

Electrolyte disturbances in children admitted at pediatric intensive care unit in BP Koirala institute of health sciences: A cross sectional observational study

Abstract

Objective: To investigate the types and clinical implications of electrolyte disturbances, specifically focusing on serum sodium, potassium, and calcium levels, in critically ill pediatric patients admitted to the Pediatric Intensive Care Unit (PICU) at B.P. Koirala Institute of Health Sciences (BPKIHS).

Methods: This cross-sectional study included 188 critically ill children admitted to the PICU. Serum levels of sodium, potassium, and calcium were measured, and electrolyte disturbances were categorized. Data on baseline demographics, underlying conditions, and organ systems involved, and clinical outcomes were collected. Associations between electrolyte disturbances and patient outcomes were statistically analysed.

Results: Hyponatremia was identified as the most common electrolyte disturbance, especially among patients with respiratory and gastrointestinal system involvement. Hypocalcemia was also prevalent and was significantly associated with gastrointestinal and endocrine conditions ($p = 0.029$ for total calcium, $p = 0.039$ for ionized calcium). The study found a strong association between normal levels of sodium and calcium and favourable clinical outcomes ($p = 0.0127$ for sodium, $p = 0.002$ for calcium). In contrast, hypernatremia and hypocalcemia were linked with adverse outcomes. Mixed electrolyte disturbances, particularly hyponatremia coupled with hyperkalemia or hypocalcemia, posed additional clinical management challenges.

Conclusion: Electrolyte imbalances are common in critically ill pediatric patients and are closely linked with underlying disease states and outcomes. Routine monitoring and timely correction of electrolyte disturbances are critical to improving clinical outcomes in PICU patients. The study emphasizes the need for protocol-driven management strategies for electrolyte disturbances in pediatric critical care settings.

Keywords: electrolyte disturbances, hyponatremia, hypokalemia, hypocalcemia, pediatric intensive care unit, BPKIHS, critical illness, child health, prognosis

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Background of the study

Electrolyte disturbances are a significant clinical concern in pediatric intensive care units (PICUs), where critically ill children are often admitted with complex medical conditions. These disturbances involve imbalances in essential electrolytes such as sodium, potassium, and calcium, which are crucial for maintaining physiological homeostasis.¹ This study aims to investigate the prevalence, types, and clinical implications of electrolyte disturbances in children admitted to the PICU at (BPKIHS). By understanding these imbalances, the study seeks to enhance clinical management and improve patient outcomes.²

Electrolyte disturbances in children in the pediatric intensive care unit (PICU) are often caused by pre-existing conditions or specific medications. The main electrolyte disturbances are disorders of sodium, potassium, calcium, and magnesium, which are associated with increased morbidity and mortality. Regular evaluation is essential for these disorders. Hypernatremia, primarily treatment-induced, can be used as an indicator of the quality of hospital care in the PICU.² Signs and symptoms of hyponatremia include rapid sodium drop below 125 mEq/L, potassium decrease due to medications used in the unit, and neuromuscular symptoms such as paralysis, weakness,

constipation, respiratory muscle weakness, and rhabdomyolysis. Cardiac arrhythmias are observed, particularly in patients with hypertension and heart disease.³

Hyperkalemia is another disorder in PICU children, caused by renal failure, adrenal gland, and insulin deficiency, tissue damage from rhabdomyolysis, burns, or cerebral stroke. Medications used in the PICU can increase blood potassium levels, leading to electrocardiographic changes. Severe hyperkalemia can cause life-threatening arrhythmias, such as ventricular fibrillation or asystole leading to cardiac arrest.⁴

Hypocalcemia is another major electrolyte disturbance in children, with symptoms including muscle spasms, papilledema, chest pain, neurological symptoms like emotional instability, basal ganglia calcification, and extrapyramidal abnormalities, and cardiac manifestations like long QT, ventricular arrhythmias, and heart failure. Regular evaluation and treatment are crucial for maintaining patient safety and quality of care.⁵ This study was conducted to find the clinical implications of electrolyte disturbances, specifically focusing on serum sodium, potassium, and calcium levels, in critically ill pediatric patients admitted to the PICU at BPKIHS. The study was conducted on 188 patients among which hyponatremia in 62.76%

and hyponatremia with hypokalaemia 29.78% and hyponatremia with hypokalaemia is 34.04%. Among electrolyte disturbances hyponatremia was the most common electrolyte abnormalities.

Methods

Study design

This study employs a cross-sectional observational design to investigate electrolyte disturbances in children admitted to the Pediatric Intensive Care Unit (PICU) at B.P. Koirala Institute of Health Sciences (BPKIHS). A cross-sectional study design is appropriate as it allows for the collection of data at a single point in time, providing a snapshot of the prevalence and characteristics of electrolyte disturbances in a defined population of critically ill children. This approach will facilitate the assessment of various electrolyte abnormalities including hyponatremia, hypernatremia, hypokalemia, hyperkalemia, hypocalcemia, and hypercalcemia, along with their associated clinical outcomes.

Study setting

The study will be conducted at the PICU of BPKIHS, a tertiary care hospital located in Dharan, Nepal. BPKIHS serves a diverse population from across the eastern region of Nepal, providing specialized care for children with a wide range of acute and chronic medical conditions. The PICU at BPKIHS is equipped with advanced monitoring and therapeutic facilities necessary for the care of critically ill pediatric patients, making it an ideal setting for this study.

Study population

The study population will consist of all children aged 1 month to 18 years who are admitted to the PICU at BPKIHS during the study period and meet the inclusion criteria. Children with confirmed electrolyte disturbances based on laboratory findings during their PICU stay will be included. Exclusion criteria will include children with incomplete medical records, those transferred from other hospitals with incomplete electrolyte data, and children with congenital electrolyte abnormalities identified prior to admission.

Data collection

Data collection will involve a comprehensive review of medical records and laboratory reports of eligible patients admitted to the PICU during the study period. The following data will be collected:⁶

Demographic information: Age, sex, weight, height, and Bmi.

Clinical characteristics: Admission diagnosis, comorbidities, duration of PICU stay, and severity of illness.

Electrolyte measurements: Serum levels of sodium, potassium, ionized calcium, and total calcium during the admission period. The timing of electrolyte measurements relative to admission and any interventions initiated for electrolyte abnormalities will be documented.

Clinical outcomes: Clinical outcomes including mortality, length of PICU stay, need for mechanical ventilation, renal replacement therapy, and occurrence of electrolyte-related complications such as cardiac arrhythmias, seizures, and neurological sequelae.

Data analysis

Statistical analysis will be conducted using appropriate software (e.g., SPSS 29) to describe the prevalence, types, and patterns of electrolyte disturbances observed in the study population. Descriptive statistics such as mean, standard deviation, median, interquartile range (IQR), frequencies, and percentages will be used to summarize demographic and clinical characteristics, electrolyte levels, and clinical outcomes. Comparative analyses (e.g., chi-square test, t-test) will be performed to assess associations between electrolyte disturbances, patient characteristics, and clinical outcomes.

Ethical considerations

Ethical approval was obtained from the Institutional Review Committee (IRC) of BPKIHS prior to the commencement of the study. Informed consent will be obtained from parents or legal guardians of eligible patients, ensuring voluntary participation and confidentiality of patient information. Patient data will be anonymized and securely stored to protect confidentiality and comply with data protection regulations.

Results

Electrolyte abnormalities are prevalent in critically ill children in the Pediatric Intensive Care Unit (PICU), as highlighted by a study of 188 patients. Notably, hyponatremia 62.76%, with hypokalemia and hyperkalemia present in 29.78% and 34.04%, respectively. Additionally, 34.04% had hypocalcemia. Early detection and management of these imbalances are crucial to reduce morbidity and mortality in this vulnerable population (Tables 1–4).

Table 1 Baseline characteristics of patients admitted to PICU

Baseline characteristics	N	Minimum	Maximum	Mean +/-std. Deviation	Median and interquartile range
Age (yrs)	188	0.1	14	7.60 +/-1.260	6.03 / 1.02-9.14
Weight (kg)	188	3.5	55	18.91 +/-12.94	15 / 8.02-27.0
Length(meter)	188	0.52	1.68	1.03 +/-0.324	0.98 / 0.78-1.32
BMI (kg/m ²)	188	9.7	27.28	15.68 +/-3.122	14.87 / 13.11-17.43
Duration of stay (days)	188	1	10	3.00 +/-1.324	3.00 / 2.00-6.00
Sodium (mEq/L)	188	124	165	131.97 +/-0.611	142.24 / 132.08-144.64
Potassium (mEq/L)	188	2.54	7.2	5.98 +/-0.840	3.78 / 3.04-4.56
Total calcium (mEq/L)	188	6.6	12.24	8.65 +/-0.734	9.54 /8.08-10.2
Ionized calcium (mEq/L)	188	0.8	1.54	0.97 +/-0.722	1.78 / 1.16-1.22

Table 2 Correlation of electrolytes with organ system involvement

Organ system involvement		Respiratory system	Cardio vascular system	Gastro intestinal system	Neuro logical system	Endocrine system	Genito urinary system	Others	p-value
Sodium	Normonatremia	N(%) 19(23.2)	1(20.0)	0(0.0)	7(18.4)	0(0.0)	3(25.0)	8(22.2)	0.26
	Hyponatremia	N(%) 54(65.9)	3(60.0)	6(75.0)	22(57.9)	7(100.0)	7(58.3)	19(52.8)	
	Hypertremia	N(%) 9(11.0)	1(20.0)	2(25.0)	9(23.7)	0(0.0)	2(16.7)	9(25.0)	
Potassium	Normokalemia	N(%) 27(32.9)	1(20.0)	2(25.0)	16(42.1)	3(42.9)	4(33.3)	15(41.7)	0.763
	Hypokalemia	N(%) 22(26.8)	3(60.0)	5(62.5)	10(26.3)	1(14.3)	4(33.3)	11(30.6)	
	Hyperkalemia	N(%) 33(40.2)	1(20.0)	1(12.5)	12(31.6)	3(42.9)	4(33.3)	10(27.8)	
Total calcium	Normocalcemia	N(%) 47(57.3)	2(40.0)	2(25.0)	17(44.7)	3(42.9)	5(41.7)	19(52.8)	0.029
	Hypocalcemia	N(%) 24(29.3)	1(20.0)	5(62.5)	15(39.5)	3(42.9)	5(41.7)	11(30.6)	
	Hypercalcemia	N(%) 11(13.4)	2(40.0)	1(12.5)	6(15.8)	1(14.3)	2(16.7)	6(16.7)	
Ionized calcium	Normocalcemia	N(%) 45(54.9)	2(40.0)	3(37.5)	14(36.8)	3(42.9)	5(41.7)	18(50.0)	0.039
	Hypocalcemia	N(%) 27(32.9)	1(20.0)	4(50.0)	19(50.0)	3(42.9)	5(41.7)	11(30.6)	
	Hypercalcemia	N(%) 10(12.2)	2(40.0)	1(12.5)	5(13.2)	1(14.3)	2(16.7)	7(19.4)	

Table 3 Correlation of outcomes related to electrolyte profiles

Electrolytes			Good outcome	Bad outcome	Total no of patients	P-value
Sodium	Normonatremia	n(%)	31(81.6)	7(18.4)	38(100.0)	0.0127
	Hyponatremia	n(%)	93(78.8)	25(21.2)	118(100.0)	
	Hypertremia	n(%)	21(65.6)	11(34.4)	32(100.0)	
	Normokalemia	n(%)	54(79.4)	14(20.6)	68(100.0)	
Potassium	Hypokalemia	n(%)	42(75.0)	14(25.0)	56(100.0)	0.0692
	Hyperkalemia	n(%)	49(76.6)	15(23.4)	64(100.0)	
	Normocalcemia	n(%)	82(86.3)	13(13.7)	95(100.0)	
Total calcium	Hypocalcemia	n(%)	45(70.3)	19(29.7)	64(100.0)	0.002
	Hypercalcemia	n(%)	18(62.1)	11(37.9)	29(100.0)	
Ionized calcium	Normocalcemia	n(%)	77(85.6)	52(14.4)	90(100.0)	0.002
	Hypocalcemia	n(%)	52(73.3)	18(25.7)	70(100.0)	
	Hypercalcemia	n(%)	16(57.1)	12(42.9)	28(100.0)	

Table 4 Prevalence of combined dyselectrolytemias

Combined dys-electrolytemia	n (%)
Hyponatremia + hypokalaemia	30(16)
Hyponatremia + Hyperkalemia	44(23.6)
Hyponatremia + Hypocalcemia	40(21.3)
Hyponatremia+ hypercalcemia	17(9.0)
Hypertremia + Hypokalemia	12(6.4)
Hypertremia + Hyperkalemia	6(3.2)
Hypertremia + Hypocalcemia	11(5.9)
Hypertremia + hypercalcemia	5(2.7)
Hypokalemia + Hypocalcemia	17(9.0)
Hypokalemia + hypercalcemia	10(5.3)
Hyperkalemia + Hypocalcemia	22(11.7)
Hyperkalemia + hypercalcemia	7(3.7)

Conclusion

This data provides an overview of electrolyte imbalances and their associations with organ involvement and patient outcomes in PICU admissions at BPKIHS. The following insights are highlighted:

- 1. Electrolyte imbalances and organ systems:** Sodium, potassium, and calcium levels show varied involvement across organ systems, with calcium showing significant associations.

- 2. Patient outcomes:** Normal sodium and calcium levels correlate with better outcomes, underlining the importance of maintaining balanced electrolyte levels.

- 3. Combined dyselectrolytemias:** Certain combinations, such as hyponatremia with hyperkalemia or hypocalcemia, are more prevalent and may necessitate more complex management strategies.

Discussion

This study aims to find out the electrolyte disturbances in critically ill children. Critically ill children are at higher risk for electrolyte abnormalities due to sepsis, renal dysfunction, massive fluid shifts and endocrine disturbances. Early identification of electrolyte disturbance and its correction will prevent from complications and improving outcome. It is a cornerstone of intensive care management.

Hundred eighty eight patients were evaluated in our study for electrolyte disturbance. Hyponatremia was found in 62.76% with hypokalemia Electrolyte abnormalities are prevalent in critically ill children in the Pediatric Intensive Care Unit (PICU) as highlighted by a study of 188 patients. Notably, hyponatremia affected 62.76%, with hypokalemia and hyperkalemia present in 29.78% and 34.04%, respectively. Additionally, 34.04% had hypocalcemia. Early detection and management of these imbalances are crucial to reduce morbidity and mortality in this vulnerable population.

The prevalence of electrolyte imbalance upon admission and its effect on morbidity and mortality in children hospitalized to a pediatric intensive care unit were investigated by Subba Rao et al.⁷ A prospective study was conducted on 305 hospitalized children over an 18-month period to look for potassium and salt abnormalities. It was discovered that 32.45% had abnormal electrolytes. In 14.4% of instances, hyperkalemia was the most prevalent, followed by hyponatremia in 9.5% of children. Children with dyselectrolytemias had a 24.2% death rate. Children with hyperkalemia and hyponatremia were shown to have a considerably longer mean length of hospital stay. Children with dyselectrolytemias also had a greater risk of mortality.

Singhi et al. performed a retrospective review of the case files of 290 kids who were brought to the PICU over the course of a year.⁸ They examined the prevalence, severity, risk factors, and mortality of hypokalemia as well as the effectiveness of the medication employed to address it. Hypokalemia was detected in 14.8% of the patients. Predisposing variables included malnutrition, pharmacological therapy (diuretics, corticosteroids, and antiasthma medicines), and the kind of main illness (19% septicemia, 19% acute diarrhea, 14% heart disease with CCF, 12%, and meningoencephalitis, 12%). Compared to the remaining PICU patients (10.9%), the overall death rate was considerably greater among patients with hypokalemia (25%).

In a prospective research conducted by Singhi et al. on 727 critically unwell children up to the age of 12, it was discovered that 5.4% of the children had hyperkalemia and 13.9% of the children had hypokalemia. Hyponatremia was seen in 51.48% of children who were hypokalemic.⁹ Individuals with hypokalemia exhibited a markedly elevated risk of death in contrast to children who were normokalemic. As hypokalemia worsened, there was a discernible rise in mortality.

Thomas et al. carried out a prospective cross-sectional research in a South Indian referral teaching hospital. A total of 143 individuals with hyperkalemia (>5 mEq/L) were chosen for assessment.¹⁰ The study found that males were twice as likely as females to have hyperkalemia. The main risk factors for hyperkalemia were medications and potassium supplements, with renal failure coming in close second. In about 75% of cases, hyperkalemia occurred after hospital admission.

In a prospective research, 727 hospitalized children under the age of 12 had their hyponatremia frequency, clinical features, and etiology assessed by Prasad et al. 29.8% of patients had hyponatremia, which was more common in the summer (36%).¹¹ Twenty percent of cases were related to acute diarrhea and acute lower respiratory infections, including pneumonia. According to concurrent measurements of plasma and urine osmolality, hyponatremia linked to meningitis, pneumonia, septicemia, convulsions, and severe diarrhea was hypovolemic in type and hypotonic in euvoletic type. According to the study, hyponatremia is a common condition among unwell children who need emergency treatment, particularly during the summer. These children should receive the proper focus.

Samadi et al. conducted a retrospective study on 1330 children under 3 years old who were brought to the general ward of the ICDDR due to diarrhea with complications.¹² The study examined the relationship between age, nutritional status, and kinds of dehydration. 68.8% of the samples were isonatremic, 6.5% hypernatremic, and 20.8% hyponatremic. As people aged, hyponatremia became more common. Types of dehydration and nutritional status were strongly correlated. 10% of cases of hyponatremia, 4% of cases of isonatremia, and 12% of cases of hypernatremia were fatal

In a prospective research by Kaplan et al. on bacterial meningitis in infants, serum sodium values less than 135 mEq/L were found in 58% of the patients who were admitted.¹³ Significant correlations were found between the existence of neurologic symptoms of the condition and low initial blood sodium concentration and sustained decline in serum sodium despite fluid restriction

Limitations

Several limitations may affect the interpretation of study findings, including the prospective nature of data collection, potential incomplete documentation in medical records, and variability in clinical practices and management protocols within the PICU. These limitations will be addressed by ensuring rigorous data collection procedures, comprehensive data validation, and appropriate statistical analyses to minimize bias and enhance the validity and generalizability of study result.

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Author's contributions

DN, GSS and SPK – involved in concept and design of study, AT and LS- collection and analysis of data, OPM-analysis of data and drafting of manuscript. All authors read and approved the final manuscript.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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