

Profile of serum electrolytes in critically ill children: A prospective study

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ABSTRACT

Objective: The objective of this study is to identify the various electrolyte abnormalities in critically ill children admitted to pediatric intensive care unit (PICU) and their association with morbidity and mortality. **Methods:** This was a hospital-based prospective observational study conducted on 180 critically ill children in the age group 2 months to 15 years admitted in the PICU of a tertiary care hospital. Venous blood sample was obtained for the estimation of serum sodium, potassium, calcium, magnesium, and phosphate. The incidence of electrolyte abnormalities and their relation to the primary illness was calculated. Morbidity (mean duration of hospital stay) and mortality rates were evaluated and compared to patients with normal electrolyte levels. **Results:** Electrolyte abnormalities were seen in 108 children (60%); 72 patients (40%) were having normal electrolyte levels. Most common abnormality seen was hyponatremia in 50.5% patients (n=91). Morbidity and mortality were also higher in these patients. Overall mortality with dyselectrolytemia was 30.5% (n=33) as compared to those with normal electrolyte levels (4.1%, n=3) and was statistically significant ($p<0.01$). **Conclusion:** The present study showed a high incidence of electrolyte abnormalities in acutely ill children admitted to PICU. Since the specific symptoms of electrolyte abnormality often merge with the underlying disease, they remain unrecognized and contribute significantly to the morbidity and mortality besides the primary illness. Close monitoring and appropriate correction of electrolyte abnormalities will be useful in lowering mortality.

Key words: Critically ill children, Electrolyte abnormalities, Morbidity, Mortality

Electrolytes play a vital role in maintaining homeostasis within the body. They help to regulate myocardial and neurological function, fluid balance, oxygen delivery, and acid-base balance. The major cation of the extracellular fluid is sodium responsible for regulating fluid balance. The sodium-potassium activated pump helps to maintain low intracellular sodium [1,2]. Potassium is the most important intracellular cation which maintains cellular osmolarity and nerve impulse transmission. It has an important role in regulating “biologic electricity”. Derangements in potassium homeostasis can cause potentially life-threatening consequences such as cardiac arrhythmias, muscular paralysis, and respiratory failure [3].

Electrolyte abnormalities are common in children who need intensive care, may remain unrecognized and result in morbidity and mortality. Although hyponatremia has been reported to be the commonest electrolyte abnormality in intensive care, precise information on its pathophysiologic significance and outcome of hyponatremia in sick children is lacking [4]. Some view it as having little clinical significance [4], whereas others believe that it is often associated with significant morbidity and mortality [5]. Hypokalemia can have profound effects on electrical activity in cardiac, skeletal, and smooth muscle. If severe, these may result in life-threatening conditions such as cardiac arrhythmias, respiratory failure, muscular paralysis, and

paralytic ileus [3,6]. Studies addressing its incidence and outcome are few [6-8]. Hypocalcemia is also a common problem in critically ill children [9]. Phosphorus also plays an important part in metabolism as the main intracellular anion. Studies addressing the serum levels of calcium, magnesium and phosphorus are few and are chiefly from developed countries [9-13].

In our study, besides serum sodium and potassium, we have also evaluated the incidence and outcome of calcium, phosphorus, and magnesium abnormalities in critically ill children. Analysis of various electrolyte disorders in relation to the underlying illness and their association with the morbidity and mortality in critically ill children was also evaluated.

MATERIALS AND METHODS

This prospective study was conducted in critically ill children in the age group 2 months to 15 years who were admitted in emergency/pediatric intensive care unit (PICU) of Children's Hospital, Medical College Kanpur, over a period of 1½ years. The study was approved by the Institutional Ethical Committee, and written informed consent was obtained from all the patients. Children with gastroenteritis were excluded as the electrolyte abnormalities are well known in them; hence, it was considered of interest to determine the electrolyte abnormalities in other

diseases, in which they go unrecognized. Children with history of receiving electrolyte solutions before admission were also excluded from the study.

A detailed clinical history was taken, thorough physical examination was done. At the time of admission, the age and sex, brief clinical features including symptoms, physical findings, investigations, provisional diagnosis, and the final outcome (discharge/mortality) was recorded in a predesigned proforma. We categorized children according to the underlying illness. Estimation of serum electrolytes was done at admission, at 24 h and at 48 h. A venous blood sample was used to determine serum sodium, potassium, and ionized calcium by ion-selective-electrode method. Serum total calcium was analyzed by Arsenazo III colorimetric method. Serum magnesium and serum phosphorus was also estimated.

Hyponatremia in our study was defined as serum sodium <130 meq/L, hypernatremia as sodium > 150 meq/L, hypokalemia as <3.5 meq/L, hyperkalemia >5.5 meq/L, hypocalcemia <4mg/dl, magnesium and phosphate normal values according to age.

Statistical Analysis

We calculated the overall incidence of various electrolyte abnormalities among critically ill children and also evaluated their incidence in relation to the primary illness. Morbidity was determined by the mean duration of hospital/ICU stay in days and mortality rate was compared to patients having normal electrolyte levels. Chi-square test was used to test the significance of difference in morbidity and mortality in children with normal and abnormal electrolytes. $p < 0.1$ was considered as statistically significant.

RESULTS

A total of 180 cases admitted to the PICU aged 2 months to 15 years. Among those, 110 were males and 70 were females. Majority of the children were in the age group 1–6 years ($n=62$). We categorized our cases according to the body systems predominantly involved. Central nervous system (CNS) disorders: Viral meningoencephalitis ($n=31$), tuberculous meningitis ($n=24$), acute bacterial meningitis ($n=20$), cerebral malaria ($n=8$), and status epilepticus ($n=4$). Respiratory disorders: Pneumonia ($n=16$), bronchiolitis ($n=5$), acute severe asthma ($n=7$). Sepsis ($n=26$). Renal disorder: Acute kidney injury ($n=20$), diabetic ketoacidosis ($n=12$). Gastro-Intestinal disorders: Hepatic encephalopathy ($n=3$). Others: Poisoning, congestive cardiac failure ($n=4$). Maximum number of patients were of CNS disorders ($n=87$) followed by respiratory diseases and sepsis. Out of the total 180 patients, electrolyte abnormalities were present in 108 patients (60%) while 72 patients (40%) were having normal electrolyte levels.

Hyponatremia was the most common electrolyte abnormality, seen in 50.5% patients ($n=91$) while hypernatremia was present in 9.4% patients ($n=17$) (Table 1). About half the number of

Table 1: Incidence of electrolyte abnormalities

Electrolyte abnormality	Percentage
Hyponatremia	50.56
Hypernatremia	9.44
Hypokalemia	34.44
Hyperkalemia	16.12
Hypocalcemia	40.0
Hypomagnesemia	13.88
Hypophosphatemia	7.77

cases of CNS disorders were having hyponatremia (47.1%, $n=41$) (Tables 2 and 3). Hospital stay and mortality were higher in children with serum sodium abnormality (14.2%- mortality in hyponatremia ($n=13$) and 35.2% mortality ($n=6$) in children with hypernatremia) as compared to those having normal sodium levels (mortality rate 4.1%, $n=3$) which is statistically significant ($p < 0.1$) though the underlying disease conditions were similar (Table 4). Out of all electrolyte abnormalities, maximum mortality was seen in patients of hypernatremia.

We found hypokalemia in 34.4% cases ($n=62$, mostly in children with sepsis) and hyperkalemia in 16.1% patients ($n=29$). Out of total 62 patients with hypokalemia, symptoms such as abdominal distension, paralytic ileus, and skeletal muscle weakness were observed in 35 patients. To eliminate the possibility of spurious hyperkalemia (laboratory error), we obtained venous blood sample without squeezing the extremity and in equivocal cases, we obtained a second sample for confirmation. Electro cardiographic (ECG) changes of hypokalemia were observed in four patients. Eleven patients with hyperkalemia and serum potassium >6.5 meq/L had ECG changes of hyperkalemia.

Maximum incidence of hyperkalemia was seen in children with renal failure ($n=13$). The mean duration of ICU stay, and mortality was higher in children with potassium abnormality. 17.2% children ($n=5$) with hyperkalemia expired; whereas the mortality rate in children with hypokalemia was 14.5% ($n=9$) as compared to children with normal electrolyte levels (3.37%) which was statistically significant ($p < 0.1$) (Table 5).

The overall mortality rate was 30.5 % in children having dyselectrolytemia as compared to those with normal electrolyte levels (4.1%) which is statistically significant. The incidence of hypocalcemia in our study was 40% ($n=72$), (Table 1); maximum number of which was seen in children with renal failure and sepsis. The incidence of hypophosphatemia was 7.7% ($n=14$), hypomagnesemia 13.8% ($n=25$); both were most commonly seen in children with sepsis.

The Table 6 shows that mean ICU stay was significantly higher in patients having dyselectrolytemia as compared to those having normal electrolyte levels.

DISCUSSION

In our study, overall electrolyte abnormalities were found in 108 out of 180 children (60 %). Rao and Thomas [8] in a prospective

Table 2: Incidence of hyponatremia in relation to the primary illness

Primary illness	n (%)		
	Total number of cases	Cases with hyponatremia	Cases with normal sodium levels
Intracerebral disease	87	41 (47.13)	38 (43.68)
Respiratory disease	28	9 (32.14)	17 (60.71)
Septicemia	26	12 (46.15)	8 (30.76)
Renal failure	20	15 (75.00)	4 (20)
Diabetic ketoacidosis	12	12 (100.00)	
Viral Hepatitis	3	-	3 (100)
Others	4	2 (50.00)	2 (50.00)
Total	180	91 (50.56)	72 (40.00)

Table 3: Incidence of hypernatremia in relation to the primary illness

Primary illness	n (%)		
	Total number of cases	Cases with hyponatremia	Cases with normal sodium levels
Intracerebral disease	87	8 (9.19)	38 (43.68)
Respiratory disease	28	2 (7.14)	17 (60.71)
Septicemia	26	6 (23.07)	8 (30.76)
Renal failure	20	1 (5.00)	4 (20)
Diabetic ketoacidosis	12	-	
Viral hepatitis	3	-	3 (100)
Others	4	-	2 (50.00)
Total	180	17 (9.44)	72 (40.00)

Table 4: Mortality rate in different groups of cases of serum sodium abnormalities as compared to cases having normal sodium levels.

Serum sodium concentrations	Number of cases (n=180)	Cases expired (%)
Hyponatremia	91	13 (14.28)
Hypernatremia	17	6 (35.29)
Cases with normal sodium levels	72	3 (4.17)
Total mortality in patients with abnormal sodium levels	108	19 (17.59)

Table 5: Mortality rate in different groups of cases of serum Potassium abnormalities as compared to cases having normal potassium levels

Serum potassium abnormality	Number of cases (n=180)	Cases expired (%)
Hypokalemia	62	9 (14.52)
Hyperkalemia	29	5 (17.24)
Cases with normal Potassium levels	89	3 (3.37)
Total Mortality in Patients with abnormal Potassium levels	91	14 (15.38)

Table 6: Mean values of electrolytes and morbidity and mortality statistics

Electrolyte abnormality	Hyponatremia	Hypernatremia	Hypokalemia	Hyperkalemia
Number of cases	91	17	62	29
Mean value at admission (meq/L)	121.22±6.99	156.61±3.60	2.96±0.53	6.37±0.95
Mean ICU stay (days)	5.01±3.99	3.50±2.62	3.5±1.1	4.1±2.0
Morbidity compared to patients with normal electrolytes	2.7±2.9	2.7±2.9	2.8±2.9	2.8±2.9
Mortality	13	6	9	5
Percentage	14.28	35.29	14.52	17.24
p values	0.08	0.005	0.04	0.05

ICU: Intensive care unit

study of 305 children found the overall incidence of electrolyte abnormalities in 32% patients. They studied only sodium and

potassium levels. Thus, electrolyte abnormalities are quite common in critically ill children.

Hyponatremia was the most common electrolyte abnormality seen in 91 out of 180 children (50.5%). Singhal and Khilnani [14] have found the incidence of hyponatremia in 36.3% (109/300) children admitted in PICU which is consistent with our findings. In the study of Rao and Thomas [8], the incidence of hyponatremia was only 9.5%. The variation in incidence of hyponatremia may be due to difference in the nature of primary illness included in these studies. We observed high incidence of hyponatremia in children with CNS disorders (47%) which is consistent with the findings of Reddy *et al.* [15], who similarly reported hyponatremia in 53% of the children with CNS disorders. Hyponatremia in acutely ill children was associated with higher morbidity and mortality (14.2%) as compared to patients having normal sodium levels (4.1%) which is statistically significant and is in agreement with the findings of Rao and Thomas [8] (mortality rate 20.7%), Singhi *et al.* [5] (mortality 13.2%), and Reddy *et al.* [15] (mortality 11.8%); although the present study did not aim at defining various factors which could have contributed to the higher mortality. Several factors including the nature and severity of the underlying illness could have contributed.

In our study, we found hypernatremia in 9.4% of cases with a mean value 156 ± 3.6 meq/L most commonly in children with sepsis. In the study of Moritz and Ayus [16], the mean value of sodium in hypernatremic children was 159 meq/L. In the study done by Rukesh and Shalini [17], the incidence of hypernatremia was 12.6%, which is comparable to our study. Out of all electrolyte abnormalities, maximum mortality was seen in patients with hypernatremia (35.2%), which is consistent with the finding of Muraleetharan *et al.* [18] who similarly observed highest mortality in patients with hypernatremia. Mortality rate in our study was 35.2% which is consistent with other studies.

The incidence of hypokalemia was 34.4% in our study. Singhi and Marudkar [6] found the incidence of hypokalemia as 14.8% in their study (43/290 patients) mostly in patients of sepsis. Singhi *et al.* [7] in their study found the incidence of hypokalemia as 13.9%. Factors responsible for this variation in incidence may be the nature of the primary disease, malnutrition, and therapy with drugs. We also found high incidence of hypokalemia in patients of sepsis. Mortality rate in our study was 14.5% which is consistent with the study of Singhi and Marudkar [6].

Hyperkalemia was seen in 16.1% patients with a mean value 6.3 meq/L. Rao and Thomas [8] similarly reported hyperkalemia in 14.4% of critically ill children with a mean value of 6.5 meq/L, which is in proximity to our observations. Rukesh and Shalini [17] observed hyperkalemia in 18.3% of acutely ill children. We found maximum incidence of hyperkalemia in children with renal diseases. In the study of Rao and Thomas [8] also, the majority of hyperkalemic children were of renal disorders. The mortality rate in our study was 17.2% supporting the findings of Rao and Thomas (mortality rate 22.7%) [8].

We found hypocalcemia in 40% of critically ill children, primarily in patients of renal failure and sepsis. Dinarello [12] also was of the opinion that sepsis is often associated with hypocalcemia, the exact mechanism of which is unclear.

Muraleetharan *et al.* [18] found the incidence of hypocalcemia in 32% of critically ill children admitted to PICU which is close to our finding. The incidence of hypocalcemia has varied from 15% to 50% in different studies. Our incidence (40%) falls in this range. Hypocalcemia is common in critically ill children and associated with higher mortality [9].

In our study, the incidence of hypophosphatemia was 7.7%, and it was mostly seen in patients of sepsis. Antachopoulos *et al.* [13] have similarly reported hypophosphatemia in 35.7% cases of bacterial infections. Hypomagnesemia was seen in 13.8% cases in our study mostly in children with sepsis. Chernow *et al.* [11] reported hypomagnesemia in 13% of their critically ill children which is nearly comparable to our findings.

The overall mortality rate was 30.5% in our study in children having dyselectrolytemia as compared to those with normal electrolyte levels which is comparable to the study of Rao and Thomas [8]. The present study and previous studies all found electrolyte abnormalities increase mortality in acutely ill children.

The main limitation of our study was that it did not aim at defining the various factors which could have contributed to the higher morbidity and mortality. Several factors, including the nature and severity of the underlying illness could, have contributed. Further studies need to be done to find out the correlation between electrolyte abnormalities and the clinical outcome in critically ill children.

CONCLUSION

The present study showed high incidence of electrolyte abnormalities in critically ill children. They were associated with significantly higher morbidity and mortality as compared to children with normal electrolyte levels. Electrolyte abnormalities remain significant predictors of morbidity and mortality in critically ill children. We suggest that timely recognition through regular monitoring and appropriate correction of electrolyte abnormalities will help in improving outcome besides the usual management of the primary disease.

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