Original Article

Assessment of electrolyte imbalance and its predictors in children admitted with Acute Gastroenteritis-Cross Sectional study

Sabyasachi Kazi[1], Rahul Majumdar[2], Divya Mahajan[3]

From, [1]Senior Resident, [2]Associate Professor, Department of Pediatrics, North Bengal Medical College, [3]Consultant Pathologist, Debargha Diagnostic Centre, West Bengal

ABSTRACT

Background: Acute Gastroenteritis is considered to be a major cause of morbidity and mortality among children all around the globe. Annually, 3 to 5 billion cases of Acute Gastroenteritis are reported from all over the world and it is estimated to be responsible for 2 million deaths among children below 5 years of age. **Methods:** An observational descriptive study with a cross-sectional design was conducted at the pediatric department of North Bengal Medical College and Hospital. The sample size was calculated using the Cochrane formula using the prevalence of the outcome in the population. The patients admitted to the study institution with clinically diagnosed acute gastroenteritis were selected by a consecutive sampling technique till the required sample size was reached. At the time of admission, the sociodemographic details of the patients were obtained from their parents using a predesigned questionnaire. After that, blood was drawn from the patients to measure serum haemoglobin, sodium, potassium, and calcium. **Results:** Out of 160 children, most of the children were between 49-60 months with male predominance born out of Spontaneous Vaginal Delivery; mothers were young and resided in rural areas. Exclusive breastfeeding was not practised, improper administration or lack of Oral Rehydration Solution contributed to the high prevalence of electrolyte abnormality. **Conclusions:** The study concludes that there is an urgent need for effective educational interventions to improve ORS administration and breastfeeding practices, especially in rural areas. Enhancing caregiver knowledge and public health strategies could substantially reduce the incidence of electrolyte disturbances and improve clinical outcomes for children with acute gastroenteritis.

Key words: Acute Gastroenteritis, Spontaneous Vaginal Delivery, Oral Rehydration Solution, Exclusive Breast Feeding, World Health Organization

Acute respiratory infections, diarrheal diseases, congenital anomalies, low birth weight, malnutrition, infectious diseases, accidents, and injuries are the major causes of mortality in large groups of infants and under-fives. Among all these diseases acute gastroenteritis occupies the second leading cause of death in children worldwide. Acute gastroenteritis (AGE) is considered to be a major cause of morbidity and mortality among children all around the globe [1]. Annually, 3 to 5 billion cases of AGE are reported from all over the world while AGE is estimated to be responsible for 2 million deaths among children below 5 years of age [2].

The burden of pediatric AGE is the highest among the developing and underdeveloped countries of the world, including India, where it is one of the major killers of children under 5 years of age. Acute diarrheal infection has been implicated as the second most prevalent cause of under-5 mortality in the country, and one of the most important preventable causes of death in the pediatric population [3].

Several potential determinants have been identified in this observation. Chronic poverty, lack of access and practices to proper sanitation and hygiene, poor infrastructure, and lack of proper healthcare access have all been implicated in the high observed incidence of acute gastroenteritis in children [4]. It has also been observed that poor education and knowledge levels among the parents are also important predictors of AGE incidence, as this poor knowledge about the condition leads to complacency concerning identifying danger signs and seeking prompt and proper treatment [5].

Acute gastroenteritis is most commonly occurring due to bacterial, viral, and protozoal infections. The incidence of acute gastroenteritis may be as high as 6-12 episodes per child per year in most developing countries including India. Acute gastroenteritis is an inflammation of the mucus membrane of the stomach and intestine. It is defined as diarrheal disease of rapid onset with or without accompanying manifestations such as nausea, vomiting, fever and abdominal pain. Approximately

Correspondence to: Dr. Rahul Majumdar, Department of Pediatrics, North Bengal Medical College

Email: rahulslg28@gmail.com

15% of children die of acute gastroenteritis before 3 years of age in developing countries. The infection is transmitted through the fecal-oral route, either water-borne, foodborne or direct transmission through contaminated hands, fingers, nails and fomites. More severe or prolonged illnesses can result in dehydration with significant morbidity and mortality.

Dehydration, electrolyte abnormalities and renal impairment are some of the major complications of AGE. It has been observed that hyponatremia is the most common electrolyte abnormality affecting 28% of children with AGE while hypernatremia and hypokalemia were the other most commonly identified abnormalities along with AGE respectively. In this context, the present study aimed to assess the burden of electrolyte imbalance among pediatric patients aged 6 months to 60 months admitted with acute gastroenteritis and find out their predictors, if any.

METHODS

An observational descriptive study with a cross-sectional design was conducted at the North Bengal Medical College and Hospital at the Department of Pediatric Medicine. After the protocol submission, data collection was done for 12 months, analysis for 4 months and report preparation and submission for 2 months, yielding a total timeline of 18 months, The inclusion criteria for the present study are patients aged 6 months to 60 completed months, patients of both the sexes, patients admitted to the study institution during the study period with clinically diagnosed acute gastroenteritis. The exclusion criteria for the present study were patients' parents unwilling to provide written informed consent to participate in the study, patients with underlying acute, acute or chronic malnutrition, and patients with multisystem involvement.

Sample size and technique

The sample size for the present study was calculated using Cochran's formula for the estimation of sample size using the prevalence of the outcome in the study population.

The formula used was as follows: $N = [Z1-\alpha/22 \; X \; p \; X \; (1-p)]/d2$

Where,

P = proportion of outcome

Z = critical value at α level of significance

d = Absolute precision

Based on the results obtained by Iqbal et al. and considering the prevalence of hypernatremia as the outcome variable, the sample size was derived. Taking P as 17.6%, at 10% significance level and 5% absolute precision the sample size for each group was calculated as 156, which was rounded off to 160.

A consecutive sampling technique was employed to recruit participants for the present study. All pediatric patients admitted with acute gastroenteritis to the study institution during the study period and fulfilling the inclusion and exclusion criteria were considered for the present study. The present study was continued till the sample size was reached. At the time of admission, the socio-demographic details of the patients were obtained from their parents using a predesigned questionnaire. After that, blood was drawn from the patients to measure serum haemoglobin, sodium, potassium, and calcium. The blood test was done using an analyser and electrolyte analyser machine.

Data analysis

The collected data were checked for consistency, and completeness and entered into a Microsoft Excel (MS-EXCEL, Microsoft Corp.) datasheet. The data set was analysed with the statistical program Statistical Package for the Social Sciences (IBM SPSS, version 22). Data were organised and presented using the principles of descriptive and inferential statistics. The data were categorised and expressed in proportions. The continuous data were expressed as Mean ± SD. The data were graphically presented in tables, where analytical statistics were performed, a p-value of < 0.05 was considered statistically significant for the study.

Appropriate permissions and clearance were obtained from the Institutional Ethics Committee of North Bengal Medical College before conducting the study. All participants and their parents were informed in their language about their rights to participate before providing data for the researcher-administered questionnaire. The participants were informed about roles and rights, to clarify that their participation was voluntary, the information was treated confidentially, and they could withdraw from the study at any time.

RESULTS

It was observed that majority of the study participants were aged between 49 and 60 months (4-5 completed years). The mean age of the babies in the present study was 35.7 ± 15.7 months. Most of the study participants (54.4%) were male babies with majority of the mothers aged between 18 and 24 years (45.6%). The mean age of the women in the present study was 25.3 ± 4.5 years suggesting young mothers were inexperienced in handling electrolyte imbalance in their children.

It was seen that most of the babies were born to families who lived in the rural area (66.3%) emphasizing the impact of limited access to healthcare and sanitation facilities in these regions. It was seen that most of the babies were delivered by spontaneous vaginal delivery (65.6%). The majority of the babies were not exclusively breastfed during the first 6 months of their life (50.6%) highlighting the protective effects of EBF against gastrointestinal infections and related complications. Only 14.4% of the children were given ORS properly before presenting to the study institution. 28.1% were given ORS, but improperly, and the rest were not given ORS thus proper administration of ORS is crucial as it significantly impacts

serum electrolyte levels.

Table 1. Demographic Details of the study participants

Parameters		Frequency	Percentage
Age (months)	6-12	15	9.4
	13-24	29	18.1
	25-36	34	21.3
	37-48	35	21.8
	49-60	47	29.4
Sex	Female	73	45.6
	Male	87	54.4
Age of mother (Years)	<25	73	45.6
	25-29	48	30
	≥30	39	24.4
Residence	Rural	106	66.3
	Urban	54	33.7
Mode of Delivery	Spontaneous vaginal delivery	105	65.6
	Lower segment cesarean section	55	34.4
Exclusive Breast Feeding done	Yes	79	49.4
	No	81	50.6
Oral Rehydration solution intake	None	92	57.5
	Improper	45	28.1
	Proper	23	14.4

It was seen that the prevalence of hyponatremia and hypernatremia in the participants were 28.1% and 36.3% respectively. These results are consistent with the spectrum of sodium imbalances commonly observed in children with acute gastroenteritis. Also, the prevalence of hypokalemia and hyperkalemia in the participants was 38.8% and 40.6%, respectively. These results highlight the significant variability in potassium levels among children with acute gastroenteritis, reflecting the challenges in managing this common electrolyte disturbance.

Table 2: Serum sodium and potassium levels of the assessed individuals

Parameters		Frequency	Percentage
Serum sodium	Hyponatremia (<135 mg/dl)	45	28.1
	Normal (135-145 mg/dl)	57	35.6
	Hypernatremia (>145 mg/dl)	58	36.3
Serum potassium	Hypokalemia (<3.5mg/dl)	62	38.8
	Normal (3.5-5 mg/dl)	33	20.6
	Hyperkalemia (>5 mg/dl)	65	40.6

Table 3. Factors associated with the serum sodium levels of the study participants (numbers=160)

Parameters	Unstandardized coefficient	p-value
Age	-0.019	0.717
Mothers' age	-0.345	0.062
Birth weight	0.200	0.866
Female sex	-3.011	0.071
Rural residence	-1.101	0.530
Lower segment caesarean section delivery	6.684	**<0.001***
Not exclusively breastfed	-2.612	0.122
Improper Oral Rehydration solution	4.231	0.446
Proper Oral Rehydration solution	-1.336	0.718
History of previous admission	-2.157	0.600
Serum hemoglobin	-0.047	0.938

*Statistically significant

It was observed that on running a multivariable linear regression, controlling for all other factors, only lower segment cesarean section delivery in the participants was associated with a significant increase in their mean serum sodium levels. The lack of significant associations for these factors may indicate that their influence on serum sodium levels is minimal or that other unmeasured variables play a more critical role in determining electrolyte balance.

Table 4. Factors associated with the serum potassium levels of the study participants (numbers=160)

Parameters	Unstandardized coefficient	p-value
Age	0.002	0.831
Mothers' age	0.017	0.607
Birth weight	0.097	0.643
Female sex	-0.256	0.387
Rural residence	0.04	0.937
Lower segment caesarean section delivery	0.284	0.360
Not exclusively breastfed	0.671	**0.036***
Improper Oral Rehydration solution	1.220	0.248
Proper Oral Rehydration solution	-0.962	0.488
History of previous admission	0.500	0.337
Serum hemoglobin	-0.018	0.869

*Statistically significant

It was observed that on running a multivariable linear regression, controlling for all other factors, only non-exclusive breastfeeding in the participants was associated with a significant increase in their mean serum potassium levels. The analysis indicated that non-exclusive breastfeeding was significantly linked to higher mean serum potassium levels (p

0.036), underscoring the importance of exclusive breastfeeding (EBF) in maintaining optimal electrolyte balance in children.

DISCUSSION

The age distribution of study participants in this study reveals a majority aged between 49 and 60 months, accounting for 29.4% of the total sample, with a mean age of 35.7 ± 15.7 months. This finding aligns with previous studies highlighting the prevalence of acute gastroenteritis (AGE) in this age group [6]. Similarly, Iqbal et al. reported a mean age of 2.1 ± 1.7 years in their study, emphasising the vulnerability of younger children to electrolyte imbalances associated with gastroenteritis [7]. Furthermore, the study by Memon et al. also noted a high frequency of AGE in children aged between 6 months and 5 years, underscoring the susceptibility of this age group to dehydration and electrolyte disturbances [8]. Additionally, Tavakolizadeh et al. found that children with AGE had a mean age of 25.36 months, reinforcing the trend of higher incidence rates among younger pediatric populations [9]. Research by Milani et al. further supports these findings, observing that the risk of AGE and associated electrolyte imbalances is notably high in children under 5 years, especially those under 2 years, due to their developing immune systems and higher susceptibility to infections [10].

Regarding the age of mothers, the study reveals that most mothers (45.6%) were aged under 25 years, with a mean age of 25.3 ± 4.5 years. This demographic detail is crucial as maternal age can influence child health outcomes. Additionally, Assar et al. highlighted the role of maternal age in managing and preventing AGE, noting that younger mothers might have less experience in handling dehydration and electrolyte disturbances in their children [11].

The residence data of the study participants indicates that a majority (66.3%) were from rural areas. This finding aligns with other studies that have highlighted a higher prevalence of acute gastroenteritis (AGE) and its associated complications in rural populations. Iqbal et al. observed that 65.4% of children presenting with AGE were from rural areas, emphasising the impact of limited access to healthcare and sanitation facilities in these regions. Similarly, Chakravarthi et al. found that children from rural backgrounds exhibited higher rates of dehydration and electrolyte disturbances due to inadequate healthcare resources and education [12]. Additionally, a study by Riaz et al. underscored that children from rural areas are more susceptible to Age-related complications, with a higher incidence of both sodium and potassium abnormalities [13]. Findings reported by Mosav et al. also emphasise the challenges faced by rural populations, noting that children in these areas are at a heightened risk of developing severe AGE due to environmental factors and limited medical infrastructure [14].

The finding that most participants (50.6%) were not exclusively breastfed during the first 6 months of life is

significant, as exclusive breastfeeding (EBF) has been shown to play a critical role in reducing the incidence and severity of acute gastroenteritis (AGE) in infants and young children. Several studies support this observation, highlighting the protective effects of EBF against gastrointestinal infections and related complications.

It was found that only 14.4% of the children received ORS correctly before hospital admission, while 28.1% received it improperly, and the remainder did not receive ORS at all. Proper administration of ORS is crucial as it significantly impacts serum electrolyte levels. Improper administration of Oral Rehydration Solution (ORS) at home in children aged <5 years suffering from acute gastroenteritis can significantly predispose them to developing serum electrolyte abnormalities such as hyponatremia, hypernatremia, hypokalemia, and hypocalcemia [15]. Incorrect preparation or dosing of ORS, such as using too much or too little water, can alter the intended electrolyte balance. This can lead to a disproportionate intake of sodium and potassium, either depleting or excessively increasing their levels in the bloodstream [16]. Additionally, over-reliance on ORS without adequate dietary intake can result in insufficient calcium levels, further exacerbating electrolyte imbalances. These disturbances can result in serious clinical manifestations, including lethargy, seizures, cardiac arrhythmias, and muscle weakness, which complicate the management of gastroenteritis and increase morbidity [17].

The study's findings on serum electrolyte levels indicate a mean sodium level of 140.9±11.1 mg/dl among participants, with 28.1% experiencing hyponatremia, 35.6% having normal sodium levels, and 36.3% presenting with hypernatremia. These results are consistent with the spectrum of sodium imbalances commonly observed in children with acute gastroenteritis (AGE). Hyponatremia, noted in 28.1% of participants, is a frequent electrolyte disturbance in AGE, often resulting from prolonged diarrhea and inadequate sodium intake. Eke et al. reported similar findings, where hyponatremia was prevalent among malnourished children with diarrhea, underscoring the importance of monitoring and correcting sodium levels to prevent severe complications [18]. Oniriyuka et al. also highlighted that hyponatremia is a common issue in children with AGE, particularly those with severe dehydration [19]. The presence of hypernatremia in 36.3% of participants is noteworthy, as it suggests significant fluid loss or improper rehydration practices.

The study's findings on serum potassium levels indicate a mean potassium level of 4.6±1.9 mg/dl, with 38.8% of participants experiencing hypokalemia, 20.6% having normal levels, and 40.6% presenting with hyperkalemia. These results highlight the significant variability in potassium levels among children with acute gastroenteritis (AGE), reflecting the challenges in managing this common electrolyte disturbance. Hypokalemia, observed in 38.8% of participants, is a well-documented issue in AGE. Hypokalemia can lead to severe

complications, including muscle weakness, cardiac arrhythmias, and increased morbidity, necessitating careful monitoring and timely potassium supplementation. Hyperkalemia, found in 40.6% of participants, is equally concerning, as it indicates either excessive potassium intake or impaired renal function in managing potassium excretion.

The multivariable linear regression analysis, controlling for various factors, revealed that only lower segment cesarean section (LSCS) delivery was significantly associated with increased mean serum sodium levels among the participants. The analysis showed that participants delivered via LSCS had significantly higher mean serum sodium levels (p < 0.001). This finding aligns with previous research indicating that delivery methods can influence neonatal outcomes, including electrolyte balance. In contrast, other factors such as age (p = 0.717), mother's age (p = 0.062), birth weight (p = 0.866), female sex (p = 0.071), rural residence (p = 0.530), history of previous admission (p = 0.600), and serum haemoglobin level (p = 0.938) were not found to be significantly associated with the serum sodium levels of the patients. The lack of significant associations for these factors may indicate that their influence on serum sodium levels is minimal or that other unmeasured variables play a more critical role in determining electrolyte balance

The analysis also revealed that only non-exclusive breastfeeding in the participants was associated with a significant increase in their mean serum potassium levels. The analysis indicated that non-exclusive breastfeeding was significantly linked to higher mean serum potassium levels (p 0.036), underscoring the importance of exclusive breastfeeding (EBF) in maintaining optimal electrolyte balance in children. Exclusive breastfeeding (EBF) has long been recognized as a critical factor in promoting infant health and preventing various illnesses, including acute gastroenteritis (AGE). The protective effects of EBF against gastrointestinal infections are well-documented.

The study faced several limitations that need to be acknowledged. Firstly, the sample size, while adequate for certain statistical analysis, may not fully represent the larger population of children with acute gastroenteritis in different regions or settings. The study was conducted at a single institution, which could limit the generalizability of the findings to other geographic areas or healthcare settings. Additionally, the cross-sectional design of the study restricts the ability to infer causality between identified factors and electrolyte imbalances. Another limitation is the reliance on caregiver reports for certain variables, such as ORS administration and breastfeeding practices, which could be subject to recall bias or misreporting. Furthermore, the study did not account for potential confounding factors such as nutritional status, underlying health conditions, and environmental factors that could influence electrolyte levels. The lack of longitudinal follow-up also means that the long-term outcomes and potential recurrent electrolyte disturbances were not assessed. These findings suggest that both perinatal factors and early nutritional practices play crucial roles in the health outcomes of children with acute gastroenteritis. The study concludes that there is an urgent need for effective educational interventions to improve ORS administration and breastfeeding practices, especially in rural areas.

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