Original Research Article

Demographic variation of electrolyte imbalance in a tertiary care pediatric intensive care unit

Mrutyunjay Routray[1], Kishore S. V.[2], Jyotiranjan Champatiray[2]*, Saroj Kumar Satpathy[2]

[1]Department of Pediatrics, AIIMS, Bhubaneswar, Odisha, India
[2]Department of Paediatrics, SVPPGIP, SCB MCH, Cuttack, Odisha, India

*Correspondence:
Dr. Jyotiranjan Champatiray,
E-mail: jrcray@rediffmail.com

ABSTRACT

Background: Electrolyte imbalances are common in critically ill paediatric patients. When present, they can significantly affect the outcome. Critical care provision through Paediatric Intensive Care Units (PICU) is aimed at maintaining 'homeostasis' in the body which is vital for the organ's support and optimal function. This involves fluids and electrolytes balance.

Methods: This prospective observational study was conducted in the PICU, SCB MC and Hospital, Cuttack during November 2015 to October 2017. includes Children admitted to PICU (Based on consensus guidelines for PICUs in India, Indian Society of Critical Care Medicine (Pediatric Section) and Indian Academy of Pediatrics (Intensive Care Chapter).

Results: Percentage of male children was 65.9%, with male to female ratio 1.9:1, showing male dominance. Most electrolyte imbalances were seen in age group of 1 to 5 years (67.06%). Abnormal serum electrolyte was seen in 37.91% in our study. SIADH was observed in 43.5% of euvolemic hyponatremic patients. SIADH was observed in 27.8% of hyponatremic patients. Respiratory disorder was the most common attributing factor for SIADH followed by CNS disorder.

Conclusions: The present study showed high incidence of electrolyte abnormalities in patients admitted to pediatric intensive care unit. Though at times symptoms of electrolyte disorder is indistinguishable from symptoms of primary pathology, so a close monitoring and correction of electrolyte abnormalities is necessary for better outcome. SIADH is recognizable and common cause of electrolyte imbalance in PICU. Thus, this study recommends early routine monitoring of serum electrolytes in all patients admitted to PICU.

Keywords: Demography, Electrolyte imbalance, Pediatric Intensive Care, SIADH

INTRODUCTION

Electrolyte abnormalities are common in children who need intensive care, they occur in variety of condition, may remain unrecognized and result in morbidity and mortality irrespective of primary problem. Early recognition, a high index of suspicion and a thorough understanding of common electrolyte abnormalities is necessary to ensure their correction.[1]

TBW is divided into 2 compartments mainly: intracellular fluid (ICF) and extracellular fluid (ECF). In fetus and newborn, the ECF is larger than ICF. There is continued expansion of the ICF volume, which results from cellular growth. By 1 year of age, the ratio of ICF volume to ECF volume approach to adult level. ECF is 20-25% of body weight. ICF is 30-40% of body weight. ECF is divided into 2 parts, plasma (5% of body weight) and interstitial fluid (15% of body weight).[2]

The composition of solutes in the ECF and ICF are very different. sodium and chloride are the dominant cation and anion. Potassium is the most abundant cation and proteins, organic anions, and phosphate are the most plentiful anions in the ICF. Osmolality of plasma is normally 285-295 mosm/kg. Sodium is the dominant cation of the ECF and is the principal determinant of extracellular osmolality. Normal serum SODIUM (Na+) concentration is 135-145 mEq/L. Sodium is unique among electrolytes because water balance, not sodium balance, usually determine its concentration. Hyponatremia is less than 135mEq/L, classified on overall volume status of the body. Hypernatremia is defined as a serum sodium concentration of more than 145 mEq/L.

Sodium is considered as the most active electrolyte present inside the cell and the body keeps it at normal level by regulating the water level outside the cell and its increase in blood results from inadequate water intake, diarrhea or dehydration and this results in disturbance in brain function like convulsion and disturbance in conscious level, but its decrease results from inadequate water excretion and this leads to brain edema and this condition increase in critically ill child.[3]

Major causes of hypokalemia include low dietary potassium intake, shifting of K+ into the intracellular compartment, extrarenal K+ loss and renal K+ loss. Medications like insulin, sympathomimetics, diuretics, dobutamines etc. also causes hypokalemia in ICU. Non-absorbable anions such penicillin and aminoglycosides can cause hypokalemia by increasing K+ loss in urine.[4] Renal failure, adrenal insufficiency, insulin deficiency and tissue damage from rhabdomyolysis, burns or trauma are predisposing factors for hyperkalemia in critically ill patients. A lot of medications used in ICU can also cause hyperkalemia like β-blockers, Angiotensin Receptor blockers, K+ sparing diuretics, heparin and its derivatives, Non-Steroidal Anti-Inflammatory Drugs. Hypocalcemia is one of frequent electrolyte abnormalities encounter in ICU. The prevalence of hypocalcemia as measured as ionized Ca+ is estimated to be 15 to 20%. Hypocalcemia is associated with increased mortality in patients in ICU.[5] Hypercalcemia is an elevated calcium in blood. It can be an asymptomatic laboratory finding, but because an elevated is often indicative of other diseases, a workup should be undertaken. It can be excessive skeletal calcium release, increased intestinal calcium absorption or decreased renal calcium excretion.[6] Those patients clinically euvolemic, hyponatremia, with normal renal function with urinary spot sodium greater than 20 mEq/l, urine osmolality greater than 500 mEq/l and plasma osmolality less than 285mEq/l are diagnosed to be SIADH.[7]

METHODS

The study was carried out in the Paediatric Intensive Care Unit at a tertiary care hospital after obtaining approval and waiver of consent from the Institutional Ethics Committee. We enrolled all the patients admitted in PICU of age 29 days to 14 years during November 2015 to October 2017. At the time of admission, the patients' clinical picture was recorded in a prefixed case record form consisting of age, sex, date of admission, provisional clinical diagnosis, duration of PICU stay, organ system primarily involved and final outcome in terms of discharge from PICU or death. Information of blood investigations like serum electrolytes (sodium, potassium) was collected from the hospital records. children were classified into groups according to presence or absence of electrolyte abnormality.

Diagnosis

- Normal sodium value 135 -145 mEq/l.
    a. Hyponatremia >145 mEq/l
    b. Hypernatremia<135mEq/l
- Normal potassium value 3.5- 5.5 mEq/l
    a. Hypokalemia < 3.5 mEq/l
    b. Hyperkalemia >5.5 mEq/l
- Normal ionized calcium 1.12 millimols/l -1.23 mmols/l
    a. Hypocalcemia <1.12 millimols/l
    b. Hypercalcemia >1.23 millimols /l

Those patients clinically euvolemic, hyponatremia, with normal renal function with urinary spot sodium greater than 20 mEq/l, urine osmolality greater than 500 mEq/l and plasma osmolality less than 285mEq/l are diagnosed to be SIADH.[7]

Blood urea=5 to 18 mg/dl, serum creatinine=0.17 to 0.71 mg/dl.

Inclusion criteria

Based on consensus guidelines for PICUs in India, Indian Society of Critical Care Medicine (pediatric section) and Indian Academy of pediatrics (Intensive Care Chapter).[8]

Exclusion criteria

Children admitted to PICU with major congenital anomaly.

Statistical analysis

The collected data were analyzed with SPSS 16.0 version. To describe about the data, descriptive statistics, frequency analysis, percentage analysis were used for categorical variables and for continuous variables the mean and SD were used. To find the significant difference between the bivariate samples in independent groups, the independent t test was used. To find the significance in categorical data, Chi-Square test was used. In all the above statistical tools, the probability value of <0.05 was considered as significant level.

The sample size for my study was 340 patients after substituting the data in Fischer formula.

Z= The value representing 95% Confidence interval.

d=precision of the study or absolute error fixed at 5%.

P=Prevalence (based on a study done in developing country like India previously).

RESULTS

Study consist of 340 patients, the sex distribution that author noted were, number of males to be 224 comprising of 65.9% of the study population. Whereas the number of females were 116 which formed 34.1% of this study. In this study there is male predominance, with male: female ratio is 1.9:1 (Table 1).

Table 1: Sex distribution in study population.

Sex distribution	Number	Percentage
Male	224	65.9%
Female	116	34.1%
Total	340	100%

Out of these 340 patients, 37.91% patients are found to be associated with electrolyte abnormalities. The percentage of patients with no electrolyte abnormalities in our study was 62.09%. 129 patients had electrolyte disturbance (Table 2). When various electrolyte were analyzed imbalances, Hyponatremia found to be 10.59%, Hypernatremia 4.70%, Hypokalemia 3.82%, Hyperkalemia 16.18% being highest, Hypocalcemia (2.62%). No case was found with hypercalcemia (Figure 1).
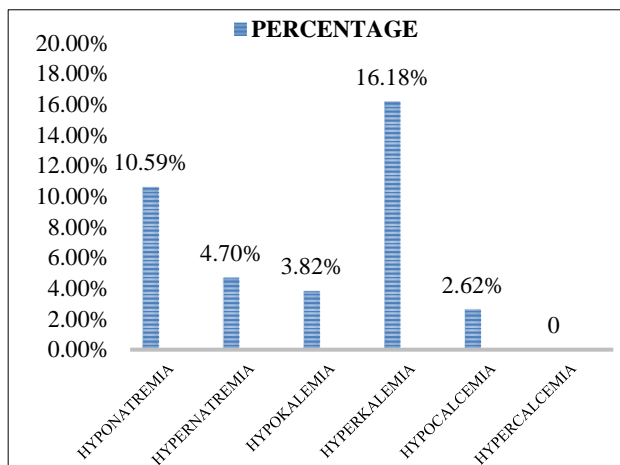

Figure 1: Distribution of different electrolyte abnormalities in study population.

Out of 122 patients between the age of 1-month to 1-year, 24.59% have electrolyte abnormalities and 75.41% without electrolyte abnormalities. Out of 85 patients

between the age of 1 year to 5 year, 67.06% have electrolyte abnormalities and 32.94% without electrolyte abnormalities. Out of 98 patients among 5year to 10 year, 37.76% have electrolyte abnormalities and 62.24% without electrolyte abnormalities. Out of 35 patients between the age of 10-year to14 year, 14.28% have electrolyte abnormalities and 85.72% without electrolyte abnormalities. The p- value is <0.05. The result is significant (Figure 2).

Table 2: Prevalence of electrolyte imbalance in study population.

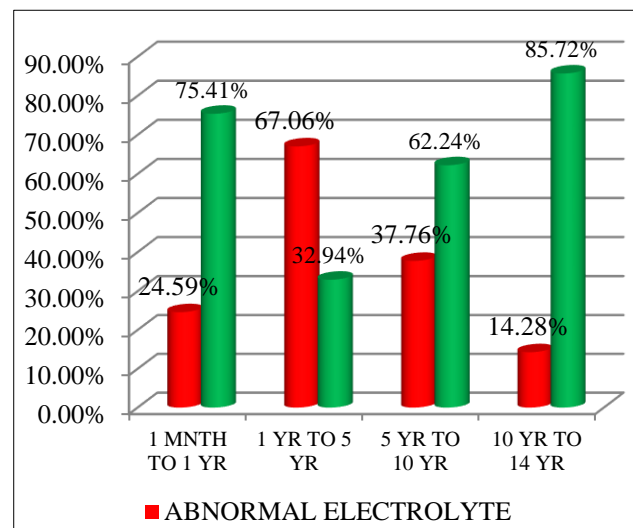| Electrolyte	Number	Percentage
Normal	211	62.09%
Abnormal	129	37.91%
Total	340	100%

Figure 2: Electrolyte abnormalities according to age.

Out of total 36 hyponatremic patients 38.84% from Central Nervous System (CNS), 55.55% RESPIRATORY SYSTEM (RS), 2.78% INFECTION, 2.78% from Cardiovascular (CVS). Out of total 16 hypernatremia patients 25% from CNS, 12.5% from RS, 12.5% from INFECTION, 12.5% from Gastrointestinal (G.I) system, 31.25% from RENAL system, 6.25% from OTHERS. Out of total 13 hypokalemic patient 23.08% from CNS, 38.46% from RS, 28.08% from INFECTION, 15.38% from CVS. Out of total 55 hyperkalemic patient 18.19% from CNS, 9.09% from RS, 16.36% from INFECTION, 27.27% from CVS, 9.09% from G.I., 7.27% from RENAL system, 3.64% from HEMATOLOGY, 9.09% from OTHER. Out of total 9 hypocalcemia patient 55.56% from CNS,22.22% from RESP., 11.11% from INFECTION,11.11% from G.I. system (Table 3).

When we analyzed the primary systemic pathology for which the patients were admitted to our PICU, with respect to the systems involved the electrolyte imbalance

irrespective of the type of electrolyte imbalance the results are as follows: out of total 129 electrolyte abnormalities, 27.90% from CNS, 13.95% from CVS, 26.36% from RS, 12.40% from infection, 6.98% from RENAL system, 6.20% from G.I., 1.56% from hematology, 4.65% from other diseases (Table 4).

Table 3: Systemic distribution of disease with electrolyte abnormalities.

System	Hyponatremia		Hypernatremia		Hypokalemia		Hyperkalemia		Hypocalcemia	
	N	%	N	%	N	%	N	%	N	%
Central nervous system	14	38.89%	4	25%	3	23.08%	10	18.19%	5	55.56%
Respiratory system	20	55.55%	2	12.5%	5	38.46%	5	9.09%	2	22.22%
Cardiovascular system	1	2.78%	-	-	2	15.08%	15	27.27%	-	-
Infection	1	2.78%	2	12.5%	3	23.08%	9	16.36%	1	11.11%
Gastrointestinal system	-	-	2	12.5%	-	-	5	9.09%	1	11.11%
Renal system	-	-	5	31.25%	-	-	4	7.27%	-	-
Hematology	-	-	-	-	-	-	2	3.64%	-	-
Other	-	-	1	6.25%	-	-	5	9.09%	-	-
Total	36	100%	16	100%	13	100%	55	100%	9	100%

Table 4: System wise distribution of cases with electrolyte.

	System	No. of cases	Percentage
Abnormalities	CNS	36	27.90%
	CVS	18	13.95%
	RESP.	34	26.36%
	Infection	16	12.40%
	Renal	9	6.98%
	G.I.	8	6.20%
	Haematology	2	1.56%
	Other	6	4.65%
	Total	129	100%

Table 5: Distribution of SIADH in hyponatraemic patient.

	Number	SIADH	Percentage
Euvolemic hyponatremia	23	10	43.5%
Total no of hyponatremia	36	10	27.8%

Table 6: Etiological distribution of SIADH.

Etiological diagnosis	Number	100%
Pneumonia	4	40%
Pyogenic meningitis	3	30%
TB meningitis	2	20%
Pleural disease	1	10%
Total	10	100%

Most of the hyponatremic patients in our study were euvolemic. That is amongst the 36 hyponatremic patients 23 patients (63.9%) where euvolemic. Amongst the 23 euvolemic hyponatremic patients 10 were diagnosed with Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH). Which makes 43.5% of the patients with euvolemic hyponatremia and 27.8% of the total patients with hyponatremia (Table 5). Amongst the etiology of SIADH, it was observed that 40% had Pneumonia, 30% had Pyogenic meningitis, 20% had TB meningitis, 10% had Pleural diseases (Table 6).

DISCUSSION

Table 1 displays the sex distribution of study population. The male to female ratio was 1.9:1 noted. In Indian society the male dominance noted, may be due to the preference of health care seeking behavior for male child still persisting in certain section of the society. Similar study done by Subba Rao et al, showing male predominance with male to female ratio 2:1.[8]

Table 2 shows out of 340 patients 37.91% are found with electrolyte abnormalities and 62.09% patients with no electrolyte abnormalities. Studied done by S.D Subba Rao. et al, found 32.45% had electrolyte abnormalities, but they had not included diarrhea in their study. Studied done by Dr. Rukesh chary, Dr.B. Shalini had 53.79% had electrolyte abnormalities.[9,10] Naseem et al, found 84.15% study population with electrolyte abnormalities. Mayank Jain et al, found 31.40% had electrolyte abnormalities.[11,12] Hypokalemia is serum potassium concentration below 3.5 mEq/l.[9] It occurs in about 15% children admitted to PICU.[13]

Figure 2 shows that in this study distribution of electrolyte abnormalities were Hyponatremia (10.59%), Hypernatremia (4.70%), Hypokalemia (3.82%), Hyperkalemia (16.18%) being highest, Hypocalcemia (2.62%).

S.D. Subba rao et al, and Biju Thomas et al, analysed 305 patients in St.john's hospital aged between 1 month and 14 years , who were admitted in PICU during the period. Ninety-nine (32.45%) had electrolyte abnormalities.[9] Of these 24 (7.9%) had mixed electrolyte imbalance, hyperkalemia was the commonest found in 44 (14.4%) cases, hyponatremia was seen in 11 (3.6%) cases which is second commonest abnormality noted.

These findings are in contrast to those by Singhi et al, who found hyperkalemia in 5.4% PICU admissions. This difference could be due to fact in their study hyperkalemia was defined as potassium level >6 mEq/L.[12] Hyperkalemia was how-ever, defined as serum potassium levels >5.5mEq/L in this study which probable explains a higher frequency of the abnormality.

SV.S.S. Prasad, Sunit Singhi, K.S. Chugh et al, analysed Children admitted in PICU, the frequency distribution of serum sodium concentration in children, hyponatremia was present in (29.8%) children, hypokalemia was found in (13.9%) and (5.4%) had hyperkalemia.[13]

Cummings BM et al, observed that one third had abnormal values. Hypokalemia affected 40% of the admissions.[14] Hyperkalemia affected 29% 0f admissions.

This is in contrast to Mayank Jain et al, had found hyponatremia being highest 40.90% patients, hypernatremia 18.18%, hyperkalemia 18.18%, hypokalemia 36% of patients.[15]

Figure 2 showed electrolyte abnormalities according to age. Out of 122 patients (1-month to 1 year),24.59% have electrolyte abnormalities and 75.41% without electrolyte abnormalities. Out of 85 patients (1 year to 5 year), 67.06% have electrolyte abnormalities and 32.94% without electrolyte abnormalities. Out of 98 patients (5year to 10 year), 37.76% have electrolyte abnormalities and 62.24% without electrolyte abnormalities. Out of 35 patients (10-year to 14 year), 14.28% have electrolyte abnormalities and 85.72% without electrolyte abnormalities. The p- value is <0.05. The result is significant.

Maximum number of electrolyte abnormalities seen in age group 1 year to 5 year, followed by 5year to 10 year.

This was in contrast to Dr. Rukesh Chary, Dr. B. Shalini.[10] In their study they found maximum no. of electrolyte abnormalities between 1 month to 1 year. Mayank Jain et al, also found similar situation as DR. Rukesh chary, Dr.B. Shalini.[10,15]

Table 3 shows systemic distribution of disease in children with electrolyte abnormalities. Out of total 36 hyponatremic patients 38.84% from CNS,55.55% RESP., 2.78% infection, 2.78% from CVS. Out of total 16 hyponatremic patients 25% from CNS, 12.5% from RESP., 12.5% from infection,12.5% from G.I system,

31.25% from RENAL system, 6.25% from OTHERS. Out of total 13 hypokalemic patient 23.08% from CNS, 38.46% from RESP., 28.08% from infection, 15.38% from CVS. Out of total 55 hypokalemic patient 18.19% from CNS, 9.09% from RESP., 16.36% from infection, 27.27% from CVS, 9.09% from G.I.,7.27% from renal system, 3.64% from hematology, 9.09% from other. Out of total 9 hypocalcemic patient 55.56% from CNS, 22.22% from RESP., 11.11% from infection, 11.11% from G.I. system.

Similar study done by S.D. Subba Rao et al, described different system involvement in different electrolyte.[9]

Table 4 showed system wise distribution of cases with electrolyte abnormalities. Out of total 129 electrolyte abnormalities, 27.90% from CNS, 13.95% from CVS, 26.36% from RESP., 12.40% from infection, 6.98% from renal system, 6.20% from G.I., 1.56% from hematology, 4.65% from other diseases.

Study done by DR. Rukesh chary, Dr.B. Shalini showed 26.51% CNS, 5.3% CVS,6.8% hematology,33.33% RESP,6.6% RENAL, 21.96% others.[9]

Table 5 shows, out of 23 patients of euvolemic hyponatremia 43.5% (10) patients found to have SIADH. The remaining 13 cases could not be confirmed by laboratory values. Bussman et al, described 55% SIADH found in hyponatremic patients. S.D. Subba Rao et al, had found 52.63% are having SIADH.[9,16]

Table 6 shows etiological distribution of SIADH. Out of total 10 SIADH patient, 40% had Pneumonia, 30% had Pyogenic meningitis, 20% had TB meningitis, 10% had Pleural diseases. S.D. Subba Rao et al, 10 patients,6 had infection of CNS,1 of each bronchiolitis, septicemia, snake bite, Steven Johnson syndrome.[9]

Study conducted by Al-Namma LM et al, also included one patient with Tubercular meningitis had also hyponatremia due to SIADH.[17] Kudva BT and Kamat SR found 50% patient with SIADH with respiratory disorder.[18]

CONCLUSION

The present study shows that the incidence of electrolyte imbalance is high in children with critical illness which is at 37.91% of the total admission. With hyperkalemia followed by hyponatremia being highest. Children between the age of 1 to 5years have higher incidence of electrolyte disturbance. Patients with pathology in Central Nervous System followed by respiratory system are more often involved. Higher degree of suspension regarding SIADH must be kept in mind when electrolyte imbalance pertaining to euvolemic hyponatremia patients, especially with respect to respiratory system illness followed by central nervous system.

REFERENCES

1. Conley SB. Hypernatremia. Pediatr Clini North AM. 1990;37(2):365-2.
2. Greenbaum LA. Fluid and Electrolyte Disorders. In: Kleigman RM, Stanton BF, St Geme JW, Schor NF, eds. Nelson text book of pediatrics. 1st South Asia ed. New Delhi: Elsevier; 2016:346-347.
3. Stelfox HT, Ahmed SB, Khandwala F, Zygun D, Shahpori R, Laupland K. The epidemiology of intensive care unit-acquired hyponatraemia and hypernatraemia in medical-surgical intensive care units. Crit Care. 2008;12(6):R162.
4. Buckley C, Oger J, Clover L, Tüzün E, Carpenter K, Jackson M, et al. Potassium channel antibodies in two patients with reversible limbic encephalitis. Annals Neurol: Official J Am Neurol Assoc Child Neurol Soci. 2001;50(1):73-8.
5. Zaloga GP. Hypocalcemia in critically ill patients. Critical Care Med. 1992;20(2):251-62.
6. Zivin JR, Gooley T, Zager RA, Ryan MJ. Hypocalcemia: a pervasive metabolic abnormality in the critically ill. Am J Kidney Dis. 2001;37(4):689-98.
7. Alian H, Jorge W, Martin S. Serum sodium abnormalities in children. Pediatr Clin Am. 1982;29:419-27.
8. Khilnani P, Indian Society of Critical Care Medicine (Pediatric Section. Consensus guidelines for pediatric intensive care units in India. Indian pediatrics. 2002 Jan;39(1):43.
9. Subba RS, Thomas B. Electrolyte abnormalities in children admitted to pediatric intensive care unit. Indian Pediatr. 2000;37(12):1348.
10. Chary DC, Shalini B. Correlation between serum electrolytes and clinical outcome in children admitted to PICU. IOSR J Dental Med Sci. 2017;11:24-7.
11. Naseem F, Saleem A, Mahar IA, Arif F. Electrolyte imbalance in critically ill paediatric patients. Pak J Med Sci. 2019;27;35(4).
12. Singhi S, Marudkar A. Hypokalemia in a pediatric intensive care unit. Indian pediatrics. 1996;33(1):9-14.
13. Singhi S, Prasad SV, Chugh KS. Hyponatremia in sick children: a marker of serious illness. Age. 1994;125:126-30.
14. Cummings BM, Larry A. Greenbaum, Pathophysiology of Body Fluids and Fluid Therapy, Electrolyte and Acid-Base Disorders, Nelson Textbook of Pediatrics. 19th Edition. 45;190-208.
15. Jain M, Shah A, Prajapati R. Study of electrolyte imbalance in critically ill children. Int J Internal Res. 2015;2(2):56-9.
16. Bussmann C, Bast T. Hyponatraemia in children with acute CNS disease: SIADH or cerebral salt wasting?. Child's Nervous System. 2001;17(1-2):58-62.
17. Al-Naama LM, Hassan MK, Al-Shawi EA, Hassan JKA. Hyponatremia in Children with Acute Central Nervous System Diseases. Bahrain Medical Bulletin. 2008;30(1).
18. Kudva BT, Kamat SR, Bhandarkar SD. Syndrome of inappropriate ADH secretion; prevalence in respiratory disorders. J postgraduate med. 1982;28(2):92.