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Original Research Article

Clinical and Biochemical Profile of Children with Acute Diarrhoea: An Assessment of Dehydration and Electrolyte Status

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Abstract

Background: Acute diarrhoeal diseases remain a major cause of morbidity and mortality among infants and young children, particularly in developing countries. Dehydration is the most important and potentially fatal complication of diarrhoea.

Objective: To describe the serum electrolyte profile at admission among children with some or severe dehydration due to diarrhoea and compare blood glucose and electrolyte profiles between children who received ORS before admission and those who did not during the first three days of hospitalisation.

Methods: A hospital-based prospective observational study was conducted among 148 children aged ≤60 months admitted with acute diarrhoea and some or severe dehydration to the Paediatric Ward of R.G. Kar Medical College and Hospital, Kolkata. Data were collected using a pretested, standardised questionnaire through caregiver interviews, clinical examination, anthropometry, laboratory investigations, and review of treatment records. Blood glucose and serum electrolytes were assessed on days 1, 2, and 3. Data were entered in an MS Excel spreadsheet and analysed in SPSS version 29.

Results: Children aged <24 months constituted 17.7% of those with some dehydration and 45.7% of those with severe dehydration. Prior ORS intake was significantly associated with dehydration severity (p=0.0001). Significant differences were also observed in admission blood glucose, sodium, potassium, bicarbonate levels, and IV fluid requirements according to prior ORS intake.

Conclusion: Appropriate ORS administration, correct preparation, caregiver education, and early recognition of dehydration are essential to reduce the severity and treatment burden of acute diarrhoeal illness. Particular attention should be given to children below two years of age.

Keywords: Acute diarrhoeal illness, dehydration in children, ORS, serum electrolyte profile, blood glucose level.

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Introduction

Acute diarrhoeal diseases remain a major cause of morbidity and mortality among infants and young children, particularly in developing countries. Dehydration is the most important and potentially fatal complication of diarrhoea and accounts for a substantial proportion of diarrhoea-related deaths. However, adequate fluid replacement at home can largely prevent dehydration, and an appropriate glucose-electrolyte solution, such as Oral Rehydration Salts (ORS), can be used effectively and inexpensively across all age groups. [1] Diarrhoea causes excessive loss of water and electrolytes, including sodium, chloride, potassium, and bicarbonate, through liquid stools. Additional losses may occur through vomiting, sweating, urine, and respiration. When these losses are not adequately replaced, a progressive deficit of water and electrolytes develops, resulting in dehydration. The volume of fluid lost through stools can vary considerably, from approximately 5 mL/kg per day to 200 mL/kg or more, with substantial variation in the concentration and total amount of electrolytes

lost. In young children with severe dehydration, the total body sodium deficit is generally around 70–110 mmol/L of water deficit, while potassium and chloride losses may be of a similar magnitude. Such disturbances can occur irrespective of the aetiology of acute diarrhoea. Common causes of diarrhoeal dehydration include rotavirus and enterotoxigenic Escherichia coli (ETEC), while Vibrio cholerae O1 and O139 are important causes during epidemics. [2,3]

Dehydration represents a loss of both water and essential electrolytes required for maintaining circulating blood volume and normal cellular and physiological functions. It is also an important contributor to nutritional loss and impaired growth among children with diarrhoeal illness. [4] In the early stages, dehydration may be clinically difficult to recognise, although thirst and dryness of the mouth may be present. With increasing severity, children may develop restlessness, irritability, dry mucous membranes, sunken eyes, sunken fontanelle in infants, and absence of tears. [5,6] Severe dehydration can progress to hypovolaemic shock, characterised by altered consciousness, oliguria or anuria, cool extremities, rapid and weak pulse, hypotension, and peripheral cyanosis. If prompt and appropriate rehydration is not initiated, severe dehydration may result in convulsions, cardiovascular compromise, and death. [7]

Diarrhoea may also cause significant biochemical disturbances involving fluid, electrolyte, and acid–base balance. Alterations in serum sodium may result in either hyponatraemia or hypernatraemia, while other important abnormalities include hypokalaemia and metabolic acidosis. [9,10] The severity of dehydration is generally classified clinically as mild, moderate, or severe according to estimated fluid loss and relevant clinical parameters.[11] Since dehydration is a major determinant of morbidity and mortality in children with acute diarrhoeal disease, assessment of biochemical parameters at admission may provide important prognostic information and assist in appropriate and individualised management. [12]

In developing countries, diarrhoeal diseases continue to be among the leading causes of childhood morbidity and mortality. Approximately one billion episodes of diarrhoea and substantial numbers of childhood deaths occur annually, with nearly 80% of diarrhoeal deaths among children under five years occurring during the first two years of life. [13,14]

Recurrent diarrhoeal episodes may further contribute to malnutrition, growth retardation, and impaired immunity. Children under five experience an average of approximately 3.2 diarrhoeal episodes per year, although the severity varies considerably and some episodes can become life-threatening. [15,16] Against this background, a cross-sectional study was conducted at RG Kar Medical College and Hospital, Kolkata, to describe the serum electrolyte profile at admission among children with some or severe dehydration due to diarrhoea. The study also aimed to compare blood glucose and electrolyte profiles between children who received ORS before admission and those who did not, on days 1, 2, and 3 of hospitalisation.

Materials & Methods

A hospital-based prospective observational study was conducted among children aged 60 months and below admitted with acute diarrhoea and some or severe dehydration to the Paediatric Ward of R.G. Kar Medical College and Hospital (RGKMCH), Kolkata. RGKMCH is a tertiary-care teaching and referral hospital providing healthcare services to children from Kolkata and the surrounding districts of West Bengal. The study was conducted for 18 months, from February 2023 to August 2024, following approval from the Institutional Ethics Committee of RGKMCH (IEC approval number: RMC/720). Eligible children were enrolled at admission and prospectively followed throughout their hospital stay to assess hydration status, electrolyte changes, clinical course, and treatment outcomes.

The study population comprised children aged 6–60 months who were admitted with diarrhoea-associated some or severe dehydration. Diarrhoea was defined according to WHO criteria as the passage of three or more loose or watery stools within 24 hours, or more frequent passage than is normal for the individual child. Dehydration status was classified according to the Integrated Management of Childhood Illness (IMCI) criteria.

The required sample size was calculated using the single population proportion formula:

$N= Z^2pq/ l^{2.}$, where N represents the required sample size; Z represents the standard normal deviate corresponding to a 95% confidence level (1.96); p represents the expected proportion of hypokalaemia among children with diarrhoea (44.3%), based on the previously published study by Matthias Maliereokposio et al [17].; $q = 100 − p = 55.7\%$; and l represents the absolute precision, set at 8 percentage points. Thus, N became 148.

Approximately 150 eligible admissions were anticipated (based on the previous year's records) during the study period. Since the calculated sample size of 148 was almost equivalent to the expected number of eligible admissions, all consecutive eligible children admitted during the study period were enrolled until the required sample size was achieved. A total of 148 children were included in the study. A consecutive sampling approach was used. Every child fulfilling the

eligibility criteria and admitted during the study period was assessed for enrolment and included after obtaining informed consent until the required sample size was reached. Thus, no selective sampling or alternate-case selection was performed.

Children were eligible for inclusion if they:

1. were aged 60 months and below
2. were admitted to the paediatric ward with acute diarrhoea and some or severe dehydration according to IMCI criteria; and
3. Had written informed consent provided by a parent or legally authorised caregiver.

Children were excluded if they:

1. Had an obvious severe concurrent illness likely to independently influence hydration or electrolyte status, including severe pneumonia or meningitis, as defined by WHO criteria.
2. had grossly visible blood in the stool; or
3. Had any other condition identified by the treating clinician that made participation or serial blood sampling inappropriate.

Data were collected using a pretested and standardised structured questionnaire. Information was obtained through caregiver interviews, clinical examination, anthropometric measurements, laboratory investigations, and review of treatment records. The baseline assessment included sociodemographic characteristics, breastfeeding status, diarrhoeal history, vomiting, and fever, and prior antibiotic use, ORS intake before admission, immunisation history, and history of measles, anthropometric measurements, hydration status, and relevant clinical findings.

A detailed history was obtained at admission, including age, sex, breastfeeding status, duration of diarrhoea, number and consistency of stools during the preceding 24 hours, history and number of vomiting episodes during the preceding 24 hours, history of fever, antibiotic use before admission, duration of illness and treatment, ORS use before admission, measles immunization status, and history of measles during the preceding three months.

Hydration status was assessed at admission and during follow-up using clinical signs recommended by IMCI. The following parameters were assessed:

- General condition and level of consciousness;
- Presence of sunken eyes.
- Ability and eagerness to drink; and
- Skin-pinch test.

General condition was categorised as alert, restless/irritable, lethargic, or unconscious. If the child appeared sleepy, responsiveness was assessed by attempting to arouse the child. The child's eyes were examined for evidence of sunken eyes. Drinking ability was assessed by offering the child fluid and observing whether the child drank normally, drank eagerly, was unable to drink or drank poorly. For the skin-pinch test, a fold of skin over the abdomen was gently pinched and released. The time required for the skin fold to return to its normal position was categorised as immediate, slow, or very slow.

According to IMCI criteria, severe dehydration was defined as the presence of at least two of the following signs: lethargy or unconsciousness, sunken eyes, inability to drink or drinking poorly, or skin pinch returning very slowly. Some dehydration was defined as the presence of at least two of the following signs: restlessness or irritability, sunken eyes, drinking eagerly, or skin pinch returning slowly. Children who did not fulfil the criteria for either some or severe dehydration were classified as having no dehydration.

Because conventional clinical signs of dehydration may be unreliable in children with severe acute malnutrition, hydration status in this subgroup was assessed with particular attention to the presence of a dry mouth and tongue, eagerness to drink in children with suspected some dehydration, and very dry mouth or tongue, cool and moist extremities, and weak or absent radial pulse in children with suspected severe dehydration. Body weight was measured at admission using a calibrated weighing scale and subsequently every 24 hours until the end of follow-up. Measurements were obtained using standardised procedures.

Approximately 2 mL of venous blood was collected from the dorsum of the hand or antecubital fossa following appropriate skin antisepsis with 5% chlorhexidine solution. Blood samples for serum sodium and potassium estimation were collected on Day 0 (at admission), Day 1, and Day 2, depending on the duration of hospitalisation and availability of the child for follow-up sampling. Following collection, blood samples were transported to the Clinical Biochemistry Laboratory of RGKMCH. Serum was separated within 15 minutes of collection and stored at 4–8°C until analysis. Electrolyte estimation was performed within one week of sample collection. Serum sodium (Na^+) and potassium (K^+) concentrations were measured using an automated electrolyte analyser based on the ion-selective electrode (ISE) principle. Venous blood gas (VBG) analysis was performed to assess acid–base status, including pH and relevant acid–base parameters.

Operational definitions of electrolyte abnormalities: Electrolyte abnormalities were classified using the laboratory reference ranges and/or predefined study cut-offs. For analysis, the following operational definitions were used:

- **Hypokalaemia:** serum potassium < 3.5mmol/L
- **Hyperkalaemia:** serum potassium > 5.5 mmol/L
- **Hyponatraemia:** serum sodium < 135 mmol/L
- **Hypernatremia:** serum sodium > 145mmol/L

Monitoring and follow-up

All enrolled children were prospectively monitored during the rehydration and maintenance phases of treatment.

The following parameters were recorded at predefined intervals:

1. ORS intake**:** recorded hourly during the rehydration phase and subsequently at hourly intervals during the maintenance phase.
2. Hydration status: assessed hourly during the rehydration phase and every 8 hours during the maintenance phase.
3. Stool frequency**:** recorded every 4 hours during the rehydration phase and every 8 hours during the maintenance phase.
4. Vomiting episodes**:** recorded every 8 hours.
5. Body weight**:** measured at admission and every 24 hours thereafter.
6. Serum sodium and potassium**:** assessed on Days 0, 1, and 2, subject to duration of hospitalisation.
7. Acid–base status**:** assessed using VBG analysis.

Treatment, including ORS and other supportive measures, was administered according to the treating physician's clinical assessment and applicable institutional and WHO recommendations.

Data Management and Statistical Analysis: Data were checked for completeness and consistency before being entered into a computerised database. Statistical analysis was performed using SPSS version 29.0. Continuous variables were assessed for distribution using appropriate tests of normality and graphical methods. Normally distributed continuous variables were summarised as mean ± standard deviation (SD). Categorical variables were presented as frequencies and percentages. The prevalence of electrolyte abnormalities was estimated with corresponding 95% confidence intervals where appropriate. For comparison of continuous variables between two groups, the independent-samples t-test. For categorical variables, the chi-square test or Fisher's exact test was used as appropriate. Potential factors associated with electrolyte abnormalities were evaluated using univariate analysis. Effect estimates were reported with 95% confidence intervals. A two-sided p-value <0.05 was considered statistically significant.

Quality Assurance: The data-collection questionnaire was pretested before the study began and subsequently standardised. All investigators involved in data collection were trained to assess dehydration according to IMCI criteria. Standardised procedures were followed for clinical examination, anthropometric measurements, ORS administration, and recording of stool and vomiting frequency. The ORS preparation was checked to ensure that the commercially available ORS powder was reconstituted using the recommended volume of safe drinking water and according to standard instructions.

Blood samples were collected and processed by trained laboratory personnel in the Department of Biochemistry, RGKMCH. Serum was separated within 15 minutes of specimen collection and maintained under appropriate storage conditions until analysis. The electrolyte analyser was routinely calibrated and maintained according to the manufacturer's recommendations. Serum sodium and potassium measurements were performed using the ISE method. The VBG analyser was checked for functionality and quality control before use.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of R.G. Kar Medical College and Hospital (IEC approval number: RMC/720).

Written informed consent was obtained from the parent or legally authorised caregiver of every enrolled child before participation. Participation was voluntary, and refusal to participate did not affect the child's treatment. Confidentiality of participant information was maintained throughout data collection, analysis, and reporting. Data were anonymised using unique study identification numbers.

Results

In the present study, the average age of the admitted children with acute diarrhoea was 31.20 ± 13.27 months (Mean ± SD), with a minimum of 2 months and a maximum of 60 months. There were 23.65% of children suffering from severe dehydration, and the rest were suffering from some dehydration. It had been observed that the mean ± SD age of the children suffering from severe dehydration was 24.86 ± 14.27 months, which was less than that of the children suffering from some dehydration, which was 33.35± 12.23 months; this result was statistically significant (p-value 0.00) (Fig. 1). In some dehydration, only 17.7% of children were under 24 months of age, whereas in severe dehydration, 45.7% were under 24 months of age. During history-taking and clinical examination, we found that prior ORS intake was significantly associated with the degree of

dehydration (p=0.0001). Among those who had a history of prior ORS intake, only 10% were suffering from severe dehydration, but about 37% of the children who did not have a history of prior ORS intake became severely dehydrated (Fig.2).

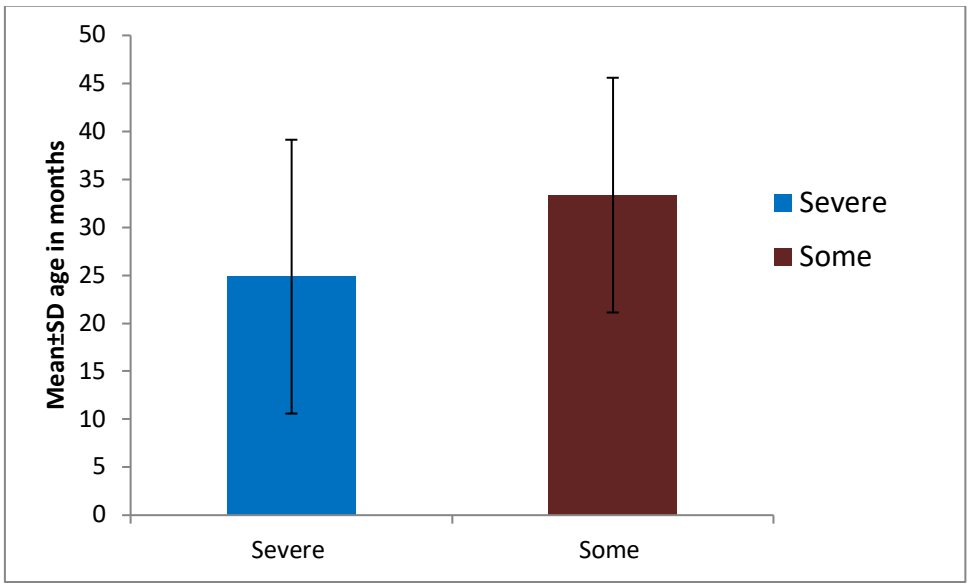

Figure 1: showing mean ± SD age of children suffering from severe and some dehydration (n=148)

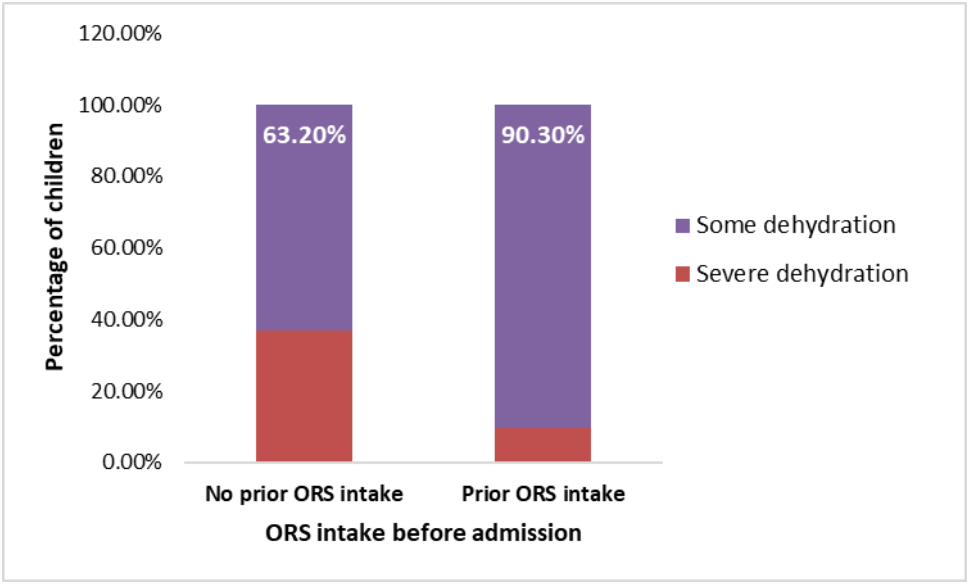

Figure 2: showing children suffering from severe and some dehydration and their history of prior ORS intake (severe dehydration, n1= 35 and some dehydration, n2=113)

Even prior ORS intake had a significant role in the difference in blood glucose level, admission sodium, potassium, and bicarbonate levels (Table 1), and IV fluid requirements. Among patients without prior ORS intake, 36.8% required IV fluids, whereas only 11.1% of patients with a history of prior ORS intake required IV fluids (Fig 3). This result was statistically significant (p=0.0002). On the second day, the electrolyte picture was slightly different. Prior ORS intake had a significant role in the difference in sodium and bicarbonate but not potassium and calcium. On the third day, only a significant difference existed in Bicarbonate level (Table 2). Children with severe dehydration required a longer hospital stay (mean±SD was 3.57 ± 0.69 days) 1 than those with some dehydration (mean±SD was 2.89 ± 0.37 days). This result was statistically significant (Table 3). Also, the requirement of IV fluid was higher in severe dehydration (100%) than in some dehydration (0.9%); this result was also statistically significant (p-value <0.0001).

Table 1: Distribution of study participants among prior ORS intake and other attributes on admission (n=148)

Attributes	Prior ORS n1(No)=76, n2(Yes)=72	Mean±SD	Statistic	p-value
Blood glucose level (mg/dl)	No	97.28±18.23	t test	**0.0141**
	Yes	104.68±18		
Na+ on admission (mmol/L)	No	131.71±4.33	t test	**0.0013**
	Yes	134.14±4.71		
K+ on admission (mmol/L)	No	3.5±0.37		
	Yes	3.66±0.29	t test	**0.0035**
Ca+ on admission (mmol/L)	No	2.1 ± 0.09	t test	0.957
	Yes	2.1 ± 0.07		
$HCO3^-$ on admission (mmol/L)	No	21.43 ± 1.63	t test	**<0.0001**
	Yes	22.46 ± 1.21		

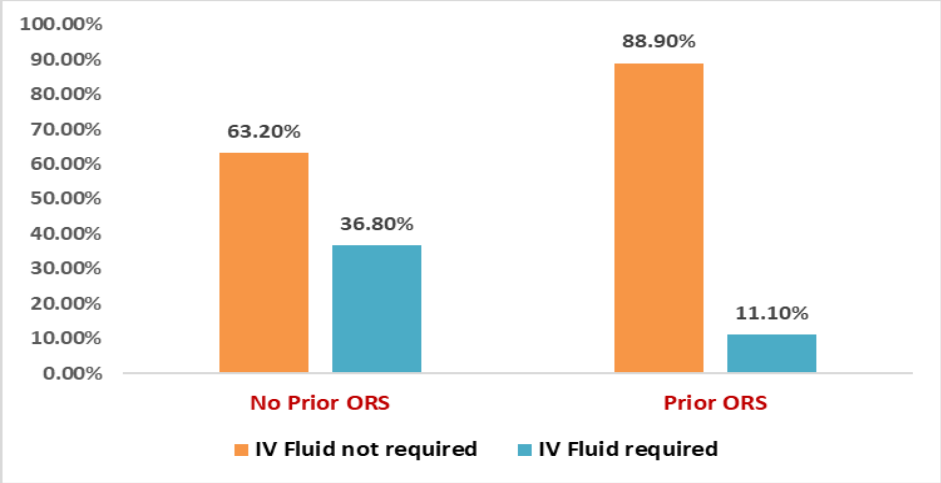

Figure 3: Distribution of children among prior ORS intake and IV fluid requirements

Table 2: Distribution of study participants among prior ORS intake and electrolyte levels on day2 and day3

Attributes		Prior ORS N1(No)=76, N2(Yes)=72	Mean±SD	Statistic	p-value
Day 2	Na+ (mmol/L)	N1	131.2±2.61	t test	**0.0002**
		N2	138.15±3.55		
	K+ (mmol/L)	N1	3.75±0.26	t test	0.2599
		N2	3.8±0.25		
	Ca+ (mmol/L)	N1	2.1 ± 0.12	t test	0.6014
		N2	2.11± 0.04		
	$HCO3^-$ (mmol/L)	N1	22.74± 0.83	t test	**0.0002**
		N2	23.22 ± 0.66		
Day 3	Na+(mmol/L)	N1	138.31±2.17	t test	0.0614
		N2	138.97±2.06		
	K+ (mmol/L)	N1	3.83±0.21	t test	0.7175
		N2	3.85±0.18		
	Calcium (mmol/L)	N1	2.12±0.04	t test	0.7255
		N2	2.11±0.04		
	$HCO3^-$ (mmol/L)	N1	23.18±0.46	t test	**0.0031**
		N2	23.42±0.52		

Table 3: Distribution of study participants among the mean duration of hospital stay and degree of dehydration (N=148)

	Degree of dehydration	Number	Mean	SD	Minimum	Maximum	p-value
Duration of Hospital stay	Severe	35	3.5714	.6981	3.0000	5.0000	<0.0001
	Some	113	2.8850	.3721	2.0000	4.0000	

Discussion

Acute diarrhoeal disease remains an important cause of dehydration and electrolyte disturbances among children, particularly in younger age groups. In the present study, the mean age of the admitted children was 31.20 ± 13.27 months (range: 2–60 months). Severe dehydration was observed in 23.65% of children, while the remaining participants had some dehydration. Children with severe dehydration were significantly younger than those with some dehydration (24.86 ± 14.27 vs. 33.35 ± 12.23 months). Furthermore, 45.7% of children with severe dehydration were below 24 months compared with 17.7% of those with some dehydration. These findings indicate that younger children may be particularly vulnerable to progression of dehydration during acute diarrhoeal illness, highlighting the importance of early recognition and timely rehydration.

Dagar et al. [18] identified diarrhoea as an important cause of morbidity and mortality among children below five years of age. Similarly, Onyiriuka et al. [19] reported that serum electrolyte disturbances were common among under-five children with acute diarrhoea, with most affected children being below 36 months. Notably, all deaths in their study occurred among children younger than 24 months, further supporting the vulnerability of younger children to severe outcomes.

A significant association was observed between prior ORS intake and dehydration severity. Prior ORS use was reported in 57.5% of children with some dehydration compared with only 20.0% of those with severe dehydration (p=0.0001). Children who had received ORS before admission also had significantly higher mean serum sodium, potassium, and bicarbonate concentrations at presentation than those without prior ORS intake. The lower sodium and bicarbonate concentrations among children without prior ORS use may reflect greater dehydration and associated metabolic disturbance. However, because of the observational design, these findings represent associations and cannot establish a causal protective effect of ORS. Differences in illness severity, timing of presentation, and quantity of ORS administered, and appropriateness of its preparation may also have influenced the results.

The importance of appropriate rehydration is supported by Anigilaje et al. [20], who emphasised oral rehydration therapy for mild-to-moderate dehydration and close clinical and biochemical monitoring in children with severe dehydration or sodium abnormalities. Shah et al. [21] similarly reported hyponatraemia and hypokalaemia as important electrolyte disturbances in children with acute diarrhoea and emphasised appropriate ORS use to prevent severe dehydration and dyselectrolytaemia.

In the present study, biochemical parameters progressively converged during hospitalisation. By the second day, differences associated with prior ORS intake persisted mainly for serum sodium and bicarbonate, while potassium and calcium differences were no longer significant. By the third day, sodium, potassium, and calcium were comparable between groups, whereas bicarbonate remained significantly different. This may indicate correction of dehydration and electrolyte abnormalities with treatment, although acid–base disturbances may require longer to normalise. Islam et al. [22] similarly demonstrated gradual correction of metabolic acidosis during rehydration, with substantial improvement by 48 hours.

Prior ORS intake was also associated with reduced IV fluid requirement (11.1% vs. 36.8%; p=0.0002). Severe dehydration was associated with greater IV fluid requirement and significantly longer hospitalisation than some dehydration (3.57 ± 0.69 vs. 2.89 ± 0.37 days; p<0.0001). Ghosh Dastidar et al. [23] highlighted the importance of correct ORS preparation, particularly avoiding inappropriate dilution, in preventing hyponatraemic dehydration.

Conclusion

Acute diarrhoeal illness in young children is frequently associated with dehydration and electrolyte disturbances, with younger children demonstrating greater vulnerability to severe dehydration. In this study, prior ORS intake was associated with less severe dehydration, more favourable biochemical parameters at admission, reduced requirement for intravenous fluids, and shorter hospitalisation. Electrolyte and acid–base abnormalities progressively improved during inpatient management, emphasising the importance of timely rehydration and monitoring. Appropriate ORS administration, correct preparation, caregiver education, and early recognition of dehydration are essential to prevent disease progression and reduce treatment burden. Particular attention should be given to children below two years of age.

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