

# Biochemical Analysis of Electrolytes and Their Role in Paediatric Patients Admitted in Intensive Care Unit (PICU)

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## ABSTRACT

### BACKGROUND

Electrolyte balance plays key role in maintaining homeostasis along with fluids in paediatric patients. The higher and lower value of critical electrolytes like sodium, potassium and chloride can affect cellular processes drastically as it may result in cardiac and neurological complications. This can alter patient status in terms of morbidity and mortality. Hence, Electrolyte imbalance significantly affects the quality of life of the patient. In this study we have analysed three electrolytes; sodium, potassium and chloride. The accurate measurement of electrolytes is an important prognostic indicator in PICU patients where greater attention and proper analysis is recommended.

### METHODS

180 paediatric patients in the age group of 2-15 years with various critical illnesses admitted in PICU of a tertiary care hospital were included in the study. The serum samples were analysed on Transasia Biomedicals XL 640 – a fully automated biochemistry analyser which has Ion Selective Electrode (ISE-Na/K/Cl) and diffraction grating for high resolution measurement.

### RESULTS

Out of the 180 paediatric patients enrolled for the study, 83 were females and 97 were males. Hyponatremia was observed in 35% patients while hyponatremia in 31%. Hyperkalaemia was observed in 27% patients while hypokalaemia in 14%. Hyperchloremia in 24% while hypochloreaemia 5% patients.

### CONCLUSIONS

The electrolyte balance plays a key role in treatment of patients admitted in PICU. The accurate measurement of electrolyte like sodium, potassium & Chloride is an important prognostic indicator where greater attention and proper analysis is recommended. Also, the presence of electrolyte imbalance at the time of admission is an important prognostic indicator in critically ill children irrespective of primary disease process and needs to be addressed aggressively. The study helped us in maintaining the electrolyte 'homeostasis' in the body which is vital for the organ's support and optimal function and also evaluating therapies and matching severity of illness in the PICU.

### KEYWORDS

Critically Ill Children, Electrolyte Imbalance, Hyponatremia, Hyponatremia, Hyperkalaemia, Hypokalaemia, Hyperchloremia, Hypochloreaemia, XL-640

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## BACKGROUND

Human body contains electrically charged minerals like sodium, potassium, calcium, phosphorous, and magnesium which are critical for the normal functioning of the nerves and muscles. They are found in the body fluids.<sup>1</sup> Dehydration disturbs the delicate balance of electrolytes in the individuals; predominantly children are found to be more susceptible to dehydration due to their small size and fast metabolism, which results into rapid replacement of water & electrolytes compared to that in adults. Dehydration causes severe vomiting, diarrhoea followed by high grade fever, and taking medication sometimes results in excessive urination all leading to more fluid loss from the body. Profuse sweating from physical exertion can also add to dehydration. The loss of fluids along with the vital electrolytes from the body is very common in children with a serious underlying medical condition. In pre-existing conditions like chronic kidney disease wherein the ability of the kidneys to maintain proper fluid and electrolyte levels is minimal, Hormonal imbalances like that of thyroid or parathyroid hormones, which help regulate calcium and other electrolytes, can also make the patient susceptible to fluid and electrolyte imbalance. Children with cardiac issues tend to retain sodium and water in the body which in due course develops abnormal electrolyte levels.

In dehydration the colour of the urine appears darker than usual. Sometimes electrolyte imbalance results in confusion, weakness and muscle spasms. At times symptoms like difficulty in breathing, dizziness and increased heart rate is also observed in children with dehydration.<sup>2</sup> If Parents or caretakers notice any of these symptoms, especially if a child has an underlying medical condition or a fever, should immediately rush the child to PICU unit to get evaluated by the Critical care experts. Early diagnosis and instant treatment are extremely important in these conditions. Severe fluid loss with electrolyte disturbance reduces the blood and mineral flow to vital organs including the brain, heart and liver. In some instances, this can make brain tissue swell or shrink, causing seizures, or life-threatening disturbances in heart rhythm, known as arrhythmia. Hence electrolyte balance plays key role in maintaining 'homeostasis' along with other body fluids in critically ill paediatric patients in PICU unit of the hospital. The higher and lower value of critical electrolytes like sodium, potassium and chloride can affect cellular processes drastically as it may result in cardiac and neurological complications altering the patient's status in terms of morbidity and mortality. Electrolyte imbalance significantly affects the quality of life of the patient.<sup>3,4</sup>

Paediatric Intensive Care Unit (PICU) is an essential component of in any tertiary hospital. The main function of PICU is to keep check on mortality of the critically ill paediatric patients. The paediatric patients with high risk of mortality need to be monitored intensively and treated with expert clinical services and advance lifesaving equipment. It is also important to estimate risk of mortality by assessing patient's provisional diagnosis, PICU resources utilization,

evaluating therapies, and matching severity of illness in clinical studies. Critical care provision through PICU is aimed at maintaining homeostasis in the body which is vital for the organ's support and optimal function. Fluid and electrolyte balance plays important role in this. It has been observed that mortality rate is high in patients with sepsis and hypocalcaemia as compared with patients with normocalcaemia. Same is true for patients with hypernatremia and hyperkalaemia which are commonly found in PICU patients.<sup>5,6</sup>

Major electrolytes important in this regard are sodium, potassium and chloride.<sup>7</sup> Their imbalance in either direction i.e. lower or higher than normal can affect cellular processes, which can significantly affect morbidity and mortality.<sup>8</sup> These imbalances also result in longer stay in hospitals,<sup>9</sup> thus adding significantly to the costs of stay and medical management in the hospital. Thus, early recognition and intervention to correct these imbalances is essential to avoid poor outcome<sup>6</sup> The precise information about exact level of essential electrolyte has great significance in treatment of patients in PICU.

Five possible mechanisms for the occurrence of electrolyte imbalance are:

- Underlying disease process,
- End organ injury,
- Fluid & electrolyte interventions,
- Use of medications with potential electrolyte derangements
- Application of critical care technology i.e. positive pressure ventilation.<sup>10</sup>

If these critical electrolytes are compromised then, it may result in life-threatening conditions such as cardiac arrhythmias, respiratory failure, muscular paralysis and paralytic ileus. The purpose of our study was to analyse the level of sodium, potassium and chloride in critically ill PICU patients. These electrolytes were studied and evaluated for various electrolyte disorders in relation to the underlying illness and their association with the morbidity and mortality in these critically ill patients in PICU.

We wanted to study the biochemical analysis of electrolytes like sodium, potassium & chloride and their respective role in paediatric patients admitted in intensive care unit.

## METHODS

80 paediatric patients (97 Males and 83 Females), in the age group 2-15 years with various critical illnesses admitted in PICU of Rajiv Gandhi Medical College & Hospital, Kalwa, Thane, Maharashtra, during the time period of 6 months from September 2019 to February 2020 were included in the study. Patients who underwent electrolyte therapy before admission were excluded from the study. The PICU patients were regularly monitored for the electrolyte imbalance. Serum samples were collected for sodium, potassium and

chloride for electrolyte analysis. Demographics of patients and their detailed medical history were documented for the study. The parents or the guardian of these patients have signed information consent for this study. The patients were admitted in PICU for critical illnesses related to respiratory, central nervous system (CNS), sepsis, cyclic vomiting syndrome (CVS), etc. Various outcomes for these patients were - discharged with proper clinical treatment, or discharged against medical advice (DAMA) or expired. The discharge outcome has been documented along with length of stay in PICU.

**Equipment**

Fully Automated Biochemistry Analyzer XL-640 manufactured by Transasia Biomedicals (Erba Mannheim) which has Ion Selective Electrode (ISE-Na/K/Cl/Li) and diffraction grating for high resolution measurement.

**Statistical Evaluation**

The statistical analysis was done by using SPSS analysis version 16. Descriptive statistics were applied to describe the results in terms of percentages and frequencies. Chi-square was applied for association of electrolyte imbalance with the outcome, P-value <0.05 was considered significant. The patient values matched with values mentioned in table no. 1 and any value less than or higher than the cut off values was considered abnormal.

No.	Parameter	Normal range
1.	Sodium	135- 145 mEq/L
2.	Potassium	3.3-4.6 mEq/L
3.	Chloride	95-105 mEq/L

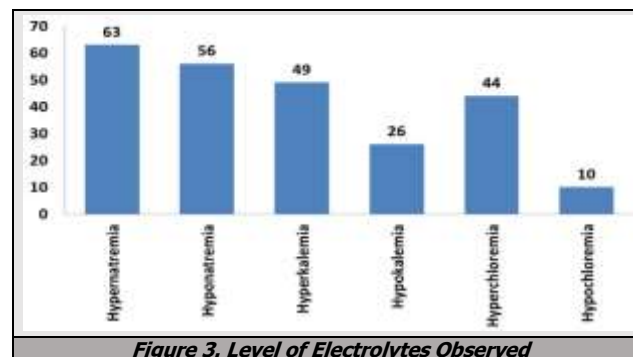
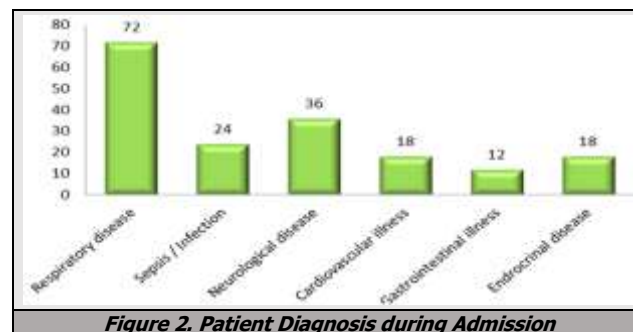
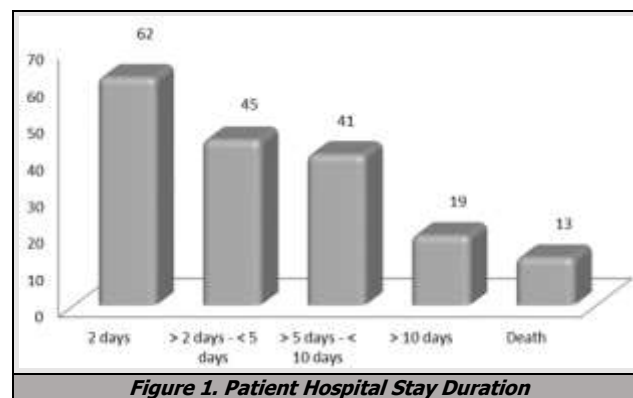
**Table 1. Electrolyte Normal Range**

**RESULTS**

During the study, 180 paediatric patients admitted in PICU were enrolled for the analysis. Amongst these patients, 83 patients (46%) were females and 97 patients (54%) were males. 69 patients (38%) were under five years of age, 73 patients (41%) were between 5 and 10 years of age and 38 patients (21%) were above 10 years of age. There were 62 patients (34%) whose hospital stay was 2 days, 45 patients (25%) stayed for more than 2 days but less than 5 days, and 41 patients (23%) stayed for more than 5 days but less than 10 days and 19 patients stayed for more than 10 days and 13 patients (7%) who expired due to critical illnesses (Figure 1).

During admission, 72 patients (40%) had respiratory diseases, 24 patients (14%) had sepsis/infection, 36 patients (20%) had neurological diseases, and 18 patients (10%) had cardiovascular illnesses, 12 patients (6%) had gastrointestinal illnesses and 18 patients (10%) had endocrinal diseases (Figure 2). Hyponatremia was observed in 63 patients (35%) while hyponatremia in 56 patients (31%). Hyperkalaemia in 49 patients (27%) while hypokalaemia in 26 patients (14%). Hyperchloremia was

observed in 44 patients (24%) while hypochloreaemia in 10 patients (5%) (Figure 3).



**DISCUSSION**

It is critical to identify clinical state of paediatric patient, as it may result in cardiac and neurological complications. Bhadoria and Bhagwat (2008) has included a lot of criteria of patients admitting to PICU like conscious level (Glasgow coma scale), heart rate, blood pressure, respiratory rate, ABG, bleeding tendency, bilirubin level and blood sugar.<sup>11</sup> In this study, we have analysed three electrolytes sodium, potassium and chloride. Laville et al, has reported hyponatremia is most commonly results from an abnormality in the handling of water and the common cause of hyponatremia is Syndrome of inappropriate antidiuretic hormone secretion (SIADH).<sup>12</sup>

Singhi et al., has very well documented the renal capacity of excreting 15-20 litres of free water per day. Hence, hyponatremia can occur when a clinical condition impairs normal free water excretion. The incidence of

hyponatremia depends largely on the patient population and the criteria used to establish the diagnosis. Amongst the hospitalized patients, 15-20% have a serum sodium level of <135 mEq/L, while only 1-4% have a serum sodium level of less than 130 mEq/L.<sup>13</sup> The prevalence of hyponatremia is lower in the ambulatory setting & severe hyponatremia (< 125 mEq/L) has a high mortality rate. In instances when the serum sodium level is less than 105 mEq/L, the mortality is over 50%.<sup>13</sup> In our study Hyponatremia cases are more than hyponatremia in children; they were about 63 patients out of 180 admitted in PICU, associated with metabolic disorder, sepsis, gastroenteritis & renal tubular acidosis. 12 cases out of these developed convulsion.

Darmon & Funk et al., reported higher prevalence of hypernatremia, 9–26% in critically ill patients. The mortality rates 30–48% have been reported by this study in ICU patients with serum sodium levels exceeding 150 mEq/L.<sup>14</sup> According to Cummings et al, Potassium abnormalities are common in critically ill patients, who found that one-third had abnormal values. Hypokalaemia affected 40% of the admitted cases.<sup>15</sup> In our study Hyperkalaemia affected 49 patients out of 180. Unlike our study, hyperkalaemia is a life threatening condition that is most often seen in the PICU patients. Hyperkalaemia cases are more in numbers than hypokalaemia cases. The hypokalaemia is commonly associated with CNS- Central Nervous System infection, chest infection with gastroenteritis, sepsis with gastroenteritis, sepsis with renal tubular acidosis, diabetic ketoacidosis, diabetes insipidus & haemolytic uremic syndrome.

In 2018, Stenson et al., have reported 93% mortalities in hyperchloremia cases. A minimum chloride greater than or equal to 110 mEq/L was associated with increased odds of complicated course (odds ratio, 1.9; 95% CI, 1.1-3.2;  $p = 0.023$ ) and mortality (odds ratio, 3.7; 95% CI, 2.0-6.8;  $p < 0.001$ ). A mean chloride greater than or equal to 110 mEq/L was also associated with increased odds of mortality (odds ratio, 2.1; 95% CI, 1.3-3.5;  $p = 0.002$ ). The secondary analysis yielded similar results. In our study we have reported more hyperchloremia cases as compare to hypocholemaemia with less mortality rates with cardiac and neurological complications.

## CONCLUSIONS

The electrolyte balance plays a key role in the treatment of critically ill patients. Also the presence & accurate measurement of the electrolyte imbalance at the time of admission in critically ill children irrespective of the primary disease process is an important prognostic indicator in PICU patients where greater attention and proper analysis of electrolytes is recommended.

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