The Pattern of Electrolyte Imbalance in Critically Ill Children admitted in Pediatric Emergency Unit at Sohag University Hospital

Safaa Hussein Ali, Montasar Mohammed Mohammed, Raafat Shawky Youssef
Department of Pediatrics, Faculty of Medicine, Sohag University, Sohag, Egypt
Corresponding author: Raafat Shawky Youssef, **Mobile:** (+20) 01274794073, **E-Mail:** raafatyoussef77@yahoo.com

ABSTRACT

Background: Electrolyte abnormalities are one of the common medical problems that should be addressed well in hospitalized children. Electrolyte abnormalities could occur due to underlying illness or incorrect management with fluid input. Electrolyte disorders have a significant impact on patient outcomes; treating physicians usually pay attention to the underlying medical illness but preventable and manageable electrolyte disorders are often overlooked.

Objective: To identify the pattern of electrolyte imbalance in critically ill children in the pediatric emergency unit at Sohag University Hospital.

Patients and methods: We included 150 children aging from one year to 12 years age, presenting with manifestations suggesting electrolyte imbalance coming to the pediatric emergency unit at Sohag university hospital, the period from May 2018 to May 2019.

Results: Hypocalcaemia was the most common electrolyte imbalance accounted for (83.33 %) of studied cases, followed by hypokalemia accounted for 96 (64.00%) of studied cases, then hyponatremia accounted for 54 (36.00%) of studied children, then hypernatremia accounted for 31 (20.67%) of studied children, followed by hyperkalemia accounted for 23 (15.33%) of studied cases. According to our study, it was found that children with hypernatremia had an 8.9 times higher risk of dying, AOR 8.92, 95% CI, 2.26:35.24 than children with normal sodium levels. As regard to our study, we found that children with hyperkalemia had 8 times higher risk of death than children with normal potassium level (AOR=8.07, 95% CI, 1, 39-47, 00).

Conclusion: Electrolyte abnormalities are common in children admitted to the emergency with an underlying medical illness and contribute to significant morbidity and mortality. Preventive measures in high-risk patients and early treatment would decrease morbidity and mortality.

Keywords: Pattern of Electrolyte Imbalance, Critically Ill Children.

INTRODUCTION

Infants and Children have been recognized as having more frequent episodes of electrolyte disturbances than do adults, these disturbances may alter the delicate homeostasis that is normally maintained by the growing and developing human [(1)].

Children are more vulnerable to electrolyte disturbances than adults due to several characteristics of the young infants that emphasize the importance of this normally tightly regulated "salt and water" balance include: A larger body surface area per unit of body mass, promoting the loss of water via the skin; A larger percentage of total body weight composed of water; A higher metabolic rate, requiring more water for energy dissipation and waste product excretion; In the very young infant, immaturity of certain discrete renal functions; Rapid utilization of body fluids; A much greater likelihood of many different types of disease processes manifesting by dehydration or electrolyte imbalance [(2)].

Electrolytes are ions that can have either a negative charge such as, chloride (CL), Hydrogen phosphate (HPO4), Bicarbonate (HCO3), Sulfate (SO4), or positive charge such as, Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca).

Electrolytes imbalances are present in the form of excesses (Hyper) or Deficits (Hypo) such as Sodium imbalance (hypernatremia or hyponatremia), Potassium imbalance (hyperkalemia or hypokalemia), Calcium imbalance (hypercalcemia or hypocalcemia), these are the most common types of electrolyte disturbances [(2, 3)].

The most important and common electrolyte imbalance is Sodium imbalance, sodium plays a primary role in terms of body fluid balance and also has an impact on the functioning of body muscles and the central nervous system. The second one is Potassium imbalance, potassium promotes and facilitates electrical impulses that are necessary for muscular contractions and also for the normal functioning of the brain. The third one is calcium imbalance, calcium is essential for bone health [(4)].

Electrolyte disturbances are involved in many disease processes and are an important part of patient management in medicine. The causes, severity, treatment, and outcomes of these disturbances can vastly differ depending on the implicated electrolyte [(5)].

The major purpose of this study was to study the pattern of electrolyte disorders as regards the diagnosis and management in the Pediatric Emergency Unit.

Received:8 /10 /2020
Accepted:26 /11 /2020

PATIENTS AND METHODS

We included 150 children aging from one year to 12 years age, presenting with manifestations suggesting electrolyte imbalance coming to the pediatric emergency unit at Sohag University Hospital, during the period from May 2018 to May 2019.

Inclusion Criteria:

Any Children (aged from one month to 12 years) admitted to the emergency pediatric unit with manifestations suggesting electrolyte imbalance such as nausea, vomiting, disorientation, restlessness, agitation, seizures, disturbed conscious level, and edema.

Exclusion Criteria: neonates.

Ethical consideration: An informed consent was taken from caregivers of patients included in the and **the protocol of the study was approved by the scientific ethical committee at Sohag Faculty of Medicine.**

All patients in this study were subjected to the followings:

(1) Full history taking.

(2) Full clinical examination with special concern on signs of electrolyte imbalance such as body weight loss, dry mucous membrane, delayed skin Turgor, absent tears, depressed anterior fontanel, tachycardia, rapid and weak pulse, convulsions, pallor, low arterial blood pressure, oliguria.

(3) Laboratory Investigations:

- Serum Electrolytes (Sodium – Potassium- Calcium – Magnesium – Chloride).
- Zrterial Blood Gases (Acidosis – Alkalosis).
- Complete Blood Count.
- Kidney Function Tests.
- Urine Analysis.
- Blood Glucose Level.

ALL patient data, measurement, and outcomes were collected in a special case sheet.

Tentative timetable: one year.

Statistical analysis

The collected data were coded, processed, and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA).

Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi-square test ($\chi 2$) to calculate the difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P-value < 0.05 was considered significant.

RESULTS

Our study was conducted on 150 Children (91 male, 59 female), who were presented to the pediatric emergency unit at Sohag University Hospital from May 2018 to May 2019.

Table (1): Age and gender of studied patients:

Variable	Summary statistics
Age /months	
Mean ± SD	18.62±21.64
Median (range)	10 (1.5:121)
Age group	
<1 year	83 (55.33%)
1-5 year	59 (39.33%)
>5 year	8 (5.33%)
Gender	
Female	59 (39.33%)
Male	91 (60.67%)

From table (1), we found that the mean age of studied children was 18.62±21.64 months. Males predominate in 91 patients.

Table (2): The presenting complaints of studied children:

Variable	Number (%)
Compliant	
Fever	88 (58.67%)
Vomiting	112 (74.67%)
Diarrhea	107 (71.33%)
Convulsions	44 (29.33%)
DCL	39 (26.00%)
Others	86 (57.33%)
Duration of complaint	
Mean ± SD	8.15±10.10
Median (range)	3 (1:37)

According to table (2), the most common complaint was vomiting 112 (74.67%), followed by diarrhea 107 (71.33%), then fever 88 (58.67%), convulsions 44 (29.33%), and DCL 39 (26.00%). The Mean duration of the complaint was 8.15±10.10 days.

Table (3): Pattern of electrolyte imbalance among studied children:

Variable	Summary statistics
Serum sodium Mean ± SD Median	 136.01±16.16 134
Classification of sodium group Normal Hyponatremia Hypernatremia	 65 (43.33%) 54 (36.00%) 31 (20.67%)
Serum potassium Mean ± SD Median	 3.43±0.66 2.6
Classification potassium group Normal Hypokalemia Hyperkalemia	 31 (20.67%) 96 (64.00%) 23 (15.33%)
Serum total calcium Mean ± SD Median	 7.15±0.86 7.4
Classification of calcium group Normal Hypocalcemia	 25 (16.67%) 125 (83.33%)
Serum chloride Mean ± SD Median	 98.49±9.23 95.5
Classification of serum chloride group: Normal Hyperchloremia	 126 (84.00%) 24 (16.00%)
Serum magnesium Mean ± SD Median	 2.21±0.27 2.2
Classification of serum Magnesium group: Normal Hypomagnesaemia	 146 (97.33%) 4 (2.67%)

From table (3), we found that 54 (36.00%) of studied children developed hyponatremia, 31 (20.67%) developed hypernatremia, 96 (64.00%) developed hypokalemia, 23 (15.33%) had hyperkalemia and 125 (83.33%) had hypocalcemia, whereas, 24 (16.00%), 4 (2.67%) of the studied children had hyperchloremia and hypomagnesemia respectively.

Table (4): Distribution of diagnosis of studied children.

Variable	Number (%)
Gastro-enteritis	56 (37.33%)
GE with iatrogenic hypernatremia	6 (4.00%)
Hypocalcemic Convulsions	18 (12.00%)
DKA	16 (10.67%)
Acute Kidney Injury	8 (5.33%)
Barter Disease	8 (5.33%)
Chronic Renal Failure	8 (5.33%)
Chronic Diarrhea	7 (4.67%)
Renal Tubular Acidosis (RTA)	7 (4.67%)
Hypomagnesaemia	4 (2.67%)
Acute Glomerulonephritis	3 (2.00%)
Near Drowning	3 (2.00%)
Sepsis	3 (2.00%)
Congenital Adrenal Hyperplasia	2 (1.33%)
Addisonian Crisis	1 (0.67%)

According to table (4), we found that the most common varieties of diagnosis in our cases were acute gastroenteritis (56) cases, hypocalcemic convulsions (18) cases, and DKA (16) cases.

Table (5): Distribution of signs of electrolyte imbalance and dehydration, degree of dehydration, and hospital stay and outcome of studied children.

	Variable	Number (%)
Distribution of signs of electrolyte imbalance and dehydration	**Weight loss**	109 (72.67%)
	Dry mucus membrane	99 (66.00%)
	Delayed skin turgor	111 (74.00%)
	Absent tears	34 (22.67%)
	Depressed ant. fontanel	115 (76.67%)
	Tachycardia	71 (47.65%)
	Convulsion	44 (29.33%)
	Pallor	91 (60.67%)
	Hypotension	43 (28.67%)
	Oliguria	23 (15.33%)
Degree of dehydration	**No**	**35 (23.33%)**
	Mild	**16 (10.67%)**
	Moderate	**55 (36.67%)**
	Severe	**44 (29.33%)**
Hospital stay and outcome	**Duration of hospital stay** Mean ± SD Median	 7.3±3.91 7
	Outcome Discharged (improved Transferred Died	 99 (66.00%) 38 (25.33%) 13 (8.67%)

According to table (5), as regards signs of electrolyte imbalance and dehydration we found that, the most important and common sign was depressed

anterior fontanel (115) cases, delayed skin turgor (111) cases, and weight loss (109) cases. As regards the degree of dehydration of studied children we found that, 35 (23.33%) of studied patients had no dehydration, 16 (10.67%) had mild dehydration, 55 (36.67%) had moderate dehydration and 44 (29.33%) had severe dehydration. We found that 99 (66.00%) of studied children were discharged with improvement, 38 (25.33%) of the children were transferred to the wards (inpatient admission), Whereas 13 (8.67%) of the patients died. The mean of hospital stay was 7.3±3.91 days.

Table (6): Association of hypernatremia with the adverse outcome

Variable	Hypernatremia		OR (95%CI)	P-value	AOR (95%CI)	P-value
	No	Yes				
Age group						
>1 year	**45(37.82%)**	**13(41.94%)**	**1**		**1**	
≤1 year	**74(62.18%)**	**18(58.06%)**	**0.84(0.38:1.88)**	**0.67**	**1.33(0.54:3.28)**	**0.54**
Gender						
Female	**45(37.82%)**	**14(45.16%)**	**1**		**1**	
Male	**74(62.18%)**	**17(54.84%)**	**0.73(0.33:1.64)**	**0.46**	**0.66(0.28:1.53)**	**0.34**
Hospital stay						
≤1 week	**64(53.78%)**	**16(51.61%)**	**1**		**1**	
>1 week	**55(46.22%)**	**15(48.39%)**	**1.09(0.49:2.41)**	**0.83**	**1.48(0.49:4.49)**	**0.49**
Outcome						
Discharged	**84(70.59%)**	**15(48.39%)**	**1**		**1**	
Transferred	**29(24.37%)**	**9(29.03%)**	**1.74(0.69:4.39)**	**0.24**	**1.46(0.46:4.64)**	**0.52**
Died	**6(5.04%)**	**7(22.58%)**	**6.53(1.92:22.15)**	**0.003**	**8.92(2.26:35.24)**	**0.001**

OR=Non adjusted odds ratio, CI = confidence interval, AOR adjusted odds ratio.

According to table (6), males had 0.66 times lower risk of developing hypernatremia (AOR 0.66, 95% CI 0.28:1.53), children less than 1 year had 1.33 times higher risk of developing hypernatremia with AOR 1.33, 95% CI, 0.54–3.28. Of 150 studied children, 80 (53.33 %) stayed in the Hospital less than or equal 1 week, and 70 (46.67 %) stayed in the hospital for more than 1 week. In binary logistic regression analysis, it was found that children who stayed for more than one week were 1.48 times more likely to have hypernatremia AOR=1.48; 95% CI, 0.49-4.49 compared to children who stayed less than one week in the hospital. In multi-logistic regression analysis, it was found that children with hypernatremia had 8.9 times higher risk of dying, AOR 8.92, 95% CI, 2.26:35.24 than children with normal sodium levels.

Table (7): Association of hyperkalemia with adverse outcome.

Variable	Hyperkalemia		OR (95%CI)	P-value	AOR (95%CI)	P-value
	No	Yes				
Age group			**1**			
>1 year	**38 (29.92%)**	**20 (86.96%)**	**0.06**		**1**	
≤1 year	**89 (70.08%)**	**3 (13.04%)**	**(0.02:0.23)**	**<0.0001**	**0.08 (0.2:3.2)**	**<0.0001**
Gender			**1**			
Female	**48 (37.80%)**	**11 (47.83%)**	**0.66**		**1**	
Male	**79 (62.20%)**	**12 (52.17%)**	**(0.27:1.62)**	**0.37**	**(:)**	**0.**
Hospital stay			**1**		**1**	
≤1 week	**76 (59.84%)**	**4 (17.39%)**	**7.08**		**7.61**	
>1 week	**51 (40.16%)**	**19 (82.61%)**	**(2.27:22.02)**	**0.001**	**(2.24:25.80)**	**0.001**
			1		**1**	
Outcome			**23.27**		**21.38**	
Discharged	**96 (75.59%)**	**3 (13.04%)**	**(6.23:86.88)**		**(5.09:89.67)**	
Transferred	**22 (17.32%)**	**16 (69.57%)**	**14.22**	**<0.0001**	**8.07**	**0.02**
Died	**9 (7.09%)**	**4 (17.39%)**	**(2.47:73.72)**	**0.002**	**(1.39:47.00)**	**0.001**

OR=Non adjusted odds ratio, CI = confidence interval, AOR adjusted odds ratio.

From table (7), we found that studied children with hyperkalemia, 12 were males and 11 were females. Bivariate analysis showed that males had a higher risk of developing hyperkalemia than females. Among these hyperkalemic children, 3 (13.04%) were below one year of age, and 20 (86.96%) were above one year of age. In multivariate analysis, the outcome of hospitalized children was found to be significantly associated with serum potassium level. Children with hyperkalemia had 8 times higher risk of death than children with normal potassium levels (AOR=8.07, 95%CI, 1, 39-47, 00).

DISCUSSION

In our study, as regards sociodemographic data: we found that 60.67% of our cases were males and 39.33% were females and this is similar to many published studies like **Elala and Shimelis [6], Naseem *et al.* [7], Agarwal *et al.* [8] and Sadeghi-Bojd *et al.* [9].**

According to our study, hypocalcemia was the most common electrolyte imbalance accounted for (83.33 %) of studied cases, similar to a study done by **Naseem *et al.* [7]**, where hypocalcemia accounted for (57.6%) of all studied cases, and also a study by **Sadeghi-Bojd *et al.* [9]** where hypocalcemia accounted for (56.6%) of studied cases.

These findings dissimilar to a study done by **Elala and Shimelis [6]** as they showed that hyponatremia was the most common electrolyte imbalance, accounted for (51.4 %) of all studied cases. Also, a study by **Agarwal *et al.* [8]**, showed that hyponatremia was the commonest electrolyte imbalance accounted for (84.2%) of all studied cases.

According to our study, the pattern of electrolyte imbalance among the studied children, the most common electrolyte imbalance was hypocalcemia which accounted for 125 (83.33%) of studied cases, followed by hypokalemia that accounted for 96 (64.00%) of studied cases, then hyponatremia which accounted for 54 (36.00%) of studied children, hypernatremia which accounted for 31 (20.67%) of studied children, followed by hyperkalemia that accounted for 23 (15.33%) of studied cases. These findings were similar to the study done by **Naseem *et al.* [7],** where the most common electrolyte imbalance was hypocalcemia which accounted for 49 (57.6%) of the studied cases, followed by hypernatremia that accounted for 32 (37.6%) of the studied cases, then hypokalemia that accounted for 26 (30.6 %), then hyponatremia which accounted for 20 (23.5%), and hyperkalemia 16 (18.8%) of the studied children. Also similar to the study done by **Sadeghi-Bojd *et al.* [9],** where the most common electrolyte imbalance was hypocalcemia which accounted for 107 (56.6%) of the studied children, followed by hyperkalemia that accounted for 64 (33.9%) of the studied cases, then hyponatremia which accounted for 38 (20.1%) of the studied cases, hypernatremia which accounted for 32 (17 %).

These findings dissimilar to the study by **Elala and Shimelis [6]**, where hyponatremia was the most common electrolyte imbalance accounted for 89 (51.4%) of the studied cases, followed by hypokalemia which accounted for 85 (49.1%) of the studied children, then hypernatremia that accounted for 64 (37%) of the studied cases, hypocalcemia which accounted for 59 (34.1%) and hyperkalemia which accounted for 43 (24.9 %) of the studied cases.

In our study, according to serum sodium abnormalities, 85 cases of the studied children of which 54 cases had hyponatremia, the most prevalent diagnosis was gastroenteritis 24 (44.44%), followed by barter disease 8 (14.81%) and renal tubular acidosis 7 (12.96%) of cases.

These findings dissimilar to the study done by **Elala and Shimelis [6],** where serum sodium abnormalities were found in 153 cases, of which 91 cases had hyponatremia, the most prevalent causes were cardiovascular causes among 23 cases, followed by renal causes among 19 cases, then central causes within 17 cases, and gastrointestinal causes among 14 cases. Also, these findings dissimilar to the study by **Agarwal *et al.* [8]** where 91 cases had hyponatremia, the most prevalent causes were central causes 41 (47.13%), followed by renal causes 15 (16.5%), and septicemia 12 (13.2%) of all cases. Also, dissimilar to the study by **Sadeghi-Bojd *et al.* [9],** where 38 cases had hyponatremia, the most prevalent causes were central causes 9 (23.7 %), followed by respiratory causes 8 (21%) and gastrointestinal causes 5 (13.2 %) of cases. These findings are explained that our country is one of the most endemic areas with gastroenteritis either bacterial or viral due to the low socioeconomic state of our country.

In our study, the diagnosed children who have hypernatremia were 31 cases, the most prevalent diagnosis was gastroenteritis 14 (45.16%), followed by DKA 8 (25.81%) and gastroenteritis with iatrogenic hypernatremia 8 (25.81%) of all cases. These findings dissimilar to the study done by **Elala and Shimelis [6],** who found 64 cases had hypernatremia and the most prevalent causes were hematological 18 (28.1%), followed by central causes 14 (21.9%), then gastrointestinal causes 8 (12.5%) of all cases. Also, these findings were dissimilar to the study by **Agarwal *et al.* [8],** who found 17 cases had hypernatremia and the most prevalent causes were central causes 8 (47%), followed by septicemia 6 (35.3%) and respiratory causes 2 (11.8%) of them.

As regard to serum potassium abnormalities, in our study, 119 cases of which 96 had hypokalemia. The most prevalent diagnosis was gastroenteritis 52 (54.17%) cases, followed by DKA 11 (11.46%) cases and barter disease 8 (8.33%) cases. These findings were similar to the study done by **Elala and Shimelis [6],** who recorded128 cases had serum potassium abnormalities, of which 85 cases had hypokalemia and the most prevalent causes were gastrointestinal causes, 23 cases, followed by hematological causes, 20 cases, and cardiovascular causes, 19 cases. These findings refer to the high incidence of gastroenteritis in our locality.

These findings dissimilar to the study conducted by **Sadeghi-Bojd *et al.* [9],** where 9 cases had hypokalemia and the most prevalent causes were respiratory causes 3 (33.3%) and gastrointestinal causes 1 (11.1%) of them. This is can be explained by the small sample size of their studied cases and the time of the study was out of the season of gastroenteritis.

In our study, 23 cases had hyperkalemia, the most prevalent diagnosis was acute kidney injury 8 (34.78%), followed by chronic renal failure 8 (34.78%) and acute glomerulonephritis 3 (13.04%) of them.

These findings similar to the study conducted by **Elala and Shimelis [6],** who recorded 43 cases had hyperkalemia and the most prevalent causes were renal

causes among 19 and hematological causes among 13 of them.

Also, these findings dissimilar to the study done by **Sadeghi-Bojd *et al.* [9],** who recorded 64 cases had hyperkalemia, the most prevalent causes were central causes among 13 (20.3 %), followed by respiratory causes 10 (15.6 %) and cardiovascular causes 9 (14 %) of all cases. This could be explained by the high incidence of renal failure and acute glomerulonephritis following streptococcal infections.

In our study, according to the association between hypernatremia and adverse outcome, males had 0.66 times lower risk of developing hypernatremia (AOR 0.66, 95% CI 0.28:1.53).

These findings are dissimilar to the study done by **Elala and Shimelis [6],** where the male gender had 1.5 times higher risk of developing hypernatremia (AOR 1.5, 95% CI, 0.85-2.74).

As regard to our study, it was found that children who stayed for more than one week were 1.48 times more likely to have hypernatremia AOR=1.48; 95% CI, 0.49-4.49 compared to children who stayed less than one week in the hospital.

These findings are similar to the study by **Elala and Shimelis [6],** it was found that children who stayed for more than two weeks were 2 times more likely to have hypernatremia AOR=2.1; 95% CI, 0.99-4.47 compared to children who stayed less than one week in the hospital.

According to our study, it was found that children with hypernatremia had 8.9 times higher risk of dying, AOR 8.92, 95% CI, 2.26:35.24 than children with normal sodium levels.

These findings are similar to the study done by **Elala and Shimelis [6],** who was found that children with hypernatremia had 3 times higher risk of dying, AOR 3.3, 95% CI, 1.07-10.62 than children with normal sodium level.

A study done by **Mokhtari *et al.* [10]** showed that the mortality rate was higher in patients with hyponatremia (34% vs. 16%) and hypernatremia (55% vs. 18%) than in other patients significantly. The mortality rate in the hypernatremic group was higher than the hyponatremic group, and both were higher in patients with no disorder significantly. These disorders are associated with increased mortality and are more common in older ages; moreover, mortality rates are higher in hypernatremia. The results of this study are similar to those of our study.

In our study, according to the association between hyperkalemia and adverse outcome, males had a higher risk of developing hyperkalemia than females. These findings are similar to the study by **Elala and Shimelis [6]**, who recorded that males had a twice higher risk of developing hyperkalemia than females (AOR 2.01, 95% CI, 0.96-4.20).

According to our study, the outcome of hospitalized children was found to be significantly associated with serum potassium level. Children with hyperkalemia had 8 times higher risk of death than children with normal potassium levels (AOR=8.07, 95%CI, 1, 39-47, 00).

These findings are similar to the study done by **Elala and Shimelis [6]**, where the outcome of hospitalized children was found to be significantly associated with serum potassium level. Children with hyperkalemia had 8 times higher risk of death than children with normal potassium levels (AOR=8.12, 95%CI, 2.44-26.96).

CONCLUSION

Electrolyte abnormalities are common in children admitted to the emergency with an underlying medical illness and contribute to significant morbidity and mortality. Preventive measures in high-risk patients and early treatment would decrease morbidity and mortality.

The present study showed a high incidence of electrolyte abnormalities in critically ill children. They were associated with significantly higher morbidity and mortality as compared to children with normal electrolyte levels.

Electrolyte abnormalities remain significant predictors of morbidity and mortality in critically ill children. We suggest that timely recognition through regular monitoring and appropriate correction of electrolyte abnormalities will help in improving outcomes besides the usual management of the primary disease.

REFERENCES

1. **Roberts K (2005):** Pediatric fluid and electrolyte balance: critical care case studies. Critical Care Nursing Clinics of North America, 17(4):361-73.
2. **Holliday M, Friedman A, Warner S (2008):** Extracellular fluid restoration in dehydration: a critique of rapid vs slow. Pediatr Nephrol., 13:292–297.
3. **Choong K, Kho M, Menon K *et al.* (2006)**: Hypotonic versus isotonic saline in hospitalized children: a systematic review. Arch Dis Child., 91(10): 828–835.
4. **Henry C (2005):** Basal metabolic rate studies in humans: measurement and development of new equations. Public Health Nutr., 8(7A):1133-52.
5. **Walls Ron M, Hockberger R, Gausche-Hill M (2018):** Rosen's Emergency Medicine: Concepts and Clinical Practice. Philadelphia, PA: Elsevier., Pp. 1516–1532.
6. **Elala G, Shimelis D (2018):** Patterns of electrolyte abnormalities in children 0-15 years of age admitted to Pediatric Emergency and Intensive Care Units of a Tertiary Hospital. IOSR Journal of Dental and Medical Sciences, 17: 12-16.
7. **Naseem F, Saleem A, Mahar I *et al.* (2019):** Electrolyte imbalance in critically ill pediatric patients. Pak J Med Sci., 35(4):1093-1098.
8. **Agarwal N, Saxena R, Acharya R (2018):** Profile of serum electrolytes in critically Ill children: A prospective study. Indian J Child Health, 5(2): 128-132.
9. **Sadeghi-Bojd S, Mohammad N, Damani E *et al.* (2019):** Electrolyte Disturbances in PICU: A Cross-Sectional Study. Nephro-Urol Mon., 11(2):87925-32.
10. **Mokhtari M, Goharani R, Miri M *et al.* (2010):** Frequency of Hyper-and Hypo-natremia in patients admitted in the ICU & comparison of their association with mortality. Res Med., 33(3):183–8.