International Journal of Contemporary Pediatrics
Shankar P et al. Int J Contemp Pediatr. 2020 Sep;7(9):1910-1917
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20203654

Original Research Article

Study of electrolyte disturbances and renal parameters in acute gastroenteritis under 5 years of age in a tertiary care hospital of Bengaluru, India

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Received: 14 July 2020
Accepted: 08 August 2020

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ABSTRACT

Background: Diarrhoea still continues to be a major cause of hospitalization and death in under fives. Electrolyte disturbances play an important role in the associated morbidity and mortality. Acute renal failure is one of the important complications of acute gastroenteritis (AGE) in children. Early intervention and proper fluid replacement may lessen this risk. This study was designed to find out the incidence of acute gastroenteritis and the status of associated electrolyte derangements and renal involvement.
Methods: This was a cross sectional study conducted at KIMS, Bengaluru in which 117 children from the age of 1 month to 5 years with acute diarrhea were included based on a predefined inclusion and exclusion criteria. Demographic profile of the patients, details of diarrhea, clinical examination and accompanying degree of dehydration (defined as per WHO criteria) were recorded. Serum electrolytes along with renal parameters were investigated.
Results: Total 117 children with acute gastroenteritis were enrolled in the study as per the inclusion criteria which constituted 5% of total paediatric admissions. Children aged 1-12 months had the highest incidence of diarrhea (50%). Male to female ratio is 1.3:1. 65% had some dehydration, 19% no dehydration and 16% had severe dehydration. Isonatremia was seen in 58% followed by hyponatremia in 35% and hypernatremia in only 7%. 83% had isokalemia, hypokalemia in 12%, hyperkalemia in 5%. Levels of serum sodium and potassium decreased with the severity of dehydration. Serum urea and creatinine were significantly high in severe dehydration (p value 0.001). Out of 28 children who were given diluted ORS before admission, majority had hyponatremia (39%) and all of them who received concentrated ORS had hypernatremia.
Conclusions: Hyponatremic dehydration is the second most common type of dehydration next to isonatremic dehydration, but it is more common in children who took diluted ORS. Increased awareness regarding ORS preparation may help in preventing electrolyte imbalance in AGE. The levels of serum sodium and potassium decreased and urea and creatinine increased with severity of dehydration. Measurements of serum electrolytes and renal parameters early can help to predict the complications due to AGE and may help in the prevention of diarrhea related complications in children.

Keywords: Acute gastroenteritis, Diarrhea, Electrolytes, Hyponatremia, Hypokalemia, ORS

INTRODUCTION

Acute Gastroenteritis (AGE) is a leading cause of illness and death amongst children in developing countries. Diarrhoea as defined by WHO is the "passage of loose or watery stools at least three times in a 24 hour period" but emphasizes the importance of change in stool consistency rather than frequency, and the usefulness of parental insight in deciding whether children have diarrhea or not.[1,2]

Gastrointestinal diseases are considered worldwide as the second most common cause for visits to physicians, and according to WHO is the second leading cause of death in children under five years old, and is responsible for killing around 5,25,000 children every year.

In 2017, diarrhoea accounted for approximately 8 per cent of all deaths among children under age 5 worldwide. This translates to over 1,300 young children dying each day, or about 480,000 children a year, despite the availability of simple effective treatment. About 80% of deaths due to diarrhea occur in the first 2 years of life.[3] WHO estimated that worldwide, 1 child dies of diarrhea every 6 seconds.[4] In India, at least 1.5 million under-5 children die every year due to acute diarrhea.[5] From 2000 to 2017, the total annual number of deaths from diarrhoea among children under 5 decreased by 60 per cent. Many more children could be saved through basic interventions.

The high incidence of diarrheal diseases in developing countries is related to consumption of contaminated water and food, poor sanitation and hygiene, under-nutrition, deficiencies in micronutrients like zinc or vitamin A, increased vulnerability to infections, rotavirus vaccine unavailability, poor education, socio-economic status, crowded environment, and living close to domestic animals and the unfortunate trend of early breast milk substitutes. Decreasing trend of exclusive breast feeding and faulty practices of bottle-feeding play an important role. The main cause of death in acute diarrhea is dehydration, which results from the loss of fluid and electrolytes in diarrheal stools.

Broadly speaking majority of the diarrhoea in paediatric practice is acute in nature (80-90%), a few are recurrent, and fewer still are chronic.[6] In this regard, the biochemical derangement in children with dehydration may be isonatremic, hyponatremic or hypernatremic.[7]

Isonatremic dehydration is the commonest (70-80%) type of dehydration and the type with the best prognosis. Other biochemical disturbances observed include hypokalaemia and metabolic acidosis and impaired renal function. However, in clinical settings, the degree of dehydration is often classified as no dehydration, some dehydration and severe dehydration based on the estimated fluid loss and other clinical parameters.[8] Dehydration is the most frequent and dangerous complication responsible for morbidity and mortality in children with acute diarrhoeal disease.[9] Serum electrolyte and acid base disturbances are common in under-five children with acute diarrhea but may remain unrecognized, resulting in morbidity and sometimes mortality. Timely recognition, a high index of suspicion and a thorough understanding of common electrolyte abnormalities is necessary to ensure their correction.

During the past three decades, factors such as the widespread availability and use of Oral Rehydration Solution (ORS), improved rates of breastfeeding, improved nutrition, better sanitation and hygiene, and increased coverage of measles immunization are believed to have contributed to a decline in the mortality rate in developing countries. However, the morbidity from diarrheal diseases has remained relatively constant during the past two decades.

Different studies have shown different incidences of electrolyte disorders among children with dehydration. In the present study, an attempt has been made to outline the spectrum of electrolyte disturbances and renal involvement in children with acute gastroenteritis. The effect of consumption of improperly diluted ORS on electrolytes status has also been studied.

METHODS

This was a hospital based cross-sectional type of observational study conducted at KIMS, a tertiary care hospital in Bengaluru, Karnataka over a period of 1year (2019).

Out of 228 acute gastroenteritis cases admitted in the paediatric ward, 117 children were enrolled in the study as per the inclusion criteria.

Inclusion criteria

All children aged one month to 5 years with acute gastroenteritis admitted in the Paediatric department were included.

Exclusion criteria

Any child with history of diarrhea more than two weeks (Persistent diarrhoea) at the time of admission; parentral diarrhea; children with dysentery (blood and mucus in stool); children with known pre-existing renal disease, children who underwent renal replacement therapy before admission were excluded.

Demographic profile of the patients, detailed history, details of diarrhea such as duration, frequency, consistency of stools, examination and investigations were recorded. ORS intake before coming to the hospital was also made. Preparation of the ORS was asked in detail. A detailed examination was done to assess the degree of dehydration as per the WHO criteria and any associated complication, presence or absence of features suggestive of dyselectrolytemia and renal involvement.

Before starting any rehydration measures, 2 ml of blood was drawn to estimate the serum electrolyte and renal parameters. The levels of serum sodium (Na^+), potassium (K^+), serum urea, serum creatinine were investigated. Serum sodium and potassium were analysed by biochemical analyser (Ion Selective Method) based on the principle of electrochemistry. Similarly, serum urea

and creatinine concentration were determined by kinetic urease-GLDH and alkaline picrate method respectively.

Normal range of serum electrolyte levels are as follows:

- Sodium (Na^+) – 135-145 mEq/l
- Potassium (K^+) – 3.5-5.5 mEq/l
- Blood Urea -15- 40 mg/dl
- Creatinine – 0.3-0.7 mg/dl in children.

Statistical Analysis was performed. The data was entered in predesigned proforma and was analysed with SPSS version 23 software. Frequency of the qualitative variables was presented as percentage. Value of continuous variables was presented as Mean±SD. Analysis of variance (ANNOVA) was used for comparison of mean of continuous variables. *p* value of less than 0.05 was considered statistically significant. Post Hoc analysis with Bonferroni correction was done for dependent variables.

RESULTS

Total 117 children were enrolled in the study as per the inclusion criteria which represented 5% of the total paediatric admissions. Figure 2 show that children aged 1-12 months had the highest incidence of diarrhea (50%), which was followed by 13-24 months (23%), 49-60 months (13%), 25-36 months (10%). The age group 37-48 months had the lowest incidence (4%). The mean age of presentation was 23.299±17.992 months.

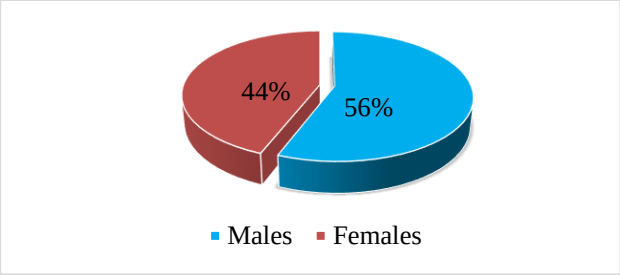

Figure 1: Gender distribution of children admitted with age.

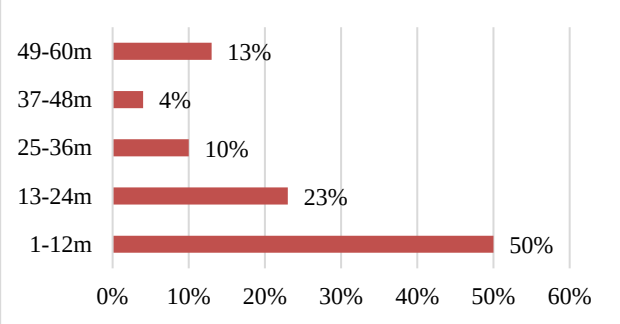

Figure 2: Frequency of age in different age groups.

There were 56% males and 44% females of the study population presented to us with AGE with ratio of 1.3:1 (Figure 1).

Table 1: Degree of dehydration based on WHO criteria.

Degree of dehydration	Frequency	Percentage
No dehydration	22	19
Some dehydration	76	65
Severe dehydration	19	16

Table 1 shows that majority (65%) had some dehydration, 19% had no dehydration and 16% had severe dehydration.

Table 2: Frequency of patients with different status of electrolytes and renal parameters.

Biochemical Parameters	Levels	Frequency	Percentage
Serum sodium	Normal	68	58
	Low	41	35
	High	8	7
Serum potassium	Normal	97	83
	Low	14	12
	High	6	5
Serum urea	Normal	90	77
	High	27	23
Serum creatinine	Normal	109	93
	High	8	7

Majority of admitted children with AGE had isonatremia (58%) followed by hyponatremia in 35% cases. Hypernatremia was seen in only 7% of the study population.

Isokalemia was seen in majority (83%) followed by hypokalemia in 12% cases. Hyperkalemia was seen in 5% of the children (Table 2).

Table 3 depicts the frequency of different biochemical parameters in children with AGE. The mean levels of serum sodium, potassium, urea, creatinine in different age groups of our study population were not significant statistically.

Mixed electrolytes disturbances were seen in 11(9.4%) of the cases out of which the most common was hyponatremia with hypokalemia seen in (n=9, 82%) cases and 1 case each of hyponatremia with hyperkalemia and hypernatremia with hyperkalemia. Isolated hyponatremia was seen in (n=31, 26.5%) cases, isolated hypokalemia in (n=5, 4.3%) cases and isolated hyperkalemia was seen in (n=4, 3.4%) cases (Table 4).

Table 3: Mean (SD) levels of biochemical parameters in different age groups in months.

Parameter	1-12m	13-24m	25-36m	37-48m	49-60m	F Value	P value
Na^+	137.71±6.75	135.85±4.86	133.25±4.80	134.8±7.46	134.6±6.61	1.8	0.12
K^+	4.35±0.71	4.29±0.64	4.4±0.75	3.88±0.66	3.92±0.88	1.4	0.21
Urea	34.43±17.76	30.29±13.62	26.5±17.4	37.6±19.47	26.33±9.63	1.1	0.33
Creatinine	0.41±0.17	0.4±0.25	0.42±0.153	0.54±0.195	0.42±0.137	0.67	0.62

*p value <0.05 is significant

Table 4: Frequency of type of dyselectrolytemia in children.

Type of Dyselectrolytemia	Age (in months)	Frequency (N)	Percentage (%)
Isolated Hyponatremia	1-12	17	14.5
	13-24	9	7.7
	25-36	7	6
	37-48	2	1.7
	49-60	6	5.1
Isolated Hypokalemia	1-12	5	4.3
	13-24	0	0
	25-36	0	0
	37-48	0	0
	49-60	0	0
Isolated Hypernatremia	1-12	6	5.1
	13-24	1	0.8
	25-36	0	0
	37-48	0	0
	49-60	1	0.8
Isolated Hyperkalemia	1-12	3	2.6
	13-24	1	0.8
	25-36	0	0
	37-48	0	0
	49-60	0	0
Hyponatremia + Hypokalemia	1-12	2	1.7
	13-24	1	0.8
	25-36	1	0.8
	37-48	2	1.7
	49-60	3	2.6
Hyponatremia + Hyperkalemia	1-12	0	0
	13-24	0	0
	25-36	1	0.8
	37-48	0	0
	49-60	0	0
Hypernatremia + Hypokalemia	1-12	0	0
	13-24	0	0
	25-36	0	0
	37-48	0	0
	49-60	0	0
Hypernatremia + Hyperkalemia	1-12	1	0.8
	13-24	0	0
	25-36	0	0
	37-48	0	0
	49-60	0	0
Total		69	59

Table 5 shows that levels of serum sodium and potassium decreased with the severity of dehydration (no dehydration- 137.41±3.35; 4.25±0.53, some dehydration 136.99±4.45; 4.28±0.65, severe dehydration-132.26±11.76; 4.23±1.15). Majority had normal urea (83%) and creatinine (93%) levels. Urea and creatinine levels were raised in 23% and 7% of the children respectively.

Table 5: Comparison of serum electrolytes mean (SD) with hydration status of children.

Serum Electrolytes (mEq/L)	Group 1	Group 2	Group 3
Sodium	137.41±3.35	136.99±4.45	132.26±11.76
Potassium	4.25±0.53	4.28±0.65	4.23±1.15

Group 1 - no dehydration; group 2 - some dehydration; group 3 - severe dehydration.

Table 6: Comparison of renal parameters mean (SD) with hydration status of children.

Renal Parameters (mg/dl)	Group 1	Group 2	Group 3	F value	P value
Urea	22.95±9.17	30.26±14.04	45.10±20.19	12.5	0.001*
Creatinine	0.33±0.049	0.39±0.154	0.6±0.281	14.8	0.001*

*p value <0.05 is significant.

Table 7: Multiple comparisons- post Hoc.

Group	Group	Mean difference	Std. Error	P value
1	2	-7.3086	3.5048	0.118
	3	-22.1507*	4.5339	0.001*
2	3	-14.8421*	3.7132	0.001*

*p value <0.05 is significant

Table 8: Multiple comparisons- post Hoc.

Group	Group	Mean difference	Std. Error	P value
1	2	-0.0603	0.0408	0.428
	3	-0.2682*	0.0528	0.001*
2	3	-0.2079*	0.0433	0.001*

*p value <0.05 is significant

Table 9: Type of ORS given before admission.

Type of ORS before admission	Frequency	Percentage
Appropriate	9	32
Diluted	16	57
Concentrated	3	11
Total	28	100

Table 6 shows serum urea and creatinine were significantly high in severe dehydration [45.10±20.19; 0.6±0.281] as compared to some dehydration [30.26±14.04; 0.39±0.154] and no dehydration [22.95±9.17; 0.33±0.049] p value 0.001*.

The levels of serum urea and creatinine of no dehydration versus severe dehydration and some dehydration versus severe dehydration were statistically significant; p value 0.001* (Table 7, 8).

Out of the 28 patients who were given ORS before admission, most of them (57%) were given diluted ORS (Table 9).

Amongst the children who were given diluted ORS, 69% had hyponatremia and all the children who had concentrated ORS had hypernatremia (Figure 3).

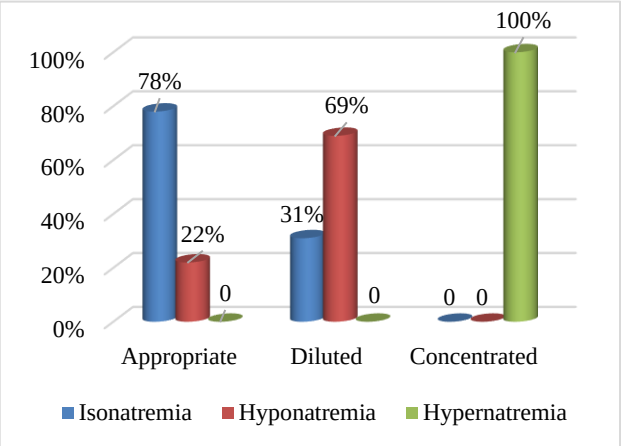

Figure 3: Sodium levels with respect to type of ORS administration before admission.

DISCUSSION

AGE continues to be a common cause of mortality in infants and pre-school children throughout the developing world.

The incidence of AGE is varied in different areas of India among hospitalised cases. Ramanaiah et al, Srivastava et al, Behera et al and Ahmed et al reported an incidence of 12.1%, 12.3%, 11.3% and 14.2% respectively.[10-13] In the present study, the incidence was 5%. Poo et al reported that acute gastroenteritis was responsible for 6% of the total paediatric admission which was similar to our study.[14] In another study done by Yilgwan et al in Nigeria, the incidence of acute gastroenteritis was only 2.7%.[15]

The present study shows that children aged 1-12 months had the highest incidence of diarrhea (50%), which was followed by 13-24 months (23%), 49-60 months (13%), and 25-36 months (10%). The least number of cases were seen in the age group 37-48 months (4%). These results were similar to studies conducted by Okposio MM et al, Srivastava et al and Behera et al which report a higher incidence of AGE in infants.[16,11,12]

AGE was more common in boys than girls with the ratio of 1.3:1, a finding which is similar to that reported by Srivastava et al and Behera et al.[11,12] The type of dehydration had no significant association with gender.

The present study shows that some dehydration was observed in most number of cases (n=76, 65%), followed by no dehydration (n=22, 19%) and severe dehydration (n=19, 16%). Mittal et al had reported 50.52% of some dehydration and 21.95% severe dehydration in their study.[17] Tavakolizadeh et al in their study reported that among children admitted with acute gastroenteritis, 64.9% had no dehydration, 32.7% had some dehydration and 2.4% cases had severe dehydration.[18] A study done by Azemi et al.[19] in Kosovo reported some dehydration to be present in 42.29% of cases and severe dehydration in 14.08% cases.

In the present study, electrolyte disturbances were seen in 57(48.7%) cases while 60(51.3%) cases had no electrolyte disturbance. Isonatremic dehydration was the commonest (n=69, 59%), followed by hyponatremic dehydration (n=41, 35%) and hypernatremic dehydration (n=7, 6%). Samadi et al in their study in Bangladesh reported that 72.8% were isonatremic, 20.8% hyponatremic and 6.4% were hypernatremic which was close to our study.[20] A study by Krishnan S et al also reported isonatremia in majority of the cases (59%), followed by hyponatremia (25%) and then hypernatremia (15%).[21] Hyponatremia was found to be the most common electrolyte abnormality in children with diarrhea in studies conducted by the authors such as Dastidar RG et al and Hanna M et al.[22,23]

Majority of the study population were normokalemic (n=97, 83%). Hypokalemia which was the second common electrolyte disturbance was seen in 14(12%) cases. Hyperkalemia was seen in 6(5%) patients.

Mixed electrolytes disturbances were seen in 11(9.4%) of the cases out of which the most common was hyponatremia with hypokalemia seen in (n=9, 82%) cases and 1 case each of hyponatremia with hyperkalemia and hypernatremia with hyperkalemia. Isolated hyponatremia was seen in (n=31, 26.5%) cases, isolated hypokalemia in (n=5, 4.3%) cases and isolated hyperkalemia was seen in (n=4, 3.4%) cases. Similar electrolyte disturbances were seen in studies conducted by Prathima et al and Ukaropol et al from Thailand.[24,25] In our study, levels of serum sodium and potassium decreased with the severity of dehydration.

Hoxha et al reported that serum urea and creatinine cannot discriminate between mild and moderate dehydration but showed a good specificity for severe dehydration.[26]

Similar result was seen in the study conducted by Ukarapol et al where 24% of the patient had increased BUN and the BUN correlated statistically with the degrees of dehydration.[25] Gauchan et al reported that out of 188 cases, high blood urea was found in 20 of severe dehydration as compared to 63 of some and 15 of no dehydration. Further high serum creatinine was found in 18 of severe, 79 of some and 17 of no dehydration.[27] In our study, out of 117 acute gastroenteritis cases, 90 (77%) had normal urea, whereas 27 (23%) had increased serum urea level. This study also shows that 8 (7%) cases had increased serum creatinine, while 109 (93%) had normal serum creatinine level. Furthermore, out of the cases with increased serum urea, majority was seen in some dehydration 15 (55%) followed by 11 cases of severe dehydration (41%) and only 1 (4%) case of no dehydration. Out of the cases with increased serum creatinine levels, majority was seen in some dehydration (n=5, 62.5%), followed by 3 cases of severe dehydration (37.5%). None of the cases with no dehydration had raised creatinine levels.

Serum urea and creatinine were significantly high in severe dehydration as compared to some dehydration and no dehydration (p value 0.001*).

Most of the children (n=89, 76%) were not given ORS before admission. Out of the 28 patients who were given ORS before admission, most of them (n=16, 57%) were given diluted ORS before admission. 3(11%) children were given concentrated ORS and 9(32%) were given appropriate ORS before admission.

One concern is the confusion between 2 different sizes of ORS packets leading to preparation of standard ORS packet in 200 ml of water causing hypernatremic dehydration and on the other hand, dissolving the smaller

packet in 1 litre of water increasing the risk of hyponatremia in children with diarrhea.[28] Unfortunately, most of the parents still do not have the correct information and knowledge regarding the proper preparation of ORS.

Out of 28 children who were given ORS before admission, 13 (46.4%) had hyponatremia. Out of 13 children who had hyponatremic dehydration and had ORS before admission, 11 (85%) were given diluted ORS. All the 3 children who had taken concentrated ORS prior to admission had hypernatremic dehydration.

Out of the 9 children who had appropriately reconstituted ORS before admission, only 2 had hyponatremia and none of them had hypernatremia. Thus, concentration of home-prepared ORS had an important role to play in the electrolyte disturbances occurring in AGE. Gauchan et al reported that out of 72 children who had been on ORS prior to admission, hypernatremia was seen in 14 (19.4%) and hyponatremia in 6 (8.3%); as compared to 13.8% and 12.9% respectively in those who had not been on ORS.[27]

ORS has been considered the "gold standard" of oral rehydration therapy. However, a Cochrane review which included seventeen trials (1811 participants) did not show a significant advantage of ORS over intravenous hydration in the outcome in dehydration associated with diarrhea in children. ORT is the cheap, simple and effective way to prevent/treat dehydration caused by diarrhea. Timely and appropriate use of ORS is associated with reduced need for hospitalizations, intravenous infusions, risk of dehydration and electrolyte abnormalities and in turn reduces the rates of morbidity and mortality.

CONCLUSION

The incidence of diarrhea peaks in children less than 1 year of age. Isonatremic dehydration was encountered commonly in children with acute diarrhea. Dyselectrolytemia particularly hyponatremia and hypokalemia are seen in children with acute diarrhea. The level of serum sodium and potassium decreased and urea and creatinine increased with severity of dehydration. Improper dilution of ORS can lead to electrolyte imbalance.

Timely recognition and correction of electrolyte disturbances, promotion of health awareness, breastfeeding, weaning with hygienically prepared foods, demonstration of how to prepare appropriate ORS solution, better female literacy and health education will go a long way in reducing the morbidity and mortality associated with AGE.

The present study was based on a small sample size. A larger study group is recommended to come to a very definite conclusion.

ACKNOWLEDGEMENTS

Authors would like to thank Dr Sreekanth Bose for his assistance in statistical analysis.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Shankar P, Mahamud S, Anjum ACA. Study of electrolyte disturbances and renal parameters in acute gastroenteritis under 5 years of age in a tertiary care hospital of Bengaluru, India. Int J Contemp Pediatr 2020;7:1910-7.