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The diagnostic value of complete blood parameters in determining the severity of community-acquired pneumonia in children

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ABSTRACT

Aim: In children, community-acquired pneumonia (CAP) has a high mortality and morbidity rate. Platelet, neutrophil, lymphocyte, monocyte, eosinophil, red cell distributions width (RDW), mean platelet volume (MPV), platelet distributions width (PDW), platelet to lymphocyte ratio (PLR), and neutrophil to lymphocyte ratio (NLR) have all been suggested as markers of systemic infection and inflammation. Several research, however, have centered on the clinical significance of blood parameters in pediatric CAP. We aim to determine the diagnostic value of complete blood parameters for CAP and to look into their relationship to disease severity.

Material and Method: A retrospective, the cross-sectional study enrolled children aged 3 months to 18 years who were diagnosed with CAP at Ankara Atatürk Sanatorium Training and Research Hospital's pediatrics clinics between January 2018 and June 2021, as well as age-matched healthy children. CAP case definition was made according to the CAP case definition defined by the World Health Organization (WHO). Patients were evaluated according to the criteria of WHO and British Thoracic Society 2011 guidelines as severe and mild CAP.

Results: 400 CAP and 400 control patients were included in the study. The mean age of the CAP group was 2.40±3.20 years and the control group was 2.38±3.17 years. Eosinophil, hemoglobin, MPV, PDW and PLR values of the CAP group was statistically significantly lower; leukocytes, lymphocyte, monocyte, neutrophil, basophil, platelet, RDW, and NLR levels of the CAP group were higher than the control group ($p<0.05$). 30.3% of the CAP patients had severe disease. The mean age of the severe group was 2.92±3.80 and 2.17±2.88 in the mild group. The ratio of males in the CAP group was 62%, while 80.2% in severe, 54.1% in the mild group ($p<0.001$).The mean hospitalization length for the severe group was 6.16±2.00 days and 4.89±1.78 days for the mild group ($p<0.001$). CRP, neutrophils, monocyte, eosinophil, and NLR levels were statistically significantly higher in patients in the severe group than the mild group ($p<0.001$). In ROC analysis, the area under the characteristic curve (AUC) for CRP, monocyte, neutrophils, eosinophil, and NLR was calculated as 0.574, 0.569, 0.601, 0.628, and 0.583, respectively and all found statistically significant ($p<0.001$). Correlation analysis revealed that CRP had a positive correlation with neutrophil count ($r=0.231$, $p=0.011$) and NLR ($r=0.221$, $p=0.015$) in the severe COP patients.

Conclusion: Increased neutrophils, eosinophil, monocytes, CRP, and NLR, were predicting the severity of CAP. NLR and neutrophils had a significant correlation with CRP and potential parameters for evaluating the severity of CAP disease.

Keywords: Community-acquired pneumonia, children, neutrophils, neutrophil-to-lymphocyte ratio, monocyte, eosinophil, diagnostic value

INTRODUCTION

Community-acquired pneumonia (CAP) is a significant and common cause of hospitalization in children (1, 2). In developing countries, hospitalization for childhood CAP accounts for 8.7% of all hospitalizations and accounts for approximately 19% of all deaths in children below the age of five (3). Because CAP can cause mild to severe illness, it continues to cause an increasing rate of complications and fatality, despite the advancement of new therapeutic interventions (4). The greatest difficulty for a clinician is risk determination of children with CAP; thus, therefore, earlier risk detection is important to reduce mortality and morbidity.

Leucocyte count, erythrocyte sedimentation rate, and C-reactive protein (CRP) widespread utilized with chest X-ray for diagnosis, treatment planning, identifying patients at risk and evaluating progression of CAP. Their specificity and sensitivity for forecasting CAP severity, even so, are changeable and primarily not enough (4). As a result, more screening tests are speedily required to determine disease severity and clarify the diagnostics. While these tests are being developed, it is critical that they are affordable and easily accessible so that they can be used in less developed countries where CAP is most prevalent.

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Complete blood count (CBC) markers; such as platelets, monocyte, lymphocytes, neutrophils, as well as the red cell distribution width (RDW), mean platelet volume (MPV), platelet distribution width (PDW) platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR) have been suggested as predictors of infection and inflammation in variety of diseases (5-8). Although there are few studies in adults on the importance of blood parameters in CAP, there are almost none in children (4,9).

As a result, this research analyzed the clinical and laboratory characteristics of 400 children with CAP and looks back at platelet, monocyte, lymphocyte, neutrophil, eosinophil, RDW, PDW, MPV, PLR, and NLR levels in CAP patients to assess their clinical utility and connection with disease severity.

MATERIAL AND METHOD

The study was carried out with the permission of Health Science University Keçiören Training and Research Hospital Clinical Researches Ethics Committee (Date: 9.11.2021, Decision No: 2012-KAEK-15/2416). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. With the ethics committee approval, the data were scanned retrospectively using the Hospital Information Management System.

A retrospective, cross-sectional study included children aged 3 months to 18 years who diagnosed with CAP at Ankara Atatürk Sanatorium Training and Research Hospital's pediatrics clinics between January 2018 and June 2021, as well as age-matched healthy children. CAP case definition was made according to the community-acquired pneumonia case definition defined by the World Health Organization (WHO):

- Any child presenting with cough or difficulty breathing;
- Tachypnea >40/min (12-59 months); >30/min (≥60 months);
- Abnormal chest X-ray findings accompanying drawling findings (consolidation or perihilar infiltration) with or without wheezing (10).

The presence of severe disease will be determined according to WHO and British Thoracic Society 2011 guidelines (11, 12). Patients with underlying chronic disease, a history of recent hospitalization, and suspected hospital-acquired infection did not be included in the study. The control group will consist of healthy children aged between 3 months and 18 years, without chronic inflammatory disease, blood disease, and acute infection.

Data on the patient age, gender, clinical features, CBC and CRP were collected: CBC was performed using the ADVIA 2120 Hematology System (Siemens Healthcare Diagnostics, Erlangen, Germany). A radiologist evaluated the patients' chest radiographs, which were derived from the hospital's dataset, for the existence of indications promoting a diagnosis of CAP. All variables were compared between groups.

Statistical Analyses

SPSS for Windows, version 22.0, was used to analyze the data (SPSS Inc., Chicago, IL, United States). The Kolmogorov Smirnov test was used to determine whether the distribution of continuous variables was normal or not. The Levene test was used to assess variance homogeneity. For skewed distributions, continuous data were described as mean SD and median (Q1: first quartile - Q3:third quartile). The number of cases (%) was used to describe categorical data. The Mann Whitney U test was used to compare differences in not normally distributed variables between two independent groups. Pearson's chi-square test or Fisher's exact test were used to compare categorical variables. On all statistical analyses, the p-value of 0.05 was accepted as the significant level. The cutoff values for CRP, monocytes, neutrophils, eosinophil, and NLR associated with the risk of severe disease were determined using ROC curve analysis. It was evaluated degrees of relation between variables with Spearman Correlation analysis.

RESULTS

400 CAP patients and 400 control patients were included in the study. The mean and median age of the CAP group was 2.40±3.20 years and 0.93 (0.33-3.29) years, respectively. The mean and the median age of control group were 2.38±3.17 years and 0.93 (0.32-3.24) years, respectively. There was no statistically significant difference between the ages of CAP and control group (p=0.926). 62% of CAP patients were male and 38% female. There was no statistically significant difference between the CAP and control group in terms of gender (p=0.999). The mean hospitalization length was 5.27±1.94 days in CAP patients. 121 (30.3%) of CAP patients had severe disease while 279 (69.7%) had mild disease. Recurrent pulmonary infections were present in 88 (22%) of the total CAP patients. 36.4% of severe CAP patients and 15.8% of mild CAP patients had recurrent pulmonary infections. The most common symptoms were cough (97.8%), wheeze (64.5%), and fever (41.8%). Feeding difficulties (25.0%), diarrhea (14.2%), nasal congestion (13.0%), restlessness (8.0%), vomiting (4.3%), abdominal pain (3.0%), hoarseness (2.0%) and febrile seizure (1.0%) were other first application symptoms. The most common findings observed in patients' initial physical examinations were rhonchi (71.8%), tachypnea (69.5%) and wheezing (64.5%) followed by tachycardia (50.2%), respiratory

distress (46.3%), SpO_2<%90 (32.3%), rales (35.3%), skin rash (5.0%), shock (2.0%), cyanosis (4.0%), dehydration (1.0%), lethargy (1.0%) , and conjunctivitis (1.0%). The most common finding in posterior-anterior chest X-Ray was paracardiac infiltration (49.5%), followed by reticular and (38.5%) lobar infiltration (5.0%). Rotavirus (5.3%) and Influenza were (5%) accompanying viral infections. 35.3% of CAP patients got oxygen treatment with mask or nasal cannula, 3.0% with airvo, none of the patients needed mechanical ventilation. Antibiotic treatments applied to the patients were: clarithromycin (66.8%), sulbactam ampicillin (41.5%), oseltamavir (40.3%), ceftriaxone (33.5%), cefotaxime (19.0%), and vancomycin (5.0%). Inhaled salbutamol was given to 78.8% of patients inhaled budesonide 31%. Dexamethasone was given 37.3% of the patients.

Eosinophil, hemoglobin, mean platelet volume (MPV), platelet distribution width (PDW) and PLR values of CAP group was statistically significantly lower than the control group (p<0.05). Leukocyte, lymphocyte, monocyte, neutrophil, basophil, platelet, red cell distribution width (RDW), NLR levels of CAP group was statistically significantly higher than the control group (p<0.05) (**Table 1**).

The mean age of the severe group was 2.92±3.80, while it was 2.17±2.88 in the mild group. There was no statistically significant difference in age between severe and mild groups (p>0.05). The ratio of males in severe group (80.2%) was statistically significantly higher than mild (54.1%) group (p<0.001) (**Table 2**). The mean hospitalization length in severe group (6.16±2.00 days) was statistically significantly higher than mild (4.89±1.78 days) group (p<0.001). Recurrent pulmonary infections were statistically significantly higher in severe group (36.4%) than mild (15.8%) group (p<0.001). Vomiting and abdominal pain symptoms were statistically significantly higher in mild group than severe group (p<0.001). Wheeze, restlessness, febrile convulsion and feeding difficulty symptoms were statistically significantly higher in severe group than mild group (p<0.001). In the physical examination, rhonchi, wheezing, tachypnea, respiratory distress, low oxygen saturation (SpO_2<90%), cyanosis, tachycardia and lethargy were statistically significantly high in severe group than in mild group (p<0.001). In the physical examination, skin rash was statistically significantly high in mild group than in severe group (p<0.001). Oxygen treatment with nasal/mask and airvo was statistically significantly high in severe group than in mild group (p<0.001). In severe group, antibiotic treatments included cefotaxime, clarithromycin, vancomycin, and oseltamavir; rates of salbutamol, budesonide inhaler treatments, and intro venous dexamethasone treatment were statistically significantly higher (p<0.001) (**Table 2**). CRP, neutrophils, monocyte, eosinophil, and NLR levels were statistically significantly high in patients with severe group than mild group (p<0.001) (**Table 3**).

In ROC analysis, the area under the characteristic curve (AUC) for CRP, monocyte, neutrophils, eosinophil, and NLR was calculated as 0.574, 0.569, 0.601, 0.628, and 0.583, respectively (**Figure 1**). CRP, neutrophils, monocyte, eosinophil and NLR were found to be statistically significant (p<0.001). This finding suggests that CRP, neutrophils, monocyte, eosinophil, and NLR levels can be used to screen for severe disease. The best cut-off point for CRP was calculated to be 10.85, with 53.7% sensitivity and 62.7% specificity. The best cut-off point for monocyte was 0.79, with a sensitivity of 66.9% and a specificity of 58.3%. A cut-off value of 9.31 was calculated for neutrophils with a sensitivity of 33.9% and a specificity of 88.2%. The best cut-off point for eosinophil was calculated as 0.16 with 57% sensitivity and 72% specificity. The best cut-off point for NLR was calculated to be 1.68, with 50.4% sensitivity and 68.3% specificity (**Table 4**).

Table1. Comparison of the laboratory findings of patients with community-acquired pneumonia and controls.

	Community-acquired Pneumonia Group (n:400)	Control Group (n:251)	p
	$\bar{x}$ ± SD Med (Min-Max)	$\bar{x}$ ± SD Med (Min-Max)	
CRP (mg/L)	19.66±29.36 8.02 (2.29-20.00)	-	-
Leukocytes ($\times10^3$/μL)	11.95±4.66 11.20 (8.70-13.50)	7.31±1.84 7.09 (6.02-8.60)	<0.001
Lymphocytes ($\times10^3$/μL)	4.60±2.84 4.15 (2.24-6.39)	2.94±0.87 2.84 (2.24-3.56)	<0.001
Monocyte ($\times10^3$/μL)	0.89±0.72 0.79 (0.56-1.06)	0.49±0.19 0.44 (0.36-0.55)	<0.001
Neutrophils ($\times10^3$/μL)	6.21±4.48 4.93 (3.42-8.43)	3.73±1.34 3.69 (2.61-4.63)	<0.001
Eosinophil ($\times10^3$/μL)	0.18±0.22 0.08 (0.02-0.30)	0.21±0.18 0.15 (0.08-0.26)	<0.001
Basophile ($\times10^3$/μL)	0.29±2.26 0.03 (0.02-0.04)	0.07±0.15 0.03 (0.02-0.06)	<0.001
Hemoglobin (g/dL)	11.57±1.83 11.50 (10.60-12.60)	13.43±0.91 13.60 (12.90-14.00)	<0.001
RDW (%)	15.12±2.74 14.00 (13.50-15.80)	14.13±1.63 13.70 (12.95-15.10)	<0.001
Platelet ($\times10^3$/μL)	383.07±129.32 362.00 (297.00-451.00)	296.07±63.05 287.94 (252.48-330.67)	<0.001
MPV (fL)	8.48±0.87 8.40 (7.80-9.10)	8.94±1.60 9.18 (7.60-10.18)	<0.001
PCT (%)	3.24±1.04 3.10 (2.40-3.90)	-	<0.001
PDW (%)	15.57±0.40 15.50 (15.30-15.80)	16.38±1.32 16.20 (15.70-16.90)	<0.001
PLR	119.24±82.59 91.36 (63.96-143.21)	107.66±31.82 104.53 (85.08-33.33)	0.007
NLR	2.48±3.19 2.15 (0.57-3.34)	1.39±0.66 1.33 (0.84-1.93)	0.006

*CRP: C-reactive protein; MPV: Mean Platelet Volume, PDW: Platelet Distribution Width; RDW: Red Cell Distribution Width; NLR: Neutrophil to Lymphocyte Ratio;; PLR: Platelet to Lymphocyte Ratio

Table 2. Comparison of the demographic and clinical features of patients with severe and mild community-acquired pneumonia

	Community acquired pneumonia patients (n:400)		p
	Severe (n:121) $\bar{x}$± SD Med (Min-Max)	Mild (n:279) $\bar{x}$± SD Med (Min-Max)	
Age (years)	2.92±3.80 1.18 (0.25-4.30)	2.17±2.88 0.93 (0.33-3.08)	0.366
Gender			<0.001
Male	97 (80.2%)	151 (54.1%)	
Female	24 (19.8%)	128 (45.9%)	
Length of hospitalization (days)	6.16±2.00 6 (4-8)	4.89±1.78 5 (4-6)	<0.001
Recurrent pulmonary infection (%)	44 (36.4%)	44 (15.8%)	<0.001
Symptoms (%)			
Cough	117 (96.7%)	161 (57.7%)	<0.001
Wheeze	97 (80.2%)	274 (98.2%)	0.463
Fever	53 (43.8%)	114 (40.9%)	0.584
Nasal congestion	16 (13.2%)	36 (12.9%)	0.930
Hoarseness	0 (0.0%)	8 (2.9%)	0.112
Restlessness	16 (13.2%)	16 (5.7%)	0.011
Vomiting	0 (0.0%)	17 (6.1%)	0.006
Febrile seizure	4 (3.3%)	0 (0.0%)	0.008
Abdominal pain	12 (0.0%)	12 (4.3%)	0.021
Feeding difficulty	56 (46.3%)	44 (15.8%)	<0.001
Diarrhea	12 (9.9%)	45 (16.1%)	0.103
Physical Examination (%)			
Rales	36 (29.8%)	93 (33.3%)	0.482
Rhonchi	97 (80.2%)	190 (68.1%)	0.014
Tachypnea	117 (96.7%)	161 (57.7%)	<0.001
Wheezing	97 (80.2%)	161 (57.7%)	<0.001
Respiratory distress	117 (96.7%)	68 (24.4%)	<0.001
Cyanosis	8 (6.6%)	0 (0.0%)	<0.001
SpO_2<%90	109 (90.1%)	32 (11.5%)	<0.001
Tachycardia	117 (96.7%)	84 (30.1%)	<0.001
Dehydration	4 (1.4%)	0 (0.0%)	0.320
Shock	4 (1.4%)	0 (0.0%)	0.320
Lethargy	4 (3.3%)	0 (0.0%)	0.008
Skin rash	0 (0.0%)	20 (7.2%)	0.003
Conjunctivitis	0 (0.0%)	4 (1.4%)	0.320
Posterior-anterior Chest X-Ray (%)			
Reticular infiltration	52 (43.0%)	102 (36.6%)	0.226
Para cardiac infiltration	65 (53.7%)	133 (47.7%)	0.266
Lobar infiltration	4 (3.3%)	16 (5.7%)	0.306
Accompanying viral infection (%)			
Rotavirus	8 (6.6%)	13 (4.7%)	0.421
Influenza	8 (6.6%)	12 (4.3%)	0.330
O_2 treatment (%)			
With mask or nasal cannula	109 (90.1%)	32 (11.5%)	<0.001
With airvo	12 (9.9%)	0 (0.0%)	<0.001
Medical treatment (%)			
Ceftriaxone (i.v.)	36 (29.8%)	98 (35.1%)	0.296
Cefotaxime (i.v.)	32 (26.4%)	44 (15.8%)	0.012
Sulbactam ampicillin (i.v)	49 (40.5%)	117 (41.9%)	0.788
Clarithromycin (i.v.)	109 (90.1%)	158 (56.6%)	<0.001
Vancomycin (i.v.)	16 (13.2%)	4 (1.4%)	<0.001
Oseltamivir (p.o)	60 (49.6%)	101 (36.2%)	0.012
Salbutamol (inh)	109 (90.1%)	206 (73.8%)	<0.001
Budesonide (inh)	76 (62.8%)	48 (17.2%)	<0.001
Dexamethasone (i.v.)	93 (76.9%)	56 (20.1%)	<0.001

i.v. : intravenosus, inh: inhaler

Table 3. Comparison of laboratory findings of patients with severe and mild community-acquired pneumonia

	Community acquired pneumonia patients (n:400)		p
	Severe (n:121)	Mild (n:279)	
	x-± SD Med (Min-Max)	x-± SD Med (Min-Max)	
CRP (mg/L)	23.05±31.13 11.19(3.45-28.60)	18.14±28.45 7.50(1.97-19.95)	0.019
Leukocytes (×10³/μL)	12.50±4.37 11.50(9.30-15.10)	11.72±4.77 11.10(8.70-13.20)	0.063
Lymphocytes (×10³/μL)	4.44±2.83 3.85(2.29-5.33)	4.68±2.85 4.23(2.14-6.39)	0.358
Monocyte (×10³/μL)	0.87±0.36 0.83(0.68-1.10)	0.90±0.83 0.74(0.49-1.06)	0.035
Neutrophils (×10³/μL)	6.90±4.09 5.74(3.91-9.51)	5.91±4.62 4.62(2.92-7.69)	0.002
Eosinophil (×10³/μL)	0.22±0.20 0.20(0.04-0.42)	0.16±0.22 0.06(0.02-0.19)	<0.001
Basophile (×10³/μL)	0.13±0.53 0.03(0.02-0.04)	0.36±2.69 0.03(0.02-0.05)	0.052
Hemoglobin (g/dL)	11.85±2.02 11.50(10.20-12.90)	11.44±1.73 11.50(10.60-12.20)	0.269
RDW (%)	15.21±3.01 13.90(13.50-15.50)	15.07±2.62 14.00(13.50-16.30)	0.832
Platelet (×10³/μL)	377.72±104.24 345.00(299.00-430.00)	385.39±138.90 364.00(291.00-451.00)	0.916
MPV (fL)	8.48±0.83 8.30(7.80-9.10)	8.49±0.88 8.50(7.80-9.10)	0.728
PCT (%)	3.18±0.80 3.10(2.50-3.70)	3.26±1.13 3.10(2.30-3.90)	0.755
PDW (%)	15.52±0.35 15.40(15.30-15.70)	15.60±0.42 15.50(15.30-15.80)	0.189
PLR	124.66±90.95 92.27(73.36-143.75)	116.89±78.75 91.36(63.96-142.86)	0.480
NLR	2.76±3.09 1.70(0.71-3.94)	2.36±3.23 1.02(0.55-2.93)	0.009

*CRP: C-reactive protein; MPV: Mean Platelet Volume, PDW: Platelet Distribution Width; RDW: Red Cell Distribution Width; NLR: Neutrophil to Lymphocyte Ratio;; PLR: Platelet to Lymphocyte Ratio

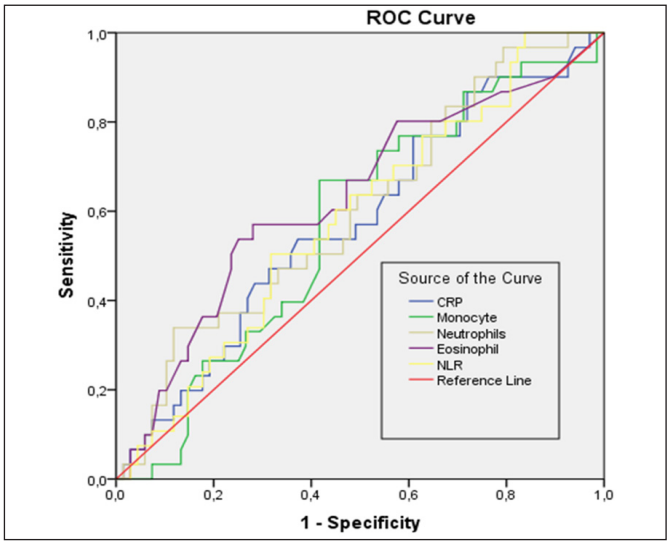

Figure 1. ROC curve was used to evaluate the diagnostic value of CRP, neutrophil, monocyte, eosinophil, and NLR

Correlation analysis revealed that CRP had a positive correlation with neutrophil count (r=0.231, p=0.011) and NLR (r=0.221, p=0.015) in severe COP patients (**Figure 2**).

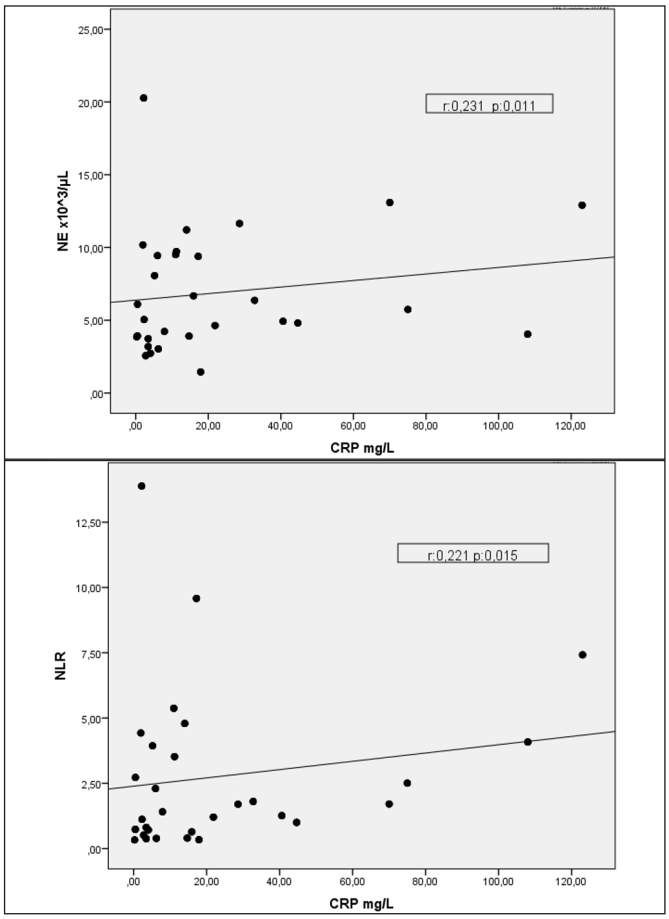

Figure 2. Significant correlation between CRP and neutrophils (r=0.231, p=0.011) and, CRP and NLR (r=0.221, p=0.015) in Spearman Correlation Analysis.

DISCUSSION

CAP continues to cause a high rate of complications and death, notwithstanding the sudden innovation of unique treatment options. Further, simple and low cost screening tests are desperately required to determine disease severity and clarify treatment plan. For this purpose, we have brought a new perspective that can help the classification of CAP severity in children by using complete blood parameters. The major results of our research were that platelets, leukocytes, lymphocytes, monocyte, neutrophils, RDW and NLR levels were significantly higher in CAP than in the control group

Table 4. ROC curve was used to evaluate the diagnostic value of blood parameters for severe community-acquired pneumonia

	AUC	p	Asymptotic	95% Confidence Interval	Cut-Off	Sensitivity	Specificity
CRP	0.574	0.019	0.513	0.635	10.85	53.7%	62.7%
Monocyte	0.569	0.030	0.509	0.628	0.79	66.9%	58.3%
Neutrophils	0.601	0.001	0.541	0.660	9.31	33.9%	88.2%
Eosinophil	0.628	<0.001	0.567	0.689	0.16	57.0%	72.0%
NLR	0.583	0.009	0.524	0.642	1.68	50.4%	68.3%

while hemoglobin, eosinophil, PDW, MPV and PLR levels lower. However, when disease severity was considered, neutrophils, monocytes, eosinophil, CRP, and NLR levels were found to be statistically significantly higher in the severe group. In the ROC analysis, we showed that these values can be used to differentiate severe disease. A significant positive correlation was discovered in the correlation analysis between CRP and NLR, as well as between CRP and neutrophil levels.

CRP is an effective indicator that stimulates cytokine production in eight to twelve hours of inflammatory process and is unaffected or only mildly affected by gender and age so it is frequently utilized in the diagnosis and follow-up of acute infection (13). CRP is reported in the literature to be a much specific and sensitive indicator for CAP (14,15). In our study, we found that CRP had a predictive value for both CAP diagnosis and severity.

Neutrophils and lymphocytes were demonstrated to be shown to play critical roles in inflammatory conditions. It has been reported that the increase in neutrophils and again decrease in lymphocytes in CAP patients is associated with disease severity (16). Elevated neutrophils were associated with disease severity in our study; however we did not found a link between lymphocytes.

NLR is a parameter determined by the ratio of neutrophils to lymphocytes. NLR is recognized to enhance inflammatory process and thought to be a forecaster of several inflammation process better than CRP (17). In some studies NLR was reported to be an important marker, particularly for hospitalized children with CAP (18-21). Neutrophils and NLR values together were reported a stronger predictor of severity than pneumonia severity score and the tenacity of high levels of NLR with neutrophils count might be a crucial factor in the rapidly deteriorating of patient's poor outcome (16,22,23). Continuous elevations in these variables might well indicate a severe and unmanaged immune reaction, causing the inability to fix the systemic inflammation process. Similar to these studies, NLR and neutrophil count were found to be elevated in severe disease, significantly predicting disease severity and positively correlated with CRP in our study.

Monocytes can differentiate into a variety of irredeemably distinguishable cells that can execute a wide range of functions throughout infection. They can boost microbicidal activity. Monocyte levels were reported to be increased in CAP patients (4). Similar to previous studies, the monocyte level was found to be statistically significantly higher in the CAP patient group than in the control group in our study. However, in addition to previous research, we discovered that it was elevated in severe CAP and predicted disease severity.

Eosinopenia is commonly associated with acute stress or infection responses (24). There have been very few studies on the relationship between CAP and eosinophilia, and the majority of them have been conducted on adults with chronic disease. In some of them, the presence of eosinopenia was found to be associated with the severity of CAP (25), but not in others (26). Eosinophil counts were found to be statistically significant lower in CAP patients compared to the control group in our study. The eosinophil count, on the other hand, was found to be significantly higher in the severe CAP group compared to the mild group, and the increase in eosinophil count was found to be associated with disease severity. The reason for this could be that the etiological factors of CAP in children differ from those in adults. At the same time, because eosinophil counts are high in children with reactive airway disease who can develop severe pneumonia, we may have detected higher eosinophil counts in severe patients.

Platelets are essential inflammation cells that generate a big portion of cytokines and also can behave as acute phase reactants as well. Platelet counts were reported to be higher in children with pneumonia (27, 28). Similarly we found statistically significant increase in platelet counts of CAP patients than controls. On the other hand; we did not find an association between platelet counts and CAP severity.

MPV and PDW are two key platelet markers associated with inflammation. MPV and PDW levels in pneumonia patients were lower than in the control group in our study, as previously reported (2,27-30). The level of MPV was reported to decrease with the severity of the pneumonia however we did not find an association between MPV and CAP severity.

PLR levels were found to be elevated in CAP patients (4,18,31,32). While PLR has been linked to disease severity in some studies (4,32,33), it has not been found in others (4,18). In another study, children with bacterial infectious pneumonia had significantly lower PLR values than healthy children (33). PLR was found to be significantly lower in the CAP group compared to the control group in our study, and no correlation was found between PLR and disease severity. Due to the retrospective nature of our study, the causative agent could not be determined because most of the patients' blood culture results could not be obtained. Therefore, we cannot say that we found low PLR levels due to higher bacterial pneumonias.

RDW, which is an indicator of anisocytosis, is a measurement that is reported in total blood cell counts. RDW has been used primarily to determine

the type of anemia and for diagnosis. The RDW index is now regarded as a crucial measure of the level of inflammation. In CAP, high RDW values have been linked to a poor prognosis (31,34,35). Although the RDW level was found to be statistically significantly higher in the CAP patient group than in the control group in our study, no correlation with disease severity was found.

Our study had some limitations: it was a single-center study, and we did not investigate the effect of treatment on these serum inflammatory parameters due to a lack of data; additionally, the causative agent could not be determined because most of the patients' blood culture results could not be obtained. To validate, additional controlled studies with a larger number of patients from various centers are required.

CONCLUSION

According to the findings of this study, platelets, leukocytes, neutrophils, lymphocytes, monocytes, RDW, CRP, and NLR were elevated in CAP patients while hemoglobin, eosinophil, PDW, MPV and PLR were decreased, indicating a diagnostic value for CAP. Elevation in neutrophils, eosinophil, monocytes, CRP, and NLR, were predicting the severity of CAP. NLR and neutrophils had a significant correlation with CRP for severe disease. These parameters have the potency to be a credible, cost-effective, and unique potential parameter for diagnosing and assessing the severity of CAP disease.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Health Sciences University, Keçiören Training and Research Hospital Clinical Research Ethics Committee (Date: 9.11.2021, Decision No: 2012-KAEK-15/2416).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. DeFrances CJ, Lucas CA, Buie VC, Golosinskiy A. 2006 national hospital discharge survey. Natl Health Stat Report 2008; 5: 1-20.
2. Karadag-Oncel E, Ozsurekci Y, Kara A, Karahan S, Cengiz AB, Ceyhan M. The value of mean platelet volume in the determination of community acquired pneumonia in children. Ital J Pediatr 2013; 39: 16.
3. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. Bull World Health Organ 2008; 86:408-16.
4. Huang Y, Liu A, Liang L, et al. Diagnostic value of blood parameters for community-acquired pneumonia. Int Immunopharmacol 2018; 64: 10-5.
5. Ramby AL, Goodman DM, Wald EL, Weiss SL. Red Blood Cell Distribution Width as a Pragmatic Marker for Outcome in Pediatric Critical Illness PLoS One 2015; 10: e0129258.
6. Golwala ZM, Shah H, Gupta N, Sreenivas V, Puliyel JM. Mean platelet volume (MPV), platelet distribution width (PDW), platelet count and plateletcrit (PCT) as predictors of in-hospital paediatric mortality: a case-control Study Afr Health Sci 2016; 16: 356-62.
7. Gul A, Takçı Ş, Seyyah BA, Yılmaz R. Independent predictors of severity and hospitalization in acute bronchiolitis: neutrophil/lymphocyte ratio and mean platelet volume. J Pediatr Infect Dis 2018; 13: 268-73.
8. Zhang S, Luan X, Zhang W, Jin Z. Platelet-to-lymphocyte and neutrophil-to-lymphocyte ratio as predictive biomarkers for early-onset neonatal sepsis. J Coll Physicians Surg Pak 2021; 30: 821-4.
9. Pantzaris ND, Platanaki C, Pierrako C, et al. Neutrophil-to-lymphocyte ratio relation to sepsis severity scores and inflammatory biomarkers in patients with community-acquired pneumonia: a case series. J Transl Int Med 2018; 6: 43–6.
10. World Health Organization. The Management of Acute Respiratory Infections in Children. Practical Guidelines for Outpatient Care. Geneva: World Health Organization; 1995.
11. World Health Organization. Pocket Book of Hospital Care for Children. Guidelines for the Management of Common Illnesses with Limited Resources.WHO Press 2005:72–81.
12. Harris M, Clark J, Coote N, et al. British Thoracic Society Standards of Care Committee. British Thoracic Society guidelines for the management of community acquired pneumonia in children. Thorax 2011; 66: 1–23.
13. Litao MK, Kamat D. Erythrocyte sedimentation rate and C-reactive protein: how best to use them in clinical practice. Pediatr Ann 2014; 43: 417–20.
14. Berg AS, Inchley CS, Fjaerli HO, Leegaard TM, Lindbaek M, Nakstad B. Clinical features and inflammatory markers in pediatric pneumonia: a prospective study. Eur J Pediatr 2017; 176: 629–38.
15. Khan DA, Rahman A, Khan FA. Is procalcitonin better than C-reactive protein for early diagnosis of bacterial pneumonia in children? J Clin Lab Anal 2010; 24:1–5.
16. Curbelo J, Bueno SL, Galván-Román JM, Ortega-Gomez M, Rajas O, Fernandez-Jimenez G. Inflammation biomarkers in blood as mortality predictors in community-acquired pneumonia admitted patients: Importance of comparison with neutrophil count percentage or neutrophil-lymphocyte ratio. PLoS One 2017; 12: e0173947.
17. de Jager CP, Wever PC, Gemen EF, et al. The neutrophil-lymphocyte count ratio in patients with community-acquired pneumonia. PloS One 2012; 7:e46561.

18. Kartal O, Kartal AT. Value of neutrophil to lymphocyte and platelet to lymphocyte ratios in pneumonia. Bratisl Lek Listy 2017; 118: 513–6.
19. Bekdas M, Goksugur SB, Sarac EG, Erkocoglu M, Demircioglu F. Neutrophil/lymphocyte and C-reactive protein/mean platelet volume ratios in differentiating between viral and bacterial pneumonias and diagnosing early complications in children. Saudi Med J 2014; 35: 442–7.
20. Bekis BH. Is there any relationship between C-reactive protein/albumin ratio and clinical severity of childhood community-acquired pneumonia. Turk J Biochem 2021; 46, 647-53.
21. Najm RA, AL-dujaili ANG, Hashim JM. Study of procalcitonin and neutrophil/ lymphocyte count ratio in children infected with Community-acquired pneumonia. Int J Health Sci 2022; 6: 4218–32.
22. Fernandes CD, Arriaga MB, Costa MCM, et al. Host inflammatory biomarkers of disease severity in pediatric community-acquired pneumonia: a systematic review and meta-analysis. Open Forum Infect Dis 2019; 6:ofz520.
23. Yang T, Wan C, Wang H, et al. The prognostic and risk-stratified value of neutrophil-lymphocyte count ratio in Chinese patients with community-acquired pneumonia. Eur J Inflamm 2017; 15: 22-7.
24. Abidi K, Khoudri I, Belayachi J, et al. Eosinopenia is a reliable marker of sepsis on admission to medical intensive care units. Crit Care 2008, 12: R59.
25. Huang WC, Lee CH, Wu MF, et al. Clinical features, bacteriology of endotracheal aspirates and treatment outcomes of patients with chronic obstructive pulmonary disease and community-acquired pneumonia in an intensive care unit in Taiwan with an emphasis on eosinophilia versus non-eosinophilia: a retrospective case-control study. BMJ open 2018; 8, e020341.
26. Perelló R, Miró O, Ma Miró J, Moreno A. Role of the eosinophil count in discriminating the severity of community-acquired pneumonia in HIV-infected patients. Critical Care 2008; 12: 425.
27. Sahin M, Duru NS, Elevli M, Civilibal M. Assessment of platelet parameters in children with pneumonia. J Pediatr Infect 2017; 11: 106-12.
28. Choudhury J, Rath D. Thrombocytosis in under-five children with lower respiratory tract infection. Arch Pediatr Infect Dis 2018; 6: e61605.
29. Afyon M, Artuk C. Could mean platelet volume be a useful marker for infectious diseases? a review of literature. Med Sci 2016; 5: 1059-62.
30. Robbins G, Barnard DL. Mean platelet volume change in infection. J Clin Pathol 1983; 36: 1320.
31. Qi X, Dong Y, Lin X, Xin W. Value of neutrophil to lymphocyte ratio, platelet to lymphocyte ratio, and red blood cell distribution width in evaluating the prognosis of children with severe pneumonia. Evid Based Complement Alternat Med 2021: 1818469.
32. Bolatkale M. Toplumda gelişen pnömoninin öngörülmesinde trombosit-lenfosit oranı ve pnömoni ağırlık skorunun karşılaştırılması. Dokuz Eylül Üniversitesi Tıp Fakültesi Derg 2018; 32: 191-200.
33. Zheng HH, Xiang Y, Wang Y, Zhao QS, Fang R, Dai R. Clinical value of blood related indexes in the diagnosis of bacterial infectious pneumonia in children. Transl Pediatr 2022; 11:114-9.
34. Bello S, Fandos S, Lasierra AB, et al. Red blood cell distribution width [RDW] and long-term mortality after community-acquired pneumonia. a comparison with proadrenomedullin. Respir Med 2015; 109: 1193–206.
35. Lee S-M, Lee JH, Kim K, et al. The clinical significance of changes in red blood cell distribution width in patients with community-acquired pneumonia. Clin Exp Emerg Med 2016; 3: 139–47.