Investigation of hematological blood values in COVID-19 patients according to discharge and exitus groups

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Abstract. – **OBJECTIVE:** The investigation was conducted on hematological blood values examined in COVID-19 patients in order to assess whether these values could provide a prediction about the severity and course of the disease. In this way, the study aims to help determine the treatment plans of patients and monitor the recovery process with simple and common tests such as hematological blood values.

PATIENTS AND METHODS: This was a retrospective study. The study group consisted of patients with positive PCR test results registered in the Patient Automation System of the Emergency Department of Malatya Training and Research Hospital between 1 January and 30 April 2021. The patients were divided in discharge (n=187) and exitus (n=52) groups.

RESULTS: The study showed that Neutrophil (AUC=0.889, $p<0.05$), Lymphocyte (AUC=0.805, $p<0.05$) and mean corpuscular hemoglobin concentration (MCHC) (AUC=0.739, $p<0.05$) values may be a good predictive factor for disease severity and mortality risk of COVID-19 patients.

CONCLUSIONS: Neutrophil, Lymphocyte and MCHC blood test samples can be used as a biomarker in the effective fight against COVID-19.

Key Words:
COVID-19, Hematology, Biomarker, Pandemic.

Abbreviations

RBCs: Red Blood Cells, HB: Hemoglobin, HCT: Hematocrit, MCH: Mean Corpuscular Hemoglobin, MCHC: Mean Corpuscular Hemoglobin Concentration, MCV: Mean Corpuscular Volume, RDW: Red Cell Distribution Width, PCT: Plateletcrit, PDW: Platelet Distribution Width, MPV: Mean Platelet Volume, NRBC: Nucleated Red Blood Cells, NRBC%: Nucleated Red Blood Cell Percentage.

Introduction

In December 2019, a new coronavirus was discovered in Wuhan, China, while investigating a reported viral pneumonitis case. In the early stages of discovery, the virus was named 2019-nCoV due to its similarity to the Severe Acute Respiratory Syndrome (SARS) virus. Later, this viral infection was renamed as "SARS-CoV-2." Due to the spread of the disease, it was declared a global pandemic by the WHO in March 2020[1]. As of January 26, 2023, a total of 669,752,300 million people have been infected with the virus, and 6,820,723 people have lost their lives as a result of this infection[2].

The limited information about this newly encountered infected species has encouraged scientists to conduct in-depth studies on this subject. Determining the risk factors of COVID-19 is very meaningful in terms of preventing the disease. When we look at the literature studies on COVID-19, it is seen that most of these studies[3-10] are related to multiple medical (e.g., diabetes, hypertension) and sociodemographic (e.g. gender, age and race/ethnicity) risk factors and blood groups. At the same time, many of these studies[11] were conducted taking into account various confounding factors, including comorbidities.

One of the important biomarkers in medicine is hemogram blood test samples[12-15]. At the same time, since it is a directly accessible element in the genetic structure of the individual, it is frequently preferred in clinical applications[16,17].

COVID-19 infection remains a global public health concern. This study aims to demonstrate the usability of hematological values as a biomarker in preventing COVID-19 and predicting the course and severity of the disease.

Patients and Methods

This study was designed as a single-center retrospective study. The study was approved by the Ethics Committee of Malatya Training and Research Hospital (approval number: 23536505-000-13874).

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Data Collection Tools

The hematologic blood values tests used in the study were performed using Roche Cobas 6000 (Roche Diagnostics, Basel, Switzerland). Our average reference ranges accepted for healthy individuals were as follows: white blood cells (WBC) 4.6-10.2 $10^3/\mu L$, red blood cells (RBCs) 4.04-6.13 $10^6/\mu L$, Thrombocytes 142-424 $10^3/\mu L$, Hemoglobin (HB) 12.2-18.1 g/dL, Hematocrit (HCT) 37.7-53.7%, Neutrophil 2-6.9 $10^3/\mu L$, Lymphocyte 0.6-3.4 $10^3/\mu L$, Monocyte 0-0.9 $10^3/\mu L$, Basophil 0-0.2 $10^3/\mu L$, Eosinophil 0-0.7 $10^3/\mu L$, Neutrophil 50-70%, Lymphocyte 10-50%, Monocyte 0-12%, Eosinophil 0.5-5%, Basophil 0-1%, mean corpuscular hemoglobin (MCH) 27-31.2 pg, mean corpuscular hemoglobin concentration (MCHC) 31.8-35.4%, mean corpuscular volume (MCV) 80-97 fL, red cell distribution width (RDW) 11.6-17.2%, PCT 0-9.99%, platelet distribution width (PDW) 0-99.9%, mean platelet volume (MPV) 0-99.9 fL, nucleated red blood cells (NRBC) 0-0 $10^3/\mu L$, NRBC% 0-0 /100.

A total of 1,478 patients with positive COVID-PCR test results registered in the Emergency Department Patient Automation System of Malatya Training and Research Hospital between 1 January and 30 April 2021 were screened. A total of 239 patients (Females=106, Males=133) aged 18-65 and over, with or without chronic diseases [asthma, diabetes mellitus (DM), Arrhythmia, Dementia, Chronic obstructive pulmonary disease (COPD), other], with hematological blood values outside the average reference range were included in the study. The patient group was divided into discharge (n=187) and exitus (n=52) groups.

Statistical Analysis

The statistical analysis was performed using the "IBM SPSS Statistics (Version 25.0) for Windows" (IBM Corp., Armonk, NY, USA) and "Jamovi (Version 2.3) for Windows" (The Jamovi Project, Melbourne, Australia) software. The significance level (*p*-value) was set at 0.05. Numerical data and percentages were used to display descriptive statistics and categorical variables, while median (minimum-maximum) and mean/standard deviation were used for continuous variables. The Chi-square test was utilized to examine the connection between two independent categorical variables. The Mann-Whitney U test was employed to evaluate the significance of the difference between the means of two non-parametric variables. The COVID-19 diagnostic test performances of the biochemical blood values that were significant in the comparison analyses of the discharge and exitus group were tested with receiver operating characteristic (ROC) analysis. Additionally, multivariate logistic regression analysis was conducted to assess the independent factors that were statistically significant.

Results

In the study, age (*p*<0.05), chronic diseases (*p*<0.05) and duration of hospitalization (*p*<0.05) were found to be associated with discharge and exitus. No significant relationship was found between gender and discharge and exitus group (Table I). In the study, the mean age, length of hospital stay, WBC, platelet, basophil, % neutrophil, MCV, RDW, PDW, MPV, NRBC and NRBC% values of the patients in the exitus group were found to be significantly and high. On the other hand, the RBCs, HB, HCT, Neutrophil, Eosinophil, Lymphocyte%, Monocyte%, Eosinophil%, and MCHC values were significant and higher in the group discharged (Table II).

In the literature, an AUC of 0.5 suggests no discrimination (i.e., the ability to diagnose the disease based on the test), 0.7 to 0.8 is considered acceptable, 0.8 to 0.9 is considered excellent, and more than 9 is considered exceptional[15,16]. Accordingly, while the AUC values of WBC (AUC=0.86), Neutrophil (AUC=0.88), NRBC (AUC=0.80), and Lymphocyte (AUC=0.805) parameters were excellent, the AUC values of Neutrophil% (AUC=0.904) and Lymphocyte% (AUC=0.924) parameters were exceptional (Table III). In our study, diagnostic performance was evaluated for each blood value and ROC curves were drawn by determining cut-off points (Figures 1 and 2).

Hematological blood parameters found to be significant as a result of univariate analyses were included in the multivariate logistic regression model. First, Variance Inflation Factor (VIF) analysis was performed to detect multiple linear correlations. VIF was calculated to determine the degree of relationship of an independent variable with other independent variables[18]. If VIF was greater than or equal to 10, there was a multicollinearity problem[19]. In order to ensure the assumption in the study, parameters with VIF values greater than 10 (WBC, Eosinophil, Neutrophil%, Lymphocyte%, Eosinophil%, MCV and NRBC) were excluded from the model.

Table I. Comparison of patients' exitus and discharge group according to demographic variables.

Categories	Discharge	Exitus	p
Age			
<65	99 (92.5%)	8 (7.5%)	**0.00***
≥65	88 (66.7%)	44 (33.3%)	
Gender			
Female	78 (73.6%)	28 (26.4%)	0.119
Male	109 (82.0%)	24 (18.0%)	
Chronic Disease			
Yes			
Asthma			
DM			
HT	38 (55.1%)	31 (44.9%)	**0.00***
Arrhythmia			
Dementia			
COPD			
Others			
No	149 (87.6%)	21 (12.4%)	
Duration of Hospitalization			**0.01***
<7	100 (84.0%)	19 (16.0%)	
≥7	81 (71.1%)	33 (28.9%)	

*$p<0.05$ significant diffrence. DM, diabetes mellitus, HT, hypertension, COPD, Chronic obstructive pulmonary disease.

Logistic regression analysis showed that the model was statistically significant (Pseudo $R^2=0.58$, $p<0.01$) (Table IV). Among the independent variables, only Neutrophil (ß=0.25049, $p<0.05$), Lymphocyte (ß=-1.60186, $p<0.05$) and MCHC (ß=-0.36575, $p<0.05$) values were statistically significant. Accordingly, a 1-unit increase in Neutrophil value increased the patient's risk of death by 1.2%, a 1-unit increase in Lymphocyte value increased the patient's risk of death by 0.2%, and a 1-unit increase in MCHC value decreased the patient's risk of death by 0.6% (Table V).

Discussion

According to the results of this study, in which hematological blood values were examined in COVID-19 patients, there was a significant difference between the mortality rate of patients under the age of 65 (7.5%) and the discharge rate of patients aged 65 years and over (33.3%) in the age category. In a study conducted by Grasselli et al[20] in Italy, found that COVID-19 patients over the age of 65 had a higher mortality rate. A study by the Centers for Disease Control and Prevention (CDC)[21] showed the differences in COVID-19 deaths by age. In this study, the rates of COVID-19-related deaths by age were examined and it was stated that the highest mortality rates were seen in the age group of 65 years and older. It is also emphasized that people aged 85 years and older had the highest risk of death due to COVID-19. These results show that age may affect the course of the disease and mortality rate.

In the gender category, there is no significant difference between the mortality rate of female patients (26.4%) and the mortality rate of male patients (18.0%). In the literature[21-24], COVID-19-related deaths differ according to gender. Hormonal and lifestyle differences may be shown as the reason for the differentiation of COVID-19-related deaths by gender.

There is a significant difference between the mortality rate of patients with chronic conditions (44.9%) and the mortality rate of patients without chronic conditions (12.4%). A CDC study[25] shows that 94% of patients who died from COVID-19 had at least one chronic condition. These chronic conditions include obesity, diabetes, heart disease, kidney disease and lung disease. Flythe et al[26] found that patients with chronic kidney disease had a higher risk of death due to COVID-19 than patients with other chronic conditions. These results show that chronic diseases can affect the patient's health status and affect treatment outcomes.

Table II. Comparison of hematological blood measurements according to discharge and exitus groups.

	Discharge		Exitus		
	Median(Min-Max)	M±SD	Median (Min-Max)	M±SD	*p*
9 Age	64 (21-93)	63.20±15.6	79 (55-93)	76.13±10.83	**0.00***
Duration of Hospitalization	7 (0-52)	7.93±6.4	12 (1-65)	14.33±13.19	**0.00***
WBC	8.13 (0.38-43.25)	8.8±4.39	16.42 (6.53-1,284)	42.59±175.7	**0.00***
RBCs	4.63 (2.80-6.57)	4.62±.62	4.21 (2.05-5.66)	4.17±0.79	**0.00***
Thrombocytes	269.5 (3.70-648.0)	289.5±120.8	246.5 (17-31,110)	7,439.3±44,379.2	**0.01***
HB	13.1 (7.20-514.10)	15.53±36.69	11.25 (6.20-16.70)	11.37±2.15	**0.00***
HCT	39.6 (27.80-397.7)	41.11±26.63	36.05 (18.60-53.60)	36.27±6.57	**0.00***
Neutrophil	5.65 (1.95-40.21)	6.44±4.03	14.50 (5.72-43.75)	16.07±8.44	**0.00***
Lymphocyte	1.45 (0.23-66.00)	2.02±4.84	0.58 (0.10-4.70)	0.87±0.82	**0.00***
Monocyte	0.61 (0.13-9.86)	0.74±0.83	0.62 (0.11-5.43)	0.83±0.90	**0.92**
Basophil	0.01 (0.00-0.09)	0.01±0.01	0.02 (0.00-0.20)	0.02±0.03	**0.00***
Eosinophil	0.05 (0.00-1.25)	0.11±0.17	0.00 (0.00-0.42)	0.03±0.07	**0.00***
Neutrophil%	72.6 (10.70-93.90)	70.39±14.22	92.30 (47.70-97.90)	89.49±8.56	**0.00***
Lymphocyte%	17.10 (2.20-49.80)	19.84±10.88	3.90 (0.30-31.20)	5.67±5.37	**0.00***
Monocyte%	7.60 (1.80-17.40)	7.66±2.89	3.80 (1.00-41.80)	4.60±5.68	**0.00***
Eosinophil%	0.70 (0.00-18.90)	1.57±2.55	0.00 (0.00-2.40)	0.21±0.43	**0.00***
Basophil%	0.10 (0.00-1.00)	0.18±0.19	0.10 (0.00-0.50)	0.13±0.10	0.19
MCH	28.30 (16.50-37.10)	27.94±2.70	28.25 (20.30-31.90)	27.46±2.56	0.20
MCHC	32.90 (23.70-36.10)	32.71±1.59	31.25 (26.10-36.00)	31.35±1.85	**0.00***
MCV	85.60 (33.10-107.9)	84.88±7.40	88.40 (68.20-861)	102.26±107.51	**0.01***
RDW	13.50 (11.10-26.40)	14.27±2.44	15.85 (12.80-28.40)	16.31±2.85	**0.00***
PCT	0.29 (0.05-0.60)	0.30±0.10	0.28 (0.03-0.60)	0.28±0.11	0.36
PDW	11.45 (8.80-181.0)	12.67±12.98	14.70 (9.40-22.80)	14.45±2.90	**0.00***
MPV	10.20 (8.40-90.20)	11.22±8.40	11.50 (8.80-100.5)	14.71±17.16	**0.00***
NRBC	0.00 (0.00-2.96)	0.01±0.21	0.02 (0.00-2)	0.19±0.41	**0.00***
NRBC%	0.00 (0.00-43.10)	0.26±3.15	0.10 (0.00-10.80)	0.90±1.99	**0.00***

*$p<0.05$ significant difference. WBC: White Blood Cells, RBCs: Red Blood Cells, HB: Hemoglobin, HCT: Hematocrit, MCH: Mean Corpuscular Hemoglobin, MCHC: Mean Corpuscular Hemoglobin Concentration, MCV: Mean Corpuscular Volume, RDW: Red Cell Distribution Width, PCT: Plateletcrit, PDW: Platelet Distribution Width, MPV: Mean Platelet Volume, NRBC: Nucleated Red Blood Cells, NRBC%: Nucleated Red Blood Cell Percentage.

In the category of length of hospital stay, there is a significant difference between the mortality rate of patients who stayed less than 7 days (16.0%) and the mortality rate of patients who stayed more than 7 days (28.9%). Chen et al[27] analyzed the clinical characteristics of 113 COVID-19 patients. The results of the study showed that most of the patients who died were elderly men and had long hospital stays. Da Costa Sousa et al[28] found that the average length of hospital stay was 10±8 days and 34% of the patients died. It was revealed that the duration of hospitalization was associated with the risk of death. It can be said that long hospitalization periods increase the risk of death.

In our study, AUC values of neutrophil, lymphocyte and MCHC parameters were found to be high. At the same time, it was concluded that these 3 parameters can be used to predict a patient's risk of death due to COVID-19. Accordingly, it was observed that the increase in neutrophil decreased the risk of death, whereas the increase in lymphocyte and MCHC decreased the risk of death. The study by Li et al[29] shows that NLR may be a good predictive factor for disease severity and mortality risk of COVID-19 patients. In the study by Zhang et al[30] it is stated that lymphocyte count can be used as an indicator of COVID-19 disease, and lymphocyte count is considered to be an important factor in determining the severity of COVID-19 disease. In the literature, no direct correlation was found between COVID-19-related deaths and MCHC. However, COVID-19 infection can lower oxygen levels in the blood in some people and, therefore

Table III. Relationship between laparoscopic hepatosteatosis grade and BMI.

n=239	AUC (95% CI)	p	Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
WBC	0.862 (.80-.92)	0.00	9.41	88.46	67.38	42.99	95.45
Neutrophil	0.889 (.83-.94)	0.00	8	82.69	76.47	49.43	94.08
Basophil	0.620 (.52-.71)	0.02	0.02	55.77	66.31	31.52	84.35
Neutrophil%	0.904 (.84-.96)	0.00	82.3	90.38	77.54	52.81	96.67
RDW	0.761 (.69-.83)	0.00	13.6	92.31	51.87	34.78	96.04
PDW	0.771 (.68-.85)	0.00	12.6	72.09	74.71	41.33	91.55
MPV	0.754 (.66-.83)	0.00	10.8	63.27	73.08	38.75	88.08
NRBC	0.802 (.71-.89)	0.00	0.01	73.08	75.81	45.78	90.97
NRBC%	0.761 (.67-.85)	0.00	0.1	69.23	77.54	46.15	90.06
Lymphocyte	0.805 (.73-.87)	0.00	1.11	82.69	66.31	40.57	93.27
Lymphocyte%	0.924 (.88-.96)	0.00	10.2	90.38	80.21	55.95	96.77
Eosinophil	0.706 (.63-.7)	0.00	0.06	86.54	45.99	30.82	92.47
MCHC	0.739 (.65-.82)	0.00	32.3	73.08	71.66	41.76	90.54
HB	0.707 (.62-.79)	0.00	12.4	67.31	62.57	33.33	87.31
HCT	0.655 (.56-.74)	0.00	39.9	76.92	46.52	28.57	57.88
Thrombocytes	0.613 (.52-.70)	0.01	294	76	44.09	26.76	87.23
Eosinophil%	0.744 (.67-.80)	0.00	0.6	90.38	50.27	33.57	94.95
RBCs	0.667 (.57-.76)	0.00	4.08	48.08	81.28	41.67	84.92

PPV: Positive predictive value, NPV: Negative predictive value, WBC: White Blood Cells, RBCs: Red Blood Cells, HB: Hemoglobin, HCT: Hematocrit, MCHC: Mean Corpuscular Hemoglobin Concentration, RDW: Red Cell Distribution Width, PDW: Platelet Distribution Width, MPV: Mean Platelet Volume, NRBC: Nucleated Red Blood Cells, NRBC%: Nucleated Red Blood Cell Percentage.

may cause a decrease in MCHC levels in blood tests. This can happen especially in cases where COVID-19 infection is severe. However, further studies are needed to support the acceptance of MCHC levels as a risk factor associated with deaths from COVID-19.
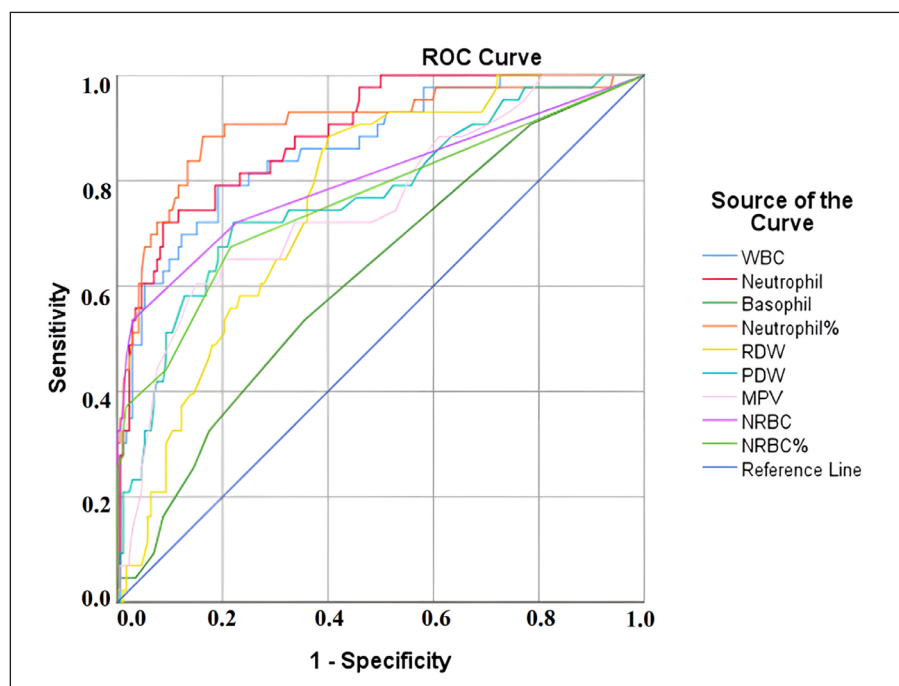

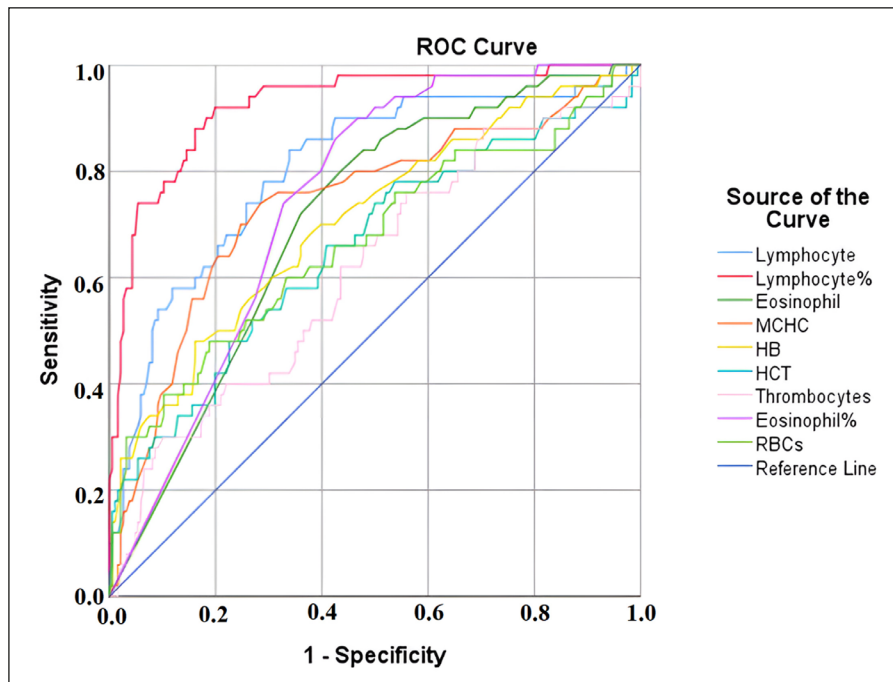**Figure 1.** Curves of hematological blood parameters of COVID-19 patients.

Figure 2. Curves of hematological blood parameters of COVID-19 patients.

Table IV. Model fit measures.

Model	Deviance	AIC	R^2_{McF}	R^2_N	Overall Model Test		
					χ^2	df	p
1	87.7	116	0.581	0.694	121	13	<.001

Table V. Evaluation of risk factors affecting ex with multivariate logistic regression analysis.

Predictor	Estimate	SE	Z	p	Odds ratio
Intercept	9.25821	8.26599	1.120	0.263	10,490.311
Thrombocytes	-0.00346	0.00263	-1.314	0.189	0.997
HCT	0.00245	0.02069	0.118	0.906	1.002
Neutrophil	0.25049	0.06651	3.766	<.001	1.285
Lymphocyte	-1.60186	0.60398	-2.652	0.008	0.202
MCHC	-0.36575	0.18287	-2.000	0.045	0.694
RDW	0.11358	0.15453	0.735	0.462	1.120
PDW	0.00557	0.02659	0.209	0.834	1.006
MPV	0.06805	0.22325	0.305	0.760	1.070
RBCs	-0.37510	0.48595	-0.772	0.440	0.687
HB	0.00677	0.04017	0.169	0.866	1.007
Basophil	4.13509	19.77919	0.209	0.834	62.495
Monocyte%	-0.00870	0.05678	-0.153	0.878	0.991
NRBC%	2.54635	2.10718	1.208	0.227	12.760

RBCs: Red Blood Cells, HB: Hemoglobin, HCT: Hematocrit, MCHC: Mean Corpuscular Hemoglobin Concentration, RDW: Red Cell Distribution Width, PDW: Platelet Distribution Width, MPV: Mean Platelet Volume, NRBC%: Nucleated Red Blood Cell Percentage.

Conclusions

Neutrophil, lymphocyte, and MCHC levels have emerged as potential biomarkers in the battle against COVID-19. Research findings suggest that alterations in these parameters can provide valuable insights into the disease's progression and severity.

Informed Consent

Since this was a retrospective study, informed consent was not obtained. Patients were not actively involved in any new intervention or interaction. Only their existing data and medical records were analyzed. Since the study is based on pre-existing data only and does not require the direct involvement of patients, informed consent is not required.

Ethics Approval

The study was approved by the Ethics Committee of Malatya Training and Research Hospital (approval number: 23536505-000-13874).

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References

1) Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, Zhao X, Huang B, Shi W, Lu R, Niu P, Zhan F, Ma X, Wang D, Xu W, Wu G, Gao GF, Tan W. A Novel Coronavirus from Patients with Pneumonia in China, 2019. N Engl J Med 2020; 382: 727-733.

2) Our World In Data. Coronavirus (COVID-19) Vaccinations. Available at: https://ourworldindata.org/covid-vaccinations?country=OWID_WRL. Accessed on January 1, 2023.

3) Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, Transmission, Diagnosis, and Treatment of Coronavirus Disease 2019 (COVID-19): A Review. JAMA 2020; 324: 782-793.

4) Zietz M, Zucker J, Tatonetti NP. Associations between blood type and COVID-19 infection, intubation, and death. Nat Commun 2020; 11: 5761.

5) Zeng X, Fan H, Lu D, Huang F, Meng X, Li Z, Tang M, Zhang J, Liu N, Liu Z, Zhao J, Yin W, An Q, Zhang X, Hu X. Association between ABO blood groups and clinical outcome of coronavirus disease 2019: evidence from two cohorts. medRxiv 2020; 2020.04.15.20063107.

6) Dai X. ABO blood group predisposes to COVID-19 severity and cardiovascular diseases. Eur J Prev Cardiol 2020; 27: 1436-1437.

7) Jordan RE, Adab P, Cheng KK. Covid-19: risk factors for severe disease and death. BMJ 2020; 368: m1198.

8) Li J, Huang DQ, Zou B, Yang H, Hui WZ, Rui F, Yee NTS, Liu C, Nerurkar SN, Kai JCY, Teng MLP, Li X, Zeng H, Borghi JA, Henry L, Cheung R, Nguyen MH. Epidemiology of COVID-19: A systematic review and meta-analysis of clinical characteristics, risk factors, and outcomes. J Med Virol 2021; 93: 1449-1458.

9) Ochani R, Asad A, Yasmin F, Shaikh S, Khalid H, Batra S, Sohail MR, Mahmood SF, Ochani R, Hussham Arshad M, Kumar A, Surani S. COVID-19 pandemic: from origins to outcomes. A comprehensive review of viral pathogenesis, clinical manifestations, diagnostic evaluation, and management. Infez Med 2021; 29: 20-36.

10) Rozenfeld Y, Beam J, Maier H, Haggerson W, Boudreau K, Carlson J, Medows R. A model of disparities: risk factors associated with COVID-19 infection. Int J Equity Health 2020; 19: 126.

11) Goel R, Bloch EM, Pirenne F, Al-Riyami AZ, Crowe E, Dau L, Land K, Townsend M, Jecko T, Rahimi-Levene N, Patidar G, Josephson CD, Arora S, Vermeulen M, Vrielink H, Montemayor C, Oreh A, Hindawi S, van den Berg K, Serrano K, So-Osman C, Wood E, Devine DV, Spitalnik SL; ISBT COVID-19 Working Group. ABO blood group and COVID-19: a review on behalf of the ISBT COVID-19 Working Group. Vox Sang 2021; 116: 849-861.

12) Kulaksızoğlu S, Ayşe AM. Kolorektal Kanser Hastalarında Nötrofil/Lenfosit, Trombosit/Lenfosit ve Trombosit Büyük Hücre Oranı Değerlerinin Tanıdaki Yeri. FÜ Sağ Bil Tıp Derg 2019; 33: 169-173.

13) Karagoz I, Aktas G, Yoldas H, Yildiz I, Ogun MN, Bilgi M, Demirhan A. Association Between Hemogram Parameters and Survival of Critically Ill Patients. J Intensive Care Med 2019; 34: 511-513.

14) Rajalingam VR, Mustafa A, Ayeni A, Mahmood F, Shammout S, Singhal S, Akingboye A. The Role of Neutrophil-Lymphocyte-Ratio (NLR) and Platelet-Lymphocyte-Ratio (PLR) as a Biomarker for Distinguishing Between Complicated and Uncomplicated Appendicitis. Cureus 2022; 14: e21446.

15) Aydemir D, Ulusu NN. Importance of the validated serum biochemistry and hemogram parameters for rapid diagnosis and to prevent false negative results during COVID-19 pandemic. Biotechnol Appl Biochem 2021; 68: 390-391.

16) Wang W, Liu L, Wang Z, Lu X, Wei M, Lin T, Zhang Y, Jiang S, Wang Q, Cao Z, Shi M. ABO blood group and esophageal carcinoma risk: from

a case-control study in Chinese population to meta-analysis. Cancer Causes Control 2014; 25: 1369-1377.

17) Cooling L. Blood Groups in Infection and Host Susceptibility. Clin Microbiol Rev 2015; 28: 801-870.

18) Salkin NJ, Rasmussen K. Encyclopedia of Measurements and Statistics (Volume 1). Sage, 2007.

19) Kennedy P. A Guide to Econometrics. John Wiley & Sons, 2008.

20) Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, Cereda D, Coluccello A, Foti G, Fumagalli R, Iotti G, Latronico N, Lorini L, Merler S, Natalini G, Piatti A, Ranieri MV, Scandroglio AM, Storti E, Cecconi M, Pesenti A; COVID-19 Lombardy ICU Network. Baseline Characteristics and Outcomes of 1591 Patients Infected With SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. JAMA 2020; 323: 1574-1581.

21) CDC. COVID-19 Pandemic Planning Scenarios. Updated September 10, 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html. Accessed on March 5, 2023.

22) Li LQ, Huang T, Wang YQ, Wang ZP, Liang Y, Huang TB, Zhang HY, Sun W, Wang Y. COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of meta-analysis. J Med Virol 2020; 92: 577-583.

23) Doerre A, Doblhammer G. The influence of gender on COVID-19 infections and mortality in Germany: Insights from age- and gender-specific modeling of contact rates, infections, and deaths in the early phase of the pandemic. PLoS One 2022; 17: e0268119.

24) Jin JM, Bai P, He W, Wu F, Liu XF, Han DM, Liu S, Yang JK. Gender Differences in Patients With COVID-19: Focus on Severity and Mortality. Front Public Health 2020; 8: 152.

25) CDC. (2021). Comorbidities. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html. Accessed on March 20, 2023.

26) Flythe JE, Assimon MM, Tugman MJ, Chang EH, Gupta S, Shah J, Sosa MA, Renaghan AD, Melamed ML, Wilson FP, Neyra JA, Rashidi A, Boyle SM, Anand S, Christov M, Thomas LF, Edmonston D, Leaf DE; STOP-COVID Investigators. Characteristics and Outcomes of Individuals With Pre-existing Kidney Disease and COVID-19 Admitted to Intensive Care Units in the United States. Am J Kidney Dis 2021; 77: 190-203.e1.

27) Chen T, Wu D, Chen H, Yan W, Yang D, Chen G, Ma K, Xu D, Yu H, Wang H, Wang T, Guo W, Chen J, Ding C, Zhang X, Huang J, Han M, Li S, Luo X, Zhao J, Ning Q. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. BMJ 2020; 368: m1091.

28) da Costa Sousa V, da Silva MC, de Mello MP, Guimarães JAM, Perini JA. Factors associated with mortality, length of hospital stay and diagnosis of COVID-19: Data from a field hospital. J Infect Public Health 2022; 15: 800-805.

29) Li X, Liu C, Mao Z, Xiao M, Wang L, Qi S, Zhou F. Predictive values of neutrophil-to-lymphocyte ratio on disease severity and mortality in COVID-19 patients: a systematic review and meta-analysis. Crit Care 2020; 24: 647.

30) Zhang HJ, Qi GQ, Gu X, Zhang XY, Fang YF, Jiang H, Zhao YJ. Lymphocyte blood levels that remain low can predict the death of patients with COVID-19. Medicine (Baltimore) 2021; 100: e26503.