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FREQUENCY OF SODIUM AND POTASSIUM IMBALANCE IN CHILDREN ADMITTED WITH ACUTE DIARRHEA IN MADINA TEACHING HOSPITAL, FAISALABAD

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Abstract

Background: *Acute diarrhea remains one of the most common morbidity causes across the world's children and often associated with electrolyte imbalances. So, the objective was to evaluate the frequency along with assessment of factors associated with sodium and potassium imbalance in children admitted with acute diarrhea in Faisalabad.*

Material & Methods: *It was an analytical cross-sectional study conducted among acute diarrhea children, aged 6-59 months of either gender, Pediatrics department, Madina Teaching Hospital, Faisalabad over a period of six months, after ethical approval, recruited through non-probability consecutive sampling. The children,* ***with documented some*** *chronic systemic disease or related treatments were excluded. The data were analyzed using SPSS version 26.0; the data association tested by chi-square/Fisher-Exact test (p≤0.05 considered significant).*

Results: *Out of 103 acute diarrheal children, the predominating age group was 6 months to 2 years (69.9%) and the majority had stools for 1 to 7 days (86.4%). There were 30.1% having hyponatremia, 12.6% suffered from hypokalemia, and 29.1% had both conditions, thus comprising (71.8%) who had electrolyte imbalance. There were significant associations with electrolyte disturbance and younger age (p=0.049), pulse rate (p=0.004), hydration status (p=0.008), abdominal distention (p=0.008), bowel sounds (p<0.001), and neuromuscular tone (p<0.001).*

Conclusion: *The common electrolyte imbalance in children [sodium (hyponatremia) and potassium (hypokalemia)] is especially prevalent in younger and dehydrated children suffering from acute diarrhea.*

INTRODUCTION

Acute diarrhea is one of the most prevalent causes of childhood morbidity in the world and often causes electrolyte disturbances which can occur quickly in children because of reduced physiological reserves and may become a serious problem if not detected or treated promptly [1] [1-3].

Diarrhea causes over 2 million deaths and 1.5 million illnesses annually, the second leading cause of under-five mortality in developing countries [2]. Poor sanitation, unsafe water, and limited healthcare burden low- and middle-income countries, with ~90% of deaths in South Asia and Sub-Saharan Africa. Recurrent episodes impair growth and nutrition [3].

In Pakistan, childhood diarrheal disease is still a serious issue that is estimated to cause nearly 16% of all childhood deaths, to which the children affected suffer an average of 3-4 episodes of childhood diarrheal disease every year and approximately 119 million children are affected by childhood diarrheal disease each year. Common complications of acute diarrhea in this population are dehydration and electrolyte disturbances, especially of sodium and potassium, which are a significant source of morbidity and mortality associated with acute diarrhea [4].

Hyponatremia commonly results from sodium loss in watery diarrhea, inadequate replacement, and impaired intestinal sodium absorption. Severe diarrhea may cause hypokalemia, manifesting as weakness, muscle cramps, or, severely, cardiac arrhythmias and respiratory muscle dysfunction. Both depend on age, illness severity, and diarrhea duration, underscoring the need for reassessment and prompt correction [5].

These electrolyte disturbances complicated management of acute diarrhea. Oral rehydration therapy or, if severe, intravenous fluids are the first line of treatment and should be used to correct dehydration and electrolytic disturbance; regular monitoring of serum electrolytes, hydration status and urine output is critical to the management of these patients to prevent complications and to determine the cause of diarrhea [6].

Although prior Pakistani studies have reported sodium or potassium disturbances separately, none from Faisalabad have jointly assessed combined sodium-potassium imbalance alongside dehydration severity in the same cohort – a gap this study addresses to guide region-specific screening. It is important to know the prevalence of electrolyte imbalance in this population so that it can be detected early and electrolyte disturbances corrected and complications may be prevented. Hence the present study was conducted to find out the frequency and assessment of factors associated with sodium and potassium imbalance in acute diarrheal children admitted at the hospital and the results of the study might help in better clinical management and to decrease the morbidity and mortality of diarrheal diseases in Faisalabad area.

Methods

It was an analytical cross-sectional study done among 103 children recruited over a period of six months having age 6-59 months and either gender presented at department of pediatrics, Madina teaching hospital, Faisalabad. The study ethical approval was taken from University Medical & Dental College, Faisalabad. The sample size calculated was using WHO sample size calculator **version 2.0 (Application Software)** with one proportion sample size formula:

$$\text{Sample size} = \frac{Z_{1-\alpha/2}^{2}\, p(1-p)}{d^2}$$

i.e., taking hypokalemia (40%) [2] and margin of error (d) as 10% and confidence level (95%) yielding sample size (n=93), and total number recruited during the data collection period was n=103. The children having acute diarrhea were recruited using non-probability consecutive sampling technique. The children with documented chronic systemic diseases or conditions that could independently influence electrolyte balance, including cystic fibrosis, celiac disease, chronic renal disease, chronic liver disease, congenital heart disease, and endocrine disorders, were excluded. Children receiving immunosuppressive therapy or electrolyte replacement therapy before admission were also excluded.

The data was collected after informed written consent from parents/guardians on pre-designed questionnaire developed by the investigator after thorough literature review. The questionnaire was not pilot tested but was reviewed by the subject experts/seniors to ensure the clarity, relevance and comprehensiveness. It comprises of the age groups (years), gender, loose stool duration (days), gastrointestinal symptoms (yes/no), general complaints (yes/no), weight (as per standard), vital signs, abdominal symptoms like distension, bowel sounds, tone, reflexes and dehydration status.

On admission, hydration status was clinically graded as no dehydration, some dehydration, or severe dehydration according to the WHO, adopted nationally under Pakistan's IMNCI program. [7] **Anthropometric measurements were recorded for each child, including weight using a calibrated digital weighing scale to the nearest 0.1 kg, length for children younger than 24 months using an infantometer and standing height for children aged 24–59 months using a stadiometer, both to the nearest 0.1 cm. Mid-upper arm circumference (MUAC) was measured using a non-stretchable measuring tape to the nearest 0.1 cm in children aged 6–59 months.** A venous blood sample (3–5 mL) observing aseptic measures was collected from each child prior to rehydration therapy for sodium and potassium levels; serum was separated by centrifugation and **serum electrolyte (sodium and potassium) were measured by using ion selective electrode (ISE) methodology on COBAS ® Pure C303 analytical unit by Roche diagnostics**, and resultant levels were used to label the child with electrolyte imbalance (if any). The operational definitions for sodium levels of 135-145 mEq/L were considered normal while <135 mEq/L as hyponatremia and >145 mEq/L as hypernatremia. While, for potassium levels of 3.5-5.5 mEq/L were labeled as normal potassium levels while <3.5 mEq/L labeled as hypokalemia and >5.5 mEq/L as hyperkalemia [8]. The collected information was kept confidential and purely for research purposes.

The collected data was **complete and correct in all aspects without any missing information** was entered in Excel and then transferred to SPSS version 26.0 for analysis. The data was categorized to ease in analysis; descriptive statistics were presented in the form of frequency (percentage) and bar chart for outcome variable (electrolyte imbalance) and symptoms while chi-square test was utilized to have insight in the association of acute diarrheal children having electrolyte imbalance or not with various factors and acute symptoms. The Fisher-Exact test value for chi-square was stated where expected count value was less than 5. The p-value≤0.05 was taken as statistical significance.

Results:

The present study was conducted among 103 children suffering from acute diarrhea and admitted at the Madina teaching hospital, Faisalabad. There were mostly female (57.3%) children and majority comprising age-bracket of 6 months to 2 years (69.9%), while frequency of loose stools was 1 to 7 days (86.4%). The children having fever (57.3%) and systemic complaint of respiratory distress (15.5%) followed by lethargy (10.7%) and fits (4.9%).

There were 30.1% children patients having hyponatremia, 12.6% had suffered hypokalemia and 29.1% had suffered both hyponatremia and hypokalemia (Figure 1). The collective number having either hyponatremia or hypokalemia or both comprised of 71.8% acute diarrhea children.

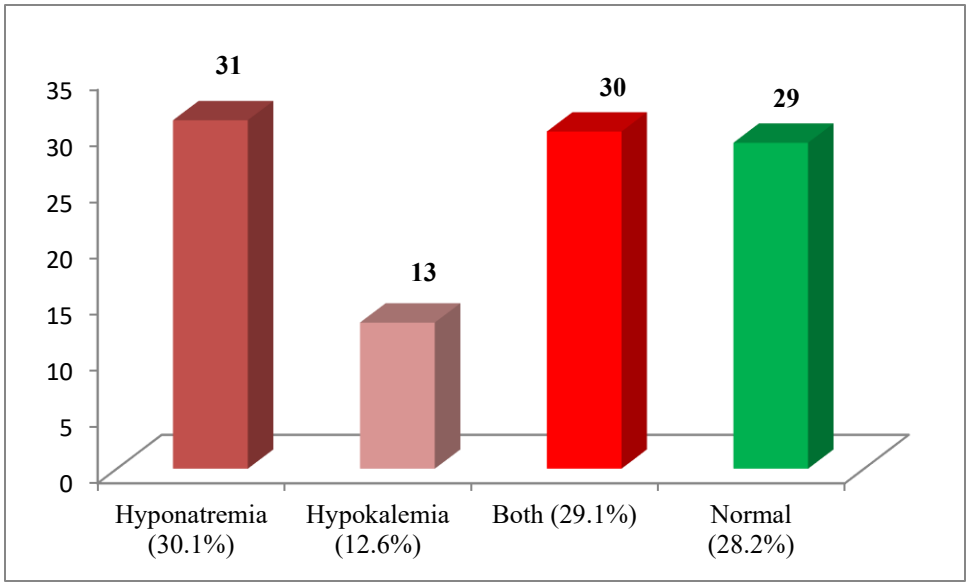

Figure 1: Frequency of Electrolyte Imbalance among the Children

The comparison made with personal factors reported that the age bracket (6 months to 1 year) suffered the most with hyponatremia (32%), hypokalemia (14%) and both (34%) children (p=0.049); regarding gender, males suffered mostly with hyponatremia (40.9%) followed by both electrolyte imbalances (18.2%) while females mostly suffered with both hyponatremia and hypokalemia (37.3%) followed by hypokalemia (22%) (p=0.101); the duration of loose stools reported as 1-3 days had suffered hypokalemia (21.1%), 4-7 days had more cases of hyponatremia (29.4%), 8-10 days had mostly suffered with hyponatremia (50%) and lastly 11-14 days duration children had suffered hypokalemia (25%) (p=0.128) and children with history of measles infection reported both hyponatremia and hypokalemia (26.9%) (p=0.008). Table 1

Table 1: Relationship of Electrolyte Imbalance with Personal Factors

Variables		Electrolyte Imbalance			Normal Levels	p-value
		Hyponatremia (%)	Hypokalemia (%)	Both (%)		
Age (Years)	6 months – 1 Year	16 (32)	07 (14)	17 (34)	10 (20)	0.049[a*]
	1 – 2 Years	09 (40.9)	02 (9.1)	04 (18.2)	07 (31.8)	
	2 – 3 Years	-	-	01 (14.3)	06 (85.7)	
	3 – 5 Years	06 (25)	04 (16.7)	08 (33.3)	06 (25)	
Gender	Males	18 (40.9)	06 (13.6)	08 (18.2)	12 (27.3)	0.101
	Females	13 (22)	07 (11.9)	22 (37.3)	17 (28.8)	
Loose Stools Duration (Days)	1-3	11 (28.9)	08 (21.1)	12 (31.6)	07 (18.4)	0.128[a]

	4-7	15 (29.4)	03 (5.9)	13 (25.5)	20 (39.2)	
	8-10	05 (50)	01 (10)	03 (30)	01 (10)	
	11-14	-	01 (25)	02 (50)	01 (25)	
Recent History of Measles Infection	Yes	-	-	05 (50)	05 (50)	0.008 [a] *
	No	31 (33.3)	13 (14)	25 (26.9)	24 (25.8)	
[a]= Fisher–Freeman–Halton exact test; *Significant p-value<0.05						

The relationship of electrolyte imbalance with clinical examination showed that, regarding pulse rate, tachycardiac children had mostly suffered both hypokalemia and hyponatremia (30.7%) followed by hyponatremia (25.3%) while bradycardiac children had suffered both (100%) (p=0.004); hydration status reported as some dehydration had suffered hyponatremia (38.1%), hypokalemia (15.4%) and both (23.1%) whereas, severely dehydrated children had suffered both (42.9%) and hypovolemic shock children had suffered hyponatremia (100%) (p=0.008); children with abdominal distension mostly suffered both (42.4%) (p=0.008); children with sluggish auscultation of bowel sounds had suffered both (63.6%) (p-value <0.001) and problem in muscle tone (hypotonic) along with tendon reflexes (hyporeflexia) had also suffered both (90.9%) (p-value <0.001). Table 2

Table 2: Relationship of Electrolyte Imbalance with Clinical Examination

Clinical Examination		Electrolyte Imbalance			Normal Levels	p-value
		Hyponatremia (%)	Hypokalemia (%)	Both (%)		
Body Temperature	Normothermic	14 (31.1)	06 (13.3)	13 (28.9)	12 (26.7)	0.354 [a]
	Hypothermia	09 (22)	06 (14.6)	11 (26.8)	15 (36.6)	
	Hyperthermia	08 (47.1)	01 (5.9)	06 (35.3)	02 (11.8)	
Pulse Rate	Tachycardia	19 (25.3)	13 (17.3)	23 (30.7)	20 (26.7)	0.004 [a] *
	Bradycardia	-	-	02 (100)	-	
	Normal	12 (50)	-	03 (12.5)	09 (37.5)	
Hydration Status	Some Dehydration	20 (38.1)	08 (15.4)	12 (23.1)	12 (23.1)	0.008 [a] *
	Severe Dehydration	01 (3.6)	03 (10.7)	12 (42.9)	12 (42.9)	
	Hypovolemic Shock	02 (100)	-	-	-	
	No Dehydration	08 (38.1)	02 (9.5)	06 (28.6)	05 (23.8)	
Abdominal Distension	Yes	13 (22)	09 (15.2)	25 (42.4)	12 (20.3)	0.008 [a] *
	No	18 (40.9)	04 (9.1)	05	17	

				(11.4)	(38.6)	
Auscultation of Bowel Sounds	Normal	30 (38)	13 (16.5)	14 (17.7)	22 (27.8)	<0.001 [a] *
	Sluggish	01 (4.5)	–	14 (63.6)	07 (31.8)	
	Absent	–	–	02 (100)	–	
Tone of Muscle on Motor System Examination	Normal	31 (33.7)	12 (13)	20 (21.7)	29 (31.5)	<0.001 [a] *
	Hypotonic	–	01 (9.1)	10 (90.9)	–	
Tendon Reflexes on Motor System Examination	Normal	31 (33.7)	12 (13)	20 (21.7)	29 (31.5)	<0.001 [a]*
	Hyporeflexia	–	01 (9.1)	10 (90.9)	–	
[a]= Fisher–Freeman–Halton exact test; *Significant p-value<0.05						

Discussion

An analytical cross-sectional study of 103 hospitalised children **selected using non-probability consecutive sampling** with acute diarrhea showed that there were 30.1% children having hyponatremia, 12.6% had suffered hypokalemia and 29.1% had suffered both hyponatremia and hypokalemia. In a study by Dhillon et al., the hyponatremia was found less from our study results that is among 14.2% children [9]. This is lower than the hypokalemia found (45.5%) in 145 children aged 1-8 years from Saidu Group Teaching Hospital and was significantly related to younger age and longer diarrhea duration [10].

Results were similar to an earlier study in North West General Hospital, Peshawar, where 32.8% of children were found to have hyponatremia [11] and were quite different from those reported from a study in Quetta where hyponatremia found in 5.7%, while hypokalemia was present in 43.7%. This regional variation within Pakistan itself may be due to the diversity of local feeding practice as well as the severity of dehydration and the electrolyte cut-off points used across the country. The prevalence of hypokalemia in the current study (12.6% isolated) was similar to the prevalence in a study at Dhaka Shishu Hospital (7.7% for hypokalemia and 10.6% for hyponatremia) indicating that sodium derangement is more common than potassium derangement in acute diarrheal illness across settings [12].

The present study showed that younger age group (<1 year) had the highest level of hypokalemia, similar to Swat-based cohort where a significant correlation was seen between younger age and hypokalemia (p=0.01) [13]. This is physically logical because the infants have a higher turnover of water in their bodies, less reserve renal function, and a greater sensitivity to water loss through vomiting; in addition, there was a high frequency of vomiting and a short duration of illness in 86.4% of the infants who had loose stools for 1-7 days. Children's age was also reported to be a similar pattern in Chittagong Medical College, Bangladesh where clinical predictors of electrolyte imbalance in children aged under 5 years is a critical concern in resource-poor areas [14].

Combined electrolyte derangements (p=0.008) was significantly associated with more severe dehydration to hypovolemia resulted in combined hypo-electrolyte profiles. In this study, the almost universal relationship of tachycardia with hyponatremia (25.3%) and of abdominal distension with electrolyte imbalance (42.4%) confirms the physiological association between potassium depletion and cardiac/gastrointestinal smooth-muscle dysfunction [15, 16]. This is also

in line with literature, which has shown that a combined derangement of sodium and potassium during diarrheal illness is associated with low potassium stores in children [17].

This was because the male predominance noted in isolated hyponatremia and hypokalemia cases in this study was contrasted with the Peshawar cohort where there was no difference in gender distribution among all the admissions of diarrhea. So, the gender distribution in the current study did not seem to indicate any particular electrolyte susceptibility as the association was not significant (p=0.101) [18].

The overall prevalence of electrolyte disturbances was high and predominantly seen in younger and clinically dehydrated children in this study which was similar to the overall prevalence in Pakistani literature. The discrepancy in the amount of sodium-predominant versus potassium-predominant imbalance found in various studies may be due to the differences in the definition of the cases, the laboratory thresholds, and the nutritional status of the populations studied [19, 20].

This study evaluated not only sodium, but also potassium derangements and includes detailed clinical correlates (bowel sounds, neuromuscular signs) which give multiple perspectives rarely seen in single electrolyte studies. The lack of generalizability of the findings to other pediatric populations in Pakistan is due to the single-center, cross-sectional design and relatively small sample size (103) along with **consecutive** sampling technique while the lack of follow-up makes it difficult to assess outcomes after electrolyte correction. The results highlight the need to conduct monitoring in severely dehydrated and infants with acute diarrhea to correct the electrolyte levels and thus minimise associated complications. These associations should be validated by future multicenter, prospective studies using probability sampling techniques with larger sample sizes.

Conclusion

Sodium and potassium imbalance was identified as being present in a significant number of children admitted with acute diarrhea, with younger infants, dehydrated children and those with highest dehydration levels being most affected. Combined electrolyte disturbances were strongly related to clinical signs of abnormal pulse rate, abdominal distention, sluggish bowel sounds and altered neuromuscular tone.

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