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Frequency of Serum Electrolytes in Children Suffering from Acute Gastroenteritis Aged 6 Months to 3 Years Admitted to MTI DHQ Hospital Dera Ismail Khan

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ABSTRACT

Acute Gastroenteritis (AGE) is a major contributor to morbidity, dehydration, and hospitalizations among young children in low-resource settings. Electrolyte disturbances are common complications that may worsen disease severity and outcomes. **Objective:** To evaluate the clinical presentation and laboratory findings, particularly serum electrolyte levels, in children aged 6 months to 3 years diagnosed with AGE, and to assess their association with dehydration severity. **Methods:** A descriptive-analytical cross-sectional study was conducted at MTI DHQ Hospital, Dera Ismail Khan, involving 110 children with AGE. Data on demographics, clinical features, hydration status, and laboratory results (including serum electrolytes) were recorded. Statistical analysis was performed using SPSS Version 25.0. Chi-square, ANOVA, Kruskal-Wallis, and Tukey's HSD post-hoc tests were applied. A p-value ≤ 0.05 was considered statistically significant. **Results:** Vomiting (76.4%) and fever (64.5%) were the most frequent clinical features. Moderate dehydration was most common. Significant differences ($p \leq 0.05$) in electrolyte levels were observed across dehydration groups: sodium, potassium, chloride, urea, and creatinine levels were elevated in severe cases, while bicarbonate and magnesium were lower. No significant associations were found between dehydration severity and demographic or most clinical variables. **Conclusions:** Electrolyte abnormalities were significantly associated with dehydration severity in children with AGE, emphasizing the need for routine electrolyte monitoring and individualized fluid management, especially in moderate to severe cases. These findings support improved diagnostic protocols and targeted treatment strategies in paediatric gastroenteritis care.

INTRODUCTION

Acute Gastroenteritis (AGE) remains a leading cause of morbidity and mortality in children under five years worldwide, particularly in low-resource settings. According to the World Health Organization, diarrheal diseases including AGE are responsible for nearly 525,000 child deaths annually, with a disproportionate burden in developing countries [1]. In Pakistan, AGE accounts for approximately 15% of paediatric hospital admissions and contributes significantly to under-five mortality [2]. AGE typically presents with diarrhea, vomiting, and dehydration caused by infections from viruses (rotavirus, norovirus), bacteria (*Escherichia coli*, *Shigella*, *Salmonella*), or parasites. The disease is particularly severe in children aged 6 months to 3 years due to immature immunity, higher fluid requirements, and limited physiological reserves [3]. While clinical features help in early diagnosis, the severity of AGE is primarily driven by the extent of dehydration and associated electrolyte disturbances, rather than by the specific pathogen. Common electrolyte imbalances include hyponatremia, hypernatremia, hypokalaemia, hyperkalaemia, metabolic acidosis (low bicarbonate), and hypomagnesemia—all of which contribute to the pathophysiology of dehydration. These abnormalities can lead to neurological dysfunction, cardiac arrhythmias, and

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renal impairment if not promptly identified and corrected [4, 5]. Regional factors such as inadequate sanitation, lack of access to clean water, and low literacy levels further amplify the burden of AGE in countries like Pakistan. However, while several studies in other countries have evaluated serum electrolyte patterns in paediatric AGE, there is limited local data from Pakistan that integrates both clinical features and biochemical profiles, particularly in tertiary care settings. Most Pakistani studies focus on microbial causes or treatment practices, without stratifying patients by electrolyte profile or severity of dehydration [6]. This gap in the literature highlights the need for comprehensive, locally relevant research. This study was conducted to evaluate both clinical presentation and laboratory findings especially serum electrolytes in children aged 6 months to 3 years diagnosed with AGE. The primary objective was to assess the clinical and laboratory characteristics of these patients.
The secondary objective was to determine the association between dehydration severity and various demographic, clinical, and biochemical parameters, thereby informing better diagnostic and therapeutic strategies in similar healthcare settings.

METHODS

This descriptive-analytical cross-sectional study was conducted at the Paediatrics Department of MTI DHQ Hospital, Dera Ismail Khan, under the supervision of pediatric faculty, from 1st June 2024 to 30th November 2024. Ethical approval was obtained from the Institutional Review Board of Gomal Medical College, D.I. Khan (Approval No: 10/GJMS) and the Research Evaluation Unit, CPSP (Ref No: CPSP/REU/PED-2022-029-6853, Dated: June 1, 2024). The sample size was calculated using the World Health Organization (WHO) sample size formula for cross-sectional studies [7]:

$$n = \frac{Z^2 \times P(1-P)}{d^2}$$

where *n* is the required sample size, Z is the standard normal deviate at 95% confidence level (1.96), P is the anticipated prevalence of electrolyte imbalance in children with acute gastroenteritis (assumed at 50% to maximize sample size), and *d* is the margin of error (5%). Based on these parameters, the initially calculated sample size was 384. However, considering the finite number of eligible paediatric patients expected during the study period (approximately 150), the Finite Population Correction (FPC) was applied, adjusting the sample size to 110. However, due to practical constraints, including the study's limited time frame, single-centre setting, and anticipated patient flow, a final sample of 110 children was enrolled using consecutive non-probability sampling [8]. This adjustment ensured the study remained feasible within the available time frame and resources. A consecutive non-probability sampling technique was used to enrol all eligible participants during the defined study duration. All children aged 6 months to 3 years with acute gastroenteritis were screened. Excluded were those with chronic GI disorders, renal/metabolic diseases, prior IV fluids, or incomplete records. Each patient underwent clinical evaluation. A structured proforma was used to record age, gender, residence, socioeconomic status, maternal education, breastfeeding history, diarrhea type, vomiting, fever, ORT use, and antibiotics. Dehydration severity was categorized as mild, moderate, or severe per WHO criteria. Venous blood samples were analyzed using an automated electrolyte analyzer. The following serum parameters were assessed: Sodium (135–145 mmol/L), Potassium (3.5–5.5 mmol/L), Chloride (98–107 mmol/L), Bicarbonate (22–28 mmol/L), Calcium (8.5–10.5 mg/dL), Magnesium (1.6–2.6 mg/dL), Urea (10–40 mg/dL) and Creatinine (0.3–1.0 mg/dL). All laboratory analyses followed standard SOPs. The dependent variables included the frequency and type of serum electrolyte disturbances, such as hyponatremia, hypernatremia, hypokalaemia, hyperkalaemia, metabolic acidosis, and metabolic alkalosis. The independent variables included age, gender, duration of diarrhea, degree of dehydration (mild, moderate, severe), vomiting frequency, presence of fever, and use of Oral Rehydration Solution (ORS). To ensure reliability, standardized laboratory protocols were followed, data were collected using a structured proforma, and assessments were performed by trained paediatric staff. Internal validity was maintained through strict inclusion and exclusion criteria, while external validity was supported by using a consecutive sampling method to include a representative sample of hospitalized children with AGE. Data analysis was conducted using IBM SPSS version 25.0. Categorical variables were reported as frequencies and percentages, and compared using the Chi-square test. The strength of associations was measured using Cramer's V, interpreted as: very weak (<0.10), weak (0.10–0.20), moderate (0.20–0.30), or strong (>0.30). Continuous variables were tested for normality using both Kolmogorov-Smirnov and Shapiro-Wilk tests. The Shapiro-Wilk test was preferred for small to moderate sample sizes (n < 200), while the Kolmogorov-Smirnov test provided cross-validation. Normally distributed variables were analyzed using one-way ANOVA; non-normally distributed variables were analyzed using the Kruskal-Wallis test. For variables with significant ANOVA results, Tukey's HSD post-hoc test was applied to determine intergroup differences. Statistical significance was set at ≤ 0.05. All p-values were reported exactly to ensure clarity.

RESULTS

Table 1 presents the demographic distribution of children based on gender, nutritional status, residence, socioeconomic status, and maternal education level. The Chi-square test revealed no statistically significant associations between these variables and the severity of

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dehydration. Gender, nutritional status, and residence exhibited very weak to weak associations (Cramer's V < 0.15), suggesting minimal influence on dehydration severity. The strongest, albeit non-significant, association was observed with maternal education (p = 0.072, Cramer's V = 0.229), indicating a moderate trend where children of mothers with lower educational attainment tended to experience more severe dehydration. Although this trend did not reach statistical significance, it may warrant further investigation in larger, more diverse samples (Table 1).

Table 1: Demographic Characteristics of Study Population and Their Association with Dehydration Severity (n=110)

Variables	Categories	Frequency (%)	Chi-square (χ^2, df)	p-Value	Cramer's V	Strength of Association
Gender	Male	70 (63.6%)	0.195 (2)	0.907	0.042	Very Weak (Not Significant)
	Female	40 (36.4%)				
Nutritional Status	Well-Nourished	48 (43.6%)	2.309 (2)	0.315	0.145	Weak (Not Significant)
	Malnourished	62 (56.4%)				
Residence	Urban	46 (41.8%)	2.180 (2)	0.336	0.141	Weak (Not Significant)
	Rural	64 (58.2%)				
Socioeconomic Status	Low	56 (50.9%)	2.961 (4)	0.564	0.116	Very Weak (Not Significant)
	Middle	32 (29.1%)				
	High	22 (20.0%)				
Mother's Education	Illiterate	27 (24.5%)	11.586 (6)	0.072	0.229	Moderate (Approaching Significance)
	Primary	30 (27.3%)				
	Secondary	18 (16.4%)				
	Higher	35 (31.8%)				

This table presented the association between dehydration severity and clinical features including breastfeeding history, diarrhea type, vomiting, fever, Oral Rehydration Therapy (ORT), and antibiotic use. The Chi-square test revealed no statistically significant relationships for any of these variables. However, certain trends were observed. Diarrhea type demonstrated the strongest association (χ^2 = 5.333, p = 0.255, Cramer's V = 0.156), suggesting that children with watery diarrhea tended to experience more severe dehydration. Similarly, vomiting (χ^2 = 2.046, p = 0.360, Cramer's V = 0.136) and fever (χ^2 = 3.424, p = 0.181, Cramer's V = 0.176) showed weak associations, with children exhibiting these symptoms more frequently classified into the severe dehydration group. Despite these observed trends, none reached statistical significance, indicating that dehydration severity in children with AGE is likely influenced more by physiological disturbances such as electrolyte imbalances and cumulative fluid loss than by individual clinical symptoms alone (Table 2).

Table 2: Clinical Characteristics of Study Population and Their Association with Dehydration Severity (n=110)

Variables	Categories	Frequency (%)	Chi-square (χ^2, df)	p-Value	Cramer's V	Strength of Association
Breastfeeding History	Exclusive	65 (59.1%)	1.303 (4)	0.861	0.077	Very Weak
	Formula-fed	13 (11.8%)				
	Partial	32 (29.1%)				
Diarrhea Type	Bloody	13 (11.8%)	5.333 (4)	0.255	0.156	Weak
	Mucoid	25 (22.7%)				
	Watery	72 (65.5%)				
Vomiting	No	26 (23.6%)	2.046 (2)	0.360	0.136	Weak
	Yes	84 (76.4%)				
Fever	No	39 (35.5%)	3.424 (2)	0.181	0.176	Weak
	Yes	71 (64.5%)				
Oral Rehydration Therapy	Not Received	41 (37.3%)	0.898 (2)	0.638	0.090	Very Weak
	Received	69 (62.7%)				
Antibiotics Used	No	44 (40.0%)	0.521 (2)	0.771	0.069	Very Weak
	Yes	66 (60.0%)				

Table 3 compared continuous variables age, weight, duration of symptoms, and frequency of diarrheal episodes across different levels of dehydration severity. Age and weight, which were normally distributed, were analyzed using one-way ANOVA, while duration of symptoms and diarrheal frequency, which did not follow a normal distribution, were analyzed using the Kruskal-Wallis test. None of the variables showed statistically significant differences across the dehydration groups (p > 0.05), indicating that these parameters did not significantly predict the severity of dehydration in the study population (Table 3).

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Table 3: Comparison of Continuous Variables across Dehydration Severity Groups

Variables	Mean ± SD	Median (IQR)	Min – Max	Statistical Test Used	p-Value
Age (months)	18.92 ± 5.83	19.05 (7.9)	6.0 – 32.4	ANOVA	0.148
Weight (kg)	9.12 ± 2.09	9.10 (2.9)	5.0 – 14.2	ANOVA	0.496
Duration of Symptoms (days)	4.27 ± 1.91	4.00 (4)	2 – 8	Kruskal-Wallis	0.766
Frequency of Diarrheal Episodes	4.40 ± 1.91	4.00 (4)	2 – 8	Kruskal-Wallis	0.667

This presented the comparison of serum electrolyte levels across dehydration severity groups using one-way ANOVA. All electrolyte parameters, including sodium, potassium, chloride, bicarbonate, calcium, magnesium, urea, and creatinine, showed statistically significant differences ($p \leq 0.05$) among the groups. Children with severe dehydration had significantly higher levels of sodium, potassium, chloride, urea, and creatinine, while bicarbonate and magnesium levels were significantly lower compared to mild and moderate cases. These results highlight the clinical importance of electrolyte monitoring in children with AGE (Table 4).

Table 4: Comparison of Mean Serum Electrolyte Levels across Dehydration Severity Groups

Serum Electrolyte	Mean ± SD	Median (IQR)	Min – Max	Statistical Test	p-Value
Sodium (mmol/L)	136.90 ± 3.82	137 (5)	130 – 145	ANOVA	0.001*
Potassium (mmol/L)	4.15 ± 0.68	4.0 (1.0)	3.0 – 5.6	ANOVA	0.000*
Chloride (mmol/L)	101.75 ± 4.25	101 (6)	94 – 109	ANOVA	0.002*
Bicarbonate (mmol/L)	21.50 ± 3.25	22 (4)	15 – 27	ANOVA	0.000*
Calcium (mg/dL)	9.15 ± 0.68	9.2 (0.8)	8.0 – 10.5	ANOVA	0.005*
Magnesium (mg/dL)	1.75 ± 0.32	1.8 (0.4)	1.2 – 2.3	ANOVA	0.000*
Urea (mg/dL)	30.25 ± 10.12	29 (10)	14 – 55	ANOVA	0.003*
Creatinine (mg/dL)	0.60 ± 0.15	0.6 (0.2)	0.3 – 1.1	ANOVA	0.004*

*Statistically significant at ≤ 0.05

It presented post-hoc comparisons of serum electrolyte levels across dehydration severity groups using Tukey's HSD test. The results revealed statistically significant differences (≤ 0.05) for all measured electrolytes. Children with severe dehydration had significantly higher levels of sodium, potassium, chloride, urea, and creatinine compared to mild and moderate groups. In contrast, bicarbonate and magnesium levels were significantly lower in the severe group, suggesting underlying metabolic acidosis and electrolyte loss. These findings reinforce the importance of routine electrolyte assessment in managing moderate to severe dehydration (Table 5).

Table 5: Post-hoc Comparison of Serum Electrolyte Levels across Dehydration Severity Groups Using Tukey's HSD Test (n=110)

Electrolyte	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Post-hoc Significant Differences
Sodium (mmol/L)	135.51 ± 4.2	135.30 ± 3.9	137.89 ± 3.7	0.001*	Severe > Mild, Moderate
Potassium (mmol/L)	3.93 ± 0.64	4.05 ± 0.61	4.58 ± 0.65	0.000*	Severe > Mild, Moderate
Chloride (mmol/L)	100.7 ± 4.5	101.3 ± 4.2	102.8 ± 4.1	0.012*	Severe > Mild, Moderate
Bicarbonate (mmol/L)	21.89 ± 3.0	21.97 ± 2.8	18.66 ± 2.9	0.000*	Mild, Moderate > Severe
Calcium (mg/dL)	9.18 ± 0.62	9.25 ± 0.59	9.45 ± 0.58	0.030*	Severe > Mild, Moderate
Magnesium (mg/dL)	1.81 ± 0.35	1.77 ± 0.33	1.55 ± 0.32	0.000*	Mild, Moderate > Severe
Urea (mg/dL)	29.5 ± 9.1	30.2 ± 9.0	32.3 ± 8.8	0.008*	Severe > Mild, Moderate
Creatinine (mg/dL)	0.61 ± 0.19	0.63 ± 0.18	0.74 ± 0.17	0.015*	Severe > Mild, Moderate

*Statistically significant at ≤ 0.05

Post-hoc analysis performed using Tukey's HSD test following one-way ANOVA.

The overall analysis of demographic, clinical and biochemical parameters suggested that imbalances in electrolytes have a much greater relationship with the severity of dehydration than demographic or elementary clinical factors. The prominent differences observed in sodium, potassium and bicarbonate as well as creatinine levels suggests that in cases of severe dehydration, attention to the fluid balance as well as correcting the metabolic derangement should be the primary focus. In figure 1 the graph demonstrated the variation of electrolyte concentrations when the level of dehydration increases. The worsening of dehydration results in higher concentration levels of sodium, potassium, chloride, urea, and creatinine likely due to the loss of fluid causing these electrolytes to be more concentrated. As bicarbonate and magnesium concentrations decrease, this indicates a probable case of metabolic acidosis and loss of an electrolyte. These trends underscore the need to assess electrolytic balance in patients who are dehydrated, which is critical.

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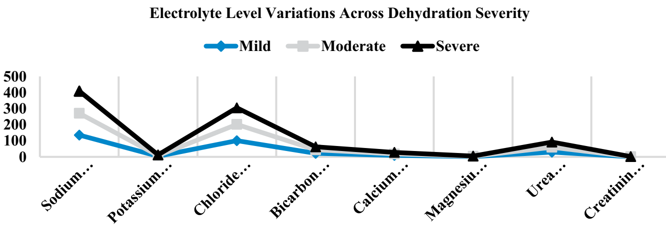

Figure 1: Trends in Serum Electrolyte Levels across Dehydration Severity

The graph illustrates how sodium, potassium, chloride, urea, and creatinine levels increase with dehydration severity, while bicarbonate and magnesium levels decrease, indicating electrolyte imbalances associated with worsening dehydration.

DISCUSSION

This study explored the relationship between serum electrolyte disturbances and dehydration severity in children with Acute Gastroenteritis (AGE). Significant differences in serum sodium, potassium, chloride, bicarbonate, calcium, magnesium, urea, and creatinine levels were observed across dehydration groups, highlighting the clinical value of electrolyte monitoring in paediatric AGE. No statistically significant associations were found between dehydration severity and demographic variables such as gender, nutritional status, or residence. Maternal education showed a moderate but non-significant association, suggesting that lower maternal education may influence care-seeking behaviour and delay rehydration, consistent with previous studies [6, 9, 10]. Among clinical features, diarrhea type and fever showed weak associations with dehydration severity. Watery stools and fever may contribute to increased fluid loss, but their predictive value was limited, reinforcing the need for biochemical assessment over clinical signs alone [11-13]. Age, weight, duration of symptoms, and diarrheal frequency were not significantly different across dehydration categories. This supports existing evidence that symptom duration alone is insufficient to predict severity and underlines the role of serum electrolytes in clinical evaluation [14, 15]. A key finding was the significant rise in sodium levels with increasing dehydration severity, particularly in children with hypernatremia, which reflects disproportionate water loss. Similarly, potassium levels were significantly elevated in severe dehydration ($p \leq 0.001$), suggesting impaired renal excretion and cellular shifts. Hyperkalaemia in paediatric patients is particularly concerning due to its potential to cause cardiac arrhythmias, muscle weakness, and life-threatening ECG changes [16]. Hypomagnesemia, also noted in severe dehydration, is equally worrisome. Magnesium is essential for neuromuscular stability, and its deficiency can lead to seizures, muscle cramps, and worsening electrolyte derangements, particularly hypokalaemia and hypocalcaemia [17]. Metabolic acidosis, indicated by significantly reduced bicarbonate levels, was prominent in severely dehydrated children. This aligns with the pathophysiology of AGE, where bicarbonate is lost via diarrheal stools [18]. Elevated urea and creatinine levels in these patients suggest perennial azotaemia, highlighting the risk of kidney dysfunction in the setting of hypovolemia [19]. Post-hoc analysis confirmed that severe dehydration was associated with marked electrolyte deviations compared to mild and moderate cases. These findings emphasize the importance of early electrolyte monitoring and timely correction, particularly in severe AGE cases. International guidelines, including those from WHO and UNICEF, recommend electrolyte assessment and tailored rehydration therapy as standard components of AGE management, especially in moderate to severe cases [20, 21]. These guidelines underscore the need for low-osmolarity ORS, zinc supplementation, and correction of electrolyte disturbances in hospitalized children with diarrhea. This was a cross-sectional study, which limits causal inferences. Real-time fluid loss monitoring and serial electrolyte measurements were not performed. Future longitudinal studies with larger samples should explore dynamic electrolyte changes during treatment and assess outcomes in relation to maternal education and socioeconomic status.

CONCLUSIONS

This study demonstrates that electrolyte abnormalities are strongly associated with the severity of dehydration in children with AGE. While demographic and clinical variables showed limited predictive value, significant changes in sodium, potassium, bicarbonate, and creatinine were observed in severely dehydrated children. These findings support the incorporation of routine serum electrolyte testing into standard clinical protocols for paediatric AGE, particularly in resource-limited settings where early detection and correction of imbalances can reduce complications and improve outcomes.

Authors Contribution

Conceptualization: IK
Methodology: FUB, IK, AY, AK
Formal analysis: FUB, IK
Writing, review and editing: OK, FUB, IK, AY, AK
All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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