Original Article

Pediatric Education and Research
Volume 4 Number 1, January - April 2016
DOI: https://dx.doi.org/10.21088/per.2321.1644.4116.2

Electrolyte Abnormalities in Children Admitted to Pediatric Intensive Care Unit

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Abstract

Serum electrolyte abnormalities are quite common in children who need intensive care. They have a significant contribution to morbidity and mortality. Electrolyte imbalance occurs frequently and should be looked for in all severely ill patients. Hyponatremia is of euvolemic type in almost all acute infection except in Diarrhea which can go undiagnosed clinically, presence of hyponatremia significantly increase the morbidity and mortality. Early detection and institution of rational therapy for hyponatremia should be done regardless of underlying disease. Careful correction of sodium level is warrented to avoid fatal neurological sequalae. In the presence of mixed electrolyte abnormalities, the risk is even higher. In general, CNS diseases, respiratory diseases and infectious diseases are more commonly associated with serum electrolyte abnormalities. SIADH quite commonly occurs in euvolemic hyponatremia, in respiratory and CVS disorders. There are no reliable clinical predictors of electrolyte abnormalities except in cases of hyponatremia and hypokalemia; and the signs of electrolyte imbalances often merge with those of the underlying diseases. In addition, electrolyte abnormalities occur commonly in an ICU setting. In view of these facts, a routine estimation of serum electrolytes should be considered in all patients getting admitted to PICU. Thus this study brings out the salient aspects of sodium and potassium abnormalities in severely ill, and focuses on the importance and need to recognize the abnormalities and acts as good predictor of morbidity and mortality in PICU.

Keywords: Electrolyte; Morbidity; Mortality.

Introduction

The practice of pediatric intensive care has thrown open new challenges to those interested in the acute effects of critical illness on metabolism. The development of increasingly more sophisticated life support and clinical laboratory technology allows patients to live long enough to develop challenging metabolic syndromes.

Neurological manifestations like seizures, coma and brain death, arrhythmias are potential consequences of electrolyte abnormalities i.e., Sodium and Potassium. Unquestionably these serious electrolyte abnormalities demand prompt diagnosis and effective therapy. On the other hand if these abnormalities are corrected too rapidly equally devastating neurologic sequel can develop.

Sodium and potassium are common electrolyte disorders and are associated with increased morbidity and mortality [1], under normal circumstances; the plasma sodium concentration is maintained within a narrow range despite wide variations in sodium and water intake. This is achieved through an integration of thirst, vasopressin secretion and renal responsiveness of the vasopressin [1].

Potassium is the most abundant cation in the ICF, and its concentration within the cells is approximately 30 times higher than in the ECF. Proteins, organic anions, and phosphate are the plentiful anions in the ICF.

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Aims and Objectives

1. To know most commonly occurring electrolyte abnormalities occurring in sick children admitted to pediatric intensive care unit at the time of admission to PICU.
2. To study the outcome pattern amongst the critically ill children seeking emergency care with electrolyte abnormalities with respect to underlying co-morbid conditions.

Methodology

Prospective study comprising of critically ill children admitted in PICU of Basaweshwar Teaching & General Hospital and Sangameshwar Teaching and General Hospital, Gulbarga attached to M.R. Medical College, Gulbarga.Critically ill children admitted to the PICU (based on the Consensus Guidelines of PICU) of BTGH and STGH, Gulbarga .

At the time of admission the patients clinical picture is recorded in prefixed proforma. Venous blood sampling obtained is obtained from each patient enrolled in the study and is sent for estimation of Electrolytes, Blood urea, Glucose levels, Serum osmolality (caluculated), Urine osmolality, Urine spot sodium, if sodium <125meq/l, ECG was done in patients with hyperkalemia and serum potassium level >6mEq/L.

SIADH was diagnosed in the presence of hypotonic hyponatremia, absence of hypovolemia or dehydration absence of edema and normal renal excretory function [2]. Morbidity is defined as prolonged ICU stay (a duration of stay more than 5 days) [2].

Results

The study group included a total of 254 patients aged between 1 month and 14 years, admitted to PICU during the period of Dec 2013 May 2015. The mean age in months was 50.96 ± 48.99. The male : female ratio was 2:1 of the total 254 Patients, 86 (33.8%) patients had Central Nervous System diseases, 52(20.4%) patients had Respiratory diseases, 20(7.8%) patients had infectious diseases.18 (7.08%) patients had Cardio Vascular System diseases, 17(6.6%) patients had Renal diseases, Gastro Intestinal System and Hematological System accounted for 14(5.5%) cases each. The miscellaneous group accounted for 27(10.6%) cases.

Of the total 254 patients studied, 109(42.91%) patients had electrolyte abnormalities. Out of this 109 patients, 19(17.4%) had mixed imbalances. Hyponatremia was the commonest electrolyte abnormality observed, with a frequency of 67 out of 254 cases i.e 26.7%. Hyperkalemia is detected in 38 (14.96%) patients, hypernatremia in 13(5.11%) cases and hypokalemia in 10(3.93%) patients.

Of the 254 patients, 34(13.38%) patients expired. Among the 34 patients expired, 26(76.47%) had electrolyte imbalance at admission to PICU, either single electrolyte imbalance or mixed abnormalities. In this study, hyponatremia accounted to 23.88% deaths, hypernatremia to 38.46% expired, hypokalemia to 20% and hyperkalemia accounted to 36.36%, while mixed electrolyte abnormalities contributed to 42.10%.

Systemic Distribution of 254 Cases

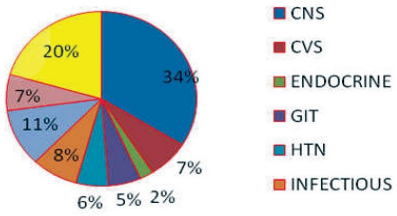

Fig. 1: Pie diagram showing system wise distribution of total number of cases

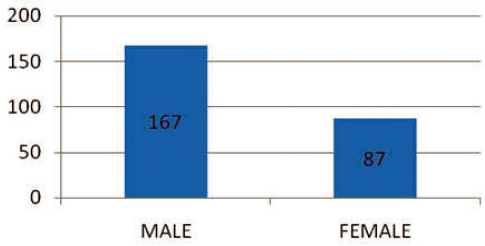

Fig. 2: Bar diagram showing gender wise distribution of 254 cases

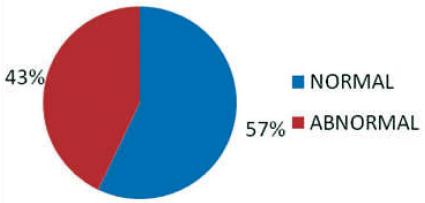

Fig. 3: Pie diagram showing percentage of electrolyte problems in PICU

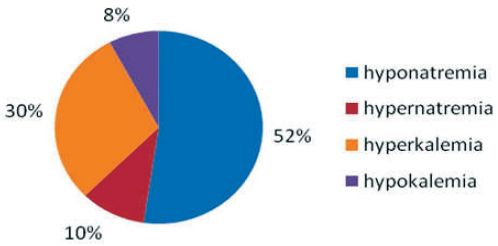

Fig. 4: Pie chart showing frequency of electrolyte imbalance in PICU

Hyponatremia

Table 1: Distribution of cases based on diagnosis among hyponatremia

System	Diagnosis	Num of cases	Per%
Cardio vascular system			
	Myocarditis, ARDS	2	2.98
	CHD,VSD	1	1.4
	Hypertensive encephalopathy	1	1.4
	Pericarditis	1	1.4
Git			
	Viral hepatitis	1	1.4
	Acute gastroenteritis	1	1.4
	Pyloric stenosis	1	1.4
	Hepatorenal syndrome	1	1.4
Renal			
	Acute glomerulonephritis	4	5.97
	VUR, Hydronephrosis	1	1.4
Infectious			
	Sepsis	2	2.98
	CSOM	1	1.4
	Cerebral malaria	1	1.4
	Dengue fever	1	1.4
	Meningococcemia	1	1.4
Endocrine			
	Diabetic ketoacidosis	2	2.98
	Congenital Adrenal hyperplasia	1	1.4
Respiratory			
	Bronchiolitis	2	2.98
	Empyema	7	10.44
	Hyper active air way disease	1	1.4
	Pnuemonia	1	1.4
Central nervous system			
	Pyogenic meningitis	10	14.92
	Seizure disorder	4	5.97
	Guillian-Barre Syndrome	2	2.98
	Atypical febrile seizures	3	4.47
	Cerebral palsy	2	2.98
	Status epilepticus	1	1.4
	Viralencephalitis,SIADH	1	1.4
Hematological			
	Haemophilia	1	1.4
	Idiopathic thrombocytopenia	2	2.98
	Acute leukemia	1	1.4
Miscelleneous			
	Scorpion sting	1	1.4
	Steven Johnson syndrome	1	1.4
	Near drowning	1	1.4
	Head trauma	1	1.4
	Snake bite, SIADH	1	1.4

Table 2: Hyponatremia: serum sodium values according to range

Na+ value (mEq/L)	Number of cases	Percentage
110-114	2	2.98
115-119	1	1.49
120-124	6	8.95
125-129	7	10.44
130-134	51	76.11
Total	**67**	**100**

Table 3: Hyponatremia: outcome according to range of serum sodium values

Na value	Discharged	DAMA	Death	Total
110-114	1	0	1(50%)	2 (2.98%)
115-119	0	0	1(100%)	1 (1.49%)
120-124	3	0	3(100%)	6 (8.95%)
125-129	5	1	1(20%)	7 (10.44%)
130-134	39	2	10(25.6%)	51 (76.11%)
Total	48 (71.64%)	3 (4.47%)	16(23.88%)	67 (100%)

SIADH

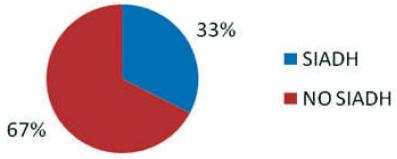

Fig. 5: Pie chart showing percentage of SIADH in hyponatremia cases

Table 4: Distribution of cases of SIADH according to diagnosis

System	Diagnosis	Num of cases	Percentage
CNS(4)			
	Pyogenic meningitis	2	13.3%
	Viral Encephalitis	1	6.66%
	Seizure Disorder	1	6.66%
Respiratory(4)			
	Pneumonia	2	13.3%
	Empyema	1	6.66%
	Hyper active airway disease	1	6.66%
CVS(3)			
	Viral Myocarditis	2	13.3%
	Hypertensive encephalopathy	1	6.66%
Renal(3)			
	Acute glomerulonephritis	2	13.3%
	VUR with dialated nephropathy	1	6.66%
Hematological	Idiopathic Thrombocytopenic purpura	1	6.66%

Of the 67 patients with hyponatremia, 46 (68.65%) patients were euvolemic, 16(23.88) were hypovolemic and 5(7.46%) were hypervolemic. Patients with euvolemia (number 46 i.e 68.65% of patients with hyponatremia) were investigated for the presence of SIADH and 15(32.26%) were found to have SIADH.

Of the 15 patients, 4(26.66%) patients died among which 2(50%) belong to CNS cases. 1(6.66%) case was discharged against medical advice.

Hypernatremia

Table 5: Cases distributed according to diagnosis among hypernatremia

System Infections	Diagnosis	No of Cases	Per%
	Sepsis	1	7.69
	Dengue haemorrhagic Fever	1	7.69
Renal			
	ARF with sepsis	1	7.69
Others			
	IEM, hyperammonemia	1	7.69
Cns			
	TB meningitis	1	7.69
	Febrile seizures	1	7.69
Respiratory			
	Croup	1	7.69
	Pneumonia	3	23.07
Git			
	Acute gastroenteritis	1	7.69
	Hepatic encephalopathy	1	7.69
Endocrine			
	Diabetic ketoacidosis	1	7.69

Table 6: Hypernatremia: serum sodium values according to range

Na value(mEq/L)	No.	%
151-160	8	61.53
161-170	2	15.38
>170	3	23.07
Total	**13**	**100**

Table 7: Hypernatremia: outcome with serum sodium values

Na value(meq/L)	Discharged	Death	Total	Death Per%
151-160	4	4	8	50%
161-170	2	0	2	0%
>170	2	1	3	33.3%
Total	8	5	13	100

Table 8: Hypernatremia: outcome

Na value	Discharged	Death	Total
Corrected	6	2	8
not corrected	2	3	5

Table 9: Distribution of hypokalemia cases according to diagnosis in the present study

Systems	Diagnosis	Num of cases	Per%
Cns	Atypical febrile seizures	2	20
	Epilepsy	1	10
Cvs			
	RHD,MS, pnuemonia	1	10
	CHD,VSD	1	10
Htn			
	Haemophilia	1	10
Git			
	Viral hepatitis	1	10
Respiratory			
	Pnuemonia	1	10
	Pleural effusion	1	10
Others			
	Snake bite	1	10

Table 10: Hypokalemia: serum potassium values and outcome

K + value	discharged	Death	Total
2.1	0	1	1
2.2	1	0	1
2.6	0	1	1
3.1	2	0	2
3.2	2	0	2
3.3	2	0	2
3.4	1	0	1
Total	8	2	10

Table 11: Hypokalemia: Outcome

Serum K+	Discharged	Death	Total
Corrected	8	0	8
Uncorrected	0	2	2
Total	8	2	10

Hyperkalemia

Table 12: Distribution of cases based on diagnosis among hyperkalemia

System	Diagnosis	Num of cases	Per%
Cns			
	Febrile seizures	6	15.7
	Cerebral Palsy with pnuemonia	2	5.29
	Guillain-Barre syndrome	1	2.63
	Pyogenic meningitis	4	10.52
	Seizure disorder	1	2.63
	Tuberculous meningitis	1	2.63
	Viral encephalitis	1	2.63
Infections	Dengue haemorrhagic fever	1	2.63
	Sepsis	1	2.63
Others	Inborn errors metabolism, Hyperammonemia	1	2.63
	Scorpion sting	1	2.63

Renal	Acute Renal Failure with sepsis	1	2.63
	Acute glomerulonephritis	1	2.63
	Acute renal failure	1	2.63
Respiratory	Pneumonia	4	10.52
	Pulmonary Tuberculosis	1	2.63
	Empyema	1	2.63
	Croup	1	2.63
Cvs	Myocarditis,ARDS	2	5.26
	Downs syndrome,VSD	1	2.63
	ASD, pneumonia	1	2.63
Endo	Congenital adrenal hyperplasia	1	2.63
Htn	Thallaesemia major in CCF	1	2.63

Table 13: Hyperkalemia: range of serum potassium values

K+ value in meq/l	No	Death	Per%
5.6-6	16	1	6.25%
6.1-7	9	3	33.3%
7.1-8	8	4	50%
8.1-9	2	2	100%
9.1-10	3	1	33.3%
>10	0		
Total	38	11	28.9%

Table 14: Hyperkalemia: outcome

Serum K+	Discharged	Dama	death	Total
Uncorrected	22	4	7	33
Corrected	1	0	4	5
Total	23	4	11	38

Table 15: Mixed electrolyte imbalances- types with outcome

Type	Discharged	Death	Total
hypernatremia, hyperkalemia	1	4	5
hyponatremia, hypokalemia	3	1	4
hyponatremia, hyperkalemia	7	3	10
Total	**11**	**8**	**19**

Discussion

Electrolyte abnormalities of (sodium and potassium) were observed in 42.9% of children getting admitted to our PICU. Thus, it's a fairly common occurrence in an intensive care unit setup. Among, the various electrolyte abnormalities detected in patients getting admitted to PICU, hyponatremia was the commonest (accounting for 26.3% of all PICU admissions) This goes in favour with the observation made in a prospective study of 727 sick children admitted in PICU, done by S. Singhi et al [3], at PGIMER, chandigarh. It was 29.8%.

In a prospective study done by DeVita et al [4] they found that the incidence of hyponatremia was 29.6% in patients admitted to the hospital this goes in favour of my study. In another study done by Nair V et al [5] among 730 patients hyponatremia was the commonest electrolyte imbalance and incidence was 27.9% and this goes in favour of my study. In my study among the patients with hyponatremia CNS diseases 34.3%(Bacterial Meningitis, Encephalitis, GBS) was the commonest cause of hyponatremia followed by Respiratory infections 17.9% (Broncho pneumonia, Bronchiolitis) followed by Renal 5% (Acute glomerulonephritis). This goes in favour with a study done by S. Singhi et al [3] Where CNS 33% (meningitis, encephalitis) was commonest cause of hyponatremia followed by Pneumonia 26% followed by Acute gastroenteritis 20%. In another study done by Subba Rao et al[2] have found 41.4% (12/29) cases of hyponatremia suffering from Central Nervous System diseases which was the leading cause for hyponatremia followed by infectious diseases this goes in favour with my study.

In another study done by S.Sitaraman, Manish Saxena [6] incidence of hyponatremia was 37% and meningitis/encephalitis (20.5%) was the leading cause followed by Pneumonia and Gastro enteritis of each (12.43%). Incidence of hyponatremia was higher

as Gastro enteritis accounted for (12.43%)where as in my study it accounted for (5.97%). In another study done by Indira Jayakumar et al hyponatremia was the most common among children with CNS infections (15%) and associated with SIADH.

Hyperkalemia was the second most common electrolyte abnormality noted in my study(14.9%) of all PICU admissions, CNS accounted for 42% (Bacterial meningitis, Cerebral palsy, Febrile convulsions) followed by Respiratory system (18%) (Pneumonia, empyema) and Renal (13%) (AGN), CVS (11%) cases. This goes in favour with prospective study done by Subba Rao et al [2] where hyperkalemia was most common and accounted for 14.4%.

Similarly hyperkalemia was the second most common electrolyte imbalance in study done by S.Singhi et al [3] it accounted for 5.4% it is when compared to my study as their value for hyperkalemia was >6 mEq / L.

Hypernatremia was detected in 5.1% of the children getting admitted to PICU and was third in order of frequency in my study among Respiratory system (27%) (Pneumonia), CNS (14%) (Meningitis), GIT (13%) (Acute gastroenteritis) followed by Sepsis (13%) are the causes. This goes in favour with study done by Subba rao et al [2](4.9%) where respiratory and CNS diseases had similar percentage (26.7%) followed by Respiratory and Renal. Similar study done by G. Lindner et al [7], incidence of hypernatremia was 9% Hypokalemia was the least common (3.9% of all PICU admissions) electrolyte imbalance noted in my study which goes in hand with similar findings in prospective study done by Mayank Jain, Archana Shah, Rajal Prajapati [8].

In study done by Subba Rao et al[2] also shown that hypokalemia was the least common electrolyte imbalance. A three times higher frequency was observed in two other similar studies done by S.Singhi et al [4] and Singhi. S and Murudkar A [9] (13.9-14%) as their study included acute gastroenteritis of (20%) which was most common cause of hypokalemia in their study.

Spectrum of Illnesses

Of the 254 patients included in this study, CNS diseases (33.8% 86 cases), respiratory cases (20.4% 52 cases) and infectious diseases (7.8% 20 cases) accounted for majority of cases.

This observation probably reflects the frequency of these diseases in our hospital and the pattern of our ICU admissions.Serum sodium abnormalities (both hyponatremia and hypernatremia) were found to be commonly associated with CNS diseases and respiratory diseases. 52.23% of patients with hyponatremia and 46.1% of patients with hypernatremia, had either CNS or respiratory diseases. Infectious diseases accounted to 8.9% in the hyponatremic patients.

This goes in favor of similar prospective study done by Subba Rao et al [2] where 62% accounted for hyponatremia and 53% to hypernatremia, had either CNS or Infectious diseases. A similar prospective study by S.Singhi et al [3]., conducted at PGIMER, chandigarh , where infectious diseases (27%) were commonly associated whereas CNS (12%) diseases were the fourth commonest with hyponatremia.This could be due to the difference in pattern of PICU admissions in these studies.

In the study by S.Singhi et al [3], only 10.3% of PICU admissions had CNS cases whereas in my study, 34% of PICU admissions had CNS diseases.

In my study, hypokalemia was almost evenly distributed in diseases of various systems. A similar observation was made by S. Singhi and A. Marudkar [9] in a descriptive analysis of 290 patient record . Another prospective study by S. Singhi et al [3]., showed that approximately 50% of cases of hypokalemia occurred in patients with diarrhoeal diseases or respiratory system diseases.

Hyperkalemia was found to be associated with CNS diseases and respiratory diseases. (both together constituting 60.5% of patients with hyperkalemia). This partly goes in favour with the observation made by S.Singhi et al [3], wherein he noticed that respiratory diseases and acute diarrhea illnesses, together, contributed to 46% of patients with hyperkalemia.

Morbidity

Morbidity as determined by the duration of ICU stay, was significantly higher in patients with hyponatremia when compared to those with normonatremia (8.11$\pm$2.08days). This observation is in agreement with the study by S.Singhi et al [3]. Where mean icu stay was (7.7$\pm$0.4 days)Yet,another study by S.Singhi and A. Marudkar [9], showed that hyponatremia was associated with a 60% longer hospital stay.

In study done by Subba rao et al [2] morbidity was significantly high among hyponatremia patients (4.69 $\pm$ 4.06) similar findings are seen in my study this goes in favour with the above study.

Study done by subba rao et al [2] showed that Hyperkalemia was significantly associated with the duration of hospital stay which goes in favor of my which showed similar finding among hypernatremia.

Prolonged duration of hospital stay among hypernatremiagoes in contrast with an other study by S. Singhi et al [3]., also did not show such a difference in morbidity.

Patients with hypokalemia or hypernatremia and those with normal serum electrolytes had comparable duration of ICU stay. prospective study of 727 children by Singhi. S et al [3] admitted to a PICU also showed that the presence of hypokalemia did not prolong the duration of PICU stay.

Mortality

Patients who had hyponatremia, hypernatremia or hyperkalemia at the time of admission to PICU were found to have a significantly higher mortality rate when compared to those with normal values of these serum electrolytes at PICU admission.A number of other studies showed similar observations. A prospective study of 727 children by S. Singhi et al [3]., concluded that presence of severe hyponatremia is associated with a threefold increase in the risk of death. Another prospective study by A.Dhawan and S.Singhi [10], also noticed a 3.5 times higher mortality in patients with hyponatremia when compared to those with normonatremia.

Similar to this study, another prospective by Subba rao et al [2] study alsoshowed a significantly higher mortality in patients with hyperkalemia when compared to those with normokalemia.

Mortality rates in hypokalemia and normokalemia was comparable in this study. This observation is in contrast to two other studies one descriptive, retrospective analysis by S. Singhi and A. Marudkar [9] and another prospective study by S. Singhi at al [3]; both of which showed a significantly higher mortality in patients with hypokalemia when compared to those with normokalemia.

Of the 254 patients studied, 34 patients expired of which 26 patients had electrolyte abnormalities either single or mixed. It is worth noting that 76.47% of patients who died had some form of serum electrolyte abnormality. The mortality rate in patients with mixed (42.10%) electrolyte abnormalities was higher when compared to patients with single electrolyte imbalance. Similar observation was made in two other prospective studies Subba rao et al [5] and S. Singhi et al [3].

SIADH

Among the patients with euvolemic hyponatremia, SIADH was detected in (26.6%) in our study. Majority of the cases were respiratory (26.6%) and CVS (26.6%) and CNS (20%). Bussmann et al reported SIADH in 7 out of 20 (35%) hyponatremic patients. Lamia. M A, Naama, Jawad Kadhum, Abdul–Hassan et al [11], performed case control study on 150 children and their study showed that 37.5% of CNS cases with hyponatremia had SIADH. Prospective study done by Patwari AK et al [12] (36.7%) of CNS cases are associated with SIADH. Study done by Prasad et al [13] says that Inappropriately high concentration of plasma vasopressin than that expected for the degree of osmolality has been demonstrated in association with euvolemic hyponatremia in children with meningitis pneumonia and asthma.

Mixed Electrolyte Imbalances

Were observed in 7.4% of patients getting admitted to PICU. In this group, a combination of hyponatremia and hyperkalemia was found to be the commonest electrolyte abnormality. CNS diseases (21%), respiratory diseases (21%), renal diseases (11%) contribute to vast majority of mixed electrolyte abnormalities in various combinations.

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