

The prevalence and prognostic effect of hyponatremia in children with COVID-19 pneumonia: a retrospective study

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ABSTRACT

Background. The aim of the study was to examine the effect of hyponatremia at admission as a negative prognostic factor in children hospitalized with COVID-19 pneumonia.

Methods. The data of patients aged 1 month-18 years, who were followed with the diagnosis of pneumonia at Çanakkale Onsekiz Mart University Hospital, Department of Pediatrics, between January 2018 and May 2021 were examined, retrospectively. Patients (n=661) were divided into two main groups; COVID-19 pneumonia (n=158) and the other pneumonias [other viral pneumonia (n=161) and pneumonia of unknown etiology (n=342)].

Results. Six hundred and twenty-three patients with a median (Q1-Q3) age of 4 (1.5-8) years, 59.4% of whom were male were included in the study. The overall prevalence of hyponatremia at admission was 11.2% and was lower in those with COVID-19 pneumonia than in those with other viral pneumonia (6.4% vs. 15.2%, p=0.013). When evaluated irrespective of their COVID-19 status, hyponatremic patients had a higher supplemental oxygen requirement (OR 2.5 [1.4-4.3], p<0.001), higher need for intensive care unit (ICU) admission (OR 3.7 [1.3-10.2], p=0.009) and longer duration of hospitalization (p=0.016) than the normonatremic patients. In patients with COVID-19 pneumonia, being hyponatremic had no effect on supplemental oxygen requirements or the duration of hospitalization. When hyponatremic patients were evaluated, the supplemental oxygen requirements and duration of hospitalization of those with COVID-19 pneumonia were similar to the other pneumonias (p>0.05 for all comparisons). However, normonatremic COVID-19 pneumonias had higher supplemental oxygen requirements than other viral pneumonias and pneumonia of unknown etiology (OR 4.7 [2.2-10.3], p<0.001; OR 1.6 [1 -2.7], p=0.043, respectively).

Conclusion. This study found that hyponatremia at admission is rarer in children with COVID-19 pneumonia than other viral pneumonias and has no effect on supplemental oxygen requirements or the duration of hospitalization.

Key words: child, hyponatremia, COVID-19, prevalence, prognosis.

Hyponatremia is the most common electrolyte disturbance in clinical practice and in critically ill children and is present in approximately 3-30% of hospitalized patients. It is also the most common electrolyte disorder in children hospitalized for community-acquired pneumonia (CAP), and its incidence is estimated to be 13-35%.^{1,2} However, despite its

clinical significance, the prognostic effect of hyponatremia in children with CAP remains unclear.³

Hyponatremia in children with pneumonia has been attributed to inappropriate antidiuretic hormone secretion (SIADH) and hypovolemia. Serum sodium levels have been shown to be inversely proportional to inflammatory biomarkers in pneumonia patients/children. Therefore, hyponatremia may be a biomarker for the degree of inflammation and may reflect the severity of infection in CAP.² Since the first case reported from Wuhan, China in December

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Received 30th November 2022, revised 3rd March 2023,
accepted 1st May 2023.

2019, the coronavirus disease 2019 (COVID-19) pandemic has resulted in approximately 586 million infections and 6.5 million deaths worldwide as of August 2022.⁴ It is known that COVID-19 causes hyponatremia in adults because it affects the lungs, heart and kidneys and causes a multisystem inflammatory response.^{5,6} COVID-19 may also cause SIADH in children through two potential mechanisms. First, interleukin-6 released from monocytes and macrophages crosses the blood-brain barrier and indirectly stimulates vasopressin release.^{2,7} Second, damage to lung tissue and alveolar cells may cause ventilation-perfusion dysfunction and compensatory hypoxic pulmonary vasoconstriction. This, in turn, causes a decrease in atrial tension and an increase in vasopressin release due to insufficient filling of the left atrium. Hyponatremia due to hypovolemia, on the other hand, is due to insufficient oral intake, insensible fluid losses (fever, tachypnea, etc.) and gastrointestinal sodium loss (vomiting, diarrhea, etc.).² In addition, hyponatremia and other electrolyte disturbances may develop as SARS-CoV-2 uses angiotensin-converting enzyme 2, which is the main regulator of the renin-angiotensin system, to enter the cell.⁸ Therefore, severe inflammation-induced hyponatremia may also be a prognostic marker for negative outcomes in patients infected with COVID-19.⁹ Although hyponatremia has been reported¹⁰ in children with multisystem inflammatory syndrome (MIS-C), we could not find a study examining the prevalence and effect on prognosis of hyponatremia in children hospitalized for COVID-19 pneumonia. Therefore, the aim of the study was to determine the prevalence and examine the effect of hyponatremia at admission as a negative prognostic factor in children hospitalized with COVID-19 pneumonia.

Material and Methods

Design sample and data collection

The data of patients aged 1 month-18 years, who were followed with the diagnosis of CAP

at Çanakkale Onsekiz Mart University Hospital, Department of Pediatrics, between January 2018 and May 2021 were examined retrospectively.

Sociodemographic variables as well as clinical features such as symptom duration, presence of dehydration, severity of pneumonia, infectious etiology, supplemental oxygen requirement ($sPO_2 < \%92$), need for intensive care unit (ICU) admission (≥ 24 hours, non-invasive/invasive ventilation), duration of hospitalization (≥ 24 hours) and laboratory parameters including complete blood count (CBC) parameters [white blood cell (WBC), neutrophil, lymphocyte, eosinophil, monocyte, platelet (PLT) counts and hemoglobin level], C-reactive protein (CRP), procalcitonin (PCT), erythrocyte sedimentation rate (ESR), serum albumin and sodium levels were evaluated from medical records. The patients with marked tachypnea, retraction, grunting respiration, nasal flaring, intermittent apnea, cyanosis, altered mental status, hypoxemia, or capillary refill time ≥ 2 seconds was classified as having severe pneumonia.

Groups and definitions

The CAP patients were divided into two main groups: the patients with COVID-19 pneumonia (COVID-19 group) and the other pneumonias. The COVID-19 group were further divided into those with a positive nasopharyngeal swab sample SARS-CoV-2 polymerase chain reaction (PCR) test or negative PCR test but having lung tomography compatible with COVID-19 pneumonia by the radiology department. The other pneumonias were also divided into two subgroups consisting of other viral pneumonia (viral group) and pneumonia of unknown etiology (unknown group). The viral group consisted of patients who had nasopharyngeal swab PCR positivity with other respiratory viral agents (influenza, respiratory syncytial virus, etc.). Clinically decided bacterial or viral CAP in which the PCR sample was negative for SARS-CoV-2 or other respiratory viruses or not studied were called "pneumonia of unknown etiology". The patients were divided into three subgroups according to their sodium

levels at admission, as hyponatremic (<135 mmol/L), normonatremic (135-145 mmol/L) and hypernatremic (>145 mmol/L). Patients with primary/secondary immunosuppression, chronic cardio-pulmonary diseases except asthma, hospitalization within 14 days before admission, MIS-C and renal or adrenal insufficiency were excluded from the study.

The study was conducted according to the principles of the Declaration of Helsinki and was approved by the local clinical research ethics committee [dated 06.05.2021, no: 05-26].

Outcome measures

The parameters examined as negative prognostic factors were oxygen requirement, need for ICU admission, and duration of hospitalization and increased and/or decreased levels of inflammatory biomarkers where appropriate in terms of CBC parameters, CRP, PCT, ESR, and albumin and serum sodium level.

Statistical analysis

Descriptive analyses were presented using mean±standard deviation (SD) or median and inter-quartile range (Q1-Q3) for normal or non-normally distributed data, respectively. Frequency (n) and percentage (%) were used for categorical variables. Continuous variables without a normal distribution including demographic variables, presence of dehydration, and severity of pneumonia were compared using the Kruskal-Wallis test and categorical variables using the chi-square test. The study parameters, prevalence of hyponatremia were tested with the chi-square, the Mann-Whitney U, Pearson or Spearman's correlations where appropriate. Odds ratios of the risk factors for adverse outcomes were calculated by binary logistic regression analysis [odds ratio (95% CI)]. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23.0 software (IBM, New York, USA).

Results

Patient demographics

Six hundred and sixty-one patients with CAP were hospitalized between January 2018 and May 2021, 38 of whom were excluded according to the exclusion criteria. Therefore, 623 patients with a median (Q1-Q3) age of 4 (1.5-8) years, 59.4% of whom were male, were included in the study (Fig. 1). The median duration of hospitalization was (Q1-Q3) 4 (2-5), 3 (1-4) and 4 (2-5) days in COVID-19, viral and unknown groups, respectively.

The main clinical features of the groups are shown in Table I. There was a higher rate of vomiting and diarrhea in the COVID-19 group compared to the viral and unknown groups (14.4% vs. 7% and 5%, p=0.002), but there was no difference in the presence of dehydration between these groups (p=0.611). The COVID-19, viral and unknown groups were similar in terms of gender and age (p=0.066, p=0.336, respectively). The viral group had a lower symptom duration than the other two groups at admission (3 vs. 2 days, p=0.001). The rate of severe pneumonia was similar in the COVID-19 and unknown groups (48% vs. 50.6%, respectively, p=0.619) but higher than in the viral group (32.9%, p=0.007).

Dysnatremia prevalence

The overall prevalence of hyponatremia and hypernatremia were 11.2% (n=70) and 2.7% (n=17) at admission in all of the study participants. Although the rates of vomiting/diarrhea and severe pneumonia were higher in the COVID-19 group, they had a lower prevalence of hyponatremia compared to the viral group (6.4% vs. 15.2%, p=0.013).

The main laboratory parameters of the groups are shown in Table II. There was no statistically significant difference between the groups in hyponatremic patients in terms of gender, age, duration of hospitalization, presence of dehydration and severity of pneumonia (p=0.995, p=0.533, p=0.063, p=0.351, p=0.959, respectively).

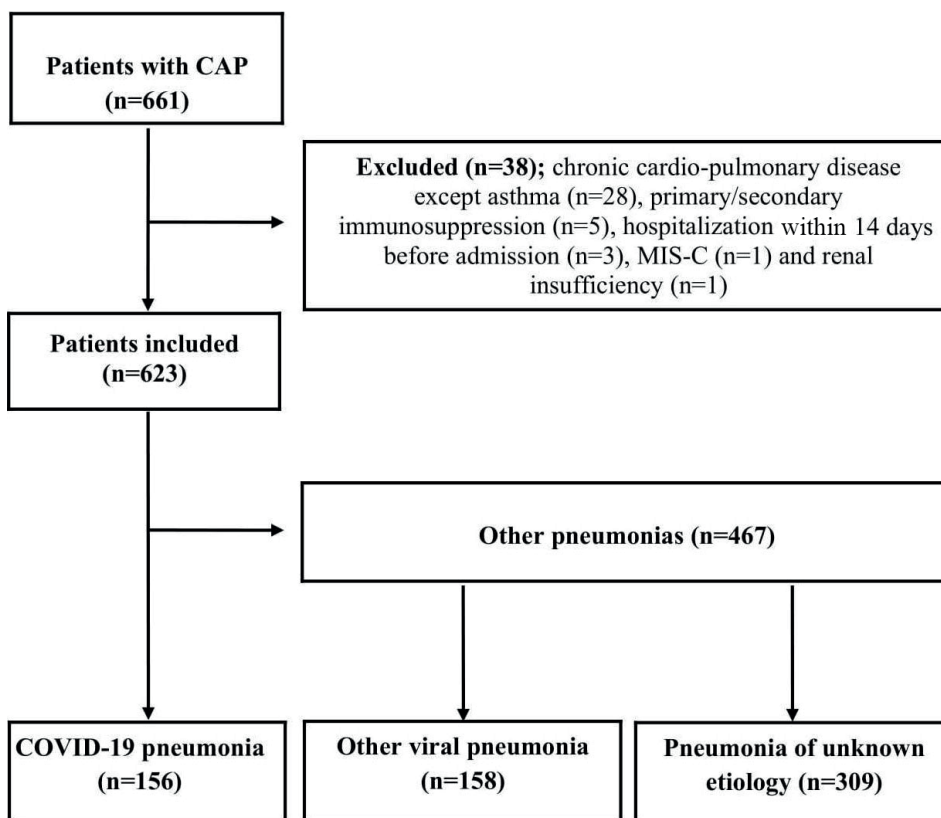


Fig. 1. Flow chart of the study. CAP: community acquired pneumonia, MIS-C: multisystem inflammatory syndrome-children.

Table I. The basic characteristics of the patients according to their serum sodium levels at admission.

Basic characteristics	COVID-19 group		Other pneumonia group									
			Viral group		Unknown group							
	Hyponatremic (n = 10)	Normonatremic (n = 142)	Hyponatremic (n = 24)	Normonatremic (n = 131)	Hyponatremic (n = 36)	Normonatremic (n = 263)						
	N	%	N	%	N	%	N	%	N	%		
Gender, male	6	60	77	54.2	14	58.3	83	63.4	21	58.3	159	60.5
Age, years	4.2 (1-6.3)		5 (2-9.6)		3.2 (1-4.3)		4 (1.5-7)		3 (1.1-6.3)		4 (1.5-8)	
Duration of symptoms, day	3.5 (2-6.2)		3 (2-6)		2 (1-4.5)		2 (1-3)		3 (2.2-6)		3 (2-5)	
Presence of dehydration	9	90	13	9.2	17	70.8	2	1.5	24	66.7	23	8.7
Severe pneumonia	6	60	67	47.2	14	58.3	37	28.2	20	55.6	131	49.2
Supplemental oxygen requirement	3	30	37	26.1	9	37.5	9	6.9	12	33.3	46	17.5
Admission to the ICU	-	-	3	2.1	2	8.3	-	-	4	11.1	10	3.8
Duration of hospitalization, day	4 (2-5)		4 (2-5)		4.5 (3-8)		3 (1-4)		3.5 (2-5)		4 (2-5)	

Numerical data are presented as median (Q1-Q3). ICU: intensive care unit.

Table II. Laboratory parameters at admission.

Laboratory parameters	COVID-19 group						Other pneumonia group					
	Viral group		Viral group		Viral group		Viral group		Viral group		Viral group	
	Hyponatremic	Normonatremic	Hyponatremic	Normonatremic	Hyponatremic	Normonatremic	Hyponatremic	Normonatremic	Hyponatremic	Normonatremic	Hyponatremic	Normonatremic
White blood cell, 10 ³ /mm ³	8.4 (6.5-15.6)	6.8 (5.1-9.5)	9.9 (7.4-11.3)	10.7 (6.9-13.4)	10.5 (7.4-11.5)	11.2 (7.6-13.7)						
Neutrophil, 10 ³ /mm ³	4.4 (2.2-7)	2.8 (2-4.4)	5 (2.5-6.6)	4.2 (2.2-8.4)	4.4 (2.5-7.3)	4.7 (2.5-9.3)						
Lymphocyte, 10 ³ /mm ³	4 (2.1-6.7)	2.5 (1.6-4.2)	3.7 (2.1-5.5)	3.8 (2.3-5)	3.6 (2.5-5.5)	3.7 (2.1-5.2)						
Eosinophil, /mm ³	100 (0-197)	85 (0-200)	100 (0-375)	80 (0-200)	100 (0-300)	70 (0-240)						
Monocyte, 10 ³ /mm ³	1 (0.6-1.4)	0.6 (0.4-0.9)	0.7 (0.6-1.2)	0.7 (0.4-1)	0.9 (0.6-1.2)	0.7 (0.4-1)						
Hemoglobin, gr/dL	11.9±0.8	12.3±1.3	10.9±1.8	11.8±1.3	11.4±1.8	11.9±1.3						
Platelets, 10 ³ /mm ³	274 (253-392)	277 (183-347)	351 (269-506)	308 (237-384)	353 (269-417)	323 (262-417)						
CRP, mg/dL	0.3 (0.1-0.9)	0.6 (0.2-1.4)	1.1 (0.7-1.8)	0.8 (0.3-1.8)	1.1 (0.3-1.8)	0.9 (0.1-1.8)						
PCT, ng/mL	0.2 (0.1-0.3)	0.2 (0.1-0.8)	0.4 (0.1-0.8)	0.7 (0.1-0.8)	0.8 (0.2-0.8)	0.8 (0.1-0.8)						
ESR, mm/h	10.8 (7.5-14.2)	9.7 (4-13)	9.3 (5-9.7)	9.7 (7-12)	10 (6-13.7)	8 (4-13)						
Albumin, g/dL	4.3 (3.7-4.4)	4.1 (3.6-4.5)	4 (3.5-4.5)	4 (3.5-4.6)	4.2 (3.7-4.5)	4.2 (3.7-4.6)						
Sodium, mEq/L	133 (132.7-134)	138 (136-139)	133 (131-134)	137 (136-138)	133 (131-134)	137 (136-139)						

Values are presented as mean ± SD or median (Q1-Q3). CRP: C-reactive protein, ESR: erythrocyte sedimentation rate, PCT: procalcitonin.

The association of hyponatremia (at admission) with negative outcomes

Hyponatremics vs. normonatremics

When evaluated irrespective of their COVID-19 status, hyponatremic patients had a higher supplemental oxygen requirement (OR 2.5 [1.4-4.3], p<0.001), higher need for intensive care unit (ICU) admission (OR 3.7 [1.3-10.2], p=0.009) and longer duration of hospitalization (p=0.016) than the normonatremic patients. Hyponatremic patients in the viral group also had higher supplemental oxygen requirements (OR 8.1, [2.7-23.6], p<0.001) and longer duration of hospitalization (p<0.001) than their normonatremic counterparts. Furthermore, within the unknown group, hyponatremic patients had higher supplemental oxygen requirements (OR 2.3 [1.1-5], p=0.027), higher need for ICU admission (OR 3.1 [0.9-10.6], p=0.064) than the normonatremic patients. However, supplemental oxygen requirements (p=0.785) and duration of hospitalization (p=0.705) were not different between the hyponatremic and normonatremic patients within the COVID-19 group.

Hyponatremics vs. hyponatremics

COVID-19 vs. Viral and COVID-19 vs. Unknown: There were no differences among the hyponatremic patients in the COVID-19, the viral and the unknown groups in terms of supplemental oxygen requirements and duration of hospitalization (p>0.05 for all comparisons).

Normonatremics vs. normonatremics

COVID-19 vs. Viral: Patients in the COVID-19 group had higher supplemental oxygen requirements (OR 4.7 [2.2-10.3], p<0.001) and duration of hospitalization (p<0.001) compared with the viral group.

COVID-19 vs. Unknown: Patients in the COVID-19 group had higher supplemental

Table III. The association of baseline laboratory parameters with serum sodium levels.

Baseline laboratory parameters	Other pneumonia group			
	General	COVID-19 group	Viral group	Unknown group
	r	r	r	r
White blood cell [†]	.046	-.123	.200*	.119*
Neutrophil [†]	.112**	-.085	.250**	.187*
Lymphocyte [†]	-.084*	-.041	-.076	-.111*
Eosinophil [†]	.084*	.232**	.034	.023
Monocyte [†]	.041	.012	.196*	-.008
Hemoglobin [†]	.151***	.126	.151*	.147**
Platelets [†]	-.059	.002	-.006	-.079
CRP [†]	-.071*	-.093	-.030	-.040
PCT [†]	-.016	-.113	.068	.078
ESR [†]	.048	.140*	-.030	.015
Albumin [†]	.067	.173*	.039	.005

CRP: C-reactive protein, ESR: erythrocyte sedimentation rate, PCT: procalsitonin. [†]Spearman's correlation test, [‡]Pearson correlation test. *p value<0.05, **p value<0.01, ***p value<0.001.

oxygen requirements (OR 1.6 [1-2.7], p=0.043), but had similar ICU admission (OR 0.5 [0.1-2], p=0.364), and duration of hospitalization (p=0.984) compared with the unknown group.

The relationship between inflammatory biomarkers and serum sodium

When evaluated irrespective of the COVID-19 status, there was a negligible but statistically significant linear correlation between serum sodium levels and lymphocyte count and CRP in a negative direction, and neutrophil, eosinophil count and hemoglobin level in a positive direction ($r < 0.190$, $p < 0.05$). This suggests that those with a higher lymphocyte count and CRP have lower serum sodium levels (Table III).

Patients in the COVID-19 group had lower levels of WBC, neutrophils, lymphocytes, PLT count, CRP and PCT levels than control groups ($p < 0.05$ for all comparisons) (Fig. 2). When hyponatremic patients were evaluated among themselves, those in the COVID-19 group had lower CRP levels than those in the viral group ($p = 0.015$), and lower CRP and PCT levels than those in unknown group ($p = 0.023$, $p = 0.025$, respectively) (Fig. 3).

Discussion

This study, which included 623 patients, had four main findings. First of all, patients with COVID-19 pneumonia had a lower prevalence of hyponatremia at admission compared to the viral pneumonia group. Furthermore, the hyponatremia of patients with COVID-19 pneumonia had no effect on supplemental oxygen requirements or the duration of hospitalization. In addition, the supplemental oxygen requirement of patients with hyponatremic COVID-19 pneumonia was similar to the that of the hyponatremic control groups. Third, although the supplemental oxygen requirement of normonatremic COVID-19 pneumonia patients was higher than the normonatremic control groups, the supplemental oxygen requirement of patients with hyponatremic COVID-19 pneumonia was similar to the hyponatremic control groups. At last, there was no statistically significant correlation between the biomarkers at admission and hyponatremia, but we found that those with a higher lymphocyte count and CRP had lower serum sodium levels. In addition, patients with hyponatremic COVID-19 pneumonia had lower CRP levels than hyponatremic control groups.

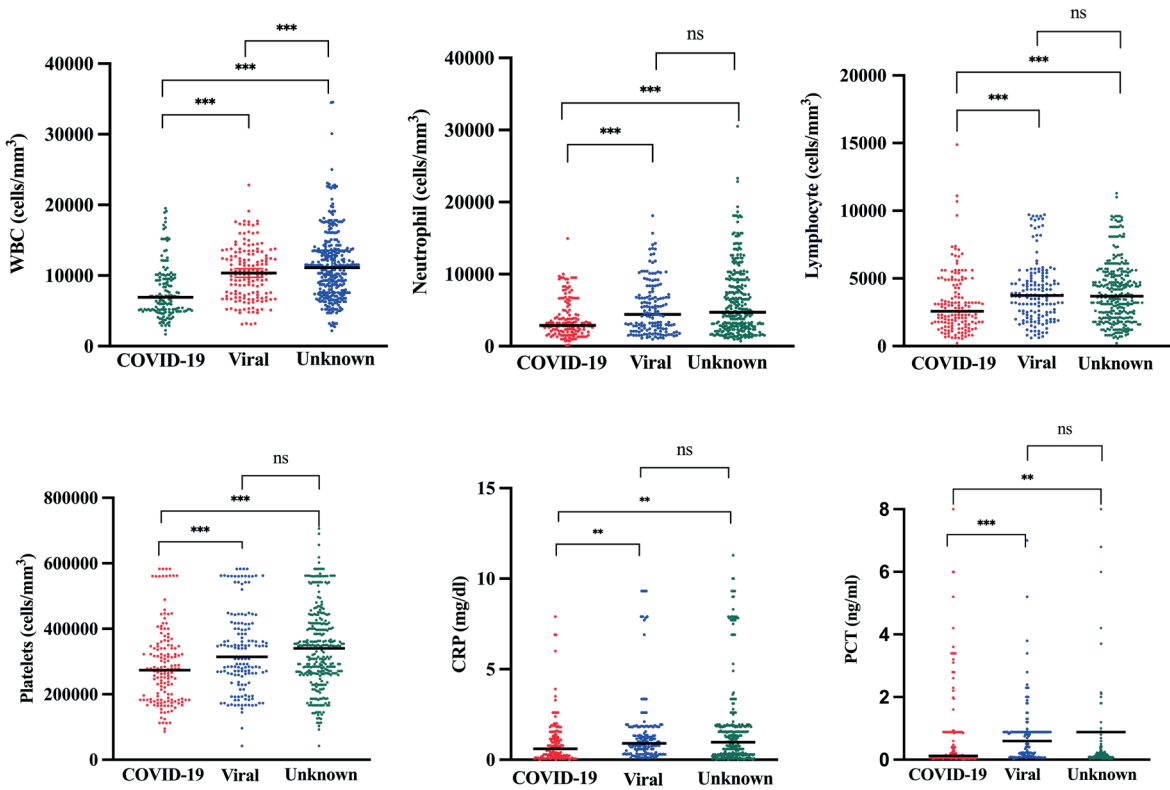


Fig. 2. Comparison of WBC, neutrophil, lymphocyte, PLT count, CRP and PCT levels of patients with COVID-19 pneumonia with the control groups (**p value < 0.01, ***p value < 0.001). CRP: C-reactive protein, PCT: procalcitonin, PLT: platelet, WBC: white blood cell.

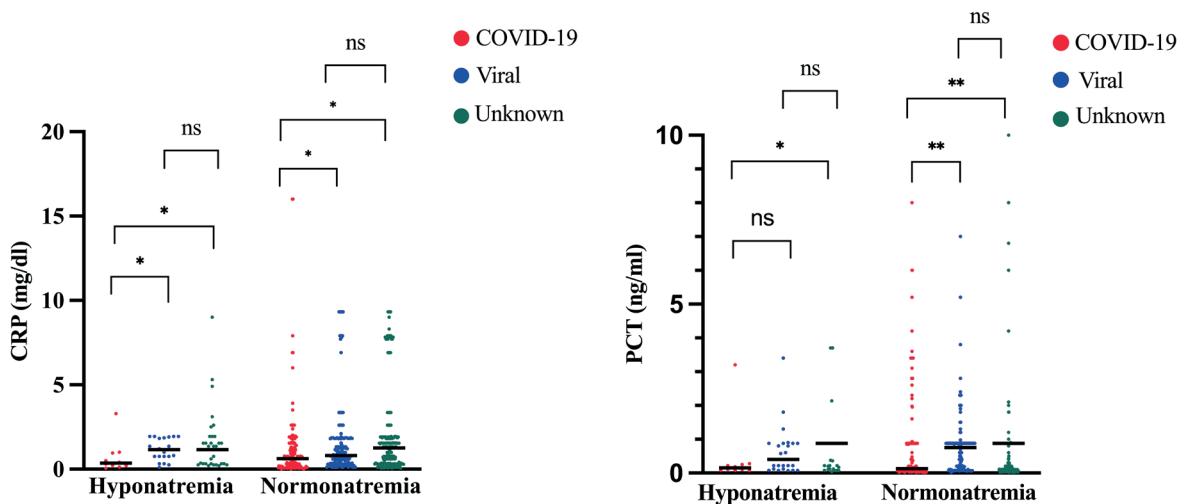


Fig. 3. Comparison of CRP and PCT levels of patients with hyponatremic COVID-19 pneumonia with the control groups (*p value < 0.05, **p value < 0.01). CRP: C-reactive protein, PCT: procalcitonin.

Although CAP is mainly caused by bacteria, viruses are the main etiologic agents in children, and studies report hyponatremia associated with COVID-19 pneumonia.^{9,11} Adult studies

examining the relationship between COVID-19 and hyponatremia report the prevalence of hyponatremia in COVID-19 as 22.9%-63.6%.^{7-9,12,13} In the study where Atila et al.¹⁴

evaluated 1041 adult patients, the prevalence of hyponatremia was higher at admission in patients with COVID-19 compared to the control group (29.1% vs. 17.6%). In studies conducted in the pre-COVID-19 period in children with lower respiratory tract infections, the prevalence of hyponatremia was reported to be 28.9-80%.^{3,15-18} In a study by Park et al.¹⁹ in which they evaluated 3938 children with respiratory tract infections, they reported that the prevalence of hyponatremia was highest (20.7%) in those with human adenovirus (HAdV) infection, and this was due to human adenovirus causing a more intense systemic inflammatory response than other viral infections. In the pediatric population, COVID-19 is known to be an overall less symptomatic and less severe infection compared to HAdV infection. Li et al.²⁰ reported that children with HAdV infection had higher neutrophil count, CRP, and PCT levels compared to COVID-19. It is also known that while COVID-19 causes a more intense systemic inflammatory response in adults due to the inability to limit the viral spread, it does not cause a significant systemic inflammatory response in children.²¹ In our study, the prevalence of general hyponatremia (11.2%) was quite low compared to the literature and was even lower (6.4%) in patients with COVID-19 pneumonia. We speculate that this is due to a lower systemic inflammatory response and thus less SIADH in pediatric COVID-19 pneumonia.

It is thought that hyponatremia may be related to the severity of pneumonia in children.²² While hyponatremia is considered a poor prognostic factor in adults with COVID-19 pneumonia, little is known about it in children.^{3,23} Studies have reported that adults with hyponatremic COVID-19 pneumonia had higher supplemental oxygen requirement, a greater need for ICU admission, a higher mechanical ventilation requirement, a longer duration of hospitalization, and a higher risk of death.^{7,9,12-15,24} Studies conducted in the pre-COVID-19 period report that children with hyponatremic lower respiratory tract infections have higher

mechanical ventilation requirements, longer ICU stays and longer hospital stays.^{3,15} When we evaluated all the patients in our study, those who were hyponatremic had a higher supplemental oxygen requirement, a higher need for ICU admission and a longer duration of hospitalization, consistent with the literature. However, the fact that patients with COVID-19 pneumonia were hyponatremic did not change their supplemental oxygen requirement or duration of hospitalization. This result may be due to the small sample size of patients with hyponatremic COVID-19 pneumonia and further research with a larger sample size is needed to reach a firm conclusion.

Oxygen therapy is necessary in the presence of critical illness in CAP. Long-term oxygen therapy is also required in the treatment of COVID-19, and this period is longer than in influenza cases.²⁵ In a study by Pucarelli et al.²⁶, in which they compared children with COVID-19 with other respiratory viral infections, it was reported that those with COVID-19 had a shorter duration of hospitalization but a higher admission to the ICU. Tasar et al.²⁷ reported that both the admission to the ICU and the duration of hospitalization were higher in children with influenza compared to COVID-19. In our study, the oxygen requirement and duration of hospitalization of patients with hyponatremic COVID-19 pneumonia were similar to those in the hyponatremic control groups. Whereas, patients with normonatremic COVID-19 pneumonia had a higher oxygen requirement and a longer duration of hospitalization than patients in the normonatremic control group, consistent with the literature. We think that this result is due to the small sample size of patients with hyponatremic COVID-19 pneumonia.

Previous studies have shown that hyponatremia is associated with CRP in various infections.¹⁹ Adult studies examining the relationship of hyponatremia with biomarkers in COVID-19 report higher CRP levels, higher WBC counts, and lower lymphocyte counts in hyponatremic patients.^{8,9,12} Studies conducted in the pre-COVID-19 period in children report that

hyponatremic children with lower respiratory tract infections have higher WBC counts and CRP levels.^{3,15,18} In the study of Liang et al.²⁸, in which they compared COVID-19 and influenza A infection in children, it was reported that patients with influenza A infection had lower lymphocyte counts and a higher CRP and PCT levels, and lower neutrophil counts in COVID-19. Tasar et al.²⁷ reported that there was more lymphopenia in the influenza group, but there was no difference between CRP levels. In the study of Liu et al.²⁹ in which they compared COVID-19 and influenza A/HAdV infection in children, they reported higher leukocyte and neutrophil rates in the influenza A and HAdV group, and higher PRC levels in the COVID-19 group. In our study, we found that patients with hyponatremic COVID-19 pneumonia had lower CRP levels compared to the hyponatremic control groups, consistent with the literature. However, the CBC parameters of patients with hyponatremic COVID-19 pneumonia were not different from the hyponatremic control groups. Evaluation of serum sodium levels in conjunction with inflammatory biomarkers in adult COVID-19 is thought to be helpful both in predicting serious disease and in identifying patients likely to benefit from early interventions.⁸ However, our results suggest that assessment of serum sodium levels with inflammatory biomarkers at admission in children cannot yet be used to predict negative outcomes in pediatric COVID-19 pneumonia.

This study has some limitations. First, we could not analyze ICU admissions in all groups due to the small number of patients in some subgroups. Second, we could not exclude viral co-infections since only SARS-CoV-2 PCR was evaluated in the microbiology laboratory during the pandemic period. Finally, we did not evaluate bacterial co-infections in SARS-CoV-2 and other viral PCR positive patients. The strength of this study is that it is one of the first studies with a control group in children with hyponatremic COVID-19 pneumonia and therefore we think that it will add valuable information to the literature.

This study found that hospital admission hyponatremia is a rarer finding in children with COVID-19 pneumonia than other viral pneumonias, and has no effect on supplemental oxygen requirements or the duration of hospitalization. However, when all pneumonia cases were considered, hyponatremic patients had a higher supplemental oxygen requirement, a greater need for ICU admission and a longer duration of hospitalization. Therefore, the authors argue that studies with larger sample sizes are needed to see if serum sodium levels are associated with negative outcomes in children with COVID-19 pneumonia.

Acknowledgement

We thank Özlem Yılmaz, Professor of Pediatric Allergy and Immunology at Çanakkale Onsekiz Mart University, for help in critically revising the manuscript.

Ethical approval

The study was conducted according to the principles of the Declaration of Helsinki and the study was approved by Çanakkale Onsekiz Mart University ethics committee (dated 06.05.2021, no: 05-26).

Author contribution

The authors confirm contribution to the paper as follows: study conception and design: TÇ, DD, ÇFP; data collection: TÇ, DD, ÇFP; analysis and interpretation of results: TÇ, DD, ÇFP; draft manuscript preparation: TÇ, DD, ÇFP. All authors reviewed the results and approved the final version of the manuscript.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

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