Research Article / *Araştırma Makalesi*

Ege Journal of Medicine / *Ege Tıp Dergisi* 2021; 60 (3): 394-401

The Importance of neutrophil-lymphocyte ratio, monocyte-lymphocyte ratio, and thrombocyte-lymphocyte ratio in addition to abnormal laboratory parameters in COVID-19 pneumonia

Anormal laboratuvar parametrelerine ilave olarak, nötrofil-lenfosit, monosit-lenfosit ve trombosit-lenfosit oranlarının COVID-19 pnömonisindeki önemi

Nermin Keni Begendi[1] Fatma Kaçar[2] Mikail Dağ[3] Arzu Tarakçı[4]
Şule Özdemir Armağan[4] Fatih Saçkan[3] Muhammet Cemal Kızılarslanoğlu[5]

[1] Internal Medicine/ Hematologist, Health Sciences University, Konya City Hospital, Konya, Turkey
[2] Infectious Diseases, Health Sciences University, Konya Training and Research Hospital, Konya, Turkey
[3] Internal Medicine, Konya City Hospital, Konya, Turkey
[4] Infection Diseases, Konya City Hospital, Konya, Turkey
[5] Internal Medicine/ Geriatrician, Konya City Hospital, Konya Turkey

ABSTRACT

Aim: We aimed to examine the importance of the neutrophil-lymphocyte ratio (NLR), monocyte-lymphocyte ratio (MLR) and thrombocyte-lymphocyte ratio (TLR) in addition to laboratory parameters in terms of pneumonia between patients with and without pneumonia diagnosed with COVID-19 infection.

Materials and Methods: In our retrospective study, 506 patients diagnosed with COVID-19 who were hospitalized and treated between April 2020 and July 2020 were included. While 50.6% (n= 256) of the patients had pneumonia, 49.4% (n= 250) did not have. File informations were scanned; the demographic data, hospitalization and discharge laboratory parameters were recorded.

Results: The median age of the patients was 44.5 (16-89) years, 55.5% (n= 281) of them were male. The median age of patients with pneumonia was higher than those without pneumonia, and the frequency of female gender was higher ($p < 0.05$ for both conditions). The lymphocyte count at hospitalization and discharge was significantly lower in patients with pneumonia ($p < 0.001$, 0.007, respectively). The count of eosinophils at hospitalization was significantly lower in patients with pneumonia ($p < 0.001$). NLR and TLR values were significantly higher in patients with pneumonia at admission and discharge ($p < 0.008$, < 0.007, respectively for NLR and $p < 0.001$, $p < 0.001$ respectively for TLR). MLR values at discharge were higher in patients with pneumonia ($p = 0.001$). In ROC analyzes made in terms of predicting pneumonia; hospitalization CRP level, eosinophil, monocyte counts and TLR values were found to be important variables.

Conclusion: In this study, the importance of monocyte, eosinophil counts and TLR values in COVID-19 pneumonia was demonstrated.

Keywords: COVID-19 pnömonisi, monosit, lenfosit, eozinofil, NLO, MLO, TLO.

ÖZ

Amaç: *COVID-19 pnömonisi olan ve olmayan hastalar arasındaki klinik ve hematolojik parametrelerdeki farklılıkların irdelenmesi, yatış ve taburculuk değerlerinin kıyaslanması, laboratuvar parametrelerinin yanında nötrofil-lenfosit oranı (NLO), monosit-lenfosit oranı (MLO) ve trombosit-lenfosit oranı (TLO)' nın pnömoni açısından öneminin karşılaştırılması amaçlandı.*

Corresponding author: Nermin Keni Begendi
Internal Medicine/ Hematologist, Health Sciences University,
Konya City Hospital, Konya, Turkey
E-mail: *nermin.keni@gmail.com*
Application date: 25.04.2021 Accepted: 11.06.2021

Gereç ve Yöntem: *Retrospektif yaptığımız çalışmada Enfeksiyon Hastalıkları servisinde Nisan 2020-Temmuz 2020 tarihleri arasında yatarak tedavi alan COVID-19 tanılı 506 hasta dahil edildi. Hastaların 256'sı pnömoni tablosu olan (%50,6), 250'si pnömoni tablosu olmayan (%49,4) COVID-19 tanılı olgular idi. Her iki hasta grubunda dosya bilgileri taranarak demografik veriler, yatış ve taburculuklarındaki laboratuvar parametreleri, NLO, MLO ve TLO irdelenip karşılaştırıldı.*
Bulgular: *Hastaların medyan yaşı 44,5 (16-89) yıl olup, %55,5 (n= 281)'i erkek idi. Pnömonisi olan hastaların medyan yaşı pnömonisi olmayanlara göre daha yüksekti ve bu grupta kadın cinsiyet sıklığının daha fazla olduğu görüldü (her iki durumda p<0,05). Pnömonisi olanların hastanede ortanca kalış süresi pnömoni olmayanlara göre daha yüksekti (p:0,009). Pnömonisi olanlarda olmayanlara göre yatış ve taburculuk lenfosit sayısı anlamlı olarak daha düşük idi (p değeri sırasıyla: <0,001, 0,007). Pnömonisi olanlarda olmayanlara göre yatış eozinofil sayısı anlamlı olarak daha düşük gözlendi (p<0,001). Pnömonisi olan hastaların yatış ve taburculuk NLO pnömonisi olmayan hastalara göre anlamlı olarak daha yüksek gözlendi (p sırasıyla <0,008, <0,007). Her iki grupta taburculuk NLO değeri yatış değerine göre düşük saptandı (her iki durumda p; <0.001). TLO pnömonisi olanlarda olmayanlara göre hem yatış hem de taburculukta daha yüksek görüldü (her iki durumda p <0,001). MLO incelendiğinde taburculuk MLO değerleri pnömonisi olanlarda daha yüksek gözlendi (p=0,001). Pnömoniyi öngörme açısından yapılan ROC analizinde; yatış eozinofil değerinin ≤0,02/μL olmasının AUC:0,668, %56,3 sensitivite, %71,2 spesifiteye, monosit değerinin ≤0,5/μL olmasının AUC:0,631, %55,1 sensitivite, %67,6 spesifiteye, TLO değerinin >105,7 olmasının AUC:0,611, %75,4 sensitivite, %46,0 spesifiteye sahip olduğu gözlendi.*

Sonuç: Bu çalışmada özellikle monosit, eozinofil sayıları ve TLO oranlarının COVID-19 pnömonisindeki önemi gösterilmiş oldu.

Anahtar Sözcükler: *COVID-19 pneumonia, monocyte, eosinophil counts, NLR, TLR, MLR.*

INTRODUCTION

While the rapid course and increased mortality of COVID-19 infection has been remarkable, the new type of coronavirus called as SARS-CoV2, which has different characteristics from other coronaviruses (SARS-CoV and MERS-CoV) was discovered as the causative agent of the disease. Worldwide more than 265.000.000 people have been infected with the virus and more than 5.000.000 deaths have been experienced since December 2019 due to the COVID-19 infection, which was accepted as a pandemic by the WHO on March 12, 2020.

The inflammatory and pro-thrombotic process, which starts with the damage of the virus in the endotelium leads to multisystem circulatory disorders especially in the pulmonary circulation, finally multipl tissue and organ disfunctions occur [1].

The virus affects natural and acquired immune system cells by directly cell damage or indirectly through cytokines and chemokines. As a result, while lymphocytes and eosinophils decrease, an increase in neutrophil and monocyte counts can be observed (1, 2).

In many studies on COVID-19 elevated neutrophil-lymphocyte ratio (NLR) has been reported which is used in the follow-up of many solid tumors, bacterial infections, acute pancreatitis and cardiovascular diseases as an inflammatory marker and prognostic factor (3). In addition, there are COVID-19 studies showing an increase in monocyte-lymphocyte ratio (MLR) and thrombocyte-lymphocyte ratio (TLR) (4-6).

However, there are not enough studies about COVID-19 pandemia comparing the laboratory parameters between patients with and without pnemonia. We aimed to investigate whether there are differences in laboratory parameters, NLR, MLR, and TLR values between patients with and without pneumonia in the course of COVID-19 infection.

MATERIALS and METHODS

In this retrospective study 506 patients diagnosed with COVID-19 were included who received inpatient treatment between April 2020 and July 2020 in the Infection Service of Konya Training and Research Hospital. Among the patients hospitalized between the dates mentioned, those with confirmed diagnosis of Covid-19 were included in the study. The demographic characteristics (age and gender) of the patients on the hospitalization day, as well as the laboratory and radiologic examinations results were recorded. These examinations included COVID-19 RT-PCR test, thorax CT, hemogram, CRP, ferritin, kidney and liver function tests. In addition, the hemogram results at discharge were also recorded.

In patients whose COVID-19 infection was confirmed with a positive COVID-19 RT-PCR test, the pneumonia status was confirmed by chest CT in addition to clinical and laboratory findings. From the hemogram parameters, NLR obtained by dividing the neutrophil count (× 10^3/μL) by the count of lymphocytes (× 10^3/μL), MLR obtained by dividing the monocyte count (× 10^3/μL) by the count of lymphocytes (× 10^3/μL) and the TLR values obtained by dividing the platelet count (× 10^3/μL) by the count of lymphocytes (× 10^3/μL) were calculated. Primarily, we have received approval from the Ministry of Health of the Republic of Turkey established scientific studies. In addition, data collection procedures started after obtaining approval from the Medical Specialization Training Board (with the letter dated 02.07.2020 and numbered 48929119/774) of Konya Training and Research Hospital.

Statistical Analysis

Analytical and graphical methods were used to evaluate the data in terms of normal distribution. The normal distribution of the data was determined using skewness-kurtosis values, Kolmogrov-Smirnov test and variance coefficient from analytical methods, and graphical methods with histogram and detrended Q-Q plot graphs. Mann Whitney U test was used to compare numerical variables between two groups. It was observed that all numerical parameters in the study did not show normal distribution and numerical parameters were shown with median (min-max). In comparison of categorical variables; Fisher's exact test or Chi-square test was used according to suitability. Wilcoxon test was used to evaluate the changes in the patients' admission and discharge laboratory values within the groups. MedCalc program was used to perform ROC analysis to evaluate the cut-off values, sensitivity and specificitiy of biochemical and hemogram parameters that best predict the status of COVID pneumonia in the course of infection. The Statistical Package for the Social Sciences software version 25.0 (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical calculations. A p value of <0.05 was accepted for statistical significance.

RESULTS

Demographic Characteristics of Patients:

A total of 506 patients diagnosed with COVID-19 treated in the infection service, 50.6% of whom with pneumonia and 49.4% without pneumonia were included. While 55.5% (n = 281) of the patients were male, 44.5% (n = 225) were female and 52% of those with pneumonia were women. The median age was 44.5 (16-89) years, and it was 51 (16-84) years in patients with pneumonia (p <0.001). While additional comorbid diseases were observed more in patients with pneumonia, complaints of fever, dry cough, shortness of breath, sputum and weakness were significantly higher in this group (p <0.001 for both).

Clinical and Laboratory Parameters:

While the median hospitalization day of all patients was 5 (4-26) days, it was observed longer in patients with pneumonia than those without pneumonia (p = 0.009).

The leukocyte count (× 10^3/μL) at hospitalization was significantly lower in those with pneumonia (p = 0.006). The lymphocyte count (× 10^3/μL) at hospitalization and discharge was significantly lower in patients with pneumonia (p <0.001, 0.007, respectively). The median value of eosinophil count (× 10^3/μL) at hospitalization was lower in patients with pneumonia (p<0,001), and a significant increase at discharge was observed in all patients (p<0,001). Monocyte counts (× 10^3/μL) at hospitalization were significantly lower in those with pneumonia (p<0,001). In all patients the RBC values (×10^6/ μL) at hospitalization were significantly higher than the values measured at discharge (p<0,001). In patients with pneumonia both hospitalization and discharge Hb values (gr/dL) were lower (for both p<0,001). The comparison of hemogram parameters has been shown in (Table-1).

It was observed that both NLR and TLR values were higher in patients with pneumonia at both hospitalization and discharge (respectively p<0.001, p<0.001 for both values and both conditions). In all patients MLR decreased significantly at discharge (p<0,001). The important values of NLR, MLR and TLR have been compared in (Table-2).

Patients with pneumonia had significantly higher CRP and ferritin levels (respectively p<0,001, p=0,003) (Table-3).

The comparison of important laboratory levels at hospitalization and discharge of patients with and without pneumonia has been shown in (Table-4).

Table-1. Comparison of the hemogram parameters of COVID patients according to pneumonia status.

	Total N=506	**Without pneumonia N=250**	**With pneumonia N=256**	**p value**
leukocyte at admission	5.8 (1.9-48.8)	6 (1.9-48.8)	5.6 (1.9-20.1)	0.006
leukocyte at discharge	6.1 (2.3-44.6)	6.2 (2.5-44.6)	6 (2.3-29.5)	0.471
neutrophil at admission	3.4 (0.7-41.8)	3.5 (1.1-41.8)	3.4 (0.7-17.6)	0.447
neutrophil at discharge	3.3 (0.7-39.8)	3.3 (0.7-39.8)	3.4 (0.9-27.1)	0.509
lymphocyte at admission	1.6 (0.2-5.1)	1.7 (0.2-5.1)	1.4 (0.4-4.5)	<0.001
lymphocyte at discharge	2 (0.2-6)	2.1 (0.2-6)	1.9 (0.4-4.9)	0,007
eosinophil at admission	0 (0-0.8)	0.1 (0-0.8)	0 (0-0.4)	<0.001
eosinophil at discharge	0.1 (0-2.5)	0.1 (0-2.5)	0.1 (0-0.5)	0.090
RBC at admission	4.8 (2.2-6.3)	4.8 (3.5-6.2)	4.7 (2.2-6.3)	0.233
RBC at discharge	4.6 (1.7-6.4)	4.7 (2.9-6.4)	4.5 (1.7-6.1)	0.004
Hb at admission	13.9 (7.7-18.3)	14.4 (8-18.3)	13.5 (7.7-17.8)	<0.001
Hb at discharge	13.4 (5.9-18.4)	13.9 (8.3-18.4)	12.9 (5.9-17.1)	<0.001
thrombocyte at admission	202.5 (43-644)	202 (61-644)	203 (43-480)	0.940
thrombocyte at discharge	246 (52-697)	228 (53-697)	268.5 (52-589)	<0.001
monocyte at admission	0.5 (0.1-8.4)	0.6 (0.1-2.3)	0.5 (0.2-8.4)	<0.001
monocyte at discharge	0.6 (0-2)	0.5 (0-2)	0.6 (0.1-1.9)	0.279

Leukocyte, neutrophil, lymphocyte, eosinophil, monocyte and thrombocyte units: (× 10^3 /μL), RBC unit: (×10^6/ μL), Hb unit: gr/dL

Table-2. Comparison of the NLR, MLR and TLR levels of COVID patients according to pneumonia status.

	Total N=506	Without pneumonia N=250	With pneumonia N=256	p value
NLR at admission	2 (0.4-26.7)	1.9 (0.5-26.7)	2.3 (0.4-23.8)	0.008
NLR at discharge	1.7 (0.5-56.5)	1.5 (0.5-17.5)	1.8 (0.5-56.5)	0.007
TLR at admission	128.9 (14.1-1160)	114.5 (37.9-1160)	143.1 (14.1-516.2)	<0.001
TLR at discharge	125.9 (15.3-663.8)	106.2 (31.5-663.8)	138 (15.3-559.3)	<0.001
MLR at admission	0.33 (0.1-3.9)	0.34 (0.1-3.4)	0.33 (0.1-3.9)	0.769
MLR at discharge	0.28 (0-3.9)	0.27 (0-2.2)	0.29 (0.1-3.9)	0.001

NLR: neutrophil count/lymphocyte count, TLR: thrombocyte count/lymphocyte count , MLR: monocyte count/lymphocyte count

Table-3. Biochemistry parameters of COVID patients according to pneumonia status.

	Total N=506	Without pneumonia N=250	With pneumonia N=256	p value
AST	26 (10-104)	25 (10-104)	27 (11-90)	0.011
ALT	20 (4-268)	20 (4-268)	21 (6-91)	0.495
Creatinine	0.9 (0.4-8)	0.9 (0.4-3.6)	0.9 (0,5-8)	0.235
Urea	27 (10.3-120)	25 (10.3-104)	29 (12.2-120)	<0.001
CRP	7 (3-271)	4.3 (3-236.7)	10.6 (3.1-271)	<0.001
Ferritin	77 (3.4-3927)	67 (4.6-3927)	98.5 (3.4-1650)	0.003

AST, ALT units: U/L, ürea and creatinine unit: mg/dL, CRP unit: mg/L, ferritin unit: ng/mL

Table-4. Differences between important laboratory values of COVID patients at admission and discharge.

	Total N=506	p value	Without pneumonia N=250	p value	With pneumonia N=256	p value
Leukocyte at admission	5.8 (1.9-48.8)	0.001	6 (1.9-48.8)	0.665	5.6 (1.9-20.1)	p<0.001
Leukocyte at discharge	6.1 (2.3-44.6)		6.2 (2.5-44.6)		6 (2.3-29.5)	
Neutrophil at admission	3.4 (0.7-41.8)	0.308	3.5 (1.1-41.8)	0.033	3.4 (0.7-17.6)	0.552
Neutrophil at discharge	3.3 (0.7-39.8)		3.3 (0.7-39.8)		3.4 (0.9-27.1)	
Lymphocyte at admission	1.6 (0.2-5.1)	p<0.001	1.7 (0.2-5.1)	p<0.001	1.4 (0.4-4.5)	p<0.001
Lymphocyte at discharge	2 (0.2-6)		2.1 (0.2-6)		1.9 (0.4-4.9)	
Eosinophil at admission	0 (0-0.8)	p<0.001	0.1 (0-0.8)	p<0.001	0 (0-0.4)	p<0.001
Eosinophil at discharge	0.1 (0-2.5)		0.1 (0-2.5)		0.1 (0-0.5)	
RBC at admission	4.8 (2.2-6.3)	p<0.001	4.8 (3.5-6.2)	p<0.001	4.7 (2.2-6.3)	p<0.001
RBC at discharge	4.6 (1.7-6.4)		4.7 (2.9-6.4)		4.5 (1.7-6.1)	
Hb at admission	13.9 (7.7-18.3)	p<0,001	14.4 (8-18.3)	p<0.001	13.5 (7.7-17.8)	p<0.001
Hb at discharge	13.4 (5.9-18.4)		13.9 (8.3-18.4)		12.9 (5.9-17.1)	
Thrombocyte at admission	202.5 (43-644)	p<0,001	202 (61-644)	p<0.001	203 (43-480)	p<0.001
Thrombocyte at discharge	246 (52-697)		228 (53-697)		268.5 (52-589)	
Monocyte at admission	0.5 (0.1-8.4)	0.915	0.6 (0.1-2.3)	p<0.001	0.5 (0.2-8.4)	p<0.001
Monocyte at discharge	0.6 (0-2)		0.5 (0-2)		0.6 (0.1-1.9)	
NLR at admission	2 (0.4-26.7)	p<0.001	1.9 (0.5-26.7)	p<0,001	2.3 (0.4-23.8)	p<0.001
NLR at discharge	1.7 (0.5-56.5)		1.5 (0.5-17.5)		1.8 (0.5-56.5)	
TLR at admission	128.9 (14.1-1160)	0.299	114.5 (37.9-1160)	0.293	143.1 (14.1-516.2)	0.746
TLR at discharge	125.9 (15.3-663.8)		106.2 (31.5-663.8)		138 (15.3-559.3)	
MLR at admission	0.33 (0.1-3.9)	p<0.001	0.34 (0.1-3.4)	p<0.001	0.33 (0.1-3.9)	p<0.001
MLR at discharge	0.28 (0-3.9)		0.27 (0-2.2)		0.29 (0.1-3.9)	

Leukocyte, neutrophil, lymphocyte, eosinophil, monocyte and thrombocyte units: (× 10^3 /μL), RBC unit: (×10^6/ μL), Hb unit: gr/dL, NLR: neutrophil count/lymphocyte count, TLR: thrombocyte count/lymphocyte count, MLR: monocyte count/lymphocyte count

ROC Analysis Results

In ROC analysis made in terms of predicting pneumonia in COVID-19 infection; CRP value of >3.93 mg/dL at hospitalization had AUC: 0.675 with 87.9% sensitivity and 47.6% specificity, the eosinophil value of ≤ 0.02/μL had AUC: 0.668 with 56.3% sensitivity and 71.2% specificity, monocyte value of ≤ 0.5/ μL had AUC: 0.631 with 55.1% sensitivity and 67.6% specificity. TLR value of >105.7 had AUC: 0.611 with 75.4% sensitivity and 46% specificity, NLR value of > 1.59 had AUC: 0.569 with 73.8% sensitivity and 40% specificity. CRP, eosinophil, monocyte and TLR were determined as markers with high positive predictive parameters in favor of COVID-19 pneumonia.

DISCUSSION

In this study, it has been shown that especially lymphocyte, monocyte, eosinophil counts and and TLR values may be important in COVID-19 pneumonia. It is thought that the comparison of the clinical and laboratory data of patients with and without pneumonia in the course of COVID-19 disease, as well as the determination of pneumonia predictive laboratory parameters will contribute to science. The lack of sufficient studies comparing these two groups during COVID-19 infection, reveals the significance and difference of the current study.

In a meta-analysis advanced age, obesity, and high fever were found to be independent variables predicting COVID-19 pneumonia (7). The importance of NLR in terms of prognosis and mortality has been frequently emphasized in studies (5, 6). The incidence of pneumonia in patients in the study was 50.6% (n = 256). The median age of patients with pneumonia was higher ($p < 0.05$).

Many significant changes develop during the course of COVID-19 disease in hemogram and biochemical parameters. In most of the studies since the beginning of the epidemic, variables in predicting organ involvement and disease prognosis have been reported (8, 9). Leukopenia, leukocytosis and lymphopenia are the most frequently reported changes. Although leukocytosis is more common in severe disease, it has been reported to be around 25% (10, 1). Lymphopenia and neutrophilia have been reported as prognostic factors for severe disease in many studies (11). Eosinopenia is frequently reported in the course of COVID-19 and is has been used as a prognostic marker for severe disease (9,12). Although the median leukocyte, lymphocyte, neutrophil and eosinophil counts of all patients diagnosed with COVID-19 in the study were mostly in the normal range, in the group with pneumonia the eosinophils and lymphocytes which frequently decrease in the course of infection especially in severe pneumonia, had been observed to be lower ($p < 0.05$). Although the monocyte count generally increases during the inflammatory process, some studies comparing the healthy population with COVID-19 patients reported a slight increase in the patient group. However, in studies with large patient groups, monocyte count has been reported generally within normal limits (13, 14). In studies on COVID-19 thrombocytopenia has also been reported as a poor prognostic marker (15). In our study, the monocyte count of all patients was mostly within the normal range and it was compatible with the literature. Median monocyte count at hospitalization of patients with pneumonia were lower.

Although studies have reported that the platelet count decreases due to consumption and low values are associated with severe disease in the prothrombotic process which starts as a result of the damage by the virus in the endothelium and there are also studies reporting that reactive thrombocytosis develops as a result of inflammation (12, 16). While thrombocyte levels were within normal range in our patients, significant increment in thrombocyte count at discharge in both groups ($p < 0.001$) can be explained by reactive thrombocytosis. The fact that the patients in the study were followed up in the clinic and the intensive care patients were not included may explain that laboratory parameters were mostly within the normal range in our patients.

It has been reported that a gradual decrease in RBC and Hb values has been observed within days in the course of the infection due to the damage developed in erythrocytes and suppression of erythropoiesis in bone marrow by the toxic effects of the virus on both mature and precursor cells (16, 17). During the recovery period of the infection, RBC and Hb values were reported as parameters that recovered at the latest (17). In the study, in all patients the lower RBC and Hb values at discharge ($p < 0.001$ for both) were consistent with the literature.

Although NLR usually increases, especially in severe infection, it has been reported as one of the most important factors predicting disease prognosis and mortality (18). Although the normal NLR value was detected in the range of 0.78-3.53 in a healthy adult population in one study, there is no known universally accepted reference range (19). It has also been reported that the NLR varies according to gender and age. The median admission NLR value of the patients included in the study was 2 (0.4-26.7).

In addition, there are studies on COVID-19 showing that MLR and TLR values which are among the new inflammation markers, increase in the course of infection, especially in severe disease. These markers can be used as significant predictive variables in terms of mortality and prognosis in COVID-19 infection (20, 21). In a multi-center study, it has been determined that MLR is the most important marker to predict COVID-19 infection [21]. In the study, it was found that NLR and TLR values at hospitalization were higher in pneumonia group (p: 0.008, <0.001, respectively).

In studies, different cut-off values with predictive importance for NLR, TLR and MLR on poor prognosis and mortality of COVID-19 infection have been reported. In the comparison of the laboratory parameters of the two groups; lymphocyte, eosinophil, monocyte, CRP, NLR and TLR values were taken into consideration to predict Covid-19 pneumonia. It was found that CRP, eosinophil, monocyte and TLR were significant predictive markers in favor of Covid-19 pneumonia.

Limitations of the study:

Since the mortality rate was low in our patient population, the importance of these variables in terms of mortality and prognosis could not be evaluated.

Multi-center studies with larger patient populations are needed to clarify the course of COVID-19 pneumonia and to determine the important laboratory parameters in the diagnosis and follow-up.

Conflict of interest: There is no conflict of interest between the authors.

REFERENCES

1. Qing Ye, Bili Wang and Jianhua Mao. The pathogenesis and treatment of the ‘cytokine storm’ in COVID-19, J. Inf. Secur. 80 (2020): 607-13.
2. Hamed Akbari, Reza Tabrizi, Kamran B. Lankarani et al. The role of cytokine profile and lymphocyte subsets in the severity of coronavirus disease 2019 (COVID-19): A systematic review and meta-analysis. ELSEVIER, *Life Sciences* 258 (2020): 118167
3. Liu Y, Du X, Chen J, Jin Y, Peng L, Wang HHX. Neutrophil to lymphocyte ratio as an independent risk factor for mortalitiy in hospitalized patients with COVID-19. *Journal of Infection* 81 (2020): e6-e12.
4. M. S. Asghar, N.A. Khan, S.J.H. Kazmi, et al. Hematological parameters predicting severity and mortality in COVID-19 patients of Pakistan: a retrospective comperative analysis. medRxiv *June* 2020.
5. Yang AP, Liu JP, Tao WQ, Li HM. The diagnostic and predictive role of NLR, d-NLR, PLR in COVID-19 patients. *Int. Immunopharmacol* 2020;84: 106504.
6. Xue Wang, Xincheng Li, Yu Shang et al. Ratios of neutrophil to lymphocyte and platelet to lymphocyte predict all-cause mortality in inpatients with coronavirus disease 2019: a retrospective cohort study in a single madical centre. *Epidemiology and Infection* 2020: 148, e211, 1-8. https://doi.org/10.1017.
7. Wannarat A. Pongpirul, Surasak Wiboonchutikul, Lantharita Charoenpong et al, Nayot Panitantum, Apichart Vachiraphan, Sumonmal Uttayamakul et al. Clinical course and potential predictive factors for pneumonia of adult patients with Coronavirus Disease 2019 (COVID-19): A retrospective observational analysis of 193 confirmed cases in Thailand. PLoS Negl Trop Dis. 2020: Oct; 14 (10): e0008806: https://doi.org/10.1371/journal.pntd.0008806.
8. W. Guan, Z. Ni, Yu Hu et al. He. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med* 2020:1708-20.
9. Ruchong Chen, MD, Ling Sang, MD, Mei Jiang, PhD et al. Longitudinal hematologic and immunologic variations associated with the progression of COVID-19 patients in China. *J Allergy Clin Immunol.* 2020: Jul; 146 (1): 89–100 doi: 10.1016/j.jaci.2020.05.003
10. Guan W-J, Ni Z-Y, Hu Y. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med.* 2020: 382 (18): 1708-1713.

11. T. A. Khartabila, H. Russchera, Ajam van der Venb, and Y. B. de Rijkea. A summary of the diagnostic and prognostic value of hemacytometry markers in COVID-19 patients. *Critical Reviews In Clinical Laboratory Sciences*. 2020: June: https://doi.org/10.1080/10408363.2020.1774736.
12. Guoguang Lu, Jing Wang. Dynamic changes in routine blood parameters of a severe COVID-19 case. *Clinica Chim Acta* 508 (2020): 98-102 doi: 10.1016/j.cca.2020.04.034
13. Qin C, Zhou L, Hu Z. Dysregulation of immune response in patients with COVID-19 in Wuhan, China. *Clin Infect Dis*. 2020 Jul 28;71(15):762-768. doi: 10.1093/cid/ciaa248.
14. Song C-Y, Xu J, He J-Q. COVID-19 early warning score: a multi-parameter screening tool to identify highly suspected patients. medRxiv. March 8, 2020: **doi:** https://doi.org/10.1101/2020.03.05.20031906.
15. Lippi G, Plebani M, Henry BM. Thrombocytopenia is associated with severe coronavirus disease 2019 (COVID-19) infections: a meta-analysis *Clin Chim Acta*. 2020: 506:145-8.
16. Yang M, Li CK, Li K. Hematological findings in SARS patients and possible mechanisms (review). *Int J Mol Med*. 2004: 14 (2): 311-5.
17. Tian S, Zhu X, Sun X. Longitudinal analysis of laboratory findings during the process of recovery for patients with COVID-19. medRxiv. April 7, 2020: **doi:** https://doi.org/10.1101/2020.04.04.20053280.
18. Feng Z, Yu Q, Yao S. Early prediction of disease progression in 2019 novel coronavirus pneumonia patients outside Wuhan with CT and clinical characteristics. medRxiv. 2020. **doi:** https://doi.org/10.1101/2020.02.19.20025296.
19. Patrice Forget, Céline Khalifa, Jean-Philippe Defour et al. What is the normal value of the neutrophil to lymphocyte ratio? *BMC* Res Notes (2017): 10:12 DOI 10.1186/s13104-016-2335-5.
20. Junnan Peng, Di Qi, Guodan Yuan et al. Diagnostic value of peripheral hematologic markers for coronavirus disease 2019 (COVID-19): A multicenter, crosssectional study *J Clin Lab Anal*. 2020: 34: e23475.
21. Gong J, Ou J, Qiu X. A tool to early predict severe 2019-novel coronavirus pneumonia (COVID-19): a multicenter study using the risk nomogram in Wuhan and Guangdong, China. medRxiv. 2020. **doi:** https://doi.org/10.1101/2020.03.17.20037515.J.