

Patterns of electrolyte abnormalities in children 0-15 years of age admitted to Pediatric Emergency and Intensive Care Units of a Tertiary Hospital

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Abstract: Electrolyte abnormalities occur in a variety of conditions and may remain unrecognized and result in morbidity and mortality irrespective of the primary problem. We studied the pattern of electrolyte abnormalities and their outcome in hospitalized children. To study the pattern of electrolyte abnormalities in children admitted to pediatric emergency and intensive care units with underlying medical illness. This was institution based, prospective observational study which was conducted at Tikur Anbessa Specialized Teaching Hospital, Department of Pediatrics and Child Health from March 1, 2017 to September 30, 2017. Among 384 children 173 (45.1%) developed electrolyte abnormalities. Among the total study subjects 89 (23.2%) developed hyponatremia and 64 (16.7%) hypernatremia. Hypokalemia was observed in 85 children (22.1%), hyperkalemia in 43 children (11.2%). The most common cause of hyponatremia was cardiovascular diseases 23(25.8%), renal abnormality 19(21.3%) and central nervous system problem 17(19.2%). Hypernatremia contributed to long hospital stay AOR 2.1, 95%CI 0.99-4.47 and significant mortality AOR 3.3, 95%CI 1.07-10.62. Eight times increase in mortality was observed in hyperkalemic children AOR 8.12, 95%CI 2.44-26.96.

Electrolyte abnormalities are common in children admitted to the emergency and intensive care units with an underlying medical illness and contribute to significant morbidity and mortality. Preventive measures in high risk patients and early treatment would decrease morbidity and mortality.

Key words: electrolyte, emergency unit, intensive care unit, tertiary

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I. Introduction

For maintaining homeostasis, understanding of fluid and electrolyte balance is an important concept. There are physiologic mechanisms that regulate fluids and electrolytes in humans. When the normal physiologic mechanisms fail or when there is a disorder of these mechanisms result in imbalances that may lead to mortality or prolonged hospitalizations (1, 2, 3). The kidney is the primary responsible organ for retention and removal of electrolytes and fluids in healthy individuals. The major sites of fluid and electrolyte losses (primarily sodium and potassium salts) are through the urine and to a lesser extent through gastrointestinal tract and the skin (1, 3, 4). Electrolyte disturbances are one of the medical complications leading to death in children with underlying medical illness unless it is handled urgently and appropriately. It must be emphasized that many electrolyte disturbances in critically sick patients can be prevented by close attention to the prescription of intravenous fluids and nutrition. Prevention of electrolyte disturbances is preferable to treatment (4, 5, 6). To date, there is limited capacity of determination of electrolytes in public health institutions in Ethiopia and also lack of drugs for managing the described abnormality. There is no training being given for primary health care professionals to improve knowhow and reduce the burden and morbidity and mortality associated with electrolyte disorders. Understanding the patterns of electrolyte abnormalities in hospitalized pediatric patients with underlying medical illness would help us devise protocols for prevention and managing electrolyte disorders.

II. Materials and methods

The study was institution based and was conducted in Tikur Anbessa Specialized Teaching Hospital from March 1, 2017 to September 30, 2017. This hospital is the largest specialized teaching hospital in the country. Addis Ababa is the capital city of Ethiopia which is the second most populous city next to Cairo of Egypt.

Study design: Prospective observational study of pediatric patients admitted to PICU and PEU. The objective was to describe patterns of common electrolyte abnormalities of pediatric patients admitted with underlying medical illness and its association with hospital stay and mortality.

Study location: This was a tertiary care and university hospital; the study was conducted at the Department of Pediatrics and Child Health.

Study duration: March 1, 2017 to September 30, 2017.

Sample size: 384 patients

Sample sized calculation: Samples size included all patients admitted PEU and PICU and sample size was calculated assuming an infinite population and population proportion of 0.5 and 95% confidence interval: $n = z^2pq/e^2$. So the calculated population size was 384. Only 5% of the true value was taken.

Study procedure and tools: The study population included all children admitted to pediatric emergency (PEU) and intensive care units (PICU) whose age is between 0- 15 years. During preparatory stage, the questionnaires were carefully designed, pre-coded and pretested to minimize errors. Data collectors and data assistants were trained prior to data collection. It was only the first electrolyte values determined which were collected for the study and final diagnosis was documented on discharge and/or death with clear diagnosis from patient records. Data were checked daily for completeness by data assistant.

Inclusion criteria:

All children between 0-15 years who were admitted to the emergency and intensive care units.

Exclusion criteria:

Children whose diagnosis is not known

Statistical analysis

Data was collected and checked for completeness, coded, entered into SPSS version 20 statistical software packages and cleaned and analyzed by the investigators. During analysis of the study, descriptive statistics, frequency and percentage were used, and the outputs were displayed through tables and graphs. Mean and confidence intervals were used for numerical variable. Frequency was used for categorical variables.

Definitions

- Normal serum sodium level 135 mEq/L -145 mEq/L
- Normal serum potassium level 3.4 mEq/L-5.3 mEq/L
- Normal serum calcium level 8.5-10.5 mg/dl (1, 2)

Ethical consideration

Electrolyte determination was routine in all patients admitted to the emergency and intensive care units of the hospital and didn't involve human subjects. No personal identification was made on the questionnaires and confidentiality of all the data was kept throughout the different stages of the study. Ethical clearance was obtained from Research and Publication Committee of the Department of Pediatric and Child Health, College of Health Sciences, Addis Ababa University.

III. Result

The study involved a total of 384 hospitalized children. Age of the study subjects ranged from 8 days to 15 years and the mean age was 3.9 years + 3.8 SD. Of 384 (70.1%) were between the age of 0-1year and males were 212 (55.2%) table 1.

Table1. Sociodemographic characteristics of children admitted to pediatric emergency and intensive care units, (N=384).

Variables		Frequency	Percentage
Age	0-1 year	269	70.1
	1-5 years	85	22.1
	5-15 years	30	7.8
Sex	Male	212	55.2
	Female	172	44.8

Among the study subjects, 330 (85.9%) were discharged with improvement while 39(10.2%) of the children were transferred to the wards whereas 14 (3.6%) of the patients died. Of 384 children, 173 (45.1%) had electrolyte abnormalities of which 73 (19%) had mixed electrolyte disorder. Among the study subjects, 89 (23.2%) developed hyponatremia and 64 (16.7%) hypernatremia. Regarding the other electrolytes, 85 children (22.1%) had hypokalemia, whereas 59 (15.4%), 43 (11.2%) and 36 (9.4%) of the study subjects had hypocalcaemia, hyperkalemia and hyperchloremia respectively. Of those with hyponatremia, 23 (25.8%) were having cardiovascular disease, 19 (21.3%) were diagnosed to have renal abnormality, and17 (19.2%) had central nervous system problem. Table 2 shows the patterns of electrolyte abnormalities with respect to their underlying illness.

Table 2: Pattern of electrolyte abnormalities with respect to their underlying systemic illness. (N=384).

System affected	Hyponatremia N (%)	Hypernatremia N (%)	Hypokalemia N (%)	Hyperkalemia N (%)	Hypocalcemia N (%)	Hypercalcemia N (%)
	89 (23.2%)	64 (16.7%)	85 (22.1%)	43 (11.2%)	59 (15.4%)	4 (1%)
Renal	19 (21.3%)	5 (7.8%)	6 (7.1%)	19 (44.2%)	14 (23.7%)	0
**CVS	23 (25.8%)	7 (11.0%)	19 (22.3%)	4 (9.3%)	12 (20.3%)	0
**CNS	17 (19.2%)	14 (21.8%)	7 (8.2%)	2 (4.6%)	4 (6.8%)	2 (50.0%)
**RS	11(12.4%)	4 (6.2%)	6 (7.1)	1 (2.3%)	7 (11.8%)	0
**GIS	14 (15.8%)	8 (12.5%)	23 (27.1%)	4 (9.3%)	5 (8.5%)	1 (25.0%)
**HE	4 (4.4%)	18 (28%)	20 (23.4%)	13 (30.1%)	10 (16.9%)	1 (25.0%)
**ES	0	1 (1.5%)	1 (1.2%)	0	3 (5.1%)	0
Other*	1(1.1%)	7 (11.0%)	3 (3.5%)	0	4 (6.8%)	0

* Other: anemia, hemophilia, sepsis

**RS, respiratory system, CVS, cardiovascular system, CNS, central nervous system, RS, respiratory system, GIS, gastrointestinal system, HE, hematology, ES, endocrine system

Male gender had 1.5 times higher risk of developing hypernatremia (AOR 1.5, 95% CI, 0.85-2.74), children less than 1 year had 2.8 times, children 1-5 years had 3.9 times higher risk of developing hypernatremia with AOR 2.8, 95% CI, 0.63 -12.43 and AOR 3.9, 95% CI, 0.85-18.56 respectively.

Of 384 participants, 210 (54.7%) stayed in the hospital for less than one week, 101(26.3%) stayed 1 to 2 weeks and 73 (19%) more than two weeks.

In binary logistic regression analysis, it was found that children who stayed for more than two weeks were 2 times more likely to have hypernatremia AOR=2.1; 95% CI, 0.99-4.47 compared to children who stayed less than one week in the hospital. In multi-logistic regression analysis, it was found that children with hypernatremia had 3 times higher risk of dying, AOR 3.3, 95% CI, 1.07-10.62 than children with normal sodium level. Association of serum sodium level with adverse outcome is shown in table 3.

Table 3: Association of hypernatremia with adverse outcome (N=384).

Variable	Hypernatremia		COR, 95%CI	AOR, 95%CI
	Yes	No		
Sex				
Male	42 (65.6%)	170 (53.1%)	1.6 (0.96-2.95)	1.5 (0.85-2.74)
Female	22 (34.4%)	150 (46.9%)	1.00	1.00
Age				
<1 year	43 (67.2%)	226 (70.6%)	2.66 (0.61-11.59)	2.8 (0.63 -12.43)
1-5 years	19 (29.7%)	66 (20.6%)	4.03 (0.87-18.47)	3.9 (0.85-18.56)
5-15 years	2 (3.1%)	28 (8.8%)	1.00	1.00
Hospital stay				
<1 week	40 (62.5%)	170 (53.1%)	1.00	1.00
1-2 weeks	10 (15.6%)	91 (28.4%)	1.9(0.8-4.78)	2.2 (0.92-5.43)
>2weeks	14 (21.9%)	59 (18.4%)	2.1 (1.02-4.48)	2.1 (0.99-4.47)
Outcome				
Discharged improved	51 (79.7%)	279 (87.2%)	1.00	1.00
Died	6 (9.4%)	8 (2.55)	4.1 (1.3-12.32)	3.3 (1.07-10.62)
Transferred	7 (10.9%)	32 (10.0%)	1.19 (0.5-2.85)	1.15 (0.46-2.81)
Other	0 (0 %)	1 (0.3%)	1.32 (0.57-2.63)	1.97 (0.86-3.14)

Of 43 children with hyperkalemia 31 (72.1%) were males and 12 (27.9%) were females. Bivariate analysis showed that male sex had twice higher risk of developing hyperkalemia than females (AOR 2.01, 95% CI, 0.96-4.20). Among these hyperkalemic children 33 (76.7%) were below one year of age.

In multivariate analysis, outcome of hospitalized children were found to be significantly associated with serum potassium level. Children with hyperkalemia had 8 times higher risk of death than children with normal potassium level (AOR=8.12, 95%CI, 2.44-26.96). Table 5 shows the relationship of hyperkalemia to patient outcome. Among 85 children with hypokalemia, 43 (50.6%) were males and 42 (49.4%) were females. Two patients with hypokalemia died. There was no significant association with hypokalemia and hospital stay and mortality both in binary logistic regression and multilogistic regression analysis.

Table 5: relationship of hyperkalemia with adverse outcome (N=384).

Variable	Hyperkalemia		COR, 95%CI	AOR, 95%CI
	Yes	No		
Sex				
Male	31 (72.1%)	181 (53.1%)	2.28 (1.13-4.59)*	2.01 (0.96-4.20)
Female	12 (27.9%)	160 (46.9%)	1.00	1.00
Age				

<1 year	33 (76.7%)	236 (69.2%)	1.95 (0.44-8.60)	1.91 (0.428-5.8)
1-5 years	8 (18.6%)	77 (22.6%)	1.45 (0.29-7.26)	1.13 (0.22-5.86)
5-15 years	2 (4.7%)	28 (8.2%)	1.00	1.00
Hospital stay				
<1 week	20 (46.5%)	190 (55.7%)	1.00	1.00
1-2 weeks	15 (34.9%)	86 (25.2%)	1.65 (0.81-3.39)	1.94 (0.91-4.14)
>2weeks	8 (18.6%)	65 (19.1%)	1.16 (0.4-2.87)	1.41 (0.57-3.49)
Outcome				
Discharged improved	30 (69.8%)	300 (88.0%)	1.00	1.00
Died	6 (14.0%)	8 (2.3%)	7.50 (2.44-23.05)	8.12 (2.44-26.96)
Transferred	7 (16.2%)	32 (9.4%)	2.86 (0.78-3.65)	1.39 (0.62-2.93)
Other	0	1 (0.3%)	2.18 (0.89-5.37)	1.92 (0.75-4.93)

Among 59 children with hypocalcaemia, 39 (66.1%) were males and 20 (33.9%) were females. There was no significant association with low serum calcium level and duration of hospital stay or mortality.

IV. Discussion

Electrolyte abnormalities are one of the common medical problems that should be addressed well in hospitalized children. Electrolyte abnormalities could occur due to underlying illness or incorrect management with fluid input. Electrolyte disorders have significant impact on patient outcomes; treating physicians usually pay attention to the underlying medical illness but preventable and manageable electrolyte disorders are often overlooked (1, 2, 3).

An Indian study has shown that 32.5% of 305 children admitted to PICU had electrolyte abnormalities (4). A study done at a tertiary care institute government medical college, Srinagar, India among 11,000 adult patients admitted to the emergency department the prevalence of hyponatremia was 49%, hypernatremia 7%, hypokalemia 36%, hyperkalemia 16%, hypocalcaemia 6% and hypercalcemia 3% (5). In our study 45.1% had electrolyte disorders indicating that electrolyte abnormalities are common disorders in patients admitted to the PEU and PICU.

Studies have also shown that electrolyte abnormalities are one of the common clinical problems in sick hospitalized children. Serum sodium abnormalities are commonly encountered in these patients and outcome depends on the severity of the disturbance (6, 7). Evidences have also shown that hospital acquired sodium disorders increased mortality in critically sick patients (8, 9). In our study hyponatremia (23.2%) is the commonest electrolyte abnormality but hypernatremic children had 3 times higher risk of death and prolonged hospitalization than normo-natremic children which is consistent with the other studies (7, 8).

A study done in 1026 hospitalized Kenyan children in general pediatrics ward with underlying medical illness, the prevalence of sodium disturbance was 46.6%. Of whom 44.4% were hyponatremic and 22% were hypernatremic. Most children had mild hyponatremia and most common primary diagnosis was malaria in this study. The overall mortality rate was 7.8% and the mortality rate was higher in hypernatremic children when compared with hyponatremia (10) which is similar to our study. The overall mortality rate in our study was 3.6% and the most common diagnosis in our children with hyponatremia was heart failure. The higher magnitude of hyponatremia and mortality of children with sodium disturbance in Kenyan children could be because of the level of care; the Kenyan study was done in a rural hospital whereas ours was in a tertiary hospital.

Jayakumar B. et al showed that hyponatremia was the commonest electrolyte abnormality in children admitted to ICU (11). Ali K. et al also demonstrated in adult patients that hyponatremia was the commonest electrolyte abnormality and the underlying diagnosis was heart failure (12). Similar other studies in adult patients with heart failure showed a prevalence rate of 27% and 23.7% (13, 14).

Serum potassium disturbance was also demonstrated in our study; hypokalemia 22.1% and hyperkalemia 11.2% and this is the second most common serum electrolyte abnormality next to sodium. This is similar to one of the Indian studies (4) but the prevalence is lower in our study. In our study the mortality rate in hyperkalemic children with an underlying medical problem was 8 times higher than children with normal potassium level which is statistically significant. This is similar to a study done by Chari C.R. et al (15) and Rao S.D. S et al (16) but Mayank et al (17) showed an increase in mortality in hypokalemic patients.

Calcium disturbance is one of the electrolyte abnormalities encountered in sick hospitalized patients. The prevalence of hypocalcaemia measured as ionized calcium ranges between 15-20% and contributes to high mortality in ICU patients (5, 18, 19, 20). The prevalence of 15.4% in our patients is similar with the above studies but didn't contribute to mortality probably because of mild to moderate hypocalcaemia in our patients.

V. Conclusion

Electrolyte abnormalities are common in children admitted to the emergency and intensive care units with an underlying medical illness and contribute to significant morbidity and mortality. Preventive measures in high risk patients and early treatment would decrease morbidity and mortality.

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