Original Article

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Correlations of Temporal Changes of CT Severity Scores and Laboratory Parameters in COVID-19 Hospitalized Patients

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Abstract

Aim: It has been reported that the increased neutrophil/lymphocyte ratio (NLR) is associated with a poor prognosis in Coronavirus disease-2019 (COVID-19) patients. We aimed to correlate three consecutive computed tomography severity score (CT-SS) values with simultaneous NLR and other laboratory parameters and investigate their temporal changes effects on the prognosis of COVID-19 patients.

Methods: This single-center cross-sectional study included 99 (aged ≥18 years) COVID-19 patients hospitalized between March 1, 2021, and June 30, 2021. Demographic data, laboratory findings, and intensive care unit (ICU) admissions were obtained from electronic medical records. We divided patients into two groups: ICU and non-ICU patients A radiologist calculated three consecutive chest CT-SSs using a 25-point visually semiquantitative system. Spearman's rho correlation was used to evaluate correlations between CT-SSs and laboratory parameters in ICU and non-ICU patients.

Results: The study population included 99 patients with a mean age of 61.17±14.36 years. Significant associations were found between the third-highest values of CRP (p=0.005), D-dimer (p=0.007), lactate dehydrogenase (p=0.027), and ICU admission. While there was no statistical significance between the first and second CT-SS and ICU admissions, there was a significant relationship between the third CT-SS and ICU admissions (p=0.013). Moderate positive correlations between the first NLR and CT-SS (p=0.025, r=0.488) and the second NLR and CT-SS (p=0.001, r=0.650) were found in ICU patients.

Conclusion: Our results demonstrate the importance of late follow-up chest CT and laboratory parameters for the prognosis and ICU admissions of COVID-19 patients.

Keywords: COVID-19, coronavirus, CT severity score, neutrophil/lymphocyte ratio, NLR, intensive care unit

Introduction

The Coronavirus disease-2019 (COVID-19) has caused a major challenge for the global health system, with the mortality of patients being related to the healthcare burden (1,2). The rapid increase in the number of COVID-19 patients worldwide has made treatment in intensive care units (ICUs) a major challenge. Therefore, triaging patients as early as possible is essential for the early recognition of severe forms of COVID-19 (3).

COVID-19 can cause critical respiratory symptoms, especially in elderly patients and those with comorbidities. In some patients, it may progress to a serious disease with significant pulmonary changes that can be seen with imaging techniques. Computed tomography (CT) has been reported to have a high sensitivity in COVID-19 patients showing signs of pneumonia; therefore, it is largely used to aid patient management (4).

Although clinical symptoms such as fever, cough, and shortness of breath are characteristic of COVID-19, some biomarkers such as lymphopenia, neutrophilia, a high neutrophil/lymphocyte ratio (NLR), elevated C-reactive protein (CRP), and D-dimer concentrations may also indicate this infection (3,5).

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According to previous studies, changes in hematological parameters are more pronounced in severe COVID-19 patients than in non-severe patients (3). In particular, increased NLR, lactate dehydrogenase (LDH), and D-dimer and CRP concentrations are closely related to the poor prognosis of COVID-19 (6,7).

Chest CT findings and CT severity score (CT-SS) have been shown to be important independent prognostic factors in patients with COVID-19 (8). However, it can cause death and serious fatal complications such as fulminant myocarditis or disseminated intravascular coagulopathy, even in younger individuals without an underlying disease. It is critical to evaluate clinical and laboratory tests that may indicate a possible poor prognosis. In our study, unlike the literature, we assessed the three consecutive CT-SS values, the simultaneous NLR, and other laboratory parameters and their effects on the need for ICU treatment.

In our study, we aimed to correlate three consecutive CT-SS values with simultaneous NLR and other laboratory parameters and to investigate the effects of their dynamic changes on the prognosis of COVID-19 patients. Our second objective was to investigate the effectiveness of NLR and CT-SS in predicting the prognosis of COVID-19 patients.

Materials and Methods

Compliance with Ethical Standards

This study was approved by the Non-Invasive Clinical Research Ethics Committee of the Amasya University Faculty of Medicine (date: 02.12.2021, approval no: 153) and was conducted according to the Declaration of Helsinki and Good Clinical Practice. Because the study was retrospective, patient information was obtained from the electronic records of the hospital, and the ethics committee did not require written informed consent from the patients.

Study Population and Data Collection

Our study was a single-center cross-sectional study of COVID-19 patients who were hospitalized at our hospital. The study included patients with confirmed severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) infections who were hospitalized between March 1, 2021, and June 30, 2021. We included patients with positive real-time reverse transcriptase-polymerase chain reaction (RT-PCR) testing and at least three chest CT scans. We excluded patients with at least 3 negative RT-PCR tests, pediatric patients, and pregnant women from our study (Figure 1).

Data on the patients' demographic characteristics, comorbidities, laboratory findings, and chest CT results were extracted from electronic medical records.

Laboratory Procedures

Reverse transcriptase-polymerase chain reaction for SARS-CoV-2 was performed on the nasal and pharyngeal swab specimens of all patients according to WHO guidance. Laboratory tests involving a complete blood count, serum biochemical tests such as LDH, inflammatory markers such as CRP and ferritin, and coagulation markers such as D-dimer were recorded in the hospital records. We calculated the NLR by dividing the absolute neutrophil count by the total lymphocyte count.

Computed Tomography Protocol

Non-contrast chest CT scans were performed using a 128-slice CT scanner (GE Medical Systems; Milwaukee, WI) in a supine position. The acquisition and reconstruction parameters were as follows: tube potential, 120 kV; tube current, 100-450 mA; gantry rotation, 0.4 seconds; acquisition direction, caudocranial; reconstruction kernel, standard; beam collimation, 64 mm×0.625 mm; beam pitch, 1.375; slice thickness, 0.625 mm; and section overlap, 0.625 mm. All chest CT scans were assessed at a lung window of 1500 WW and -450 WL. A non-contrast chest CT was obtained at the end of inspiration whenever possible.

Image Analysis

A radiologist with more than 10 years of experience in chest CT imaging evaluated all CT images individually, blinded to patients' clinical data and laboratory indicators. A chest CT-SS was calculated using a visually semiquantitative CT-SS (9) by evaluating the percentage

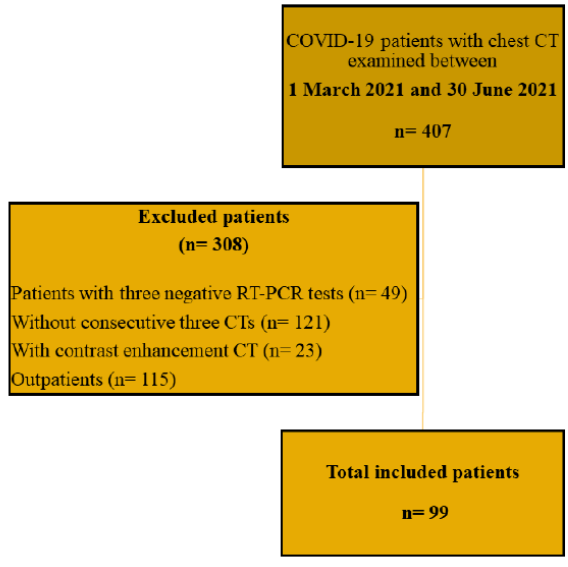

Figure 1. Flowchart of study
COVID-19: Coronavirus disease-2019, RT-PCR: Reverse transcriptase-polymerase chain reaction, CT: Computed tomography

of involvement of each of the five lobes. It was calculated as: score 0, 0% involvement; score 1, <5% involvement; score 2, 5% to 25% involvement; score 3, 26% to 49% involvement; score 4, 50% to 75% involvement; and score 5,> 75% involvement. Scoring from 0 to 5 was made for each lobe, and the total CT-SS was between 0 and 25.

Statistical Analysis

All statistical analyses were performed using IBM SSPS statistical software (version 22.0) (IBM Corp., Released 2017). Armonk, NY). Categorical data were calculated as numbers (percentages) and compared using the chi-square test. Median (25^{th} and 75^{th} percentiles) values were calculated using the Mann-Whitney U test for data with a non-normal distribution. Spearman's rho correlation was used to evaluate the relationship between CT-SS and laboratory parameters in ICU and non-ICU patients. In Spearman's rho correlation analysis, the correlation between two variables is expressed by the letter r and a number ranging from -1 to +1. Zero means no correlation; where 1 is ±1, it means perfect correlation. When the r value is negative, it means that there is an inverse relationship between the variables (10). P<0.05 was considered statistically significant.

Results

Patients who had at least three chest CT scans during clinical follow-up were included in the study. In this study, we analyzed 99 patients who were hospitalized due to COVID-19. The mean age of the patients was 61.17±14.36. 54/99 (54.5%) of the patients were male. The most common comorbidities in the study population were hypertension (45/99; 45.45%) and diabetes mellitus (36/99; 36.36%). There was a significant association between the presence of chronic pulmonary disease and ICU admission (p=0.025) (Table 1).

In our study, negative associations were found between second and third lymphocyte values (p=0.010, p=0.021) and ICU admission. In addition, significant associations were found between the third highest median values of CRP (p=0.005), D-dimer (p=0.007), LDH (p=0.027), and ICU admission. While there was no statistical significance in the first and second CT-SS values between ICU admission, there was a significant relationship between the third mean CT-SS and ICU admission (p=0.013) (Figure 2, Table 2).

In Spearman's rho correlation analysis, there was a moderate positive correlation between the second NLR and CT-SS (p<0.001, r=0.400) and a weak positive correlation between the third NLR and CT-SS (p=0.044, r=0.229) in non-ICU patients. In the ICU patients, there were moderately positive correlations between the first

Table 1. Comorbid diseases of all COVID-19 patients

		Non-ICU		ICU		
		n	(%)	n	(%)	p-value
Diabetes mellitus	Absent	50	64.10	13	61.90	0.853
	Present	28	35.90	8	38.10	
	Total	78		21		
Hypertension	Absent	44	56.40	10	47.60	0.473
	Present	34	43.60	11	52.40	
	Total	78		21		
Cardiovascular disease	Absent	53	67.90	12	57.10	0.355
	Present	25	32.10	9	42.90	
	Total	78		21		
Chronic pulmonary disease	Absent	63	80.80	12	57.10	0.025
	Present	15	19.20	9	42.90	
	Total	78		21		
Cerebrovascular diseases*	Absent	75	96.20	20	95.20	0.999
	Present	3	3.80	1	4.80	
	Total	78		21		

Chi-square or (*) Fisher's exact tests were used to compare comorbidities according to ICU admission
COVID-19: Coronavirus diseases-2019, ICU: Intensive care unit

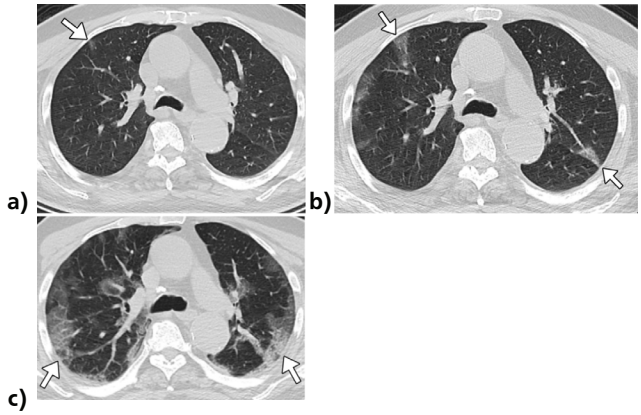

Figure 2a-c. A 76-year-old man with a positive RT-PCR test. He died after 16 days of treatment in the intensive care unit. **a)** Axial lung window of first non-contrast chest CT shows peripheral localized nodular ground glass opacity (GGO) in the upper lobe of the right lung (arrow). CT-SS_1 =2; neutrophil/lymphocyte ratio $(NLR)_1$: 2.25. **b)** Axial lung window of second chest CT shows bilateral peripheral localized GGOs (arrows). CT-SS_2 =9; NLR_2:3.19. **c)** Axial lung window of third chest CT shows increased bilateral peripheral localized GGOs (arrows). CT-SS_3 =20; NLR_3:24.58
RT-PCR: Reverse transcriptase-polymerase chain reaction, CT-SS: Computed tomography severity score, NLR: Neutrophil/lymphocyte ratio

Table 2. Comparison of the first, second and third median values of laboratory parameters and CT severity scores according to the non-ICU and ICU groups

		N	Mean	SD	Min.	Max.	Median	25th	75th	p-value
Age	Non-ICU	78	59.62	14.46	32	88	59.5	48.5	71.25	0.037
	ICU	21	66.95	12.67	43	89	66	56.5	78	
	Total	99	61.17	14.36	32	89	61	50	72	
First CT-SS*	Non-ICU	78	7.62	7.52	0	25	8	0	11.25	0.556
	ICU	21	8.43	8.08	0	25	7	1	12	
	Total	99	7.79	7.61	0	25	8	0	12	
Second CT-SS*	Non-ICU	78	14.88	7.78	0	25	15	9.75	22	0.817
	ICU	21	14.05	9.01	0	25	16	6	22.5	
	Total	99	14.71	8.01	0	25	16	9	22	
Third CT-SS*	Non-ICU	78	14.09	8.14	0	25	14.5	10	20.25	0.013
	ICU	21	19.29	5.15	8	25	20	16	24	
	Total	99	15.19	7.88	0	25	17	10	21	
NLR1	Non-ICU	78	4.05	3.66	0.81	22.48	2.83	1.84	5.11	0.337
	ICU	21	10.71	30.94	1.18	145.33	3.71	2.18	5.71	
	Total	99	5.46	14.61	0.81	145.33	2.88	2.03	5.27	
NLR2	Non-ICU	78	8.36	7.48	1.32	42.43	6.59	3.42	10.78	0.108
	ICU	21	11.65	10.72	1.71	47.37	9.36	3.45	15.42	
	Total	99	9.05	8.32	1.32	47.37	6.78	3.44	12.40	
NLR3	Non-ICU	78	7.84	8.58	0.05	52.54	5.90	2.56	10.41	0.085
	ICU	21	22.48	36.81	1.43	164	6.87	4.19	25.64	
	Total	99	10.94	19.25	0.05	164	6.27	2.89	11.20	
Neutrophil_1	Non-ICU	78	4.71	2.78	1.58	14.06	3.98	2.90	5.39	0.336
	ICU	21	8.66	18.35	1.68	87.20	3.95	2.62	5.60	
	Total	99	5.54	8.80	1.58	87.20	3.95	2.74	5.40	
Neutrophil_2	Non-ICU	78	7.88	4.12	1.76	25.61	7.29	5.11	9.39	0.227
	ICU	21	6.70	3.19	1.88	14.21	5.96	4.29	8.81	
	Total	99	7.63	3.95	1.76	25.61	6.92	4.86	9.24	
Neutrophil_3	Non-ICU	78	8.40	4.29	2.32	24.17	7.64	4.70	10.83	0.783
	ICU	21	8.71	5.09	1.69	22.96	8.69	5.09	12.17	
	Total	99	8.47	4.44	1.69	24.17	7.64	4.88	11.12	
Lymphocyte_1	Non-ICU	78	1.47	0.76	0.29	4.64	1.27	1.02	1.71	0.513
	ICU	21	1.34	0.86	0.57	4.10	1.10	0.75	1.59	
	Total	99	1.44	0.78	0.29	4.64	1.25	0.93	1.70	
Lymphocyte_2	Non-ICU	78	1.28	0.74	0.26	4.71	1.11	0.80	1.62	0.010
	ICU	21	0.88	0.54	0.30	2.14	0.67	0.50	1.18	
	Total	99	1.20	0.72	0.26	4.71	1.03	0.64	1.59	
Lymphocyte_3	Non-ICU	78	2.43	7.67	0.25	69.00	1.45	0.93	2.13	0.021
	ICU	21	1.02	0.89	0.14	3.48	0.70	0.37	1.40	
	Total	99	2.13	6.84	0.14	69.00	1.29	0.82	2.03	
D_Dimer_1	Non-ICU	78	0.84	1.96	0.03	16.79	0.40	0.22	0.90	0.98
	ICU	21	0.85	0.67	0.13	2.62	0.68	0.41	1.27	
	Total	99	0.85	1.76	0.03	16.79	0.46	0.23	1.01	
D_Dimer_2	Non-ICU	78	0.99	1.56	0.03	8.53	0.46	0.27	0.95	0.409
	ICU	21	1.31	1.52	0.20	5.38	0.58	0.42	2.12	
	Total	99	1.06	1.55	0.03	8.53	0.49	0.28	0.97	

Table 2. Continued

		N	Mean	SD	Min.	Max.	Median	25th	75th	p-value
D_dimer_3	Non-ICU	78	0.78	0.79	0.03	3.42	0.44	0.22	1.04	0.029
	ICU	21	1.23	0.98	0.28	3.43	0.88	0.56	1.86	
	Total	99	0.87	0.85	0.03	3.43	0.55	0.27	1.21	
CRP_1	Non-ICU	78	35.73	37.74	0.50	140	17.77	6.87	60	0.469
	ICU	21	42.82	46.64	1.03	145.25	19	10.29	76	
	Total	99	37.23	39.65	0.50	145.25	19	8.00	61	
CRP_2	Non-ICU	78	55.16	55.24	0.50	245	34.49	11.25	91.09	0.39
	ICU	21	66.84	54.14	0.56	178.35	51.02	16.91	119.38	
	Total	99	57.64	54.95	0.50	245	41.44	12.78	93	
CRP_3	Non-ICU	78	47.56	58.81	0.40	291	20.14	3.38	85.41	0.012
	ICU	21	85.69	68.20	1.30	256.75	96	17.34	123.5	
	Total	99	55.65	62.55	0.40	291.00	27.42	5.04	96.10	
LDH_1	Non-ICU	78	288.01	94.61	166	550	259	219	342.25	0.304
	ICU	21	328.24	168.55	134	706	286	189.5	418.5	
	Total	99	296.55	114.47	134	706	261	218	346	
LDH_2	Non-ICU	78	317.63	110.96	169	745	296.5	242.75	349.75	0.377
	ICU	21	343.29	140.57	175	727	313	230	416	
	Total	99	323.07	117.55	169	745	300	240	380.5	
LDH_3	Non-ICU	78	322.40	105.01	163	745	291	252.5	378	0.019
	ICU	21	386.95	126.15	226	679	367	283.5	452	
	Total	99	336.09	112.32	163	745	308	265	398	

The independent t-test or (*) Mann-Whitney U tests were used to compare continuous variables according to ICU admission
CT: Computed tomography, ICU: Intensive care unit, SD: Standard deviation, Min.: Minimum, Max.: Maximum, CT-SS: Computed tomography severity score, NLR: Neutrophil/lymphocyte ratio, CRP: C-reactive protein, LDH: Lactate dehydrogenase

NLR and CT-SS (p=0.025 and r=0.488) and the second NLR and CT-SS (p=0.001 and r=0.650). In the ICU group, there were positive correlations between the first CT-SS and D-dimer (p=0.023, r=0.495), CRP (p=0.006, r=0.579), ferritin (p=0.017, r=0.514), LDH (p<0.01, r=0.806), and a negative correlation with lymphocyte count (p=0.017, r=-0.513). Also, there were positive correlations between the second CT-SS and the second white blood cell (WBC) (p=0.001, r=0.653), neutrophil (p<0.001, r=0.708), and LDH values (p=0.001, r=0.650), and a negative correlation with lymphocyte count (p=0.047, r=-0.439). Also, significant correlations were found between laboratory parameters and CT-SSs, especially in the second evaluation in the non-ICU group (Table 3).

The relationship of consecutive CT-SS values between ICU and non-ICU patients was compared with the Wilcoxon test. There was a statistically significant increase between the first CT-SS and the second CT-SS values in ICU and non-ICU patients, respectively (p=0.002; p<0.001). There was also a significant increase between the second and third CT-SS in the ICU group (p=0.02) (Table 4, Figure 3).

Discussion

In our study, hospitalized COVID-19 patients who had at least three chest CTs and concomitant serum hematological parameters were investigated. We divided the patients into two groups: ICU patients and non-ICU patients. We compared serum hematological parameters and three CT-SS between both groups and investigated the importance and necessity of follow-up examinations. While there was no statistically significant difference between the first and second high CT-SS values and ICU admission, we found a significant relationship between the third high CT-SS and ICU admission. Also, significant associations were found between the third highest median values of CRP, D-dimer, LDH, and lower second and third lymphocyte counts with ICU admission. Our results show moderately positive correlations between the second NLR and CT-SS and between the third NLR and CT-SS in non-ICU patients. In addition, moderately positive correlations were found between the first and second NLR values and simultaneous CT-SSs in the ICU patients.

In the literature, CT-SS scores were found to be higher in severe or critical patients who were treated in the ICU and needed ventilation (8,11,12). We found no significant association between the first and second CT-SS and ICU

Table 3. Spearman's Rho correlations among laboratory parameters and CT severity scores

		Non-ICU			ICU		
		CT-SS$_1$	CT-SS$_2$	CT-SS$_3$	CT-SS$_1$	CT-SS$_2$	CT-SS$_3$
NLR (1)	r-value	0.135			0.488		
	p-value	0.239			0.025		
NLR (2)	r-value		0.400			0.650	
	p-value		<0.001			0.001	
NLR (3)	r-value			0.229			0.203
	p-value			0.044			0.377
Neutrophils (1)	r-value	0.016			-0.020		
	p-value	0.892			0.933		
Neutrophils (2)	r-value		0.278			0.708	
	p-value		0.014			<0.001	
Neutrophils (3)	r-value			0.135			0.016
	p-value			0.237			0.944
Lymphocyte (1)	r-value	-0.128			-0.513		
	p-value	0.266			0.017		
Lymphocyte (2)	r-value		-0.275			-0.439	
	p-value		0.015			0.047	
Lymphocyte (3)	r-value			-0.221			-0.276
	p-value			0.052			0.225
CRP (1)	r-value	0.554			0.579		
	p-value	<0.001			0.006		
CRP (2)	r-value		0.330			-0.085	
	p-value		0.003			0.714	
CRP (3)	r-value			0.198			0.171
	p-value			0.082			0.460
D-dimer (1)	r-value	0.256			0.495		
	p-value	0.024			0.023		
D-dimer (2)	r-value		0.242			0.399	
	p-value		0.033			0.073	
D-dimer (3)	r-value			0.218			-0.025
	p-value			0.055			0.915
Ferritin (1)	r-value	0.405			0.514		
	p-value	p<0.001			0.017		
Ferritin (2)	r-value		0.511			0.218	
	p-value		<0.001			0.344	
Ferritin (3)	r-value			0.440			-0.094
	r-value			<0.001			0.685
LDH (1)	p-value	0.351			0.806		
	r-value	0.002			<0.001		
LDH (2)	p-value		0.489			0.0768	
	r-value		<0.001			<0.001	
LDH (3)	p-value			0.225		0.028	0.226
	r-value			0.048			0.324

Correlation coefficient: r-value
CT: Computed tomography, ICU: Intensive care unit, CT-SS: Computed tomography severity score, NLR: Neutrophil/lymphocyte ratio, CRP: C-reactive protein, LDH: Lactate dehydrogenase

admission in our study. We found a statistical relationship between the third-higher CT-SS and ICU admission. While there was a minimal decrease in the third CT-SS in the non-ICU group compared with the second, there was an increase in the third CT-SS in the ICU group compared with the second. In addition, significant associations were found between the third-highest median values of CRP, D-dimer, LDH, and ICU admission. Our results demonstrate the importance of late-stage follow-up chest CTs and laboratory parameters for the prognosis of patients. The lymphocyte count in the second evaluation showed significant differences between the two groups. The significant difference in lymphopenia between the two groups in the second evaluation indicates that lymphopenia is an early prognostic factor compared with other parameters.

In the initial period, the clinical symptoms of the patients may be milder, and peripheral laboratory findings

Table 4. The relationship of consecutive CT-SS values between ICU and non-ICU patients was compared with the Wilcoxon test

		N	Mean rank	Sum of ranks	p-value
Non-ICU					
Second CT-SS First CT-SS	Negative ranks	7[a]	28.64	200.50	**<0.001**
	Positive ranks	63[b]	36.26	2284.50	
	Ties	8[c]			
	Total	78			
Third CT-SS Second CT-SS	Negative ranks	36[d]	34.58	1245.00	0.507
	Positive ranks	31[e]	33.32	1033.00	
	Ties	11[f]			
	Total	78			
ICU					
Second CT-SS First CT-SS	Negative ranks	2[a]	2.50	5.00	**0.002**
	Positive ranks	13[b]	8.85	115.00	
	Ties	6[c]			
	Total	21			
Third CT-SS Second CT-SS	Negative ranks	5[d]	7.40	37.00	**0.020**
	Positive ranks	14[e]	10.93	153.00	
	Ties	2[f]			
	Total	21			

a. Second CT-SS < First CT-SS
b. Second CT-SS > First CT-SS
c. Second CT-SS = First CT-SS
d. Third CT-SS < Second CT-SS
e. Third CT-SS > Second CT-SS
f. Third CT-SS = Second CT-SS

ICU: Intensive care unit, CT-SS: Computed tomography severity score

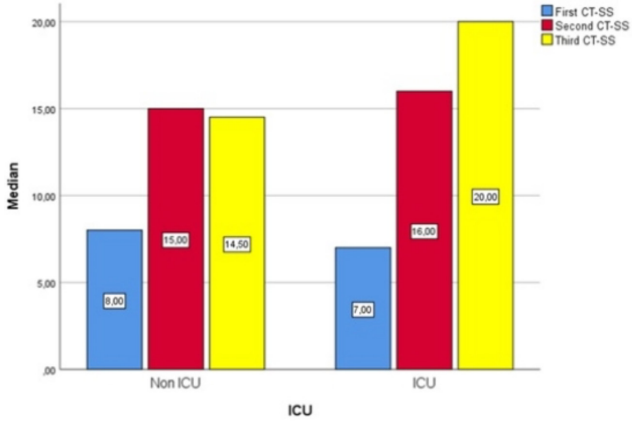

Figure 3. The statistical graphic shows the mean values of three consecutive CT-severity scores in ICU and non-ICU subgroups
CT: Computed tomography, ICU: Intensive care unit

may show normal or mild changes (13). In previous studies, when chest CT imaging was performed within the first 2 days after the onset of symptoms, nearly half of the patients had normal CT imaging findings, which was termed an early period (9). The fact that more laboratory parameters were correlated with CT-SS in the ICU group in the first evaluation compared with the other group may indicate that this patient group applied to the hospital later. Pneumonia often accompanies inpatients due to COVID-19 disease. Because pneumonia develops due to inflammatory processes, a correlation between inflammatory markers and the CT-SS is expected (14-16). In past studies that divided the patient groups into severe and non-severe groups according to the clinical symptoms of the patient, a significant difference was found between the two groups in terms of WBC, neutrophil, lymphocyte count, NLR, CRP, and D-dimer (17,18). However, in some studies, while significant differences were observed in WBC, CRP, LDH, and ferritin parameters in asymptomatic and symptomatic patient groups, no statistically significant difference was observed in neutrophil, lymphocyte count, or D-dimer parameters (14).

In previous studies, a positive correlation was found between CT-SS and NLR, D-dimer, and ferritin (14-16). El Hussini et al. (15) reported that NLR, CRP, and D-dimer values were significantly higher in severe COVID-19 patients. Çil et al. (16) divided COVID-19 patients into 3 groups according to their CT-SS values. They reported that NLR was significantly higher in patients with severe COVID-19 and was the most important factor determining CT-SS (16). Sejópoles et al. (19) reported that COVID-19 patients' serum leukocyte, neutrophil, and lymphocyte counts and NLR values at hospital admission have shown satisfactory accuracy and sensitivity in predicting patients at higher risk of death. While other studies analyzed the CT-SS and laboratory values at the time of administration, in our study, we examined the temporal changes and correlation of simultaneous NLR and other laboratory parameters with three consecutive CT-SS values and investigated their effects on ICU admission. In our study, moderately positive correlations were found between the first NLR and CT-SS and the second NLR and CT-SS in the ICU patients. Also, negative associations were found between the second and third lymphocyte values and ICU admission, and positive associations were found between the third higher median values of CRP and LDH and ICU admission. Because of the evaluation of the laboratory results of our study patients, we observed that deterioration in laboratory values in the late period, as in CT-SS, was more associated with the poor prognosis of COVID-19 patients.

Study Limitations

There were several limitations to our study. First, our study was a single-center retrospective study. Second, we do not have any information about the period between the first evaluation made at the time of admission and the onset of symptoms. Another limitation is that the three evaluations could not be made in a standard day or week interval. Despite these limitations, our study contributes to the literature as it is the first to associate three consecutive CT-SS values with simultaneous NLR and other laboratory parameters and to investigate their relationship with ICU admission.

Conclusion

Our study results demonstrate the importance of late follow-up chest CT and laboratory parameters for the prognosis and ICU admissions of COVID-19 patients.

Ethics

Ethics Committee Approval: This study was approved by the Non-Invasive Clinical Research Ethics Committee of the Amasya University Faculty of Medicine (date: 02.12.2021, approval no: 153) and was conducted according to the Declaration of Helsinki and Good Clinical Practice.

Informed Consent: Because the study was retrospective, patient information was obtained from the electronic records of the hospital, and the ethics committee did not require written informed consent from the patients.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: S.D., A.T.K., B.A., Design: S.D., A.T.K., Data Collection or Processing: A.T.K., Analysis or Interpretation: S.D., A.T.K., B.A., B.T., Literature Search: S.D., B.A., Writing: S.D., B.A.

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