

Assessment of Serum Electrolytes in Hospitalized children with Pneumonia

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Abstract

Background: Pneumonia constitutes the primary cause of hospitalizations and is the foremost reason for admissions to intensive care units. In pediatric patients who are hospitalized due to severe pneumonia, electrolyte imbalance is a significant complication. The presence of hypokalemia at the same time as hyponatremia makes the clinical prognosis even more complicated in pneumonia cases. Both hyponatremia and hypokalemia have been linked to unfavorable outcomes in pneumonia cases. The monitoring of alterations in electrolyte levels is of paramount importance in order to avert complications that may result in heightened morbidity and mortality. It is imperative to investigate the alterations in electrolyte levels occurring in hospitalized pediatric patients diagnosed with severe pneumonia. Hypokalemia may occasionally be observed in pediatric patients suffering from severe pneumonia. The objective of this study was to assess the serum electrolyte levels, specifically sodium, potassium, calcium, chloride, and magnesium, in patients diagnosed with pneumonia.

Method: This is a case control study that conducted on 150 children who were selected from those attending Bab El-sharia and Al Hussain university hospitals by sample random method from July 2023 to July 2024. Children were divided into 2 groups, aged more than 2 months and less than 15 years old and with moderate to severe pneumonia with no specified sex: Group 1 (n=100): patients with pneumonia. Group 2 (n=50): healthy controls (non-pneumonic cases).

All the studied children were subjected to complete history taking, clinical examination with some labs. and radiological imaging.

Results: Based on our findings, a statistically significant difference was observed in sodium levels between patients with pneumonia and control patients in general. In addition, the incidence of hyponatremia, particularly mild and moderate forms of the condition, was significantly different between the two groups. A statistically significant correlation has been established between serum sodium, potassium magnesium, calcium, chloride levels and the severity of pneumonia in patients, as indicated by a correlation coefficient of 0.292, which implies a mild correlation. A statistically significant correlation has been established between serum sodium levels and complications in patients diagnosed with pneumonia, as indicated by a correlation coefficient of 0.412, which implies a moderate degree of association.

Conclusion: Hyponatremia is not uncommon finding in children with Pneumonia, hypocalcemia may be occurred also with pneumonia. The degree of hyponatremia seems to be related to the severity of pneumonia and days of hospital admission. On the other hand, potassium, chloride, and magnesium were not significantly different between the pneumonia and control groups.

Keywords: Hyponatremia. Pneumonia, electrolyte disturbance

Introduction

The World Health Organization (WHO) defines pneumonia in pediatric patients as the presentation of cough or respiratory distress, accompanied by tachypnea or retraction of the chest wall, in children aged 2 to 59 months. Pneumonia represents the foremost infectious cause of mortality among children globally. It is particularly prevalent among children, notably those under the age of five, and affects families across various regions; however, it is most commonly observed in South Asia and sub-Saharan Africa. It is more prevalent in developing nations such as Egypt [1].

Community-Acquired Pneumonia (CAP) represents the predominant etiology for hospitalizations and is the leading cause of admissions to intensive care units [2].

In pediatric patients who are hospitalized due to severe pneumonia, electrolyte imbalance is a significant complication. Hyponatremia is among the most prevalent electrolyte disturbances observed in instances of pneumonia, and the concurrent presence of hypokalemia exacerbates the clinical outcomes. Hyponatremia and hypokalemia have been

linked to unfavorable outcomes in patients diagnosed with pneumonia.

The monitoring of alterations in electrolyte levels is of paramount importance in order to avert complications that may result in heightened morbidity and mortality. It is imperative to investigate the alterations in electrolyte levels occurring in hospitalized pediatric patients diagnosed with severe pneumonia. Hypokalemia may occasionally be observed in pediatric patients suffering from severe pneumonia [3].

During the active phase of lobar pneumonia, a reduction in serum electrolytes occurs, characterized by a decline in serum chloride concentration and a decrease in fixed base, as well as alterations in osmolality. Additionally, diminished serum calcium levels may be observed in certain instances of pneumonia [4]. The objective of this study was to assess the serum electrolyte levels, specifically sodium, potassium, calcium, chloride, and magnesium, in patients diagnosed with pneumonia. Furthermore, identify correlations between alterations in electrolyte levels and the severity of pneumonia.

Ethical considerations

1. Approval of ethical committee in the pediatric department, college and university was obtained before the study.
2. written consent was taken from parents of each participant before the study.
3. The parents have the right to withdraw his or her newborn from the study at any time.
4. The author received no financial Support for the research, authorship, and or publication of the article.

5. The author declared that there is no conflict of interest regarding the study.

6. Privacy of all data will be assured.

Sample Size Equation

100 cases will be included in this study according to the following equation

$$\text{Sample size} = \frac{(Z\text{-Score})^2 \times \text{Std Dev} \times (1 - \text{Std Dev})}{(\text{margin of error})^2}$$

(Naing et al., 2006)

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Inclusion criteria

- Patients admitted to pediatric inpatient ward with pneumonia.
- Patients aged more than 2 months and less than 15 years old.
- Patients with moderate to severe pneumonia according to PRESS score.

Exclusion criteria

- Patients less than 2 months.
- Any associated renal disease
- Any endocrinal disorders
- Any patient on diuretics
- Patients with mild pneumonia that take treatment at home

Study Procedure

This is A case control study was conducted out on 100 children in Pediatric Department, Bab El-sharia and Al Hussain university hospitals from July 2023 to July 2024, and they were classified into two groups:

- **Group 1 (Case group):** 100 Patients diagnosed with pneumonia.

The severity of pneumonia was classified according to pediatric respiratory severity score (PRESS) score.

- **Group 2 (Control group):** Fifty Patients not diagnosed with pneumonia.

All studied children cases and controlled were subjected to the followings:

Full history taking with special emphasis on:

- **Demographic and epidemiological data:** including age, sex, residence, and smoking status of any family member.
- **Symptoms of respiratory distress:** Tachypnea, intercostal retraction, nasal flaring, grunting, and cyanosis.
- **Review of other systems:** such as GIT, heart and CNS

Through clinical examination with special emphasis on:

- **General examination:**
which included an evaluation of Anthropometric measurements and vital signs.

* local systemic ex. of:

- **Abdomen**
- **Assessment**
- **Heart**

Along with a detailed local examination of the chest.

Laboratory Evaluation:

1. Basic routine investigations including:

Blood samples were withdrawn aseptically from all children on enrollment for the following:

- CBC assessment:** Complete blood count (Hemoglobin, platelets, total leukocyte count, neutrophils, lymphocytes) and it was done by using auto hematology analyzer (sysmex 300).
- Quantitative C-reactive protein (CRP):** It was done by latex agglutination.
- Electrolytes:** Na, K, Ca, Mg, Cl Renal function tests (Blood urea, serum creatinine):

The procedure was conducted utilizing the electrolyte analyzer Coba 311. The standard range for blood sodium concentration is 135 to 145 mEq/L or 135 to 145 mmol/L when expressed in international units.

2. Radiological examination

- Chest X-ray Postero-anterior view.
- Chest ultrasound if needed in some cases.
- CT chest if needed in selected cases.
- Echocardiogram if needed in some cases.

- Arterial blood gases (ABG):** It was done by using electrolyte analyzer GEm premier model 3000.

Blood sampling procedure:

A blood sample was obtained, and serum was subsequently prepared in accordance with established laboratory protocols. Upon admission, laboratory assessments encompass electrolyte profiles, which include sodium, potassium, chloride, calcium, magnesium, and bicarbonate levels.

A volume of four milliliters of venous blood was obtained from each patient via a sterile venipuncture and was subsequently allocated as follows: One milliliter of venous blood was introduced into a receptacle containing EDTA as an anticoagulant for the purpose of performing a complete blood count (CBC). A volume of one milliliter of blood was introduced into the unfilled tube for the purpose of performing a C-reactive protein (CRP) test. Centrifugation at 2000 to 3000 revolutions per minute for 20 minutes is the recommended procedure after letting 2 milliliters of venous blood coagulate for 10 to 20 minutes. After that, serum is obtained by painstakingly removing the supernatant. In order to perform an arterial blood gas (ABG)

analysis, half a milliliter of venous blood was added to a tube that already contained an anticoagulant, namely heparin.

- A normal range for serum sodium concentration is 135 to 145 mmol/L. Hyponatremia was defined as serum sodium levels below 135 mmol/L and hypernatremia as those above 145 mmol/L.
- It was considered normal for serum potassium levels to be between 3.6 and 5.5 mmol/L. Hypokalemia was defined as a value below 3.6 mmol/L and hyperkalemia as a value above 5.5 mmol/L.
- Serum Calcium value within 8.8 to 10.7 mg/dL range is considered normal. A value below 8.8 mg/dL was considered Hypocalcemia while a value greater than greater than 11.5 mg/dL was considered Sever hypercalcemia
- Serum Magnesium value in the 1.46 to 2.68 mg/dL range was considered normal. A value less than 1.46 mg/dL was considered Hypomagnesemia while a value greater than greater than 2.68 mg/dL was considered Hypermagnesemia.

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Results

Table 1: Demographic data and Clinical presentation for patients with pneumonia and control

1: Demographic data			
Variable		Pneumonia N=100	Control N=50
Gender	Male n (%)	50(50 %)	25 (50%)
	Female n (%)	50(50 %)	25 (50%)
Age (Months)	(Range)	(2-180)	(2-180)
2: Clinical presentation of patients with pneumonia			
Variable		Pneumonia n=100	
Fever n (%)		70 (70%)	
Tachypnea n (%)		99 (99%)	
Cough n (%)		60 (60%)	
Other manifestations n (%)		30 (30%)	
3: Descriptive statistics for vitals parameters in patients with pneumonia			
		Pneumonia n=100	
RR median (IQR)		56.5 (45, 60)	
RS (Respiratory Score) median (IQR)		5 (4, 7)	
HR mean (SD)		135.67 (15.233)	
BP Mean (IQR)	Systolic	80 (78, 80)	
	Diastolic	50 (49, 50)	
Temperature median (IQR)		38 (37, 38.5)	
O2 saturation median (IQR)		91 (89, 92.75)	

P-value $>.05$ is considered non- significant, P-value $\leq .05$ is considered significant. a: Pearson Chi-Square

This table shows no statistically significant difference between the groups with respect to age or gender, and that the most common presentation is tachypnea (99%).

Table 2: Descriptive statistics for acute phase reactants parameters of pneumonia and control patients

	Pneumonic N=100	Controlled N=50	p.value
TLC x 10 ³	14.00	7000	<0.001*
CRP mg/l	22.5	4000	<0.001*

P-value $>.05$ is considered non- significant, P-value $\leq .05$ is considered significant. *: Mann- Whitney U test.

This table shows highly significant difference between cases and control regarding acute phase reactants

Table 3: Incidence of hyponatremia and hypernatremia in patients with pneumonia and control patients

Variable	Pneumonia N=100	Control N=50	P- value
Sodium level (mEq/l) Median (IQR)	136 (132, 138)	138 (136, 139)	<0.001
Hyponatremia sodium 135mEq/l N (%)	35 (35%)	3 (6%)	<0.001
Mild hyponatremia sodium 130-134 mmol/L	20 (20%)		0.002
Moderate hyponatremia sodium 121- 129 mmol/L N (%)	15 (15%)	2 (4%)	0.045 0.056*
Normonatremia >135	65 (65%)	47 (94%)	<0.001

P-value >.05 is considered non- significant, P-value ≤.05 is considered significant. *: Fisher's exact test.

Table 3 shows that there was a statistically significant difference between patents with pneumonia and control patients regarding sodium level generally. In addition, there was also significant difference between the two groups regarding the occurrence of hyponatremia with its mild and moderate grades of severity.

Table 4: Severity and incidence of complications in patients with pneumonia

Variable	Pneumonia N=100	
Severity	Severe pneumonia (PRESS score ≥ 9 points)	7 (7%)
	Moderate pneumonia (PRESS score 5 – 8)	93 (93%)
Complications	Necrotizing pneumonia	9 (9%)
	Effusion	2 (2%)
	Lung abscess	1 (1%)

Table 4: shows that concerning the severity, 7 patients had severe pneumonia, while the remaining 93 patients had moderate pneumonia. Regarding the complications, Necrotizing pneumonia was present in 9% (9 patients) of those with pneumonia, effusion in 2% (2 patients), and lung abscess in 1% (1 patient).

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Table 5: Relationship between serum sodium levels and severity in patients with pneumonia

Contingency Tables				Correlation coefficient		
	Severity			P-value	Phi-coefficient	Cramer's V
Sodium level:	Moderate	Severe	Total			
Normonatremia	64	1	65	0.004	0.292	0.292
Hyponatremia	29	6	35			
Total	93	7	100			

Table 5: shows that there was statistically significant correlation between serum sodium levels and severity in patients with pneumonia with a coefficient of 0.292 (weak correlation).

Table 6: Relationship between serum sodium levels and complications in patients with pneumonia

Contingency Tables				Correlation coefficient		
	Complications			P-value	Phi-coefficient	Cramer's V
Sodium level	Yes	No	Total			
Normonatremia >135	1	64	65	<0.001	0.412	0.412
Hyponatremia<135	10	25	35			
Total	11	89	100			

Table 6: demonstrates that there was statistically significant correlation between serum sodium levels and complications (including consolidation, effusion, and lung abscess) in patients with pneumonia with a coefficient of 0.412 (moderate correlation). Complications are: pleural effusion, necrotizing pneumonia, lung abscess.

Table 7: Incidence of hypokalemia, hyperkalemia and other electrolytes disturbance in patients with pneumonia and control patients

Variable	Pneumonia N=100	Control N=50	P-value
Potassium level (mEq/l) Median (IQR)	4 (4, 5)	4 (4, 5)	0.867
Hypokalemia < 3.5 mEq/l N (%)	10 (10%)	4 (8%)	0.691
Normokalemia (3.5-5) mEq/l N (%)	90 (90%)	46 (92%)	0.691
Hypocalcemia < 8.5 mEq/l N (%)	1 (1%)	2 (4%)	0.216
Normocalcemia (8.5-10.5) mEq/l N (%) ¹	98 (98%)	45 (90%)	0.029
Hypercalcemia > 10.5 mEq/l N (%)	1 (1%)	3 (6%)	0.073
Hypomagnesemia < 1.8 mg/dl N (%)	3 (3%)	1 (2%)	0.72
Normo-magnesemia (1.8-2.6) mg/dl N (%) ¹	97 (97%)	49 (98%)	0.72
Chloride level (mEq/l) Median (IQR)	101 (99, 103)	100 (99, 102)	0.531
Hypochloremia < 95 mEq/l N (%)	1 (1%)	0	0.478
Normochloremia (95-110) mEq/l N (%) ¹	99 (99%)	50 (100%)	0.478

P-value >.05 is considered non- significant, P-value ≤.05 is considered significant.

Table 7 shows that there was not a statistically significant difference between patents with pneumonia and control patients regarding potassium level generally. the results show that the calcium levels of the control group and patients with pneumonia are significantly different from one another. A comparison of the magnesium and chloride levels in the control group and the pneumonia patients showed no statistically significant difference. In terms of hypomagnesemia, hyperchloremia, or hypochloremia, no statistically significant difference was found between the two groups.

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Table 8: Correlation between serum electrolyte levels and acute-phase reactants & the Relationship between serum electrolytes levels and days in hospital

		Na	K	Ca	Mg	Cl
TLC	Spearman's rho	-0.180	0.109	-0.211	0.077	0.074
	p-value	0.027	0.186	0.01	0.347	0.366
CRP	Spearman's rho	-0.274	-0.072	-0.142	0.118	0.045
	p-value	< .001	0.379	0.083	0.15	0.584
Days in hospital	Spearman's rho	0.123	0.273	-0.253	0.264	0.065
	p-value	0.132	<0.001	0.002	0.001	0.429

Table 8 shows that there is a statistically significant negative correlation between serum sodium and calcium levels and total leucocytic count; while only sodium significantly correlates with C-reactive protein and shows that there is no statistically significant correlation between serum sodium and chloride levels and days in hospital. On the other side, there was a statistically significant correlation between serum potassium, calcium, and magnesium levels and days in hospital.

Discussion

The present study evaluated the frequency of clinical features in pneumonia patients, identifying tachypnea as the most common symptom (99%). No statistically significant difference was found between the clinical presentations of basal and lobar pneumonia. Hamed et al. [5] similarly reported that, among 100 infants with community-acquired pneumonia (CAP), cough (76%), expectoration (60%), and respiratory distress (100%) were predominant symptoms.

A significant difference was observed between pneumonia patients and the control group regarding sodium and calcium levels, with pneumonia patients exhibiting reduced levels. Mild and moderate hyponatremia were more common in pneumonia patients, but no severe hyponatremia or hypernatremia was detected. However, no significant differences were noted for potassium, chloride, magnesium, urea, and creatinine. Pande et al. [6] examined 80 children

with severe pneumonia and found that electrolyte imbalances were associated with prolonged hospital stays and increased ICU admissions.

Pande et al. [6] also reported that among 80 children with severe pneumonia, 59% had dyselektrolytemia, including hyponatremia (39%), hypokalemia (15%), hypernatremia (4%), and hyperkalemia (1%). Similarly, Hamed et al. [5] found significantly lower sodium levels in pneumonia patients compared to controls ($p < 0.001$). Other studies [7, 8] have established that hyponatremia correlates with longer hospital stays. Nair et al. [9] reported a significant decrease in serum sodium levels among 342 CAP patients, suggesting that inappropriate ADH release contributes to hyponatremia in up to 68% of hospitalized children with pneumonia. [10] Hypotonic intravenous fluids further exacerbate this condition.

Pneumonia patients often exhibit lower serum vitamin D levels, impairing calcium

absorption and leading to hypocalcemia. Severe pneumonia has been linked to significantly lower vitamin D levels. The systemic inflammatory response in pneumonia affects calcium metabolism, with cytokines interfering with parathyroid hormone secretion and increasing calcitonin levels, further reducing calcium.^[11]

Our findings indicate a weak correlation between serum sodium levels and pneumonia severity ($r=0.292$) and a moderate negative correlation with complications ($r=0.412$), consistent with Joshi et al.^[3], who found higher mortality rates in patients with electrolyte disturbances. Hamed et al.^[5] reported that hyponatremia severity correlated with respiratory distress ($p=0.001$). Rahul and Jose et al.^[12], however, found that while hyponatremia was associated with increased ICU admissions (17.9%, $p=0.000$) and prolonged hospital stays (>2 days, $p=0.001$), it was not a reliable indicator of disease severity.

Jayaraj and Srinivasa^[13] found that pneumonia patients with hyponatremia had significantly longer hospital stays (9.54 ± 2.63 days) compared to normonatremic patients (6.43 ± 1.16 days). Ndirangu et al.^[14] demonstrated that hyponatremia prevalence was higher in very severe pneumonia (81.8%) than in severe cases (59.7%) ($p=0.002$). Zilberberg et al.^[15] found that hyponatremia in CAP patients was linked to worse clinical and financial outcomes. Ellison and Berl et al.^[16] observed that hyponatremia prolonged hospital stays by 60% and increased mortality risk 3.5 times.

Nair et al.^[9] also found that hyponatremia was more prevalent in severe CAP cases, correlating with increased complications. Our study noted significant increases in total leukocyte count (TLC) and C-reactive protein (CRP) levels in pneumonia patients compared to controls. A significant negative correlation was found between serum sodium and calcium levels

and TLC, while sodium alone correlated with CRP levels. These findings align with Hamed et al.^[5], who reported significantly elevated TLC and CRP levels in pneumonia patients ($p<0.001$).

Park et al.^[10] examined 3,938 children with respiratory infections, finding a negative correlation between sodium levels and WBC ($p=0.037$), CRP ($p<0.0001$), and hospital stay duration ($p=0.020$). Yılmaz et al.^[17] similarly found a negative correlation between serum sodium and CRP ($r=-0.178$; $p<0.001$) and WBC ($r=-0.121$; $p=0.004$), suggesting careful monitoring of sodium levels in patients with high acute-phase reactants.

Selcuk Duru et al.^[18] found that pneumonia patients with hyponatremia had significantly higher leukocyte counts, neutrophil percentages, CRP, and creatinine levels than normonatremic patients ($p=0.001$, $p=0.025$, and $p=0.019$, respectively). Valerio et al.^[19] reported that hyponatremia in pediatric respiratory infections correlated with increased WBC, neutrophil count, and CRP levels.

Finally, pneumonia severity influences sodium levels. Children with severe pneumonia exhibit higher heart rates and prolonged fever, leading to increased inflammatory markers such as CRP and leukocytes. This inflammation correlates with more severe hyponatremia, suggesting a direct link between inflammation and sodium imbalance.^[20]

Conclusion: Hyponatremia is not uncommon finding in children with CAP, hypocalcemia may be occurred also with pneumonia. It appears that the severity of pneumonia and the number of days admitted to the hospital are related to the degree of hyponatremia. The control and pneumonia groups did not differ significantly with respect to potassium, chloride, or magnesium levels.

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