Sodium and Potassium Imbalances in the Pediatric Emergency Department: Single-Center Experience

Çocuk Acil Kliniğinde Sodyum ve Potasyum Bozuklukları: Tek Merkez Deneyimi

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ABSTRACT

Objective: In this study, it was aimed to examine the spectrum of sodium and potassium disorders in a pediatric emergency department.

Material and Methods: Our study was cross-sectional and single-center. Patients under the age of 18, who were admitted to the pediatric emergency clinic for any reason except trauma, between 2017 and 2020 and were found to have sodium and/or potassium disorders in their examinations were included in the study. The admission diagnoses and electrolyte levels of the patients were recorded. Electrolyte disturbances were grouped as mild, moderate, and severe.

Results: A total of 757 patients were included in the study. Of these, 358 (47.3%) were female and 399 (52.7%) were male. Single electrolyte disturbance was detected in 649 (85.8%) of the participants, while mixed type electrolyte disturbance was detected in 108 (14.2%). The most common electrolyte disturbance in the patients was hyponatremia (56%). This was followed by hyperkalemia (27.5%), hypokalemia (19.9%) and hypernatremia (10.8%). Acute gastroenteritis was the most common underlying disease in both the single and mixed electrolyte disorder groups.

Conclusion: Our study detects that the most common electrolyte disturbances in pediatric emergency services occur in patients with gastroenteritis. These disorders were often of mild severity. Mild electrolyte disturbances may be subclinical, so routine electrolyte measurement in the pediatric emergency room is important for early diagnosis.

Key Words: Electrolyte Imbalance, Pediatric Emergency, Potassium, Sodium

ÖZ

Amaç: Bu çalışmada çocuk acil servis başvurularında sodyum ve potasyum bozuklukları spektrumunun incelenmesi amaçlanmıştır.

Gereç ve Yöntemler: Araştırmamız kesitsel ve tek merkezlidir. 2017-2020 yılları arasında çocuk acil kliniğine herhangi bir nedenle başvurup tetkiklerinde sodyum ve/veya potasyum bozukluğu tespit edilen, 18 yaşından küçük hastalar çalışmaya dahil edildi. Hastaların başvuru tanıları ve elektrolit düzeyleri kaydedildi. Elektrolit bozuklukları hafif, orta ve şiddetli olarak gruplandırıldı.

Bulgular: Çalışmaya toplam 757 hasta dahil edildi. Bunların 358 (%47.3)'i kız ve 399 (%52.7)'u erkekti. Katılımcıların 649 (85.8%)'nda tekli elektrolit bozukluğu saptanırken 108 (%14.2)'nde mikst tipte elektrolit bozukluğu saptandı. Hastalarda

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en sık rastlanan elektrolit bozukluğu hiponatremiydi (%56). Bunu sırasıyla hiperkalemi (%27.5), hipokalemi (%19.9) ve hipernatremi (%10.8) izledi. Akut gastroenterit, hem tek hem de mikst elektrolit bozukluğu gruplarında en sık altta yatan hastalıktı.

Sonuç: Çalışmamız, çocuk acil servislerinde en sık elektrolit bozukluklarının gastroenteritli hastalarda meydana geldiğini saptamıştır. Bu bozukluklar genellikle hafif şiddetteydi. Hafif elektrolit bozuklukları subklinik olabilir, bu nedenle pediatrik acil serviste rutin elektrolit ölçümü erken tanı için önemlidir.

Anahtar Sözcükler: Elektrolit Bozuklukları, Çocuk Acil, Potasyum, Sodyum

INTRODUCTION

Electrolyte balance is vital for the human body as it is essential for the proper functioning of organs and numerous metabolic processes (1). These electrolytes are kept in balance in the body within a very narrow range, consequently, disruption of this balance can cause a wide range of symptoms and diseases.

Electrolyte imbalance has many causes. Fever, liver or kidney problems, infections, certain medications, and many other clinical conditions can cause electrolyte imbalance. Furthermore, dehydration frequently upsets the delicate balance of electrolytes in children (2).

It has been revealed that children are more vulnerable to dehydration due to their small body size and high metabolic rate, resulting in faster replacement of water and electrolytes compared to adults (3).

Sodium, the main cation of the extracellular fluid is responsible for the balance of fluid in the human body (4, 5). Sodium also influences the function of muscles and plays a critıical role in the central nervous system. Sodium imbalances are common electrolyte disorders in children (6).

Another common electrolyte disturbance is potassium imbalance (6,7). Potassium, the most important intracellular cation plays a critical role in cellular osmolarity and nerve impulse transmission. Disturbances in potassium homeostasis can cause potentially life-threatening consequences such as cardiac arrhythmias, muscle paralysis, and respiratory failure (4).

Sodium and potassium imbalances are quite common in both hospitalized patients and emergency clinical presentations (8). Electrolyte disturbances can result in serious morbidity and mortality, depending on their severity and rate of occurrence. As these abnormalities are very common in clinical practice, immediate detection of electrolyte disturbances and determining the underlying problems are very crucial to ensure appropriate treatment.

This study mainly focuses on understanding the frequency of severity of different types of sodium and potassium imbalance among children diagnosed with dysnatremia and dyskalemia in the pediatric emergency department and determining their association with underlying diseases.

MATERIAL and METHODS

This retrospective study was conducted in the pediatric emergency department of a tertiary care hospital after obtaining ethics committee approval (Ministry of Health Ankara Training and Research Hospital Clinical Research Ethics Committee, 10 July 2020, No: E-20/305). All non-traumatic emergency applications under the age of 18 are accepted here. For this study, the electronic records of all patients who applied to the pediatric emergency department during the three years were examined and those with dysnatremia and/or dyskalemia were identified. Children with a history of intravenous serum supplementation before biochemical testing were excluded from the study. All patients' gender, age, and diagnosis according to ICD 10 were recorded.

Hyponatremia was defined as <135 mEq/L, with subcategories of mild (130-134 mEq/L), moderate (120-129 mEq/L) and severe (<120 mEq/L) (9). Hypernatremia was defined as >145 mEq/L, with subcategories of mild (146-150 mEq/L), moderate (151-170 mEq/L) and severe (>170 mEq/L) (10, 11).

Plasma potassium less than 3.5 mEq/L was considered hypokalemia. A potassium level of 3-3.4 mEq/L mild, 2.5-2.9 mEq/L moderate, and < 2.5 mEq/L was defined as severe hypokalemia (12). Plasma potassium higher than 5 mEq/L was considered hyperkalemia. 5.5-6 mEq/L were defined as mild, 6.1-7 mEq/L as moderate, and > 7 mEq/L as severe (12).

Since the number of patients with severe electrolyte disorders was low, those with moderate and severe electrolyte disorders were classified as a single group in statistical evaluations.

Statistical Analysis

Categorical variables were expressed as numbers and percentages, whereas continuous variables were summarized as mean and standard deviation and as median and minimum-maximum where appropriate. The Chi-square test was used to compare categorical variables between the groups. The normality of distribution for continuous variables was confirmed with the Kolmogorov-Smirnov test. For comparison of continuous variables between two groups, the Student's t-test or Mann-Whitney U test was used depending on whether the statistical hypotheses were fulfilled or not. All analyses were performed using IBM SPSS Statistics Version 20.0 statistical software package. The statistical level of significance for all tests was considered to be 0.05.

RESULTS

During the study period, 757 patients were diagnosed dysnatremia and/ or dyskalemia in the pediatric emergency department. Among those 358 (47.3%) were female and 399 (52.7%) were male. The most frequently detected abnormality was hyponatremia seen in 424 (56%) patients. Among those, mild hyponatremia was detected in 327 (77.1%), moderate hyponatremia in 95 (22.4), and severe hyponatremia in 2 (0.5) patients. Secondly, the predominant abnormality was hyperkalemia seen in 208 (27.5%) cases and the most frequently was mild form (n:198, 95.2%). While hypokalemia was observed in the third frequency (n:151, 19.9%), hypernatremia was detected the least (n:82, 10.8%).

The most frequent diseases found were acute gastroenteritis (n:265, %35), followed by asthma /acute bronchiolitis (n:126, %16.6) and convulsion (n:98, %12.9). Descriptive statistics for demographic and patient characteristics are presented in Table I. We reported acute gastroenteritis was the most common

Table I: Demographic features and incidence of electrolyte imbalance in relation to the primary illness (n=757).

Age (years) mean ± standard deviation median (min-max)	3.9±4.8 2.0 (0.0-18.0)
Gender*	
Female	358 (47.3)
Male	399 (52.7)
Primary illness*	
Acute gastroenteritis	265 (35.0)
Asthma and Acute bronchiolitis	126 (16.6)
Convulsion	98 (12.9)
Upper respiratory tract infection	93 (12.3)
Pneumonia	82 (10.8)
Poisoning	42 (5.5)
Meningitis	14 (1.8)
Carbonmonoxide exposure	12 (1.6)
Syncope	7 (0.9)
Others	18 (2.4)
Sodium*	
Hyponatremia	424 (56.0)
Mild	327 (77.1)
Moderate	95 (22.4)
Severe	2 (0.5)
Hypernatremia	82 (10.8)
Mild	41 (50.0)
Moderate	38 (46.3)
Severe	3 (3.7)
Potassium*	
Hypokalemia	151 (19.9)
Mild	134 (88.7)
Moderate	14 (9.3)
Severe	3 (2.0)
Hyperkalemia	208 (27.5)
Mild	198 (95.2)
Moderate	10 (4.8)
Severe	-

***** *n(%)*

Table II: Primary diseases of the patients according to the severity of dysnatremia and dyskalemia.

	Hyponatremia (n=424)		Hypernatremia (n=82)		Hypokalemia (n=151)		Hyperkalemia(n=208)	
	Mild (n=327)	Moderate+Severe (n=97)	Mild (n=41)	Moderate+Severe (n=41)	Mild (n=134)	Moderate+Severe (n=17)	Mild (n=198)	Moderate+Severe (n=10)
Acute gastroenteritis	123 (37.6)	38 (39.2)	23 (56.1)	18 (43.9)	53 (39.6)	8 (47.1)	42 (21.2)	-
Asthma/Acute bronchiolitis	42 (12.8)	16 (16.5)	1 (2.4)	2 (4.9)	34 (25.4)	-	50 (25.3)	3 (30)
Convulsion	50 (15.3)	9 (9.3)	7 (17.1)	11 (26.8)	10 (7.5)	4 (23.5)	20 (10.1)	1 (10)
Upper respiratory tract infection	42 (12.8)	18 (18.6)	2 (4.9)		11 (8.2)	1 (5.9)	30 (15.2)	1(10)
Pneumonia	28 (8.6)	4 (4.1)	5 (12.2)	5 (12.2)	7 (5.2)	2 (11.8)	36 (18.2)	-
Poisoning	20 (6.1)	5 (5.2)	2 (4.9)	1 (2.4)	11 (8.2)	1 (5.9)	3 (1.5)	1 (10)
Meningitis	3 (0.9)	1 (1.0)	-	4 (9.8)	3 (2.2)	-	5 (2.5)	-
Carbonmonoxide exposure	4 (1.2)	1 (1.0)	-	-	2 (1.5)	1 (5.9)	5 (2.5)	-
Syncope	5 (1.5)	-	1 (2.4)	-	1 (0.7)	-	1 (0.5)	4 (40)
Others	10 (3.1)	5 (5.2)		-	2 (1.5)	-	6 (3.0)	-

Data are expressed as n (%)

Table III: Demographic Characteristics and Urea, Creatinin Levels of the Patients According to the Severity of Dysnatremia and Dyskalemia.

Characteristics	Hyponatremia (n=424)			Hypernatremia (n=82)			Hypokalemia (n=151)			Hyperkalemia (n=208)		
	Mild (n=327)	Moderate + Severe (n=97)	p	Mild (n=41)	Moderate + Severe (n=41)	p	Mild (n=134)	Moderate + Severe (n=17)	p	Mild (n=198)	Moderate + Severe (n=10	p
Age(years)	4.4±4.7 2.0 (0.0-18.0)	5.2±5.3 3 (0.0-17)	0.523[a]	4.2±5.6 2.0 (0.0-17.0)	1.5±4.9 1.0 (0.0-17)	0.001[a]	5.2±5.6 2.0 (0.0-18.0)	5.8±6.4 2.0 (0.0-18)	0.775[a]	1.9±3.5 1.0 (0.0-17.0)	1.2±1.2 1.0 (0.0-3.0)	0.838[a]
Gender,n(%) Female Male	147 (45.0) 180 (55.0)	45(46.4) 52 (53.6)	0.803[b]	26 (63.4) 15 (36.6)	31 (75.6) 10 (24.4)	0.337[b]	63 (47.0) 71 (53.0)	6 (35.3) 11 (64.7)	0.512[b]	86 (43.4) 112 (56.6)	5 (50.0) 5 (50.0)	0.751[b]
Urea (mg/dL)	25.1±16.2 23.0 (4.0-177)	26.1±20.6 22 (5-183)	0.935[a]	26.5±16.6 20.5 (5.0-92.7)	50.9±38.6 38.5 (10-173)	0.001[a]	23.5±19.1 21.0 (1.0-177.0)	26.1±40.5 14.0 (4.0-173)	0.077[a]	21.4±17.5 16.0 (2 -137)	33.0±42.7 17.0 (1-121)	0.984[a]
Creatinin (mg/dL)	0.3±0.1 0.1 (0.3-1.2)	0.4±0.2 0.3 (0.1-1.3)	0.267[a]	0.4±0.3 0.3 (0.1-1.9)	0.5±0.2 0.4 (0.1-1.2)	0.043[a]	0.4±0.2 0.3 (0.1-1.1)	0.3±0.3 0.2 (0.1-1.4)	0.020[a]	0.3±0.1 0.2 (0.1-1.1)	0.4±0.3 0.2 (0.1-1.1)	0.144[a]

Unless otherwise specified data are expressed as mean ± standard deviation, median (min-max). [a]: Chi-squared test, [b]: Mann Whitney U test

Table IV: Demographic features and incidence of combined electrolyte imbalance in relation to the primary illness (n=108).

	n=108
Age(years) mean ± standard deviation	4.0±5.4
median (min-max)	1.0 (0.0-17.0)
Gender*	
Female	51 (47.2)
Male	57 (52.8)
Primary illness*	
Acute gastroenteritis	41 (38.0)
Asthma/ Acute bronchiolitis	22 (20.4)
Convulsion	14 (13.0)
Upper respiratory tract infection	12 (11.1)
Pneumonia	9 (8.3)
Meningitis	2 (1.9)
Senkop	1 (0.9)
Poisoning	1 (0.9)
Carbonmonoxide exposure	1 (0.9)
Others	5 (4.6)
Electrolyte Imbalance*	
Hyponatremia + hypokalemia	46 (42.5)
Hyponatremia + hyperkalemia	43 (40)
Hypernatremia + hypokalemia	14 (12.9)
Hypernatremia + hyperkalemia	5 (4.6)

***** *n(%)*

disease in hyponatremia, hypernatremia, and hypokalemia groups. Otherwise, asthma /acute bronchiolitis were the most common diagnosis in hyperkalemia disorders. The primary diseases of the patients according to the severity of hypokalemia and hyperkalemia are detailed in Table II.

When we evaluated electrolyte disorders according to their subcategories, it was determined that patients with moderate+severe hypernatremia were younger than patients with mild hypernatremia (p=0.001). Also, mean urea and creatinine levels were higher in the moderate+severe hypernatremia group (p=0.001 and p=0.043, respectively). In those with hypokalemia, creatinine levels were found to be significantly higher in the mild group than in the moderate + severe group (p=0.020). A comparison of demographic and clinical characteristics according to dysnatremia and dyskalemia is presented in Table III .

The mixed electrolytes imbalances were in 108 (14.3%) patients and 57 (47.2%) were male. Acute gastroenteritis was the most frequently seen in diagnosis and the most frequently mixed abnormality was the combination of hyponatremia with hypokalemia (n:46, 42.6%) (Table IV).

DISCUSSION

Children are prone to electrolyte disturbances due to their hemodynamic instability (3). Studies on electrolyte disturbances have been mainly focused on children with specific diseases or children in intensive care units. Only Rothrock et al. (13)

conducted a study on electrolyte disorders in the pediatric emergency clinic, however, the main focus of the study was the clinical findings of electrolyte disorders rather than their severity and frequency of them. To our knowledge, our study is the first to examine the severity of electrolyte disturbances and ıts relation to underlying diseases in the pediatric emergency clinic.

The most common electrolyte imbalance was hyponatremia(n: 424, 56%) and the second was hyperkalemia (n: 208, 27.5%). In both hyponatremia and hyperkalemia, imbalances were most often of mild severity (77.1%, 95.5%, respectively). Mild disorders were found to be common (88.7%) in patients with hypokalemia, while mild and moderate/severe disorders were found at a similar rate in patients with hypernatremia (50%, 50%, respectively).

Hyponatremia was the most common electrolyte abnormality in our study (56%). Several previous studies also showed that hyponatremia was the most common (4,13,14). Agarwal et al. (4) found hyponatremia in 84.2% of cases in their study in the pediatric intensive care unit. Elala et al. (14) evaluated the admitted to pediatric emergency and intensive care units patients and they showed the incidence of hyponatremia at 51.4%. Rothrock et al. (13) showed in their multicenter study that hyponatremia is the most common electrolyte disorder in pediatric emergency clinics (39.1%) and the most common underlying disease was acute gastroenteritis. Similarly, we detected a high incidence of acute gastroenteritis in children with hyponatremia. Agarwal et al. (4) reported that the most common underlying disease in patients with hyponatremia was central nervous system pathologies. However, it is important to note that children with gastroenteritis were not included in this study.

In our study, the most common electrolyte disorder was hyponatremia, while the least common was hypernatremia (9,5%). On the other hand, Naseem et al. (15) found the most common electrolyte disorder was hypernatremia after hypocalcemia in their study. Similarly, Haider et al. (18) reported hypernatremia more than hyponatremia in their study. Nevertheless, hyponatremia has been reported more commonly than hypernatremia in many studies in the literatüre (4,6,13, 14,16,17). We believe that this may be due to the diversity of the underlying disease and the intravenous fluid content given to the patients.

In this study, we detected that hyperkalemia was the second most common serum electrolyte abnormality next to hyponatremia (27.5%). Previous studies have reported the incidence of hyperkalemia as 26.8%, 26.6%, 24.8%, 14%, 18.8%, 15.3% (4,6,13-15,18). In our study, the most common underlying disease of those with hyperkalemia was asthma/acute bronchiolitis. We think that the high detection of hyperkalemia in this disease group may be associated with a critical illness (poor perfusion, lactic acidosis, etc) or age-related difficulty obtaining blood samples (hemolysis) in our study group.

The incidence of hypokalemia was detected in 19.9% of cases. The most common underlying disease in these cases was acute gastroenteritis. In different studies this incidence was reported 64%, 57.4%, 49%, 28%, 30.58%, 9.6% (4,6,13-15, 18) .The incidence of hypokalemia was higher than our results in all studies except Rothrock et al. (13).

In our study, mixed electrolyte disorders were found in 108 children. The most frequent underlying disease was acute gastroenteritis (n:41, 38%). This disease was also the most common in single electrolyte imbalances. In previous studies, the incidence of mixed acid-base disorder was reported as 69.5%(15), 57.3%(18), and 42.2%(14). These rates are higher than in our study. Since these studies were conducted in the intensive care unit, we think that the difference in the patient profile and the treatments used may cause the incidence difference.

Limitation

Our study has several limitations. First was its retrospective design. Therefore the diagnoses were based on the ICD-10 coding which the different physicians found relevant. Secondly, although blood samples were taken from the patients before treatment we could not exclude that some patients might have had medical treatment before coming to our hospital. Thirdly our study did not aim at which electrolyte disorders have contributed to the higher morbidity and mortality. The fourth our study was a single center. Therefore our results may not truly reflect the general population

CONCLUSION

Electrolyte imbalances accompany many diseases. However, no study has been reported on the frequency of electrolyte disturbances in the pediatric emergency department. To our knowledge, this study is the first the frequency of severity of different types of sodium and potassium imbalance among children diagnosed with dysnatremia and dyskalemia in the pediatric emergency department and examine their association with underlying diseases. In the current study, we demonstrated the most common electrolyte disorder was hyponatremia. This disorder was most frequently detected in cases diagnosed with acute gastroenteritis. Our study reveals a high prevalence of mild electrolyte disturbances in the pediatric emergency department. Mild electrolyte disorders may be subclinical and this may cause a delay in diagnosis. Early detection and management of these cases are important because the timely intervention is essential in the proper treatment of electrolyte disorders.

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