (47.2)	26 (49.1)	2 (3.8)	37 (66)	82 (24.5)	23 (9.4)	7 (30.4)	8 (34.8)	8 (34.8)
	P=0.011			P=0.020			P=0.01			P=0.052		
Vomiting	58 (45.3)	53 (41.4)	17 (13.3)	42 (32.8)	82 (64.1)	4 (3.1)	53 (41.4)	62 (48.4)	13 (10.2)	10 (27.8)	19 (52.8)	7 (19.4)
	P=0.003			P=0.975			P = 0.037			P=0.758		
Fever	48 (41)	45 (38.5)	24 (20.5)	45 (38.5)	68 (58.1)	4 (3.4)	46 (39.3)	49 (41.9)	22 (18.8)	11 (29.7)	18 (48.6)	8 (21.6)
	P=0.012			P=0.066			P=0.026			P=0.583		

*Chi square test.

Table 7: Association between symptoms and serum electrolytes.

Symptoms	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Altered sensorium	20 (69)	7 (24.1)	2 (6.9)	11 (37.9)	18 (62.1)	0 (0)	19 (65.5)	6 (20.7)	4 (13.8)	5 (41.7)	4 (33.3)	3 (25)
	P=0.013			P=0.493			P=0.010			P=0.271		
Irritability	28 (59.6)	16 (34)	3 (6.4)	17 (36.2)	24 (61.7)	1 (2.1)	28 (59.6)	12 (25.5)	7 (14.9)	3 (14.3)	12 (57.1)	6 (28.6)
	P=0.011			P=0.760			P=0.012			P=0.246		
Seizures	33 (82.5)	5 (12.5)	2 (5)	16 (40)	23 (57.5)	1 (2.5)	27 (67.5)	8 (20)	5 (12.5)	5 (38.5)	5 (38.5)	3 (23.1)
	P=0 .010			P=0.504			P=0.014			P=0.432		

*Chi square test

Table 8: Association between serum electrolytes and degree of dehydration.

Dehydration	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106
Mild	3 (9.1)	29 (87.9)	1 (3)	2 (6.1)	29 (87.9)	2 (6.1)	4 (12.1)	26 (78.8)	3 (9.1)
Moderate	18 (20.7)	52 (59.8)	17 (19.5)	21 (24.1)	64 (73.6)	2 (2.3)	13 (14.9)	55 (63.2)	19 (21.8)
Severe	52 (69.3)	16 (21.3)	7 (9.3)	40 (53.3)	33 (44.)	2 (2.7)	55 (73.3)	14 (18.7)	6 (8)
P value*	P=0.014			P=0.011			P=0.015		

*Chi square test

Table 9: Association between socioeconomic status and serum electrolytes.

SES	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Lower class	31 (42.5)	27 (37)	15 (20.5)	22 (30.1)	49 (67.1)	2 (2.7)	28 (38.4)	35 (47.9)	10 (13.7)	4 (19)	14 (66.7)	3 (14.3)
Middle class	40 (40.4)	53 (53.5)	6 (6.1)	37 (37.4)	59 (59.6)	3 (3.)	40 (40.4)	46 (46.5)	13 (13.1)	7 (30.4)	9 (39.1)	7 (30.4)
Upper class	2 (37.4)	17 (49.7)	4 (12.8)	4 (17.4)	18 (78.3)	1 (4.3)	4 (17.4)	14 (60.9)	5 (21.7)	2 (33.3)	3 (50)	1 (16.7)
P value*	P=0.016			P=0.442			P=0 .337			P=0.450		

* Chi square test

Table 10: Association between type of ORS taken and serum electrolytes.

Type of ORS	S. Na, (n=195) (%)			S. K, (n=195) (%)			S. Cl, (n=195) (%)			S. HCO_3, (n=50) (%)		
	≤135	136-144	≥145	≤3.5	3.6-5.4	≥5.5	≤96	97-105	≥106	≤22	23-25	≥26
Dilute	36 (65.4)	15 (27.2)	4 (7.2)	16 (29)	38 (69)	1 (1.8)	31 (56.3)	20 (36.3)	4 (7.2)	6 (40)	6 (40)	3 (20)
Appropriate	31 (29.2)	68 (64.1)	7 (6.6)	41 (38.6)	62 (58.4)	3 (2.8)	38 (35.8)	57 (53.7)	11 (10.3)	6 (23)	14 (53.8)	6 (23)
Concentrated	6 (17.6)	14 (41.1)	14 (41.1)	6 (17.6)	26 (76.4)	2 (5.8)	3 (8.8)	18 (52.9)	13 (38.2)	1 (11.1)	6 (66.6)	2 (22.2)
P value*	P=0 .010			P=0 .167			P=0 .001			P=0.617		

*Chi square test.

DISCUSSION

During the study period 195 children from 4 months to 5 years admitted in Pediatric ward with acute gastroenteritis related dehydration were enrolled for serum electrolyte analysis. Among 195 enrolled children, overall electrolyte abnormalities were present in majority (70.6%) of the cases. Hyponatreamia was the most frequent electrolyte abnormality noted (37.4%) followed by hypochloremia (36.9%) hypokalemia (32.3%). Previous studies had mentioned variable incidence of hyponatreamia. For example, Ahmed I and Webb noted an incidence of 61.5%, whereas Dastidar et al could find an incidence of 22%.[5,6]

Potassium disturbances were noted in 35.4% of the study population. Hypokaleamia was observed in 32.3% of participants and hyperkaleamia in 3.1% of cases. The findings were similar to the study done by Naeem et al who got hypokaleamia as the most common (28.5%) electrolyte abnormality in acute gastroenteritis related dehydration in children.[7]

Among 195 enrolled children, ABG analysis was done for 50 patients with severe dehydration. Among them acid base abnormality was seen in 48% of patients. The most common abnormality observed was metabolic acidosis (26%) than metabolic alkalosis (22%). The results were similar to that found by Shah et al in which metabolic acidosis was present in 94% and metabolic alkalosis in 6% of the study population.[4]

Regarding the duration of diarrhea and serum electrolyte at admission, statistically significant association ($p<0.05$) could be found, with majority (67.9%) of hyponatremic patients had prolonged duration of diarrhea (>3 days). These observations were similar to that obtained by Naeem et al who concluded in his study that electrolyte abnormalities increased in prolonged diarrhea.[7]

Majority of hyponatremic patients (45.3%) had vomiting during presentation, with a statistically significant association. Onyiriuka et al had similar observations in their study.[8] However no statistically significant association (p=0.975) could be established between hypokaleamia and vomiting.

Most of the patients with severe dehydration had hyponatremia (69.3%), hypokaleamia (53.3%), hypochloreamia (73.3%) at presentation. Even though metabolic acidosis (28.9%) was common in children with severe dehydration than metabolic alkalosis (24.4%), a significant correlation could not be established (p=0.274). These findings suggest that severity of dehydration is a good predictor of serum electrolyte abnormality. A similar observation was noted by previous studies done by Naeem et al and Aamir who also found a higher incidence of electrolyte abnormality in patients with severe dehydration.[7,9]

Regarding the type of ORS taken and the serum electrolyte at presentation, there statistically significant correlation ($p<0.001$) between type of ORS taken and serum Na at admission with most (65.5%) of hyponatremic patients taking dilute ORS, majority (64.2%) of patients who took appropriate ORS had normal serum Na levels whereas patients who took concentrated ORS mostly presented with hypernatremic dehydration. Findings similar to that obtained by Pizzaro et al, Kocaglu et al and Shankar et al in their study found that those who given diluted ORS before admission, majority had hyponatremia (39%) and all of them who received concentrated ORS had hypernatremia.[10-12]

Hence considering results of our study, serum electrolyte and acid base imbalances are a significant cause of morbidity and mortality in acute gastroenteritis related dehydration in children. Appropriate ORS administration and timely management of electrolyte imbalances are important in prevention of complications. Further studies with a larger sample size on multicentric level could add robustness to study results thereby helping in better understanding and management of condition.

CONCLUSION

Electrolyte abnormalities are common in children presenting with Acute gastroenteritis related dehydration. Hyponatreamia was the most frequent electrolyte abnormality noted followed by hypochloremia and hypokalemia. Hyponatreamic dehydration may be because of administration of dilute ORS causing excess of free water. A statistically significant association between frequency, duration of diarrhea, dehydration status and serum electrolyte at admission was found. This underlies importance of early recognition and adequate treatment in the prevention of electrolyte and acid base imbalances. Most of hyponatremic patients in the present study took dilute ORS whereas majority of patients who took appropriate ORS had normal serum sodium levels. This finding points light to the importance of appropriate ORS preparation to prevent serum electrolyte and acid base disturbances. Patients without electrolyte abnormalities had better outcome and shorter hospital stay. Hence timely recognition and management of electrolyte abnormalities and appropriate ORS administration improves outcome in Acute gastroenteritis related dehydration in children.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Joseph D, Keithellakpam S. A study of serum electrolyte imbalances and its impact in children of 4 months to 5 years of age group presenting with acute gastroenteritis. Int J Contemp Pediatr 2023;10:221-6.