



# Abnormal Serum Electrolytes as a Prognostic Factor for Adverse Clinical Outcome in Children Admitted To Picu of a Teritary Teaching Hospital

Kripa Dinesh\*, Sajitha Nair\*\*, C. Jayakumar\*\*\*

[\*Senior resident, \*\*Professor, \*\*\*Professor and HOD of Department of Pediatrics, Amrita Institute of Medical Sciences, Kochi, Kerala, India]

Corresponding Author: Dr Kripa Dinesh, Dept. of Pediatrics, AIMS, Kochi

Date of Submission: 01-06-2023

Date of Acceptance: 10-06-2023

## ABSTRACT

**Background:** Critically ill child is any child who needs supportive treatment for its biological function either by drugs or mechanical ventilation and is usually associated by disturbances in electrolytes due to different associated factors. **Methods:** Children admitted to the pediatric intensive care unit during the study period satisfying the inclusion and exclusion criteria were studied. At admission one venous sample was collected for estimation of serum sodium, potassium, calcium, magnesium and phosphorus. The PRISM III score with 17 physiological variables subdivided into 26 ranges were scored within 24 hours of admission. **Results:** 551 children were included in the study. Serum electrolyte abnormalities were seen in 64.1% (n=353) of children studied. Among them 44% (n=156) had single electrolyte abnormality while 56% (n=197) had multiple electrolyte abnormalities at admission. Hyponatremia 17.2% (n=61) was the most common single electrolyte abnormality in this study. Abnormalities of serum sodium and calcium showed a statistically significant correlation with PRISM III score and death prediction. On logistic regression, children with serum electrolyte abnormalities have 4.9 times more risk for mortality when compared to children without electrolyte abnormalities and children with multiple electrolyte abnormalities had 3.3 times more risk for mortality when compared to children with single electrolyte abnormality. **Conclusion:** Early detection of electrolyte abnormalities by regular monitoring and early correction may help in improving the outcome of critically ill children.

**Keywords:** Critically ill child, electrolyte abnormalities, PRISM III score, outcome.

## I. INTRODUCTION:

Critically ill child means a child who is in a clinical state which may result in cardiac arrest or severe neurologic complication, if not recognized promptly. This term does not refer to any particular

disease, but many diseases can lead into "critically ill state". Whether a child presents with a primary cardiovascular, respiratory, neurologic, infectious or metabolic disorder, the goal is early recognition of respiratory and circulatory insufficiency. (6) Water and electrolytes make up most of the bulk of the human body. The serum electrolytes reflect the internal milieu and their disturbances needs to be recognized early. Hence importance of electrolyte estimation is second only to vital signs. (7) Because of the fragile state of many of the pediatric intensive care unit (PICU) patients, electrolyte imbalances may have profound effects on patient outcomes and in their extreme forms may be life-threatening. Serum electrolytes such as sodium, potassium, magnesium, calcium and phosphate play important roles in cellular metabolism and energy transformation and in the regulation of cell membrane potentials, especially those of muscle and nerve cells. Depletion of these electrolytes can induce a wide range of clinical disorders, including neuromuscular dysfunction and severe arrhythmias. The risk for these disorders increases significantly when more than one electrolyte is deficient. (8)

## Objectives:

**Primary objective:** To study the prevalence of abnormalities of serum sodium in children admitted to the pediatric intensive care unit and to correlate it with outcome as assessed by mortality.

**Secondary objective:** To study the prevalence of abnormalities of serum potassium, calcium, magnesium and phosphorus in children admitted to the pediatric intensive care unit, to study outcome of children, to assess the disease severity by PRISM III score and to correlate the score with outcome in children.

**Methods:** 551 children in the age group of 1 month-18 years admitted to pediatric intensive care unit (PICU) of Amrita Institute of Medical Sciences, Kochi, during the study period of 2 years (Nov 2016 to October 2018), satisfying the



inclusion and exclusion criteria were studied. Patients were stabilized, investigated and managed as per standard protocol. At admission one venous sample was collected for estimation of serum sodium, potassium, calcium, magnesium and phosphorus. The diagnostic evaluation of the patient was done as per the proforma with the aid of detailed history, physical examination and laboratory investigations. The PRISM III score with 17 physiological variables subdivided into 26 ranges were scored within 24 hours of admission.

Electrolyte abnormalities were identified if the following criteria were met: Hyponatremia: Serum sodium <135mEq/L (1), Hypernatremia: Serum sodium >145 mEq/L (1), Hypokalaemia: Serum potassium <3.5 mEq/L (1), Hyperkalaemia: Serum potassium >5.5 mEq/L (1), Hypocalcemia: Serum calcium <8.5 mg/dl (2), Hypercalcemia: Serum calcium >10.5 mg/dl (3), Hypophosphatemia: Serum phosphorus <3.8mg/dl in < 2years and <3.5mg/dl in >2years. (4), Hyperphosphatemia: Serum phosphorus >5.5mg/dl <5years and >6mg/dl >5years. No reference value was available; hence an arbitrary value was taken. Hypomagnesemia: Serum magnesium <1.5mg/dl (5), Hypermagnesemia: Serum magnesium >2.2mg/dl (3)

Serum sodium and potassium were processed through the ion selective electrode in the Beckman Coulter AU2700plus. Serum calcium, magnesium and phosphorus were processed through photometry or colorimetry method in the Beckman Coulter AU2700plus. The children were

followed up during the hospital stay. The number of days of PICU stay was recorded. Outcome was recorded as survived or dead. Serum electrolyte values were correlated with PRISM III score and outcome.

## II. STATISTICAL ANALYSIS:

Analyzed using IBM SPSS 20. (SPSS Inc, Chicago, USA). For all the continuous variables, the results are either given in Mean ± SD, and for categorical variables as percentage. To test the statistical significance of the association of morbidity and mortality with abnormalities with respect to various parameters, chi square test was applied. Binary Logistic regression was applied to find the risk of mortality of children with and without abnormalities. A p-value < 0.05 was considered as statistically significant.

## III. RESULTS:

The age of the children in the study group ranged from 1month to 18years, 52.5%(n=289) were males and 47.5%(n=262) were females. Serum electrolyte abnormality was seen in 64.1%(n=353) of children studied(n=551). Hyponatremia 17.2%(n=61) was the most common single electrolyte abnormality in this study. Abnormalities of serum sodium and calcium showed a statistically significant correlation with PRISM III score and death prediction. (Table no:1)

**Table no:1 Serum sodium, potassium, calcium, magnesium and phosphorus correlation with PRISM III score and death prediction.**

Variables	Serum sodium (Na)			p value
	Hyponatremia(n=61)	Hypernatremia(n=5)	Normal(n=90)	
PRISM III scores (Mean ±SD)	17.3±5.81	13±4.47	10.6±3.65	<0.001
Death prediction (Mean ±SD)	29.03±14.7	20.6±8.76	16.5±7.83	<0.001
	Serum potassium(K)			
	Hypokalemia (n=8)	Hyperkalemia (n=9)	Normal (n=139)	
PRISM III scores (Mean ±SD)	10±0.0	10.5±1.6	13.6±5.8	0.064
Death prediction (Mean ±SD)	15±0.0	15.89±2.66	22.2±13.1	0.107
	Serum calcium (Ca)			
	Hypocalcemia (n=48)	Hypercalcemia (n=8)	Normal (n=100)	
PRISM III scores (Mean ±SD)	10.8±3.76	10.6±1.76	14.7±6.1	<0.001
Death prediction (Mean ±SD)	16.8±7.94	16±2.82	24.2±14	<0.001
	Serum magnesium(Mg)			



	Hypomagnesemia(n=1)	Hypermagnesemia (n=2)	Normal (n=153)	
PRISM III scores (Mean ±SD)	30	10±0.0	13.24±5.51	-
Death prediction (Mean ±SD)	63	15±0.0	21.3±12.2	-
<b>Serum phosphorus (Ph)</b>				
	Hypophosphatemia (n=14)	Hyperphosphatemia (n=6)	Normal (n=136)	
PRISM III scores (Mean ±SD)	9.64±2.37	11.6±4.08	13.7±5.79	<0.001
Death prediction (Mean ±SD)	14.7±3.22	18.3±8.1	22.3±13.1	0.077

**Serum electrolyte abnormality:**

Serum electrolyte abnormality was seen in 64.1%(n=353) of children studied(n=551). Children with electrolyte abnormalities(n=353) had a higher mean PRISM III score, higher mean death prediction score, needed ventilatory support and higher morbidity and mortality rate when compared

to children without electrolyte abnormality. (p-value <0.001)(Table no:2). On logistic regression, children with serum electrolyte abnormalities have 4.9 times more risk for mortality when compared to children without electrolyte abnormalities. (Table 3)

**Table no:2 Children with electrolyte abnormality(n=353) vs children without electrolyte abnormality(n=198)**

Variables	Serum electrolyte abnormalities		p value
	Yes(n=353)	No(n=198)	
PRISM III scores (Mean ±SD)	18.20±6.987	5.51±3.186	<0.001
Death prediction (Mean ±SD)	32.17±16.445	9.98±6.707	<0.001
Ventilator support n (%)	36(10.2%)	5(2.5%)	<0.001
Length of ICU stay(>10days) n(%)	36(10.2%)	2(1%)	<0.001
Mortality n (%)	47(13.3%)	6(3%)	<0.001

**Table no 3: Predictors of fatal outcome based on serum electrolyte abnormalities at admission to PICU(logistic regression):**

Factors	p value	Odds Ratio	95% C.I.	
			Lower	Upper
Serum electrolyte abnormalities	<0.001	4.915	2.062	11.71

**Multiple electrolyte abnormalities:**

Multiple electrolyte abnormality was considered when a child had more than one abnormality in electrolyte at admission. 56%(n=197) of children studied had multiple electrolyte abnormalities at admission to PICU. The clinical data of children with multiple electrolyte abnormalities(n=197) were compared to children who presented with a single electrolyte

abnormality(n=156).Children with multiple electrolyte abnormalities had a higher mean PRISM III score, higher mean death prediction score, needed PICU stay >10days and had higher mortality rate when compared to children with single electrolyte abnormality. (p-value <0.001)(Table no:4). On logistic regression, children with multiple electrolyte abnormalities had 3.3 times more risk for mortality when compared to



children with single electrolyte abnormality. (Table no:5).

**Table no:4 Children with multiple electrolyte abnormality(n=197) vs children with single electrolyte abnormality(n=156)**

Variables	Multiple electrolyte abnormality (n=197)	Single electrolyte abnormality (n=156)	p value
PRISM III scores (Mean ±SD)	22.08±5.32	13.3±5.6	<0.001
Death prediction (Mean ±SD)	40.5±14.1	21.5±12.5	<0.001
Ventilator support n (%)	23(11.7%)	13(36.1%)	0.303
Length of ICU stay(>10days) n(%)	28(14.2%)	8(5.1%)	<0.001
Mortality n (%)	37(18.78%)	10(6.4%)	<0.001

**Table no 5: Predictors of fatal outcome based on multiple electrolyte abnormalities at admission to PICU (logistic regression):**

Factors	p value	Odds Ratio	95% C.I.	
			Lower	Upper
Multiple electrolyte abnormalities	<0.001	3.376	1.621	7.032

**IV. DISCUSSION:**

Fluid and electrolyte abnormalities are common in critically ill children and often represent complications from underlying disease states or medications. Their clinical features may be nonspecific in critical states. They occur in a variety of conditions, may remain unrecognized and result in morbidity and mortality irrespective of the primary problem. Hence a high index of suspicion, timely recognition and a thorough understanding of common electrolyte abnormalities are necessary to ensure their timely correction.

In the present study electrolyte abnormalities were observed in 64.1% of children studied at admission to PICU. In a study by Subba Rao et al (8) the prevalence of abnormalities of serum sodium and potassium was 32.45%. In a study by Rukesh et al (12) the prevalence of abnormalities of serum sodium and potassium in 138 critically ill children was 53.79%. In a similar study by Mayank Jain et al (1) from Ahmedabad, India the prevalence of abnormalities of serum sodium and potassium was 31.4%. The prevalence of electrolyte abnormalities in our study was similar to the findings by Neha et al (10) from Kanpur, India who studied 180 critically ill children for abnormalities of serum sodium, potassium and calcium (60%).

In our study, 55.8%(n=197) of children had multiple electrolyte abnormalities at admission to PICU. Hyponatremia 17.2%(n=61) was the most common single electrolyte abnormality in the study group. The least common electrolyte abnormality was hypomagnesemia which was seen only in one child. In studies done by Mayank Jain et al (1), Rukesh et al (12), Anirudh et al (11) and Neha et al (10) the most common electrolyte abnormality was hyponatremia. In a study by Subba Rao et al (8) where abnormalities of serum sodium and potassium were studied, hyperkalemia (14.4%) was the most common electrolyte abnormality whereas in a study by Basant et al (9) from Egypt, hypocalcemia was the most common electrolyte abnormality (71.7%).

Abnormalities of serum sodium and calcium were associated with higher PRISM III score and death prediction (p value <0.001respectively) when compared to children with normal serum electrolytes. Multiple comparison test showed that hyponatremia and hypocalcemia were associated with higher PRISM III score and death prediction score when compared to children without electrolyte abnormalities. (p value <0.001respectively)

Literature search showed that Basant et al from Egypt (9), studied 120 critically ill children for abnormalities of serum sodium, potassium and



calcium. In this study, hypernatremia was associated with higher PRISM III score and death prediction score than hyponatremia. In the same study hyperkalemia was also associated with higher PRISM III score and death prediction than hypokalemia.

In the present study, disease severity by PRISM III score and death prediction was calculated in children with electrolyte abnormalities. Children with electrolyte abnormality (n=353) had higher mean PRISM III score of  $18.20 \pm 6.987$  at 24 hours of admission with corresponding higher mean death prediction score ( $32.17 \pm 16.445$ ) when compared to children without electrolyte abnormality ( $5.51 \pm 3.186$ ,  $9.98 \pm 6.707$  respectively). This data was found to be statistically significant (p value < 0.001). On logistic regression, children with serum electrolyte abnormalities have 4.9 times more risk for mortality when compared to children without electrolyte abnormalities. (p value < 0.001, OR-4.915)

Children with multiple electrolyte abnormalities had higher mean PRISM III score of ( $22.08 \pm 5.32$ ) and higher death prediction ( $40.5 \pm 14.1$ ) when compared to children with single electrolyte abnormality. This data was statistically significant (p value < 0.001). On Logistic regression, children with multiple electrolyte abnormalities had 3.3 times more risk for mortality when compared to children with single electrolyte abnormality.

Since the specific symptoms of electrolyte abnormality often merge with the underlying disease, close monitoring is important to reduce morbidity and mortality. Thus, vigilant monitoring of electrolytes and timely recognition, optimal correction of electrolyte abnormalities are the keys to survival in a critically ill child.

#### Key Message:

Estimation of serum electrolytes should be done in critically ill children admitted to the PICU irrespective of the primary problem.

**Funding:** No funding issues.

**Conflict of interest:** None declared.

**Ethical approval:** The study was approved by Institutional Ethics Committee.

#### REFERENCES:

- [1]. Mayank Jain, Archana Shah, Rajal Prajapati. Study of electrolytes imbalance in critically ill children. *Int. J. Int. Med. Res.* 2015; 2(2):56-59.
- [2]. Neha Naik, Vithalrao Punjaji Dandge. Role of Calcium in critically ill children-Incidence of Hypocalcemia in PICU set up. October 2011. *Indian Journal of Applied Research*; 4(4):409-411.
- [3]. Srivastava R. N. Bagga A. et al. Fluid, Electrolyte and Acid Base Disorders. *Pediatric Nephrology*. 6th edition.
- [4]. Shah SK, Irshad M, Gupta N, Kabra SK, Lodha R. Hypophosphatemia in Critically Ill Children: Risk Factors, Outcome and Mechanism. *Indian J Pediatr.* 2016 Nov;83(12-13):1379-1385. doi: 10.1007/s12098-016-2188-x. Epub 2016 Jul 9. PMID: 27392619.
- [5]. Nelson Textbook of Pediatrics. Volume 1. 21th Edition.
- [6]. Kinsella JP, Neish SR, Ivy DD, Shaffer E, Abman SH. Clinical responses to prolonged treatment of persistent pulmonary hypertension of the newborn with low doses of inhaled nitric oxide. *J Pediatr.* 1993 Jul;123(1):103-8. doi: 10.1016/s0022-3476(05)81551-3. PMID: 8320602.
- [7]. Gabriel J. Hauser, Aaron F. Kulick. Electrolyte Disorders in the PICU. *Pediatric Critical Care Medicine*. 2014. ISBN:978-1-4471-6415-9.
- [8]. Subba Rao SD, Thomas B. Electrolyte abnormalities in children admitted to pediatric intensive care unit. *Indian Pediatr.* 2000 Dec;37(12):1348-53. PMID: 11119337.
- [9]. Soha Abd Elhady Ebrahim, Eman Ramadan Abd El gawad and Basant Moaz Ebn Gabal Ahmed. 2016; ELECTROLYTE DISTURBANCES IN CRITICALLY ILL PATIENTS. *Int. J. of Adv. Res.* Vol:4, Issue 3,88-93. ISSN 2320-5407.
- [10]. Neha Ashok Agarwal, Yashwant Kumar Rao, Rachit Saxena et al. Profile of serum electrolytes in critically ill children: A prospective study. *Indian J Child Health.* 2018. Vol5.Issue2. 128-132.
- [11]. Anirudh Reddy Paidy, Col Rajeev Kumar Thapar, Brig Rakesh Kumar Gupta. Electrolyte disturbances in critically ill children admitted to pediatric tertiary care center. *Journal of Evolution of medical and Dental Sciences.* 2017, vol6, (3269-3273). <https://doi.org/10.14260/JEMDS%2F2017%2F708>
- [12]. C. Rukesh Chary, B. Shalini. Correlation Between Serum Electrolytes and Clinical Outcome in Children Admitted To PICU. *IOSR-JDMS.e- ISSN: 2279-0853. p-ISSN: 2279-0861.* Volume 16, Issue 11 Ver. VIII (Nov. 2017), 24-27.