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Original Article

Prognostic value of complete blood count parameters in COVID-19 patients

COVID-19 hastalarında hemogram parametrelerinin prognostik değeri

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ABSTRACT

Background: To explore the prognostic value of certain complete blood count parameters and ratios in COVID-19 patients with the definitive diagnosis.
Methods: We compared certain parameters of the complete blood count test, which are related to inflammation, between the inpatient/outpatient and the survivor/non-survivor groups to determine whether they have a prognostic role. Analyzes were performed in Statistical Package for the Social Sciences (SPSS). Parametric data were expressed as arithmetic mean±standard deviation, and nonparametric data were expressed as median (Q1-Q3). The relationship in categorical variables was examined with Chi-Square. Receiver Operative Characteristics (ROC) analysis determined cut-off values for mortality. P <0.05 was considered statistically significant.
Results: A total of 6343 patients ≥18 years old were included in the study; 4822 (76.0%) were outpatients, and 1521 (24.0%) were inpatients. 53.5% (3.396) of the patients were female, and 46.5% (2947) were male. The mean level of mean platelet volume (MPV), white blood cell count (WBC), plateletcrit (PCT), neutrophil count (NEU), red cell distribution width (RDW), platelet distribution width (PDW), neutrophil/lymphocyte ratio (NLR), monocyte/lymphocyte ratio (MLR) and platelet/lymphocyte ratio (PLR) were higher in the inpatients compared to the outpatients (p<0.05 for all). Also, the mean hemoglobin (HGB) and lymphocyte (LYM) were significantly lower in the inpatients (p<0.05 for both). On the other hand, compared to the survivors, the non-survivors had significantly higher WBC, NEU, RDW, NLR, MLR, MPV, and PLR, and lower HGB, LYM, PCT, and PLT levels (p<0.05 for all).
Conclusion: RDW, HGB, WBC, MPV, PLT, LYM, NEU, NLR, MLR, and PLR have been shown to have a robust relationship with poor prognosis of COVID-19.

Keywords: Complete blood count parameters, COVID-19, inflammation, prognosis

ÖZ

Giriş ve Amaç: Kesin tanısı olan COVID-19 hastalarında belirli tam kan sayımı parametrelerinin ve oranlarının prognostik değerini araştırmaktır.
Yöntem ve Gereçler: Tam kan sayımı testinin inflamasyonla ilişkili olduğu düşünülen bazı parametrelerini yatan/ayakta tedavi gören ve mortalite durumuna göre gruplar arasında prognostik rolü olup olmadığını anlamak için karşılaştırdık. Analizler SPSS18'de yapılmıştır. Parametrik veriler aritmetik ortalama±standart sapma olarak ifade edilmiş ve nonparametrik veriler medyan(Q1-Q3) olarak ifade edilmiştir. Kategorik değişkenlerdeki ilişki Ki-Kare ile incelenmiştir. Receiver Operative Characteristics (ROC) analizi ile mortalite için kesme (cut-off) değerleri belirlenmiştir. p<0.05 istatistiksel olarak anlamlı kabul edilmiştir.
Bulgular: Çalışmaya 18 yaş ve üzeri toplam 6343 hasta alındı; 4822'si (%76,0) ayaktan, 1521'i (%24,0) yatan hastaydı. Hastaların %53,5'i(3.396) kadın, %46.5'i(2947) erkekti. Ortalama trombosit hacmi (MPV), beyaz küre sayısı (WBC), trombosit krit (PCT), nötrofil sayısı (NEU), kırmızı hücre dağılım genişliği (RDW), trombosit dağılım genişliği (PDW), nötrofil/lenfosit oranı (NLO), monosit/lenfosit oranı(MLR) ve trombosit/lenfosit oranı(PLR)

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yatan hastalarda ayaktan hastalara göre daha yüksekti (tümü için p<0.05). Ayrıca yatan hastalarda ortalama hemoglobin (HGB) ve lenfosit (LYM) değerleri anlamlı olarak daha düşük bulundu (her ikisi için p<0.05). Öte yandan, hayatta kalanlarla karşılaştırıldığında, hayatta kalmayanlarda WBC, NEU, RDW, NLR, MLR, MPV ve PLR ile birlikte daha düşük HGB, LYM, PCT ve PLT seviyeleri vardı (tümü için p<0.05).
Tartışma ve Sonuç: RDW, HGB, WBC, MPV, PLT, LYM, NEU, NLR, MLR ve PLR'nin kötü COVID-19 prognozu ile güçlü bir ilişkisi olduğu gösterilmiştir.

Anahtar kelimeler: COVID-19, enfeksiyon, prognoz, tam kan sayımı parametreleri

INTRODUCTION

A new type of Coronavirus was identified in the last days of 2019 following several investigations to inquire about the causative agent of a cluster of pneumonia cases detected in a short time in Wuhan, China. By reason of the rapid spread of the virus, the disease started to be seen in most parts of the World in a few months. The name of this new member of the Coronavirus family, which has high contagiousness, was announced to be severe acute respiratory syndrome virus 2 (SARS-CoV-2) by the World Health Organization (WHO). Additionally, the WHO declared that infection caused by SARS-CoV-2 was a Novel Coronavirus Disease 2019 (COVID-19).

Although most COVID-19 patients seem to be asymptomatic or have mild symptoms, many cases exhibit severe clinical manifestations such as acute respiratory distress syndrome (ARDS) that may require intensive care unit and even intubation. In addition to ARDS, life-threatening vascular complications such as thromboembolic disease and disseminated intravascular coagulopathy (DIC) can develop due to excessive cytokine release (1). Furthermore, it has been shown that mortality of COVID-19 may increase regarding dysfunctions in many organs and systems such as the heart, kidney, liver, gastrointestinal system, and central nervous system following the occurrence of severe disease, mostly in the elderly and individuals with comorbid diseases (2).

Early recognition of COVID-19, which, due to its rapid spread, prevented healthcare systems' capacity from being faced with a risk of being exceeded at the beginning of the pandemic, is crucially important. An early diagnosis seems to be the more effective way to reduce mortality by administering an immediate treatment before the disease progresses. Diagnostic tools are needed to predict the severity of the disease and take precautions against the potential poor prognosis of COVID-19 (3).

To be resulting quickly, inexpensiveness and easy accessibility make a complete blood count (CBC) test irreplaceable in the routine evaluation of blood samples. A CBC test includes a wide range of parameters related to red blood cell indices, white blood cells and their subtypes, and platelet indices. Neutrophils, the most abundant subtype of white blood cells with an important function in immune response, and lymphocytes, a valuable marker in infectious pathologies, are two of the most extensively evaluated parameters in a CBC test. Playing a role in the immune system, platelets are known to be a key regulator in inflammatory diseases and have an essential task in blood coagulation. Hematological tests have a great value owing to their frequent usage to screen a broad range of diseases. Numerous parameters in a CBC test can act as biomarkers to assess the diagnosis of infectious diseases (4). Of those, increased neutrophil/lymphocyte ratio (NLR) has been reported to be associated with various inflammatory and non-inflammatory diseases, including diabetes mellitus (5), Hashimoto's disease (6), irritable bowel syndrome (7), and even COVID-19 (8). Another novel hemogram indices related to inflammation is increased platelet/lymphocyte ratio (PLR). It has been related to thyroid diseases (9), malignant diseases (10), COVID-19 infection (11), and type 2 diabetes mellitus (12). Red cell distribution width (RDW) refers to the size variability of erythrocytes and indicates anisocytosis. Moreover, it has been reported that increased RDW was associated with

diabetes mellitus (13), chronic kidney disease (14), irritable bowel disease (15), thyroiditis (16), rheumatoid arthritis (17), autoimmune hepatitis (18), and thyroid nodules (19). In addition, the association between inflammation and increased mean platelet volume (MPV) has been shown in obesity (20), nasal polyposis (21), coronary heart disease (22), diabetes mellitus (23), and hypothyroidism (24).

This study investigated the prognostic value of CBC parameters and ratios in COVID-19 infection. This devastating global issue still maintains its threatening existence in almost all territories worldwide. Thus, we aimed to detect the most likely parameters that may serve as useful biomarkers in predicting severe disease.

METHODS

Study Population

6343 patients aged 18 years or older, who have a definitive diagnosis of COVID-19 confirmed by a real-time polymerase chain reaction (RT-PCR) test between April 2020 and December 2020 in Bolu, Turkey, were enrolled in this retrospective study. Ethical approval of the study was obtained from Bolu Abant Izzet Baysal University Clinical Research Ethics Committee (Date:2020 Number:328). Data was collected by scanning the patients retrospectively from the Public Health Management System of City Health Administrative and Hospital Information Management System. At first, the participants were divided into two groups: outpatients (4822 [76.0%]) and inpatients (1521 [24.0%]). In the second phase, the inpatients were categorized based on survivability.

Laboratory Analyses

CBC test results, measured from the blood sample obtained immediately after diagnosis, were compared between the outpatients and inpatients. CBC results of the 3rd day for survivors and non-survivors were compared to explore their relationship with mortality risk among the inpatients. In the study, some parameters and ratios such as hemoglobin (HGB), erythrocyte distribution width (RDW), platelet count (PLT), plateletcrit (PCT), mean platelet volume (MPV), platelet distribution width (PDW), leukocyte count (WBC), neutrophil count (NEU), lymphocyte count (LYM), neutrophil/lymphocyte ratio (NLR), monocyte/lymphocyte ratio (MLR), and platelet/lymphocyte ratio (PLR) were compared between the groups.

Statistical Analyses

Statistical Package for the Social Sciences (SPSS) was used to carry out statistical analysis. The normality of distribution was evaluated using the Kolmogorov-Smirnov test. The appropriateness of the data to the normal distribution was checked by skewness and kurtosis coefficients taking the range between±2. Parametric data were compared with the Independent Sample t-test, and the arithmetic was expressed as mean ± standard deviation. Nonparametric data were compared with the Mann-Whitney U test and expressed as median (Q1-Q3). The relationship between categorical variables was examined by Chi-Square analysis. The effect sizes were interpreted with Cohen d, taking d: 0.20 small effect, d: 0.50 medium effect, and d: 0.80 large effect. Receiver Operative Characteristics (ROC) curve assessed cut-off values, sensitivity, and specificity analyses for the data used in mortality estimation. $P < 0.05$ was considered statistically significant.

RESULTS

A total of 6.343 patients aged ≥18 years were included in the study. Of these patients, 4.822 (76.0%) were outpatients and 1.521 (24.0%) were inpatients. 53.5% (3.396) of the participants were female, and 46.5% (2.947) were male. The mean age of the outpatients was 43.23±15.18, and that of the inpatients was 64.10±15.03 years. The mean age of all the patients was 48.24±17.57 years (Table 1).

It was observed that the mean values of MPV, WBC, PCT, NEU, RDW, PDW, MPV, NLR, MLR,

Table 1. Comparison of CBC parameters between outpatients and inpatients.

	Outpatients (n=4.822, %76.0)	Inpatients (n=1.521, %24.0)	All patients (n=6.343)	p-value	Cohen d
Gender					
Female	2657 (%55.1)	739 (%48.6)	3396 (%53.5)	<**0.001**[*,a]	-
Male	2165 (%44.9)	782 (%51.4)	2947 (%46		
		$\bar{X}$±**ss**			
Age	43.23±15.18	64.10±15.03	48.24±17.57	<**0.001**[*,b]	1.38
HGB	14.17±1.67	12.71±1.79	13.82±1.81	<**0.001**[*,b]	0.84
MPV	8.96±1.19	9.34±1.27	9.05±1.22	<**0.001**[*,b]	0.31
		Median (Q1-Q3)			
WBC	5.8 (4.7-7.08)	7.2 (5.1-9.8)	5.98 (4.78-7.63)	<**0.001**[*,b]	0.44
LYM	1.5 (1.1-2)	0.8 (0.52-1.28)	1.37 (0.9-1.9)	<**0.001**[*,b]	0.22
PLT	217 (180-259)	220 (169-285)	217 (178-264)	0.205	-
PCT	0.19 (0.16-0.23)	0.201 (0.157-0.2605)	0.191 (0.159-0.237)	<**0.001**[*,b]	0.24
NEU	3.4 (2.54-4.5)	5.4 (3.4-8.4)	3.7 (2.7-5.1)	<**0.001**[*,b]	0.80
RDW	13.4 (12.8-14.1)	13.8 (13.1-14.8)	13.5 (12.9-14.3)	<**0.001**[*,b]	0.32
PDW	16.7 (16.1-17.1)	16.9 (16.1-17.4)	16.7 (16.1-17.2)	<**0.001**[*,b]	0.01
NLR	2.2 (1.48-3.53)	6.63 (3.38-12.8)	2.62 (1.61-4.89)	<**0.001**[*,b]	0.82
MLR	0.4 (0.27-0.62)	0.5 (0.33-0.78)	0.43 (0.28-0.67)	<**0.001**[*,b]	0.21
PLR	143.75 (107.93-200.0)	263.17 (165.05-413.33)	158.75 (113.66-240.93)	<**0.001**[*,b]	2.41

*[a]Chi-Square test [b]Independent Sample t test/Mann-Whitney U test *Statistically significant*
HGB: Hemoglobin, MPV: Mean Platelet Volume, WBC: White Blood Cell, LYM: Lymphocyte, PLT: Platelet, PCT: Plateletcrit, NEU: Neutrophil, RDW: Red Cell Distribution Width, PDW: Platelet Distribution Width, NLR: Neutrophil/Lymphocyte Ratio, MLR: Monocyte/Lymphocyte Ratio, Platelet/Lymphocyte Ratio; HGB gr/dl; WBC, LYM, PLT,NEU X1000/mm^3.

and PLR were higher for inpatients compared to outpatients, and these were statistically significant (p<0.05 for all parameters). The mean HGB and LYM values were significantly lower for inpatients (p <0.05 for both parameters). However, the mean PLT values did not differ significantly between the groups (p>0.05) (Table 1).

The demographic data and mortality status of 1521 inpatients are summarized in Table 2. Accordingly, 237 (15.6%) of the inpatients did not survive. 58.6% of the non-survivors were male. The mean age of the survivors was 62.47±15.14, while the mean age of the non-survivors was 72.90±10.80. The difference was statistically significant (p<0.05) (Table 2).

The mean WBC, NEU, RDW, NLR, MLR, MPV, and PLR values were significantly higher in the non-survivors than in the survivors (p<0.05 for all parameters). On the other hand, the mean HGB, LYM, PCT, and PLT values were lower in the patients who did not survive (p<0.05 for all parameters) (Table 2).

According to the cut-off values calculated from ROC analysis, the sensitivity, specificity, AUC values, and 95% confidence intervals of NLR, MLR, and PLR in predicting mortality are shown in Table 3. The association of NLR, MLR, and PLR with mortality risk are significant (p<0.05 for all parameters). ROC curves of these parameters are displayed in Figure1.

DISCUSSION

Due to the significant contagiousness of SARS-CoV-2, the total number of COVID-19 cases worldwide continue to increase unremittingly. Therefore, many countries from various parts of the world have faced economic problems, and their health systems' capacities have exceeded. Apart from problems confronted by COVID-19 patients, the pandemic also caused difficulties for patients other than having COVID-19 in reaching healthcare services, including immediate surgical treatments (25). Since it could lead to severe/critical clinical manifestations, prompt recognition and timeous treatment of COVID-19 may prevent the potential progression of the

Table 2. Comparison of inpatients' data according mortality status.

	Survivors (n=1.284, %84.4)	Non-survivors (n=237, %15.6)	All inpatients (n=1.521)	p-value	Cohen d
Gender					
Female	641 (%49.9)	98 (%41.4)	739 (%48.6)	**0.015**[*,a]	-
Male	643 (%50.1)	139 (%58.6)	782 (%51.4)		
		$\bar{X}\pm ss$			
Age	62.47±15.14	72.90±10.80	64.10±15.03	<**0.001**[*,b]	0.79
HGB	12.77±1.67	12.38±2.17	12.71±1.76	**0.008**[*,b]	0.20
MPV	9.27±1.24	9.71±1.34	9.34±1.27	<**0.001**[*,b]	0.34
PDW	16.03±2.32	15.87±2.66	10.01±2.37	0.390	-
		Median (Q1-Q3)			
WBC	6.93 (5.0-9.49)	8.91 (6.18-12.9)	7.2 (5.1-9.8)	<**0.001**[*,b]	0.45
LYM	0.90 (0.6-1.3)	0.6 (0.4-0.9)	0.80 (0.53-1.28)	<**0.001**[*,b]	0.31
PLT	223 (172-292)	201 (150-259)	220.0 (169-285)	<**0.001**[*,b]	0.35
PCT	0.20 (0.16-0.26)	0.19 (0.14-0.24)	0.2 (0.16-0.26)	**0.006***	0.23
NEU	5.10 (3.3-7.92)	7.45 (4.86-11.54)	5.4 (3.4-8.5)	<**0.001**[*,b]	0.56
RDW	13.70 (13.1-14.6)	14.35 (13.7-15.5)	13.8 (13.1-14.8)	<**0.001**[*,b]	0.45
NLR	5.85 (3.0-11.3)	12.61 (6.95-24.0)	6.63 (3.38-12.80)	<**0.001**[*,b]	0.62
MLR	0.50 (0.33-0.75)	0.63 (0.4-1.0)	0.50 (0.33-0.78)	<**0.001**[*,b]	0.19
PLR	253.82 (161.82-401.67)	328.81 (212.92-545.42)	263.17 (165.05-413.33)	<**0.001**[*,b]	0.34

*[a]Chi-Square test [b]Independent Sample t test/Mann-Whitney U test *Statistically significant*
HGB: Hemoglobin, MPV: Mean Platelet Volume, WBC: White Blood Cell, LYM: Lymphocyte, PLT: Platelet, PCT: Plateletcrit, NEU: Neutrophil, RDW: Red Cell Distribution Width, PDW: Platelet Distribution Width, NLR: Neutrophil/Lymphocyte Ratio, MLR: Monocyte/Lymphocyte Ratio, Platelet/Lymphocyte Ratio; HGB gr/dl; WBC, LYM, PLT,NEU X1000/mm³.

Table 3. Receiver operating characteristic analysis of CBC-derived ratios.

	AUC (%95 CI)	Cut-Off	p-value	Sensitivity (%)	Specificity (%)
NLR	0.723 (0.688-0.758)	8.423	<0.001*	68.6	64.0
MLR	0.599 (0.558-0.641)	0.548	<0.001*	55.1	55.3
PLR	0.605 (0.565-0.645)	269.615	<0.001*	63.1	54.1
		Recovery n (%)	**Death n (%)**	X^2 **value**	**p-value**
NLR	0-8.423	821 (%64.0)	74 (%31.4)	87.993	<**0.001***
	8.424 and over	461 (%36.0)	162 (%68.6)		
MLR	0-0.548	709 (%55.3)	105 (%44.5)	9.370	**0.002***
	0.549 and over	573 (%44.7)	131 (%55.5)		
PLR	0-269.615	694 (%54.1)	87 (%36.9)	23.797	<**0.001***
	269.616 and over	588 (%45.9)	149 (%63.1)		

*The values in bold are statistically significant. *Chi-Square analysis. AUC: Area under the curve*
NLR: Neutrophil/Lymphocyte Ratio, MLR: Monocyte/Lymphocyte Ratio, Platelet/Lymphocyte Ratio.

disease, resulting in the reduced requirement of intensive care unit and intubation. Hence, it will be more doable to surpass the cost increase of pandemics and difficulties in utilizing health sources. Various criterions such as clinical, radiological, and laboratory findings can be used to estimate possible poor prognosis. Using some hematological parameters with a beneficial value in systemic inflammatory conditions, which have been researched in the early days of the pandemic, can aid in predicting the clinical severity and prognosis of COVID-19 (26).

This study consisting of a total of 6343 patients, intended to reveal whether there is a significant difference in the mean levels of some hematological parameters such as HGB, RDW, WBC, NEU, LYM, PLT, MPV, PDW, PCT, NLR, MLR, and PLR between outpatients and inpatients groups. Moreover, it aimed to evaluate the usefulness of these parameters in predicting mortality in inpatients. Following the previously reported results, the mean age of patients who needed to be hospitalized and those who did not survive were higher than others (27,28).

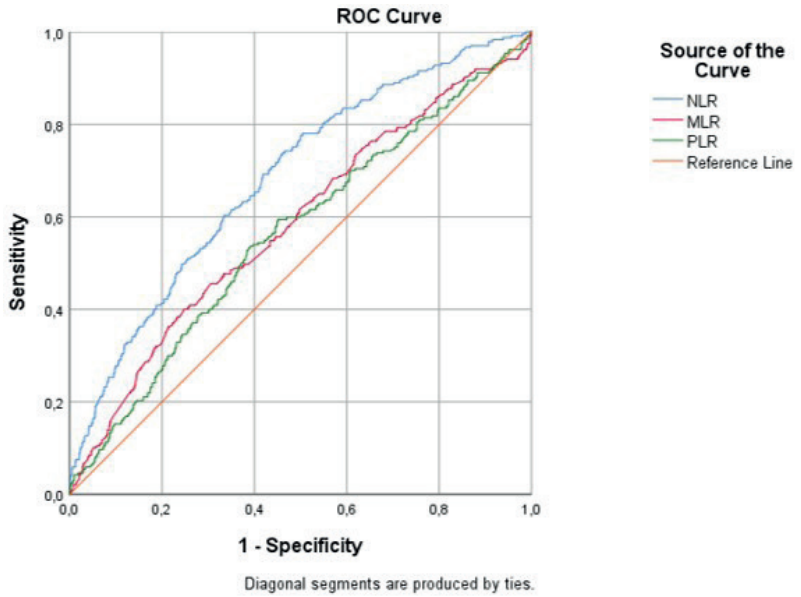

Figure 1. Receiver operating characteristic (ROC) curve for mortality.
NLR: Neutrophil/Lymphocyte Ratio, MLR: Monocyte/Lymphocyte Ratio, Platelet/Lymphocyte Ratio.

Since the RT-PCR test, the definitive diagnostic tool of COVID-19 did not have the desired sensitivity level. At the beginning of the pandemic, the availability of other diagnostic tools was needed. Moreover, there were disadvantages such as delay in diagnosing the COVID-19 infection because of the unavailability of PCR devices in every health care facility in the early days of the pandemic. Hence, using various CBC parameters and ratios such as WBC, LEU, PLT, and NLR aimed to establish an early diagnosis, which was likely to be delayed due to the poor sensitivity of the PCR kits (29). Nonetheless, numerous new RT-PCR kits have been developed, and the presence of these kits with much higher sensitivity has reduced false-negative results (30). Thus, the markers above have been investigated over time for prognostic values rather than diagnostic use (26).

Consistent with a previous study, we found higher WBC levels in patients with poor prognoses (31). Likewise, in line with the same study conducted by Ouyang et al., a significant relationship was found between clinical severity and neutrophil count in our study (31). Accordingly, significantly higher levels of WBC and NEU were observed in inpatients compared to outpatients and similar results in patients who died compared with recovered patients. Since the early period of the pandemic, it has been demonstrated that lymphopenia may occur in COVID-19 infection and is an early warning of poor prognosis (26,31). Similar to reported results from prior studies, we revealed that lymphopenia was associated with increased hospitalization and mortality rates.

In the present study, RDW seems to be a useful biomarker in evaluating the prognosis in COVID-19 patients. It has been shown that patients requiring hospitalization have significantly higher RDW levels than those undergoing outpatient treatment. Moreover, the same difference was also seen between the inpatients, with significantly higher RDW levels in non-survivors. A meta-analysis by Lee et al.[32] suggested that RDW can predict severe disease in COVID-19 infection, and elevated RDW levels at the early stage of the disease should be a warning of poor prognosis. A prospective study conducted by Henry et al.[33] with 49 patients diagnosed with COVID-19 investigated the relationship between red blood cell indices and the severity of the disease. In the study, it has been suggested that increased RDW has a relationship with severe disease. It should be considered for its likelihood of being a valuable prognostic biomarker. Moreover, it has been demonstrated that HGB

levels in severe diseases are significantly lower compared to mild and moderate diseases. A similar correlation between the severity of the disease and HGB levels was also observed in our study.

The relationship between platelet indices and mortality of COVID-19 was researched, and it has been concluded that MPV and PDW levels were higher in non-survivors than in survivors (8,11). Zhang et al.[34] have suggested that decreased levels of PLT and PCT and increased MPV and PDW in severe diseases are associated with excessive consumption caused by increased platelet activation in COVID-19. In keeping with previous reports, in our study, inpatients were found to have significantly higher PDW and MPV levels than outpatients. Moreover, we exhibited that the mean PLT and PCT levels in the non-survivors were lower than that of the survivors, with a statistically significant difference. Furthermore, the mean MPV value was significantly higher in patients who died of COVID-19. The mean PCT level was higher in the inpatients than in outpatients, and the mean PDW level did not differ between survivors and non-survivors. These results were in contradiction with a study previously reported (34). Since the pandemic's beginning, it has been known that COVID-19 patients develop coagulopathy, which is still a matter of debate for the probable pathophysiology (34,35). Therefore, the prophylactic use of anticoagulants is a requirement for certain patient groups to prevent thromboembolic disease associated with COVID-19. Accordingly, various factors, such as the disease itself, anticoagulant therapies, and disseminated intravascular coagulation, might cause changes in platelet indices in patients with COVID-19 (35). All these conditions seem likely to contribute to the unexpected differences in our patients. We believe that the time of taking blood samples may also be the reason for differences in results.

CBC-derived ratios such as NLR, PLR, and LMR in diagnosis, differential diagnosis and prognosis of many diseases, particularly inflammatory disorders, have been demonstrated (7,15,16,20,36). The utility of these ratios in COVID-19 patients has been researched in numerous studies, with a conclusion suggesting that they may serve in predicting severe disease and mortality risk (8,11). In a retrospective study conducted with 119 patients in Italy, the relationship between CBC parameters and survival was evaluated. The study observed that the mean NLR value was higher in non-survivors, whereas the mean MLR and PLR values did not differ significantly between the groups (37). In a similar study, Peng et al.[38] investigated hematological markers' diagnostic and prognostic values in COVID-19 infection. According to the study results, MLR is a useful biomarker in the differential diagnosis of COVID-19 and NLR is a valuable predictor of severe disease. High PLR level has also been associated with certain conditions such as malignant thyroid diseases and diabetes mellitus (8-10,12). In the present study, in agreement with the results of the studies above, we showed that mean NLR, PLR, and MLR values were significantly higher in the inpatients compared to outpatients. Likewise, these parameters were significantly higher in non-survivors than survivors.

Our study has several shortcomings. Firstly, this is a retrospective study with a lower level of evidence than prospective studies. Thus, prospective cohort studies with a large sample size and homogeneous distribution of participants must be performed to obtain more accurate results. Secondly, we did not consider blood disorders such as anemia, thrombocytopenia, and leukemia, which might affect the results. Furthermore, we did not research the prognostic value of some CBC parameters, e.g., eosinophil count, basophil count, and monocyte count.

In summary, using several CBC parameters, an easy, practical, and inexpensive blood test, the prognosis of patients with COVID-19 infection can be predicted at the early phase of the disease. Although many CBC parameters seem to have the potential to be used in predicting prognosis, some of them, such as RDW, HGB, WBC, MPV,

PLT, LYM, NEU, NLR, MLR, and PLR, have been concluded to have a remarkable relationship with mortality. Consequently, we suggest that after COVID-19 diagnosis, CBC parameters must be evaluated fastidiously to designate the disease's risk stratification.

Ethics Committee Approval: The study protocol was approved by the University Clinical Research Ethics Committee (2020/338).

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