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Original Research Article

Point of admission serum electrolyte profile of children with acute diarrhoea in a Nigerian Tertiary Hospital

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Abstract

Aim and Objective: This study aimed to describe the point-of-admission serum electrolyte profile of children with acute diarrhoea and to determine the associated factors.
Materials and Methods: The serum electrolyte at admission, bio data, clinical features and outcome of children aged 29 days to 15 years with primary diagnosis of acute diarrhoea, seen between January 1st, and December 31st, 2016 in the department of Paediatrics, UDUTH, Sokoto, were retrospectively analysed.
Results: Of the total of 154 subjects, 101(65.6%) were males giving a M: F ratio of 1.9: 1. Majority, 140(91.0%) were ≤ 36 months. Twenty four (15.6%), 105(68.2%), 14(9.1%) were mildly, moderately and severely dehydrated respectively while 11(7.1%) were not dehydrated. Hyponatraemia, hypokalaemia and metabolic acidosis occurred in 100(64.9%), 67(43.5%) and 21(13.6%) subjects, respectively. There were 10(6.5%) deaths. Only potassium level was significantly affected by degree of dehydration (p = 0.02). Duration of diarrhoea greater or equal to 3 days and greater or equal to 7 days before presentation was significantly associated with metabolic acidosis and hypokalaemia (p= 0.03 and 0.001) respectively. Diarrhoea duration more than 3 days and under nutrition were associated with death.
Conclusion: The degree of dehydration appears to be a good predictor of the occurrence of hypokalaemia. Diarrhoea duration is a risk factor for metabolic acidosis, hypokalaemia and death. We recommend intensified community health education on appropriate home treatment and prompt hospital presentation once diarrhoea duration is more than three days, to prevent deleterious diarrhoea consequences.
Keywords: Hyponatraemia, hypokalaemia, metabolic acidosis, children, diarrhoea duration.

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1. Introduction

Diarrhoea is defined as the passage of 3 or more loose or liquid stools per day or more frequently than is normal for the individual. [1] Acute diarrhoea is sudden onset of frequent loose stool that lasts less than 14 days. [1] Globally, diarrhoea is the 2nd leading cause of death in under-fives and responsible for 525,000 under-five deaths annually. [1] In Nigeria, it accounts for 16% of deaths annually in under-fives (U-5) giving 150,000 U-5 deaths.[2] Diarrhoea-related deaths results from immediate consequences such as dehydration, electrolyte/acid-base imbalance, and long term consequences of the disease such as malnutrition and its attendant complications, particularly if diarrhoea is recurrent. [3] Hyponatraemia, hypokalaemia and metabolic acidosis are commonly encountered electrolyte imbalances that occur during diarrhoeal episodes, and often result in death, if not recognised and treated promptly. [4]

There are no prior studies on the serum electrolyte profile in children with acute diarrhoea in our centre and few studies are available on this subject in Nigeria. The available few studies in Nigeria focused on the U-5 with dehydration. Even though, the U-5 is a high risk group for diarrhoea disease, diarrhoea does occur in older children, with varying severity. Therefore, knowing the electrolyte profile of children with acute diarrhoea across all age

groups and the factors associated with their occurrence would help in the prevention, and guide the empirical choice of intra venous fluid for rehydration and overall management of the patient irrespective of age.

The objective of this study was to describe the point of admission serum electrolyte profile of children aged 29 days to <15 years with diarrhoea disease, with or without dehydration and to determine the relationship, if any, between the degree of dehydration and point of admission serum electrolytes, as well as, determine the factors associated with electrolyte derangement in children with diarrhoea disease in Usmanu Danfodiyo University teaching Hospital (UDUTH), Sokoto.

2. Materials and Methods

This was a one year retrospective review from 1st January to 31st December 2016 in the department of paediatrics, UDUTH, Sokoto. Case files of children 29 days to 15 years with a primary diagnoses of acute diarrhoea with or without any other diagnoses were retrieved from the medical records. Information such as the age, gender, duration of diarrhoea prior to presentation, presence or absence of vomiting and duration, fever, home treatment, degree of dehydration, admission serum electrolytes and acid base, nutritional status and clinical outcome were extracted from the case folders. Ethical approval was sought from UDUTH research and ethics committee.

The serum electrolyte were analysed in the chemical pathology laboratory of UDUTH using the ion selective method. Hyponatraemia, hypernatraemia, hypokalaemia and hyperkalaemia were described as serum sodium <135 and >149mmol/l, and serum potassium <3.5 and > 5.2mmol/l respectively. Metabolic acidosis and alkalosis was described as serum HCO_3<21mmol/l and >31mmol/l respectively, according to UDUTH chemical Pathology reference range.

The degree of dehydration was classified as: none, mild, moderate and severe dehydration according to WHO criteria. [5] Nutritional status was categorized with Weight for Age (WFA) Z scores for boys and girls from birth to 10 years using age and sex appropriate WHO growth standard. [6]

The statistical package for social sciences (SPSS version 20) was used for statistical analysis Categorical variables were presented with frequency and percentages while the continuous variables as mean and standard deviation. Chi-square test was used to determine the relationship between categorical variables. Logistic regression was utilized to determine the factors influencing point of admission serum electrolyte.

A p- value of ≤ 0.05 is considered as statistically significant.

3. Results

3.1 General Characteristics of study Population

One hundred and fifty four (154) out of 174 children admitted with diarrhoea disease during the review had their point of admission serum electrolytes levels analysed and were included in the study. Mean age ± SD of study population was 18.9± 20.6 months, median- 13 months, mode- 6 months and range 2-120 months. Males were 101 and females; 53, Male: Female ratio was 1.9:1. Peak month of presentation was in November with 47(30.5%) cases. The monthly presentation for the rest of the year under review excluding November ranged from 1.9%-11%.

3.2 Socio and bio-demographic characteristics of subjects and association with serum electrolyte

Table 1 shows the socio and bio demographic characteristics of subjects and the association with serum electrolytes.

One hundred and forty (91%) subjects were aged within 36 months, of which 76 (49.4%) were < 12 months and 64 (41.6%) were ≥ 12 - 36 months. Seventy-five children (75.7%) had normal nutritional status while 36 (24.3%) had under nutrition. There were no statistical significant association between the age, nutritional status, and the serum electrolytes of subjects.

Table 1: Socio-demographic characteristics of study population and the association with serum electrolytes

Socio demographic characteristics	Serum electrolyte category (p value)			
Gender	No (%)	Na+	K+	HCO_3^-
Male	101(65.6)	0.31	0.33	0.09
Female	53(35.4)			
Age				
<12	76(49.4)			
≥12-36	64(41.6)	0.49	0.09	0.63
>36-59	5(3.2)			
>59	9(5.8)			
Nutritional status (Weight-for -age-Z score)				
Normal nutrition <-2 SD	112(75.7)	0.39	0.19	1.000
Under nutrition >-2SD	36(24.3)			

Na+category- Isonatraemia, hyponatraemia & hypernatraemia
K+category-Normokalaemia, Hypokalaemia & Hyperkalaemia
HCO_3^- category- Normal Bicarbonate & metabolic Acidosis.
WFAZ- Weight –for-age Z score.

3.3 Clinical Characteristics of study population and the association with serum electrolytes

One hundred and thirty-two subjects (86.6%) had diarrhoeal frequency of > 6 times/day, twenty (13.2%) had frequency of diarrhoea stools of < 6 times/day. Ninety children (60%) had diarrhoeal duration of ≤ 3 days, 26 (17.3%) had diarrhoea for 4-6 days while 34 (22%) had diarrhoea for ≥ 7 days at point of admission.

Vomiting and fever were associated clinical features in 124(80.5%) and 118 (76.6%) children respectively. Duration of vomiting at admission was <6 days in 105 (85.4%) and ≥7 days in 18(14.6%) children.

One hundred and ten (71.4%) subjects had no home treatment, 16 (10.4%) had ORS ± Zinc (ORS alone in10, ORS+ Zinc in 6), while 28(18.2%) had drugs, mostly antibiotics.

One hundred and forty three (93.5%) children were dehydrated, of which 24(15.6%), 105(68.2%), and 14(9.1%) had mild, moderate and severe dehydration respectively. Eleven (7.1%) children were not dehydrated.

Whereas diarrhoea and vomiting duration were significantly associated with hypokalaemia (p= 0.001 and 0.01 respectively), only diarrhoea duration was significantly associated with metabolic acidosis (p=0.03). The degree of dehydration was significantly associated with hypokalaemia (p=0.02). Serum sodium and bicarbonate level showed no statistical significant association with degree of dehydration (p=0.70, and 0.35 respectively). There were no statistically significant associations between the serum electrolyte at admission, and diarrhoea frequency, presence of vomiting, fever, home treatment, or outcome as depicted in table 2.

Table 2: Clinical characteristics of study population and association with serum electrolytes

	Serum electrolytes(p value)			
Clinical variable	**Total no (%)**	**Na^+**	**K^+**	**HCO_3**
Diarrhoea frequency				
>6x/day	132(86.8)	0.31	0.33	0.09
<6x/day	20(13.2)			
Diarrhoea duration				
≤3 days	90 (60)			
4-6 days^	26(17.3)	0.07	*0.001	^0.03
≥7 days*	34 (22)			
Presence of Vomiting				
Yes	124(80.5)	0.18	0.26	1.000
No	36(19.5)			
Duration of Vomiting				
<6 days	105(85.4)	0.52	0.01	0.07
≥7 days	18(14.6)			
Presence of Fever				
Yes	118(76.6)	0.74	0.87	0.47
No	36 (23.4)			
Home Treatment				
Nothing	110(71.4)			
ORS± Zinc	16 (10.4)	0.25	0.92	0.53
Drugs only	28(18.2)			
Degree of Dehydration				
None	11(7.1)			
Mild	24(15.6)	0.7	0.02	0.35
Moderate	105(68.2)			
Severe”	14(9.1)			
Outcome				
Discharge	144(93.5)	0.56	0.46	1.000
Death	10(6.5)			

*Hypokalaemia was found in 24/34 children with diarrhea duration ≥ 7 days (p=0.001)
^ Metabolic acidosis was present in 7/26 children with diarrhea duration of 4-6 days (p=0.03)
“ Hypokalaemia was present in 9/14 children with severe dehydration (p=0.02)

3.4. Serum Electrolyte profile of Study Population.

One hundred and twenty three (80%) children had electrolyte imbalances, either isolated or in different combinations. Fifty-eight children (37.7%) had isolated electrolyte imbalances, 62(40.3%) had combination of two electrolyte and 3 (2%) had three electrolyte imbalances. Thirty one (20%) children had normal electrolytes.

Ninety nine (64.3%) subjects had hyponatraemia, 66(43%) had hypokalaemia and 21(13.6%) had metabolic Acidosis as depicted in table 3.

Table 3: Serum Electrolyte profile of Study Population

Serum electrolyte (mmol/l)	No (%)
Serum Na+	
Isonatraemia (135-149)	53 (34.4)
Hyponatraemia (<135)	99 (64.3)
Hypernatraemia (>149)	2 (1.3)
Serum K+	
Normal (3.5-5.2)	85 (55.2)
Hypokalaemia (<3.5)	66(42.9)
Hyperkalaemia (>5.2)	3 (1.9)
Serum HCO3	
Normal (21-31)	133 (86.4)
Metabolic Acidosis (< 21)	21 (13.6)
Metabolic Alkalosis (>31)	0(0)

3.5. Isolated or combined serum electrolyte distribution of subjects

Hyponatraemia was isolated in 40 (26%) children, it was combined with hypokalaemia in 43(28%), metabolic acidosis in 11(7%), both hypokalaemia and metabolic acidosis in 3(2%) and hypernatraemia in 2(1.3%) as depicted in table 4.

Table 4: Isolated and combined Serum electrolyte distribution of Subjects

Serum electrolyte (mmol/l)	No (%)
Hyponatraemia+ Hypokalaemia	43(28)
Isolated Hyponatraemia	40(26)
Isolated Hypokalaemia	15(10)
Hyponatraemia + Metabolic Acidosis	11(7)
Hypokalaemia+ metabolic Acidosis	4(2.6)
Hyponatraemia+ Hypokalaemia+ metabolic Acidosis	3(2)
Hyponatraemia + Hyperkalaemia	2(1.3)
Isolated Metabolic Acidosis	2(1.3)
Hypernatraemia+ Hypokalaemia	1(0.7)
Hypernatraemia+ metabolic Acidosis	1(0.7)
Isolated Hyperkalaemia	1(0.7)
Normal Electrolytes (Na+, K+, & HCO_3^-)	31(20%)
Total	154 (100)

3.6 Outcome of subjects and associations with bio graphic and clinical characteristics.

There were 10 deaths giving an overall case fatality of 6.5%, all the subjects who died were moderately dehydrated (p=0.29), and majority of them (70%) were aged between 13-36 months.

Only diarrhoea duration >3 days and under nutrition were significantly associated with death outcome (p=0.01 & 0.001 respectively).

4. Discussion

Dehydration and electrolyte disturbances are common complications of acute diarrhoeal disease in children. More than three quarter(80%) of our study population had electrolyte derangement consistent with prior reports,[7-9] this could be due to the lack of appropriate home treatment in the majority of our subjects, as only 10.4% of our subjects had appropriate home treatment for diarrhoea (ORS with or without Zinc). The lack of home treatment may explain why the diarrhoeal frequency in majority of our study population was high (≥ 6x/day), and mostly associated with vomiting, suggesting more severe illness, thus resulted in early hospital presentation within 3 days of onset of diarrhoeal episode as we found. It is not surprising; therefore, that most of the patients had moderate dehydration, rather than the severe form, since it is expected that progressive diarrhoeal losses without appropriate timely intervention would result in severe dehydration. The lack of appropriate home treatment in the majority of our subjects may also explain why more than 90% of our subjects were dehydrated.

The commonest electrolyte disturbance in our study was hyponatraemia which was found in 64.3% of the population. This is similar to the findings of Onyiriuka *et al*, [7] Okposio *et al*[3] in Benin, Nigeria and Pratima *et al*[10] in Pradesh, India who reported 61.4%, 60.5 % and 62.5% respectively. Similarly, Shah *et al*[4] in Nepal, Chambuso *et al* [11] in Tanzania and Ankireddy *et al* [9] in South East India also reported hyponatraemia as the commonest electrolyte disturbance in children with acute

diarrhoea, though they found lower prevalence rates of 56%, 37.9% and 33.6% respectively.

Hyponatraemia may be attributed to intake of fluid with low sodium contents during diarrhoeal episodes such as plain water, juice or tea or diluted oral rehydration solution (ORS) as documented by a previous study. [12] Another reason is release of anti diuretic Hormone (ADH) due to volume depletion, resulting in increased thirst, consequently, increased intake of water, most of which is reabsorbed leading to further dilution of the intravascular sodium.[13]

A Study in Kolkata, India reported Isonatraemia as the commonest (71.5%) electrolyte profile while Babar *et al* [12] in Pakistan, reported hypokalaemia as the commonest(43.7%) electrolyte imbalance in children with acute diarrhoea. A likely reason for these differences could be the difference in composition of stools depending on the etiologic agents. Diarrhoea due to different pathogens can lead to significantly different amount of electrolyte loss in stools. A study by Molla *et al* [14] showed that the mean stool sodium concentration was 88.9mmol/l in Cholera, 53.7mmol/l in Entero toxigenic Escherichia Coli (ETEC) and 37.2mmol/l in Rotavirus infection, thus explaining why different studies show different incidence of electrolyte abnormality [14].

In contrast with the findings of Okposio *et al*, [3] we found no significant association between hyponatraemia and the age group, gender or associated vomiting. The reasons for this difference is not clear but may be related to the different serum sodium level utilized for defining hyponatraemia (<136mmol/l in Okposo's study versus < 135mmol/l in current study), and the different study designs/methods utilized (prospective versus retrospective in current study).

Hypokalaemia was the second common electrolyte seen, occurring in 42.9% of our study population. This is within the range of previous reports by Onyiriuka *et al* [7] (35.0%), Okposio *et al* [3] (44.3%), and Shah *et al* [2] (46.0%).

Hypokalaemia could result from increased potassium losses in diarrhoea stools and vomiting. Gastric secretion/vomitus contains up to 10-15mmol/L of potassium and diarrhoea fluid contains 10-80 mmol/L. [15] Both the metabolic alkalosis which accompanies vomiting and the dehydration resulting from vomiting and/or diarrhoea stimulates Aldosterone release. This further potentiates hypokalaemia, thus worsening the potassium losses from vomiting and diarrhoea. [8, 15]

Another risk factor for hypokalaemia is malnutrition (under nutrition). Previous studies [16, 17] have shown that potassium depletion is a common finding in malnourished children due to inadequate intake, reduced muscle mass and recurrent diarrhoea episodes. Hypokalaemia is often sub clinical in malnourished children but becomes obvious during diarrhoea and vomiting.[16, 17] There was no significant statistical association between hypokalaemia and under nutrition (WFA < -2SD) A possible explanation for this could be that some children may have been misclassified as having under nutrition since the weight at admission was used to classify their nutritional status. Acute diarrhea with dehydration could cause acute weight loss. Their weight after rehydration may have been slightly higher and may no longer have met the criteria (WFA < -2 SD) for classifying them as malnourished.

Metabolic acidosis was present in 13.6% of the cases, which is closer to the finding by Onyiriuka *et al* [7] (15.8%) but much lower than was reported by Okposio *et al* [3] (59.6%). The reason for this difference could be related to lower concentration of bicarbonate loss in diarrhoea stool of our subjects. It is documented that as little as 6mmol/L of bicarbonate is lost during diarrhoea caused by Rotavirus compared to 18-23mmol/L lost by bacteria such as Entero toxigenic Escherichia Coli (ETEC), and Vibrio Cholera.[16] It is possible that most of our patients had diarrhoea caused by Rotavirus infection, especially because majority were within 36 months and peak month of presentation was November which falls in the cold and dry seasons of our locality, both factors often associated with Rotavirus aetiology. The prior studies [3, 7] were silent on the peak month of presentation, even though majority of their subjects were within the high risk age group for rotavirus infection. It would be worthwhile for future studies to be undertaken on the aetiology of diarrhoea and electrolyte composition of stool.

The finding of significant association between hypokalaemia and degree of dehydration (p=0.02) implies that hypokalaemia tend to occur with increasing severity of dehydration. The explanation for this could be related to the triggering of the Renin-Angiotensin-Aldosterone system due to reduced renal blood flow following severe dehydration. The secondary hyperaldosteronism results in sodium reabsorption and potassium loss at the distal convoluted tubule (DCT).

The significant association of diarrhoea duration of ≥ 7 days with hypokalaemia and 4-6 days with metabolic acidosis suggests that deleterious effects of acute diarrhoea such as these electrolyte imbalances could occur once diarrhoeal duration is more than 3 days. The significant association of vomiting duration ≥ 7 days with hypokalaemia implies that prolonged vomiting rather than just presence of vomiting is an additional risk for hypokalaemia. This is due to the resulting metabolic Alkalosis and hyperaldosteronism as earlier elucidated.

We conclude that the degree of dehydration and diarrhoea duration >7days are both good predictors of the occurrence of hypokalaemia. Diarrhoea duration greater > 3 days is associated with metabolic acidosis. Under nutrition

and diarrhoea duration > 3 days are associated with death outcome. We recommend intensified community health education on early and appropriate home treatment with ORS and prompt hospital presentation advocated once diarrhoea duration is more than three days, to prevent deleterious diarrhoea consequences.

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