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Routine laboratory parameters in estimating mortality and morbidity in COVID-19 diagnosed cases followed in the intensive care unit

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Abstract. – OBJECTIVE: In this study, our goal was to assess the neutrophil/lymphocyte, platelet/lymphocyte ratios, urea/albumin, lactate, C-reactive protein/albumin procalcitonin/albumin, dehydrogenase/albumin, and protein/albumin rates in 368 critical COVID-19 cases following the entrance to the intensive care unit (ICU) to investigate the effects of biomarkers on prognosis and mortality.

PATIENTS AND METHODS: The Ethics Committee approved this study carried out in our hospital's intensive care units between March 2020 and April 2022. 368 patients, 220 (59.8%) male, and 148 (40.2%) female, diagnosed with COVID-19 and aged between 18 and 99 years were included in this research.

RESULTS: The average age of non-survivors was statistically considerably higher than survivors ($p<0.05$). There was no numerical significance in terms of gender concerning mortality ($p>0.05$). The duration of ICU stay was statistically considerably prolonged in survivors than in those who did not survive ($p<0.05$). The leukocytes, neutrophils, urea, creatinine, ferritin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), creatine kinase (CK), C-reactive protein (CRP), procalcitonin (PCT), and pro-brain natriuretic peptide (pro-BNP) levels were numerically considerably higher in the non-survivors ($p<0.05$). The platelet, lymphocyte, protein, and albumin levels statistically considerably declined in non-survivors in comparison with survivors ($p<0.05$).

CONCLUSIONS: Acute renal failure (ARF) increased mortality by 31.815-fold, ferritin by 0.998-fold, pro-BNP by 1-fold, procalcitonin by 574.353-fold, neutrophil/lymphocyte by 1.119-fold, CRP/albumin by 2.141-fold, and protein/albumin by 0.003-fold. It was found that the number of days in the ICU increased mortality by 1.098-fold, creatinine by 0.325-fold, CK by 1.007-fold, urea/albumin by 1.079-fold, and LDH/albumin by 1.008-fold.

Key Words:
COVID-19, Mortality, Albumin.

Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was found in China in December 2019 and announced as a pandemic by the World Health Organization (WHO) on March 11, 2020. While COVID-19 progresses with subclinical symptoms in most patients and results in complete recovery, it can also lead to life-threatening mortality and morbidity, requiring hospitalization in the intensive care unit (ICU)[1]. Severe COVID-19 may emerge with acute respiratory distress syndrome, sepsis, multisystem organ insufficiency, hyperinflammatory processes, neurologic and other extrapulmonary symptoms, and thromboembolic pathologies. As of November 4, 2022, there were 637,117,429 confirmed cases, and 616,514,948 recovered cases worldwide, while 6,602,572 patients died from the virus[2].

The main way for COVID-19 detection can be achieved by the real-time polymerase chain reaction (PCR) method. Radiological evaluations with computed tomography of the chest, peripheric multilobar ground glass opacities, and laboratory tests support the exact definition[3]. Diagnostic hematology parameters have been determined in COVID-19 disease. Commonly used laboratory parameters, including serum biochemistry and hemogram examination, are simple, routine, and inexpensive procedures that ease the diagnosis of the disease[4,5]. Biomarkers of inflammation, including white blood cell count, neutrophil/lymphocyte count, platelet-to-lymphocyte rate, and serum C-reactive protein level, are independent systemic parameters that have been studied in COVID-19 cases[6]. In the latest research[7,8], high neutrophil/lymphocyte ratios and lactate dehydrogenase values have a relationship to poor prognosis in COVID-19 cases.

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Alharthy et al[9] have examined the factors influencing morbidity and mortality in hospitalized COVID-19 cases. Poor prognostic factors include age, period of hospital and ICU stay, comorbidities, hemogram biochemistry, and laboratory findings such as procalcitonin. In recent years, researchers[6] have used inflammatory parameters such as neutrophils/lymphocytes, platelets/lymphocytes, and monocytes/lymphocytes ratio in the detection and prognostic process of COVID-19 cases. In this present study, we aimed to determine the neutrophil/lymphocyte, platelet/lymphocyte, urea/albumin, lactate dehydrogenase/albumin, C-reactive protein/albumin, protein/albumin, and procalcitonin/albumin rates in 368 critically ill COVID-19 cases following their admission to the intensive care unit to investigate the impact of biomarkers on prognosis and mortality. There are very few studies in the literature on this topic.

Patients and Methods

Our retrospective cross-sectional study was performed based on the Declaration of Helsinki and the Strobe Checklist after approval by the Malatya Turgut Özal University Clinical Research Ethics Committee dated February 21, 2022, and numbered 2022/39. Since our hospital works intensively as a pandemic hospital, we have achieved a wide patient potential and much experience. A total of 368 patients, 220 (59.8%) males and 148 (40.2%) female participants, aged between 18 and 99 years with a diagnosis of COVID-19 and treated in intensive care units of our hospital between March 2020 and April 2022, were included in this present study. The most frequently utilized test procedure worldwide for the determination of COVID-19 is RT-PCR. PCR, laboratory, and radiological examinations confirmed the diagnosis of all patients.

The data of the cases were gained from the patient records and the automation system of the hospital. Demographic characteristics of patients (age, sex) comorbid congestive heart failure (CHF), coronary artery disease (CAD), neurological disease, asthma, chronic obstructive pulmonary disease (COPD), diabetes, hypertension, stroke, acute renal failure (ARF), comorbid conditions such as malignancy, obesity, obstructive sleep apnea syndrome (OSAS), chronic renal failure (CRF), hospitalization, and period of stay in the ICU were analyzed. Ferritin troponin I, D-dimer, leukocytes, hemoglobin, hematocrit, platelet, neutrophil, and lymphocyte counts, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), protein, albumin, urea, creatinine, lactate dehydrogenase (LDH), creatine kinase (CK), C-reactive protein (CRP), actual bicarbonate, partial arterial oxygen pressure (PaO2), partial arterial carbon dioxide pressure (PaCO2), pro-brain natriuretic peptide (pro-BNP) and procalcitonin (PCT) were recorded as laboratory parameters of patients in the ICU. In addition, neutrophils obtained from routine laboratory tests, neutrophil/lymphocyte ratio (NLR), platelet/lymphocyte ratio (PLR), which was determined by the ratio of platelet count to lymphocyte count, and the CRP/albumin values obtained by proportioning the CRP, urea, LDH, protein, and PCT values with the albumin number, as well as the ratios of urea/albumin, LDH/albumin, protein/albumin, and PCT /albumin were calculated and recorded.

Statistical Analysis

In evaluating the results obtained in the study, IBM SPSS statistics software version 22 (IBM Corp., Armonk, NY, USA) was utilized for statistical analysis. The relevance of parameters with normal dispersion was analyzed with Kolmogorov-Smirnov and Shapiro-Wilks tests. The data analysis used definitive statistical procedures (mean, standard deviation, frequency) and student's *t*-test to match normally distributed parameters between the groups (survivors and non-survivors) when comparing quantitative data. Mann-Whitney U test was utilized to match non-normally distributed parameters between the two groups (survivors and non-survivors). The Chi-square test, Fisher's exact Chi-square test, and continuity correction (Yates) were utilized to match qualitative data. Logistic analysis was used for multivariate analysis. Significance was accepted at $p<0.05$ level.

Results

The study was conducted with 368 cases, 220 (59.8%) males and 148 (40.2%) females, with ages ranging from 18 to 99. The average age was 68.48±14.27 years. The hospital stay length of the cases differed from 1 to 119 days, with an average of 19.61±1.94 and a median of 17 days. Intensive care unit stay duration differed from 1 to 91 days, with an average of 11.23±11.79 and a median of 8 days. While 249 (67.7%) of cases died, 119 (32.3%) survived.

Table I. Distribution of chronic diseases.

Chronic Diseases	n	%
CHF	76	20.7
Neurological diseases	23	6.3
Asthma	33	9.0
COPD	68	18.5
Diabetes	114	31
CAD	86	23.4
Hypertension	188	51.1
Stroke	19	5.2
ARF	65	17.7
Malignancy	2	0.5
Obesity	49	13.3
OSAS	47	12.8
CRF	16	4.3

Congestive Heart Failure (CHF), Chronic Obstructive Pulmonary Disease (COPD), Coronary Artery Disease (CAD), Acute Renal Failure (ARF), Obstructive Sleep Apnea Syndrome (OSAS), Chronic Renal Failure (CRF).

Hypertension in 51.1% of cases, diabetes in 31%, CAD in 23.4%, CHF in 20.7%, COPD in 18.5%, ARF in 17.7%, obesity in 13.3%, OSAS in 12.8%, 9 had asthma, 6.3% had neurological diseases, 5.2% had a stroke, 4.3% had CRF and 0.5% had malignancy (Table I).

The average age of non-survivors was statistically considerably higher than that of survivors ($p<0.05$). There was no numerical significance in gender concerning mortality ($p>0.05$). The incidence of ARF was numerically considerably higher in non-survivors (20.9%), (10.9%) ($p<0.05$). There was no numerical significance in the presence of other chronic diseases as a function of mortality ($p>0.05$). There was no numerical significance in hospital stay durations between non-survivors and survivors ($p>0.05$). The period of stay in intensive care units of survivors was numerically considerably longer than that of non-survivors ($p<0.05$) (Table II). Leukocyte, neutrophil, urea, creatinine, ferritin, AST, ALT, LDH, CK, CRP PCT, and pro-BNP levels were statistically considerably higher in non-survivors ($p<0.05$). Although troponin I and D-dimer levels were higher in non-survivors, there was no statistical significance ($p>0.05$). The platelet, lymphocyte, protein, and albumin levels were statistically considerably lower in non-survivors matched to

Table II. Comparison of sociodemographic characteristics and chronic diseases according to mortality.

		Survivors (n=119)	Non-survivors (n=249)	p-value
Age Mean±SD		60.38±15.76	69.40±12.53	[1]0.001*
Gender n (%)	Male	71 (59.7)	149 (59.8)	[2]0.974
	Female	48 (40.3)	100 (40.2)	
Chronic Diseases n (%)	CHF	25 (21)	51 (20.5)	[2]0.907
	Neurological diseases	4 (3.4)	19 (7.6)	[3]0.176
	Asthma	9 (7.6)	24 (9.6)	[3]0.648
	COPD	15 (12.6)	53 (21.3)	[3]0.062
	Diabetes	41 (34.5)	73 (29.3)	[2]0.319
	CAD	28 (23.5)	58 (23.3)	[2]0.960
	Hypertension	57 (47.9)	131 (52.6)	[2]0.398
	Stroke	7 (5.9)	12 (4.8)	[3]0.858
	ARF	13 (10.9)	52 (20.9)	[3]0.028*
	Obesity	0 (0)	2 (0.8)	[4]1.000
	OSAS	11 (9.2)	38 (15.3)	[3]0.154
	CRF	15 (12.6)	32 (12.9)	[3]1.000
	Obesity	3 (2.5)	13 (5.2)	[3]0.360
Number of days of hospital stay	Mean±SD (median)	20.45±14.70 (18)	19.20±13.58 (16)	[5]0.275
Number of days of stay in intensive care	Mean±SD (median)	11.92±10.57 (8)	10.90±12.34 (7)	[5]0.037*

[1]Student *t*-test; [2]Ki-kare test; [3]Continuity (yates) fix; [4]Fisher's Exact test; [5]Mann-Whitney U Test; *$p<0.05$. The average age of non-survivors was statistically significantly higher than that of survivors ($p<0.05$). Congestive Heart Failure (CHF), Chronic Obstructive Pulmonary Disease (COPD), Coronary Artery Disease (CAD), Acute Renal Failure (ARF), Obstructive Sleep Apnea Syndrome (OSAS), Chronic Renal Failure (CRF).

Table III. Evaluation of laboratory parameters according to mortality.

	Survivors Mean±SD (median)	Non-survivors Mean±SD (median)	*p*-value
CK-MB	16.38±48.29 (2.39)	6.77±9.43 (3.18)	0.225
Ferritin, ng/mL	700.93±619.2 (495.1)	969.12±649.09 (780.85)	0.000*
Troponin I, ng/L	0.54±1.35 (0.1)	0.65±2.17 (0.13)	0.231
D-dimer, µg/L	2.8±4.16 (1.3)	3.88±5.99 (1.66)	0.131
Leukocyte, $\times10^9$/L	11.19±5.45 (9.94)	17.94±58.48 (12.86)	0.000*
Hemoglobin, g/L	12.42±2.58 (12.65)	12.19±2.76 (12.2)	[+]0.442
Hematocrit, g/L	37.67±6.02 (37.4)	36.76±6.18 (37.6)	[+]0.183
Platelet, $\times10^9$/L	280.59±99.57 (267.5)	229.88±115.97 (218)	0.000*
Neutrophil, $\times10^9$/L	9.45±5.18 (8.42)	12.33±6.57 (11.37)	0.000*
Lymphocyte, $\times10^9$/L	1.25±1 (0.87)	0.83±1.04 (0.61)	0.000*
Aspartate aminotransferase, U/L	43.28±56.49 (29.5)	115.94±442.44 (37)	0.002*
Alanine aminotransferase, U/L	176.02±266.03 (59)	327.87±457.31 (85)	0.004*
gamma glutamyltransferase, U/L	73.64±68.64 (54.5)	91.33±102.34 (52)	0.300
Protein, g/L	6.17±1.14 (6.2)	5.9±0.96 (5.9)	0.002*
Albumin, g/L	2.84±0.56 (2.8)	2.6±0.53 (2.6)	0.000*
Urea, mmol/L	58.62±45.51 (47)	91.57±64.17 (70.5)	0.000*
Creatinine, mmol/L	1.21±1.29 (0.78)	1.52±1.49 (0.94)	0.001*
Lactate dehydrogenase, U/L	454.86±271.9 (364.5)	696.08±486.05 (591.5)	0.000*
Creatine kinase, U/L	176.45±491.07 (47.42)	205.38±300.72 (92.09)	0.008*
CRP, mg/L	7.77±7.7 (5.77)	11.75±8.2 (10.75)	0.000*
Actual bicarbonate mEq/L	26.32±7.86 (26.6)	25.58±7.95 (25.5)	[+]0.499
PO_2 mmHg	74.08±42.54 (65.7)	69.44±38.21 (63.9)	0.463
PCO_2 mmHg	40.16±11.08 (38.2)	42.25±15.37 (39.05)	0.759
pro-BNP, pg/ml	2,073.66±5,621.98 (367)	7,169.75±21,944.07 (1,524)	0.000*
PCT, ng/mL	1.17±5.59 (0.18)	2.61±11.83 (0.35)	0.000*

[1]Student *t*-test; [2]Ki-kare test; [3]Continuity (yates) fix; [4]Fisher's Exact test; [5]Mann-Whitney U Test; *$p<0.05$. The average age of non-survivors was statistically significantly higher than that of survivors ($p<0.05$). Congestive Heart Failure (CHF), Chronic Obstructive Pulmonary Disease (COPD), Coronary Artery Disease (CAD), Acute Renal Failure (ARF), Obstructive Sleep Apnea Syndrome (OSAS), Chronic Renal Failure (CRF).

survivors ($p<0.05$). There was no statistical significance between other laboratory parameters as a function of mortality ($p>0.05$) (Table III). NLR was statistically considerably higher in non-survivors ($p<0.05$). Although PLR was higher in non-survivors there was no statistical significance ($p>0.05$). The ratio of CRP/albumin, urea/albumin, LDH/albumin, protein/albumin, and PCT / albumin was statistically considerably higher in non-survivors ($p<0.05$) (Table IV).

Table IV. Effect of laboratory parameter ratios on mortality.

	Survivors Mean±SD (median)	Non-survivors Mean±SD (median)	*p*-value
Neutrophil/Lymphocyte	13.06±14.96 (8.86)	25.55±28.23 (18.21)	0.000*
Platelet/Lymphocyte	434.64±499.72 (294.12)	437.37±324.11 (378.26)	0.130
CRP/Albumin	2.93±3.06 (1.91)	4.79±3.84 (4.18)	0.000*
Urea/Albumin	21.75±16.69 (17.59)	36.88±27.42 (28.71)	0.000*
LDH/Albumin	170.46±112.81 (152.37)	274.76±176 (233.53)	0.000*
Protein/Albumin	2.19±0.44 (2.17)	2.32±0.39 (2.29)	0.001*
PCT/Albumin	0.45±2.23 (0.07)	1.14±4.99 (0.14)	0.000*

Mann-Whitney U Test. *$p<0.05$. NLR was statistically considerably higher in non-survivors ($p<0.05$). C-reactive protein (CRP), Lactate dehydrogenase (LDH), Procalcitonin (PCT).

Table V. Evaluation of parameters affecting mortality with logistic regression.

	95% CI for EXP (B)			
	OR	Lower	Upper	*p*-value
ARF	31.815	2.455	412.226	0.008*
Number of days of stay in intensive care	1.098	0.99	1.216	0.076
Ferritin, ng/mL	0.998	0.995	1	0.030*
Creatinine, mmol/L	0.325	0.098	1.078	0.066
Creatine kinase, U/L	1.007	0.998	1.016	0.109
pro-BNP, pg/ml	1	1	1.001	0.032*
PCT, ng/mL	574.353	2.537	130,032.6	0.022*
Neutrophil/Lymphocyte	1.119	1.011	1.239	0.030*
CRP/Albumin	2.141	1.355	3.383	0.001*
Urea/Albumin	1.079	0.992	1.173	0.077
LDH/Albumin	1.008	0.998	1.018	0.135
Protein/Albumin	0.003	0	0.294	0.014*

Acute Renal Failure (ARF), Pro-Brain Natriuretic Peptide (pro-BNP), Procalcitonin (PCT), C-reactive protein (CRP), Lactate dehydrogenase (LDH). The effects of the number of days in the ICU, creatinine, CK, urea/albumin, and LDH/albumin levels on the model were not numerically significant ($p>0.05$), these parameters also remained in the model. It can be seen that the number of days in the ICU increases mortality by 1.098-fold, creatinine by 0.325-fold, CK by 1.007-fold, urea/albumin by 1.079-fold, and LDH/albumin by 1.008-fold.

There was no statistical significance between the number of days in the ICU, creatinine, CK, urea/albumin, and LDH/albumin levels and the mortality ($p>0.05$). The ratio of ARF and Ferritin, pro-BNP, PCT, NLR, CRP/albumin, and protein/albumin ratios were statistically considerably higher in non-survivors ($p<0.05$) (Table V).

Discussion

In this study, non-survivors between the cases with a diagnosis of COVID-19 whom we followed in the ICU were older than the survivors, which is parallel with previous research[10]. The hospital stay duration of the cases differed from 1 to 119 days, with an average of 19.61±1.94 and a median of 17 days. The duration of hospital stay in the ICU differed from 1 to 91 days, with an average of 11.23±11.79 and a median of 8 days. A study in Italy[11] involving 3,988 patients reported hospital stay as 12 days. Contrary to the literature, the hospital stay was not statistically significant for mortality, and ICU stay durations were longer in survivors.

The mortality rate of our patients followed in the ICU was 67.7%. The rate varied between 16% and 78%[12]. In this analysis, the most common concomitant diseases were hypertension (51.1%), diabetes (31%), CAD (23.4%), and heart failure (20.7), whereas the most common concomitant diseases in the study by Richardson et[12] al were hypertension (56.6%), obesity (41.7%), and diabetes (33.8%).

Organ involvement as a consequence of COVID-19 increases mortality. In a research of 360 cases conducted by Yildiz et al[10] COPD was considerably higher in non-survivors. In a research carried out by Mayet et al[13] ARF increased mortality in ICU patients with respiratory distress and shock. In a meta-analysis by Hansrivijit et al[14] that included 26 studies and 5,497 patients, ARF was related to a 13-fold raised risk of mortality. However, thromboembolism and renal microangiopathy are possible mechanisms causing ARF in COVID-19 patients[15]. In our study, the rate of ARF was considerably higher in non-survivors.

Hematologic, biochemical, and coagulation tests and acute-phase reactions show pathologic alterations in COVID-19 cases. These changes may be observed in one or more parameters. In a multicenter study by Xu et al[16] in China involving 703 patients, leukocytes, neutrophils, D-dimer, LDH and CRP increased, whereas lymphocytes, platelets, and albumin decreased in patients who did not survive. Henry et al[17] carried out a meta-analysis of laboratory abnormalities according to the severity of the disease which included 21 studies and 3,377 patients, the levels of ferritin, leukocytes, neutrophils, CRP, LDH, CK, PCT, ALT, AST, urea, creatinine, pro -BNP, troponin

I, and D-dimer were considerably raised while platelet and lymphocyte levels were considerably lower. Çil et al[18] in their 164-patient study detected that leukocyte and neutrophil count, glucose, urea, creatinine, AST, CRP, D-dimer, and procalcitonin values were higher and albumin values were lower in non-survival cases. Concistrè et al[19] in their 181-patient research, found that elevated LDH, CRP, and ferritin were associated with poor prognosis. In our analysis, Ferritin, leukocytes, neutrophils, CRP, LDH, CK, PCT, ALT, AST, urea, creatinine, and pro-BNP were considerably higher in the non-survivors, while platelet and lymphocyte levels were considerably lower. Although troponin I and D-dimer levels were high in the non-survivors, they were not statistically significant. We attribute this to the fact that there were severe COVID-19 patients in our patients group who were treated in the intensive care unit and to the high troponin I and D-dimer levels in the survivors. NLR is a readily available, inexpensive parameter that provides information about the cellular immune response and the systemic inflammatory response[10]. Yang et al[3] detected in their study of 93 cases that high NLR is a free prognostic indicator for COVID-19 cases. In a comprehensive meta-analysis study including 3,090 patients and 15 studies in which Zeng et al[4] showed that routine blood tests can be used to monitor and predict the severity and prognosis of COVID-19; patients with severe COVID-19 have a higher NLR. In their study including 115 COVID-19 cases, Liu et al[20] found a high risk of transforming to severe COVID-19 in patients with an NLR $\geq$3.13. Similarly, Shang et al[21] showed in their study of 443 patients that NLR and CRP were free risk factors for severe COVID-19. As a novel inflammatory index, PLR mainly reflects the extent of systemic inflammation. Qu et al[22] associated PLR>126.7 with poor prognosis in their study of 30 patients. In our study, high NLR increased mortality by 1.119-fold and the PLR rate was higher in non-survivors. However, this was not statistically significant. We attribute this to the fact that our patient group consisted of critically ill patients and the high mortality rate.

Hypoproteinemia and hypoalbuminemia due to liver failure are common in severe COVID-19. Huang et al[23] showed in their analysis of 2,623 patients that the cytokine storm caused by COVID-19 caused hepatotoxicity and, subsequently, critical hypoalbuminemia, leading to death in severe patients due to disease-induced inflammatory responses. In another study by Huang et al[24] serum albumin level <35 g/L was found to increase the risk of mortality at least 6-fold in COVID-19. In a study[25] of 48 patients in Spain, low albumin levels were related to longer hospital stays and higher mortality. Their study of 115 patients at Zhongnan Hospital, Wuhan University, found a significant decrease in albumin levels and a reduction in disease progression in severe COVID-19 cases[26]. Our patient's albumin levels were considerably lower and inversely correlated with survival.

CRP is a highly sensitive acute-phase reactant and an important indicator of acute and chronic inflammatory processes. Ergenc et al[27] examined CRP values in 1,700 patients with COVID-19 and low CRP was found to be significant in terms of survival. Zhou et al[28] examined the levels of CRP in COVID-19 patients according to the severity of the disease and found it statistically significant. Çelikkol et al[29] in their analysis of 102 patients determined that the CRP/albumin rate had the highest diagnostic accuracy in severe COVID-19 cases matched with other inflammatory markers. Torun et al[30] in a study of 180 cases showed that the CRP/albumin rate was more effective than NLR in assessing the severity of COVID-19. Similarly, in the research by Oh et al[31] on 811 patients, CRP/albumin rate was accepted as a useful independent biomarker for indicating short-term survival within 2 weeks in COVID-19 cases. In our study, CRP/albumin ratio in non-survivors was significantly higher. In recent research by Cekic et al[32] CRP/albumin and PCT /albumin ratios were considerably higher in non-survivors and ICU patient groups. Similarly, PCT /albumin ratio was considerably higher in our cases who did not survive than in those who did.

In our study, the rates of urea/albumin, LDH/albumin, and protein/albumin were also considerably higher in the non-survivors. We attribute this to the significantly higher rate of ARF in our cases who did not survive (p<0.05) and extensive tissue damage caused by COVID-19. It would be suitable to supplement our results with data from larger samples.

Limitations

Our study was a single-center, retrospective study, with a limited number of cases. Another limitation is that we did not have access to data such as smoking, alcohol consumption, and body mass index from hospital records that could influence laboratory results.

Conclusions

When we evaluated the effects of the parameters of age, ARF, ICU length of stay, ferritin, leukocytes, platelets, neutrophils, lymphocytes, AST, ALT, protein, albumin, urea, creatinine, LDH, CK, CRP, ProBNP, procalcitonin, neutrophils/lymphocytes, CRP/albumin, urea/albumin, LDH/albumin, protein/albumin, and procalcitonin/albumin on mortality using backward stepwise logistic regression analysis in cases with COVID-19 the model was found to be significant (p=0.000; p<0.05) the Negelkerke R-squared value was determined to be 0.682 and the explanatory coefficient of the model (87.3%) was at a good level. The effects of ARF, ferritin, pro-BNP, procalcitonin, neutrophils/lymphocytes, CRP/albumin, and protein/albumin on the model were numerically considerable (p<0.05). It was found that the presence of ARF increased mortality by 31.815-fold, ferritin by 0.998-fold, pro-BNP by 1-fold, procalcitonin by 574.353-fold, neutrophils/lymphocytes by 1.119-fold, CRP/albumin by 2.141-fold, and protein/albumin by 0.003-fold. Although the effects of the number of days in the ICU, creatinine, CK, urea/albumin, and LDH/albumin levels on the model were not numerically significant (p>0.05), these parameters also remained in the model. It can be seen that the number of days in the ICU increases mortality by 1.098-fold, creatinine by 0.325-fold, CK by 1.007-fold, urea/albumin by 1.079-fold, and LDH/albumin by 1.008-fold. We believe it would be useful to add the current ratios to the study results to determine the impact of biomarkers on prognosis and mortality clinically.

Informed Consent
Informed consent was taken from all participants.

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Conflicts of Interest
The authors' declare no conflict of interest.

Ethics Approval
Ethical approval was gained from Malatya Turgut Özal University Clinical Research Ethics Committee (Ethical Number: 2022-39).

Authors' Contributions
Erdinç Koca: design of the study, acquisition of data, analysis and interpretation of data, drafting the article, making critical revision, supervision. Sevgi Kutlusoy: acquisition of data, analysis, interpretation of data, analysis and interpretation of data, administering technical support. All authors have read and agreed to the version of the article to be published.

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