

Electrolyte imbalance in hospitalized children with infections - a tertiary care Experience

M Hassan¹, M Khan², A Mukti³, S Roy⁴, M Begum⁵, Z Ferdous⁶, B H N Yasmeen⁷

Abstract

Background: Electrolyte imbalances are a common finding in hospitalized children, especially those with infections. Infections interfere with the body's normal fluid and electrolytes balance as well as various factors also contribute to electrolyte imbalances. Sometimes medicine used in the treatment of infections contributes in electrolyte abnormalities. Usually, the types of electrolyte abnormalities found among the hospital admitted children with infections are Hyponatremia, Hypernatremia, Hypokalemia, Hyperkalemia, Hypocalcemia etc.

Objective: To find out the types of electrolyte imbalance in hospitalized children with infection.

Methodology: This is a hospital based cross sectional study conducted from 1st April 2019 to 31st March 2020 at Ad-Din Women's Medical College Hospital. A total of 120 children who met the inclusion criteria were enrolled for the study. Children aged 1 to 12 years, who were admitted into Pediatric ward with clinical diagnosis of septicemia with septic shock or with different bacterial infections were included in this study. Children with non-infectious diseases, Syndromic children, with prolonged medications like diuretics, steroids, chronic diseases, kidney diseases, protein energy malnutrition were excluded from this study. During admission, all suspected cases of infections were advised to do sepsis screening and serum electrolytes (serum sodium (Na⁺), serum potassium (K⁺), sometimes serum calcium (C⁺)). At the time of admission, who were not investigated for electrolytes; they were also advised for electrolytes (several times) during his/her hospital stay particularly who were on intravenous fluid for more than 3 days without any enteral feed. Data were collected by clinical interview, physical examination and lab investigations report using a pretested structured questionnaire. All data was entered in a master chart in Microsoft Excel sheet and was analyzed in SPSS 21.0 software.

Result: Total 120 children were enrolled in this study, age ranges from 1 month to 12 years. Male 68(56.66%) and female 52(43.33%) with male female ratio 1.3 :1. Infants from 1 month to 1 year 68(56.66%), from 1 year to 5 year 38(32.66%) and 5years up to 12 years 14 (11.66%). Children had the following clinical presentations -fever in 52(43.33%) cases, reluctant to take feed 32(26.66%) vomiting 52 (43.33%), lethargy 23(19%), loose motion 60(50%), abdominal pain 14(11.66%), cough and respiratory distress 20(16.66%),tetany/convulsion 21(17.5%), unconsciousness 10(8.33%). History of taking in appropriately prepared ORS 17(14.66%) and concentrated ORS were present in 11(9.1%) cases. Clinical diagnosis was septicemia with or without septic shock, with blood culture positive 10(8.3%), diarrhea/invasive diarrhea 58(48.33%), enteric fever 10(8.3%), pneumonia 6(5%),UTI/ Urosepsis 4(3.33%), Meningitis/ meningoencephalitis 8(6.66%), TBM 2(1.6%), dengue fever 6(5%), probable bacterial infections 8(6.66%) Among 120 cases serum Na < 135mmol/l were in 34(28.33%) cases, from 135 to 145mmol/l were in 38(31.66%) but they had isolated hypokalemia. Mild hypernatremia were in 18(15%), moderate hypernatremia was in 24(20%) and severe hypernatremia were in 6(5%). Hypokalemia found in 70(58.33%)cases, Hyperkalemia present in 8(6.66%) and normal potassium were in 42(35%) cases, but they had isolated Hypernatremia or Hyponatremia. Chloride levels between 99 to 106mmol/l were in 40(33.33%) cases, < 99mmol/l were in 30(25%) cases and > 105mmol/l were in 50(41.66%) cases.

Conclusion : Electrolyte imbalances are common in children with different types of infections specially in diarrhea with severe dehydration. Specific symptoms of electrolyte abnormality often merged with the underlying disease. A high index of suspicion is very important for identification of electrolyte imbalance.

¹Prof. Mahmuda Hassan
Professor
Dept. of Pediatrics
Ad-din Women's Medical College
Dhaka.

²Dr. Masuma Khan
Assistant Professor

³Dr. A Mukti
Assistant Professor

⁴Dr. S Roy
Assistant Professor

⁵Prof. Marium Begum
Professor and Head
Dept of Pediatrics
Bashundhara Ad-din Medical
College, Dhaka

⁶Dr. Zannatul Ferdous
Assistant Professor

⁷Prof. B H Nazma Yasmeen
Professor and Head
Dept of Pediatrics
Northern International Medical
College, Dhaka

2,3,4,6
Dept. of Pediatrics
Ad-din Women's Medical College
Dhaka.

Correspondence
Prof. Mahmuda Hassan
Professor, Dept of Pediatrics
Ad-din Women's Medical College
Hospital, Dhaka.
E mail: mahmudahasn@yahoo.com

DOI: <https://doi.org/10.3329/nimcj.v13i1.73545>

Northern International Medical College Journal Vol. 13 No. 1-2 July 2021-January 2022, Page 588-593

Introduction

Electrolytes (sodium, potassium, magnesium, calcium, phosphorus) play a vital role in maintaining homeostasis within the body. They help to regulate myocardial and neurological function, fluid balance, oxygen delivery, and

acid-base balance, also homeostatic function, maintain cell membrane functions, hormonal activity, bone structure etc.

Specific symptoms of electrolyte abnormality often merged with the underlying disease. For that reason, most of the time electrolyte

disorders remain unrecognized and may be responsible for morbidity and mortality irrespective of the primary problem. Timely recognition, a high index of suspicion and a thorough understanding of common electrolyte abnormalities are necessary to ensure their correction and thus contribute for better outcome. Electrolyte imbalance in diarrhea is very much common and associated with significant increase in mortality and the morbidity in children.¹

Other than diarrhea electrolyte imbalances are common in children who need hospitalization, as well as in PICU admission and may be associated with a wide range of infections like septicemia and or septic shock with positive blood culture, pneumonia, meningitis, encephalitis, enteric fever, genitourinary tract infection, and probable bacterial infections those had fever without any localizing sign, with leukocytosis, increase neutrophil count, raised C-reactive protein.²

These electrolyte disturbances may aid in diagnosis of the illness and can also act as markers of morbidity and the mortality, the disease severity and potential of recovery from disease.^{3,4}

Early recognition, high index of suspicion and a thorough understanding of common electrolyte imbalance and their earlier management constitute an implication on the outcome of the patient. These electrolyte disturbances may guide in diagnosis of the illness and can also act as surrogate markers of disease severity and potential signs of recovery from disease. Close monitoring and correction of electrolyte abnormalities is essential to reduce morbidity and mortality.⁵

Five possible mechanisms for the occurrence of electrolyte imbalance are the (a) underlying disease process, (b) fluid and electrolyte interventions, (c) use of medications with potential of electrolyte derangements, (d) application of critical care technology i.e. positive pressure ventilation and (e) the end organ injury.⁶ Electrolyte imbalance is an important prognostic indicator in critically ill patients. There was a significant association of electrolyte abnormalities at admission in PICU with mortality and primary organ system involvement.⁶

Sodium is the principal ion in the extracellular fluid and plays the main role for maintaining the extracellular osmolality. The intracellular osmolality is maintained by potassium. Steady intracellular water and osmolality are necessary to ensure normal cell membrane integrity and cellular processes. In health intracellular osmolality is constant so intracellular water movement is usually due to changes in extracellular osmolality. Water redistribution occurs if there is an osmotic disequilibrium across the cell membrane is present, i.e. an increase or decrease in Na^+ concentration in extracellular fluid. As a result, there is shrinking or swelling of the cells in order to adapt the changes in osmolality of the extracellular environment.⁷

As Sodium is the major cation in the extracellular fluid, ranging from 135-145 mEq/l. Hence, is major determining factor of serum osmolality and as well as responsible for maintenance of intravascular volume.⁸

The presence of either hypernatremia (serum $\text{Na} > 145\text{mmol/l}$) or hyponatremia (serum $\text{Na} < 135\text{mmol/l}$) together called dysnatremias in the intensive care unit or emergency department have a prevalence in a study was 30% and an independent risk factor for poor prognosis on admission or during ICU stay.⁶ The prevalence of electrolyte abnormality in terms of sodium or potassium abnormality in another study was 44.31% and seen in a PICU based set up.⁴ Euvolemic hyponatremia is the most common dysnatremia in critically ill patients.⁹

Potassium is the primary intracellular cation in the body, typical range 3.5–5.5 mEq/L, depending on age. It plays essential roles in cellular metabolism and maintains membrane potential as well as promotes neuromuscular and cardiac function.⁶ A total of 512 patients had a potassium measurement where hyperkalemia affected 29% admitted at PICU.¹⁰ In another study hypokalemia and hyperkalemia have been estimated to occur in about 21% and 3% of hospitalized patients, respectively.¹¹

Calcium is another major electrolyte in the body. Low total calcium has been reported in 90% of children admitted to PICU or critically ill patients, while the prevalence of ionized hypocalcemia is 15% - 20%. The most common causes are acute trauma, chronic renal failure, sepsis, hypoparathyroidism, hypomagnesemia, vitamin D deficiency, and the composition of citrate and albumin.¹² Hypomagnesaemia is relatively common in admitted patients. Mostly, they are asymptomatic because they are not routinely measured. Predominant symptom and signs of Hypomagnesaemia occur due to hypocalcemia and its levels are usually differentiated by cut point less than 0.7 mg/dL.¹³ Symptoms includes muscle spasms, the presence of signs and symptoms of shock, palpitations, and seizures.

The present study was undertaken to observe the types of electrolyte imbalance associated with different types of infections who required admission in a Pediatric indoor in a tertiary care hospital, Dhaka.

Material and Method

This was a cross sectional study conducted at Ad-Din Women's Medical College Hospital in the inpatient department of Pediatrics from 1st April 2019 to 31st March 2020. Children aged 1 year to 12 years, who were admitted into Pediatric ward with clinical diagnosis of septicemia with septic shock, diarrhea/invasive diarrhea, enteric fever, pneumonia, UTI/Urosepsis (when sepsis caused by an infection in the urogenital tract), meningitis/meningo-encephalitis, TBM, dengue fever,

probable bacterial infections were included in this study. Children with non-infectious diseases, syndromic child, with prolong medications like diuretics, steroid, chronic diseases, kidney diseases, protein energy malnutrition were excluded from this study.

A total of 585 children were investigated for electrolytes along with other investigations as per requirement of the patient. Along with sepsis screening of all suspected cases of infections, they were also advised for serum electrolytes including serum sodium, serum potassium and in few cases serum calcium at the time of admission, also during the period of hospital stay. Those who were not investigated for electrolytes at the time of admission, particularly those who required intravenous fluid for more than 3 days without any enteral feed they need electrolyte level assessment for several times (3 times or more).

After admission blood sample was collected to measure sodium, potassium level, sometimes serum calcium level assessment is required. The blood sample was taken from vein. In lab electrolytes were measured using ion selective electrode method.

Out of 585 children, 120 (20.51%) had electrolyte imbalance who were enrolled for the study. Informed written consent was taken from parents or caregiver of each child and study was approved by Scientific and Ethics Review Unit of this hospital.

Age, sex, underlying clinical history and presentation were analyzed. Data were collected by clinical interview, physical examination and lab investigations report using a pretested structured questionnaire.

The initial diagnosis of electrolyte disturbances (done on the basis of blood reports of sodium and potassium, and calcium), were made as follows:

- Hyponatremia** : sodium < 135 mEq/L
- Hypernatremia** : sodium > 145 mEq/L
- Mild hypernatremia** : sodium 146 -149 mmol/L
- Moderate hypernatremia** : sodium 150 -169 mmol/L
- Severe hypernatremia** : sodium > 170 mmol/L
- Hypokalemia** : potassium < 3.5 mEq/L
- Hyperkalemia** : potassium > 5.5 mEq/L
- Hypocalcemia** : calcium < 9 mg/dl
- Hypercalcemia** : > 10.5 mg/dl

All data was entered in a master chart in Microsoft Excel sheet and was analyzed in SPSS 21.0 software. Qualitative data was represented in the form of frequency and percentage. Results were graphically represented wherever deemed necessary.

Results

A total of 585 children were investigated for electrolytes level

along with other investigations as per requirement for infection screening. Among them 86(72%) had electrolyte imbalance in the 1st time investigation which was done just after admission at hospital. Other 34(28%) patients were investigated when patients were suspected or indicated for electrolytes imbalance during their hospital stay, 27(22.5%) patients developed electrolyte imbalance even after correction of imbalance during the hospital stay period in course of illness. Finally A total of 120 (20.51%) out of 545 had electrolyte imbalance who met the inclusion criteria were enrolled for the study. Both the male and the female child were taken for the study with a male and female ratio of 1.3:1. Male (57%) and female (43%).

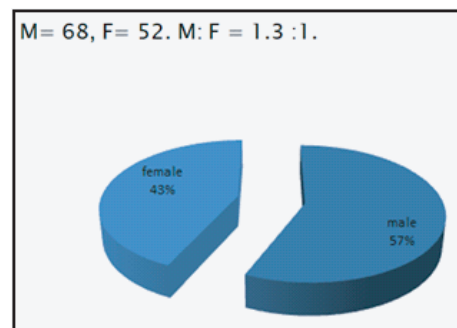


Fig 1 : Sex distribution

In this study we found that the most common clinical history and presentation of the patients was Loose Motion present in 60 (50%) cases, then fever and vomiting in 52 (43.33%) cases. Here we considered to have concentrated ORS when parents or caregiver dissolved full packet of oral rehydration salt in a feeding bottle or in a small unmeasured container, which was found in 11(9.1%) cases. Considered a patient has taken as inappropriately prepared ORS when unmeasured amount of oral rehydration salt mixed with unmeasured volume of water and those cases were not possible to categorize as concentrated or diluted ORS. We found this in 17(14.16%) children. (Table I)

Table I: Clinical history and presentation of the patients

| Clinical Presentation | No of patients | Percentage |
|--------------------------------|----------------|------------|
| Fever | 52 | 43.33 |
| Reluctant to take feed | 32 | 26.66 |
| Vomiting | 52 | 43.33 |
| Loose Motion | 60 | 50 |
| Abdominal Pain | 14 | 11.66 |
| Cough and respiratory distress | 20 | 16.66 |
| Convulsion/ tetany | 24 | 20 |
| Unconsciousness | 10 | 8.33 |
| Fever with rash | 10 | 8.33 |
| BMS / Cow's milk /MF | 37 | 30.83 |
| Signs of severe dehydration | 49 | 41 |
| Concentrated ORS | 11 | 9.1 |
| Inappropriately prepared ORS | 17 | 14.16 |

Most of the electrolyte imbalances were found among the infants in the age group up to 1 year and it was about 68 (66%) (Fig. 2).

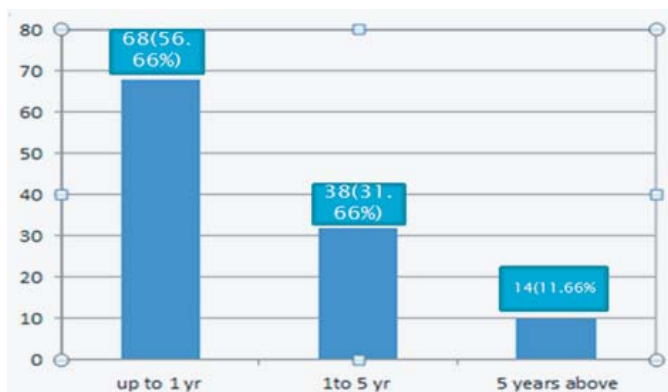


Fig 2 : Electrolyte imbalances in different age group

Regarding diseases pattern with electrolyte imbalances, we found in this study was that the most common disease was gastroenteritis which was about 58 (48.35%) and least common was TBM which was 2 (1.60%). (Fig. 3)

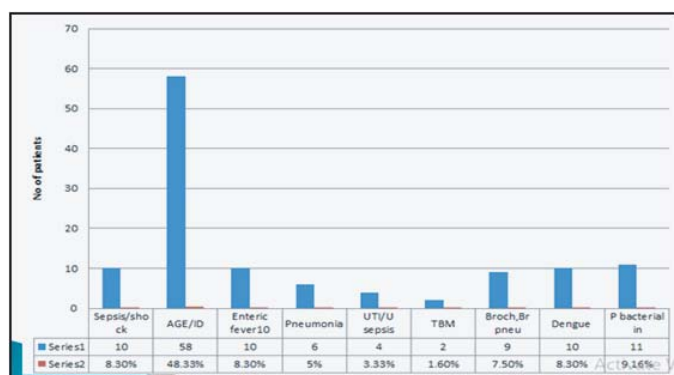


Fig 3 : Diseases pattern with electrolyte imbalances

In this study we found that electrolyte imbalance is maximum in Na and it was present in 82(63.33%) children, normal level of Na was present in 38(31.66%), but they had K imbalance. Hypernatremia present in 48(40%), 18(15%) had Na level 146-149mmol/l, 24(20%) had Na level 150-169mmol/l, 6(5%) had Na level > 170 mmol/l and hyponatremia present in 34(28.33%) patients. (Fig. 4)

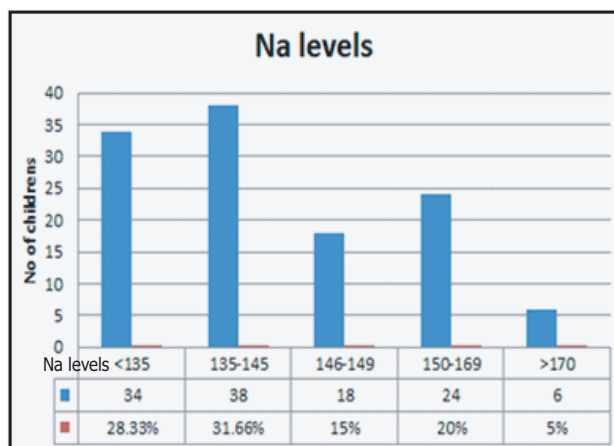


Fig 4 : Different level of Sodium in children

Among all 34 (28.33%) hyponatremia patients–18(15%) had mild (Na 130-134mmol/l), 8(6.66%) had moderate(Na 125-129 mmol/l, which were in seizure threshold) and 2 (1.6%) had severe (Na < 120mmol/l which were in a life-threatening level) hyponatremia. (Fig. 5)

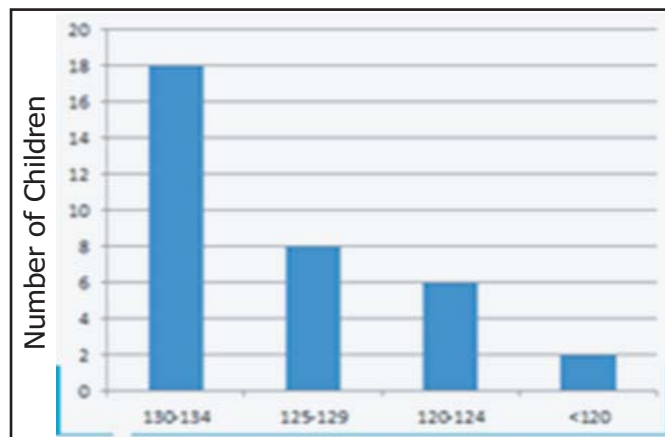


Fig 5 : Different level of Hyponatremia

In this study we found different types of potassium imbalance present in 78(65%) children, 70(58.33%) had hypokalemia (< 3.5mmol/l) and 8(6.66%) had > 5.5mmol/l, normal level in 42(35%), but they had Na imbalance. (Fig. 6)

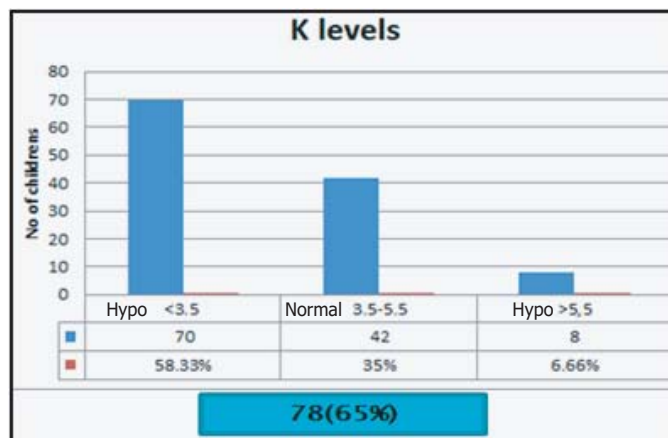


Fig 6 : Types of potassium imbalance

In this study calcium levels were investigated whenever it was suspected, like clinical features of tetany or convulsion present. Twenty-four (20%) patients had the history of convulsion or features of tetany and among them 17(14.16%) children had hypocalcemia. But these children had other electrolyte imbalance like sodium or potassium either in the form of hypo or hypernatremia or hypo or hyperkalemia. Regarding clinical conditions in patients with hypocalcaemia, out of 17 (14.16%) most of the children had Acute gastroenteritis (AGE) with or without feeding mismanagement 11 (9.16%). (Fig. 7)

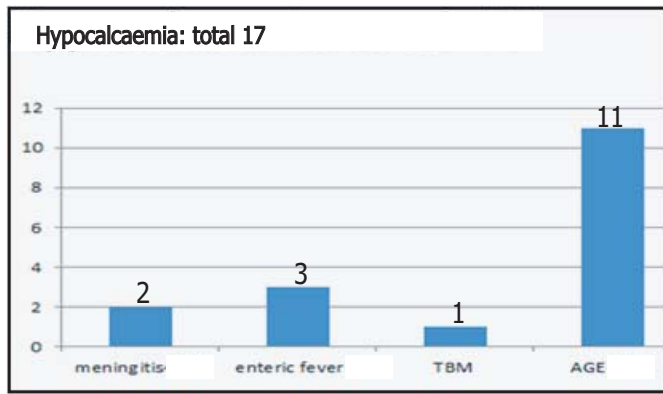


Fig 7 : Clinical conditions of patients with hypocalcemia

Discussions

Acute gastroenteritis (AGE) is a leading cause of illness and death among children in developing countries. Electrolyte disturbances play an important role in the associated morbidity and mortality. In our study highest number of children had gastroenteritis, presented with loose motion in 60 (50%), vomiting 52 (43.33%), signs of severe dehydration 49 (41%) and abdominal pain in 14 (11.66%). In a study done by Okposioal et.al 89.2% of the population examined showed at least one or more forms of electrolyte imbalance present in diarrhea patients.¹⁸ Another study also showed electrolyte imbalance in 75% of the affected children with gastroenteritis.¹⁹

In this study children with diarrhea also had history of having concentrated ORS in 11 (9.1%) and inappropriately prepared ORS in 17(14.16%). Another study also showed that the concentration of ORS has played an important role in the electrolyte imbalances in gastroenteritis.²⁰ They found diarrhea during winter season are the most important cause of hypernatremia in infancy and hypernatremia with AKI stage III (Failure) had poorest outcome.²⁰ Using diluted ORS often leads to hyponatremia and in a study showed that 22% patients presented with hyponatremic dehydration 71.5% had isonatremic dehydration and 6.5% had hypernatremic dehydration.²¹

Dehydration and electrolyte imbalance were observed as common complications of acute diarrhea in children.²² In our study 49 (41%) presented with signs of severe dehydration.

Other than diarrhoea in our study we found that sepsis with septic shock, probable bacterial infection, pneumonia, bronchopneumonia, enteric fever, urosepsis, dengue, TBM were the clinical causes of electrolyte imbalance. Brian M C et.al found in their study that 10 (%) patients had sepsis, 11(%) patients had probable bacterial infection. A hospital-based study in Nigeria, (9 – 14 years), showed electrolyte abnormalities in children suffering from typhoid fever.²⁴ In this study 10 (8.3%) had enteric fever with electrolyte imbalance. In a PICU based

study showed-hyponatremia (29.3% vs. 13.1%) and hypernatremia (18.3% vs. 15.9%) in children who had died with urosepsis were significantly higher than in alive children ($p = 0.013$).²⁵ In this study population 4 (3.33%) children had urosepsis with electrolyte imbalance.

In a study CSF from 100 pediatric patients were investigated. Among them Na^+ level was increased (>145 mmol/L), Cl^- level was increased (>107 mmol/L), K^+ level was increased (>5.1 mmol/L) and HCO_3^- level was increased up to (>28 mmol/L) in 16%, 21%, 26% and 7% patients respectively.²⁶ In this study children had meningo-encephalitis or TB meningitis with electrolyte imbalance in the blood.

In this study a total of 120 (20.51%) children out of 545 had electrolyte imbalance. Among them 86(72%) had electrolyte imbalance in 1st investigations which was done just after admission at hospital, 34(28%) had electrolyte imbalance during the period of hospital stay 27(22.5%) had even after correction. In a study, showed that electrolyte abnormality (sodium, potassium) in 44.31% patients ($n = 323$),⁵ in which electrolyte imbalance was higher than ours bredy was as the study conducted at PICU.⁵ In some other studies electrolyte abnormalities were observed in 32.45% patients and in 31.4% patients of critically ill children.^{8,15} In these 2 studies number of children with electrolyte imbalance are higher than that of our study.

In our study sodium imbalance found in 82(63.33%) children out of total 120 patients, normal Na was in 38(31.66%), but they had K imbalance. In a study which was also done in a tertiary care set up with 729 study patients. They found hyponatremia in 27.43% of patients, it being the most common electrolyte abnormality in patients, admitted to PICU at the time of admission, in our study which was 34(28.33%) . Similar results were found in a study which showed 23.33% (28 out of 120) patients with hyponatremia on admission to PICU, Hypernatremia in 3.57% of patients,¹⁶ in our study it was 48(40%) which is much higher. In study hyponatremia and hypernatremia were seen in 12.85% and 5.71% patients respectively.¹⁷

Imbalances of potassium levels are common among children with diarrhea and also among critically ill pediatric patients suffering from other ailments. Hypokalemia is a common complication among children admitted in intensive care. A study showed that 14.8% cases in pediatric intensive care unit had hypokalemia.¹⁰ In our study 70(58.33%) had hypokalemia, 8 (6.66%) had hyperkalemia and rest had normal potassium level. In another study it was found that among all children with diarrhea and severe dehydration 46% cases had hypokalemia.¹⁰

Calcium has many functions in intracellular enzymatic pathways and plays a role in cellular damage and cell death.²² In a study

showed hypo and hypercalcemia in 51% and 4% of patients respectively.²³ In this study we did serum calcium of 24 (20%) patients who had history of convulsion or features of tetany among them 17 (14.16%) children had hypocalcemia. Most of them with feeding mismanagement with AGE 11(9.1%), 3(2.5%) with Enteric fever, 2(1.6%) had Meningo-encephalitis and 1(0.8%) with TB meningitis.

In another study (68%) were hypocalcemic (19 survivors and 7 non-survivors).²⁷

Clinical suspicion is very important for identification of electrolyte imbalance in these patients. Electrolyte imbalances are common in children with different types of infections, especially in diarrhea with specific symptoms of electrolyte abnormality often merged with the underlying disease.

References

- Shah GS, Das BK, Kumar S, Singh MK, Bhandari GP. Acid base and electrolyte disturbance in diarrhoea. *Kathmandu University Med J*. 2007; 5:60-62.
- Rao SSD, Thomas B. Electrolyte abnormalities in children admitted to pediatric intensive care unit. *Indian Pediatr*. 2000;37:1348-53.
- Barron R, Freebairn R. Electrolyte disorders in the critically ill. *Anaesth Intensive Care Med*. 2010;11(12):523-8.
- Hauser GJ, Kulick AF. Electrolyte disorders in the PICU. In: Wheeler DS et al, eds. *Pediatric critical care medicine*. London: Springer-Verlag; 2014;13:147-61
- Panda I et al. Study of association of mortality with electrolyte abnormalities in children admitted in pediatric intensive care unit. *Int J Contemp Pediatr*. 2018 May;5(3):1097-1103
- Naseem F, Saleem A, Mahar IA, Arif F. Electrolyte imbalance in critically ill paediatric patients. *Pak J Med Sci*. 2019;35(4):1093-1098.
- McManus ML, Charchwell KB, Strange K. Regulation of cell volume in health and disease. *N Eng J Med* 1995;333:1260-6
- Greenbaum LA. Pathophysiology of body fluids and fluid therapy. In: Kliegman RM, Stanton BF, St Geme III JW, Schor NF, editors. *Nelson's Textbook of Pediatrics*. 20th ed. Canada: Elsevier; 2016:350-363.
- Gibbs R, Macnaughton P. Electrolyte and metabolic disturbances in critically ill patients. *Anaesth Intens Care Med*. 2007;8(12):529-33.
- Brian M. Cummings, MD, Eric A. Macklin, PhD, Phoebe H. Yager, MD. Potassium Abnormalities in a Pediatric Intensive Care Unit: Frequency and Severity. 2014;29(5):269-274.==
- Hoskote SS, Joshi SR, Ghosh AK. Disorders of potassium homeostasis: pathophysiology and management. *JAPI*. 2008;56:685-93.
- Zaloga GP. Hypocalcemia in critically ill patients. *Crit Care Med*. 1992;20(2):251-262.
- Konrad M, Schlingmann KP. Disorders of Calcium and Magnesium metabolism. *In pediatric kidney disease*. Berlin, Heidelberg: Springer; 2017; 22:921-952
- Pedada Pratima, Padma Geethanjali M. Study of electrolyte imbalance in children suffering from acute gastroenteritis of under 5 age group. *Journal of Evidence Based Medicine and Healthcare*. 2018; 5(46):3210-3213
- Jain M, Shah A, Prajapati R. Study of electrolyte imbalance in critically ill children. *Int J Int Med Res*. 2015; 2(2):56-9.
- Ebrahim SAE, El gawad ERA, Ahmed BMEG. Electrolyte disturbances in critically ill patients. *Int J Adv Res*. 2016;4(3):88-93.
- Jain M, Shah A, Prajapati R. Study of electrolyte imbalance in critically ill children. *Int J Int Med Res*. 2015;2(2):56-9
- Okposio MM, Onyiriuka AN, Abhulimhen-Iyoha BI. Point-of-Admission Serum Electrolyte Profile of Children less than Five Years Old with Dehydration due to Acute Diarrhoea. *Trop Med Health*. 2015; 43: 247-252.
- Freedman SB, Ali S, Oleszczuk M, Gouin S, Hartling L. Treatment of acute gastroenteritis in children: an overview of systematic reviews of interventions commonly used in developed countries, *Evid.-Based Child Health* 2003; 8: 1123- 1137.
- S Afroz, T Ferdous, T Sharmin, N Hossain. Etiology and outcome of Hyponatremia in Post Diarrhoeal Acute Kidney Injury in Children—An Experience in Dhaka Medical College Hospital Northern International Medical College Journal 2017; 8(2): 224-227
- Dastidar RG, Konar N . A Study of Electrolyte Disturbances in a Child Presenting with Acute Gastroenteritis, with Special Emphasis on Hyponatremic Dehydration-A Hospital based Cross-Sectional Study. *Pediatr Ther*. 2017;7: 2
- Webb A, Starr M. Acute gastroenteritis in children. *Aust Fam Physician*. 2005; 34: 227-231.
- Biomarkers of Sepsis: A Retrospective Approach. Roberts, Jose M., "Biomarkers of Sepsis: A Retrospective Approach" (2017). Honors Research Projects. 534.
- R. A. Y. Kabiru , I. Tahir , M. H. Garba, F. A. Kuta , A. Jibril and M. A. Shuaib Changes in Serum Electrolyte Levels in Typhoid Fever Patients Attending Minna General Hospital, Nigeria. *British Journal of Medicine & Medical Research* 1916;14(5): 1-7.
- Simin Sadeghi-Bojd , Noor Mohammad Noori , Elham Damani , Alireza Teimouri . Electrolyte Disturbances in PICU: A Cross Sectional Study *Nephro-Urology Monthly* . 2019 ; 11(2):e87925. doi: 10.5812/numonthly.87925
- Sangjukta Das Gupta, Md. Mohaiminul Islam, Mohammad Rashedul Hasan, et al . Electrolytic Status in Meningitis of Children in Chittagong Region: A Clinical Survey. : *British Journal of Medicine and Medical Research*, 2017;23(9): 1-10.
- CMP Buysse, DCM van der Kaay, E van der Voort, M de Hoog, JA Hazelzet, KFM Joosten . Hypocalcemia in children with septic shock. *Critical care BMJ online*. 2001 ; March 5(Suppl 1): P209. doi: 10.1186/cc1276