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The effect of CT-based cardiothoracic ratio on survival of COVID-19 patients

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ABSTRACT

Objectives: We aimed to investigate the relationship between computed tomography (CT)- based cardiothoracic ratio (CTR) with mortality rates of COVID-19 patients.

Methods: Our study was a single-center retrospective analysis of 484 patients (aged ≥ 18) who were admitted to our hospital's emergency department. We included only laboratory-confirmed COVID-19 patients who underwent chest CT. Data of demographic information, laboratory findings, survivals, and chest CT imaging findings were recorded. The radiologist calculated CTR by dividing the greatest transverse cardiac diameter by the greatest transverse thoracic diameter on the initial chest CT. Cardiomegaly was defined if "CTR > 0.5".

Results: Thirty (6.2%) patients were treated as outpatients, and 135/484 (%27.9) patients were treated in the intensive care unit (ICU). A total of 147 /484 (30.4%) patients died. We found a statistical association between cardiomegaly with mortality rates ($p < 0.001$) and ICU admission ($p = 0.008$). In multivariate analysis, older age was 1.07-fold ($p < 0.001$), cardiomegaly 1.75-fold ($p = 0.015$), history of cerebrovascular diseases 2.929-fold ($p = 0.018$), and elevated serum LDH level 1.003-fold ($p = 0.011$) associated with higher risks of mortality.

Conclusions: Since the presence of cardiomegaly on chest CT is associated with a worse prognosis for COVID-19 patients, more caution should be exercised in the evaluation, follow-up, and treatment of COVID-19 patients with cardiomegaly.

Keywords: COVID-19, computed tomography, chest, cardiothoracic ratio

The Coronavirus disease 2019 (COVID-19) pandemic has become a serious public health threat to millions of people worldwide [1]. In COVID-19 patients, the reverse transcriptase-polymerase chain reaction (RT-PCR) test is the standard for diagnosis. But in some cases, it may give a false-negative result, especially in the early stages of the disease, possibly due to insufficient viral samples in the sample or technical problems during nucleic acid extraction [2, 3]. As a result, chest computed tomography (CT) has become one of the main methods for diagnosing COVID-19 and assessing disease severity [4]. Typical chest CT imaging findings of COVID-19 are multifocal ground-glass opacities (GGOs) with or without consolidations that predominate in the posterior areas and reticulations in the lung region near the visceral pleural surface [5].

Emergency department healthcare professionals had a great role in the assessment and treatment of COVID-19 patients during the pandemic, as they are

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at the forefront of the management of patients with acute illness [6]. COVID-19 patients should be evaluated for risk factors at their first admission to the emergency department for appropriate treatment planning. Respiratory involvement in patients with COVID-19 patients' may be a mild flu-like illness or progress to potentially fatal acute respiratory distress syndrome (ARDS) or fulminant pneumonia. Patients with pre-existing cardiovascular disease (CVD) are more vulnerable to developing COVID-19 and have more severe diseases with worse prognoses [7-10]. Also, COVID-19 may worsen the underlying CVD and can precipitate new cardiac complications. In patients with comorbidities such as diabetes, cardio-cerebrovascular disease, and hypertension, the risk of developing serious disease and the need for intensive care unit (ICU) admission increases [8].

The CTR is noted as a reliable marker for cardiomegaly on computed tomography (CT). For many years, first chest radiography and then CT has been used to evaluate CTR in clinical practice. The CTR is obtained by dividing the maximal diameter of the chest by the cardiac maximal diameter and CTR > 0.5 is defined as cardiomegaly [11]. The CTR measurement is a non-invasive and easily available method used to evaluate cardiomegaly and cardiac volume [12].

In the literature, it has been shown that imaging-based cardiac indices predict an increased risk of mortality and morbidity in various non-COVID-19 acute and chronic diseases. They reported that an increase in the cardiothoracic ratio (CTR) is associated with severity in patients with respiratory diseases [13, 14]. Also, Eslami *et al*. [15] investigated the relationship between CTR values with CT severity scores and mortality rates in hospitalized COVID-19 patients with a small sample size.

In the current study, we aimed to investigate the association of the CT-based CTR with the ICU admission and survival of COVID-19 patients with large sample size.

METHODS

This study was approved by the Ethical Committee of Amasya University, Faculty of Medicine, and was conducted according to the Declaration of Helsinki and Good Clinical Practice (8 July 2021, number:126), and the requirement for informed consent was waived.

Study Population and Data Collection

Our study was a single-center retrospective analysis conducted on an original cohort of 484 patients (≥ 18 years) who applied to our hospital's emergency department between September and December 2020. We included only laboratory-confirmed patients which were determined by positive RT-PCR tests. All patients underwent at least one chest CT scan in our hospital's Radiology Department. Patients with negative RT-PCR tests and pre-existing chest wall abnormalities were also excluded from the study.

We collected the data from our hospital's electronic records including demographic characteristics, laboratory findings, lengths of hospitalization or ICU stays, and clinical outcomes of the patients.

RT-PCR tests were performed on all patients' oropharyngeal and nasopharyngeal swab specimens according to WHO interim guidelines. Laboratory tests include complete blood count (CBC), serum biochemistry parameters, inflammatory markers such as C-reactive protein (CRP), lactate dehydrogenase level (LDH), erythrocyte sedimentation rate (ESR), ferritin, coagulation markers such as D-Dimer, International Normalized Ratio (INR), fibrinogen were recorded at admission.

CT Protocol

The non-contrast chest CT examinations were performed in a supine position with the multidetector CT scanner 128- slice GE Healthcare Revolution EVO CT (GE Medical Systems; Milwaukee, WI). The acquisition and reconstruction parameters were as follows: tube potential, 120kV; tube current, 100–450 mA; beam collimation, 64 mm × 0.625 mm; beam pitch, 1.375; gantry rotation, 0.4 seconds; acquisition direction, caudocranial; reconstruction kernel, standard; 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 and a mediastinal window of 400 WW and 40 WL.

Image Analysis

A radiologist with more than 15 years of experience in chest CT imaging, performed the CT image analysis in a standard clinical picture archiving and diagnostic system (PACS) workstation, blinded to the clinical data and laboratory indicators.

The parenchymal and mediastinal imaging findings such as GGOs, consolidation, crazy paving pattern, pleural, pericardial effusion were reported by the radiologist. The severity of COVID-19 pulmonary involvement was evaluated by the semi-quantitative CT severity scoring system visually that was previously reported by Pan *et al*. [16]. Depending on the extent of lobe involvement in COVID-19 pneumonia, each lobe is scored from 0 to 5: score 0, 0% involvement; score 1, less than 5% involvement; score 2, 5% to less than 25 % involvement; score 3, 25 % to less than 50 % involvement; score 4, 50 % to less than 75 % involvement; and score 5, 75 % or greater involvement. The total score is obtained by summing the lober scores (range 0-25).

Also, the maximum transverse cardiac diameter (from outer to outer myocardium) and the maximum transverse thoracic diameter were measured manually on axial CT images. CTR was calculated as the greatest transverse cardiac diameter divided by the greatest transverse thoracic diameter (Fig. 1) [15]. CTR > 0.50 was defined as an indicator of cardiomegaly [11].

Statistical Analysis

Statistical analysis was applied using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp. Released 2017. Armonk, NY). The conformity of the variables to the normal distribution was examined using Kolmogorov-Smirnov. In descriptive analyses, normally distributed variables were represented as mean and standard deviation (SD), and non-normally distributed variables were represented as median [interquartile range (IQR)]. Pearson's chi-squared or Fisher tests were used to compare categorical variables according to cardiomegaly groups (in cases where the values displayed in the cells did not meet the assumptions of the chi-squared test). In the comparison of continuous variables according to cardiomegaly, the Student's t-test was used for those with normal distribution and the Mann-Whitney U test for those who were not normally distributed. The main factors related to mortality were evaluated by univariate binary logistic regression analysis. Explanatory variables with a $p < 0.25$ in the univariate logistic regression analysis were included in the multivariate logistic regression analysis [17]. The Hosmer-Lemeshow test was used for model fit. $p < 0.05$ was considered statistically significant.

RESULTS

Demographic features of the study population

The study population included 484 patients with

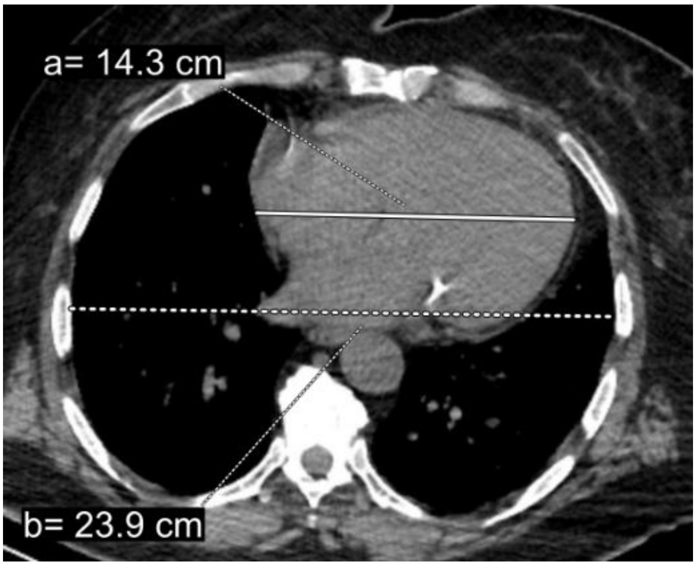

Fig. 1. Axial image of chest CT shows the measurement of maximum transverse thoracic diameter (dashed line) and maximum transverse cardiac diameter (straight line) for calculating the cardiothoracic ratio. The cardiothoracic ratio was calculated as "0.60" by dividing the maximal diameter of the chest by the cardiac maximal diameter and there was cardiomegaly.

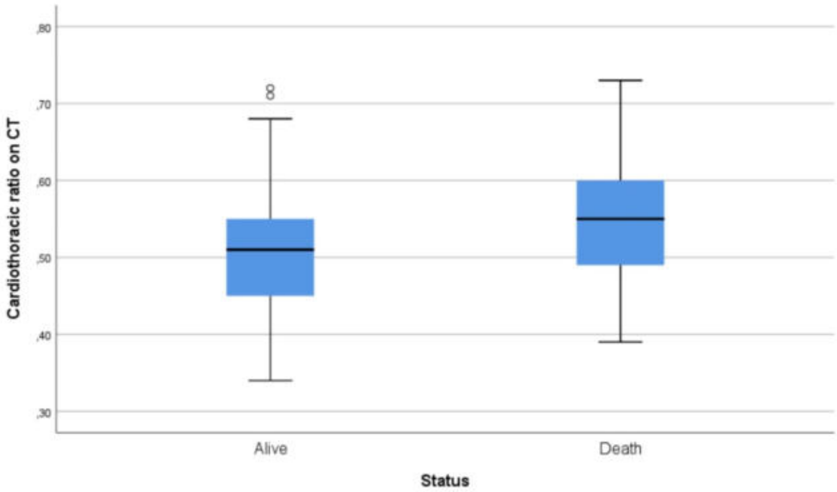

Fig. 2. Statistical graphic shows the cardiothoracic ratio values of alive and deceased patients.

a median value of age was 66 (IQR 55-75), 284 (58.7%) were male. 287/484 (59.2%) patients had cardiomegaly in their CT imaging. The median age of patients with cardiomegaly was 70 (IQR 62-78) and the median age of patients without cardiomegaly was 57 (IQR 47-68.5). Cardiomegaly was statistically associated with older age ($p < 0.001$). 148 (59.1%) patients were male in patients with cardiomegaly ($p < 0.001$). There was a statistical relationship between cardiomegaly and gender ($p < 0.001$). Of the patients 30/484 (6.2%) were treated as outpatients, 135/484 (%27.9) were treated in ICU. 147 /484 (30.4%) patients died in the total study population. 95/135 (70.4%) patients who were treated in ICU had cardiomegaly. 107/147 (72.8%) deceased patients had cardiomegaly. So, we found a statistical association between cardiomegaly with mortality rates ($p < 0.001$) and ICU admission ($p = 0.008$) (Fig 2, Fig 3). According to the chest CT imagings, cardiomegaly was statistically associated with GGOs ($p = 0.014$), consolidation, pleural, pericardial effusion, crazy paving pattern, and mediastinal lymph node enlargement (all $p < 0.001$) in the CT imaging. Most common comorbidities of the study population were hypertension (HT) 239/484 (49.4%), diabetes mellitus (DM) 162/484 (33.5%), hyperlipidemia 130/484 (26.9%) and coronary artery disease (CAD) 88/484 (18.2%). There was a significant statistical association between

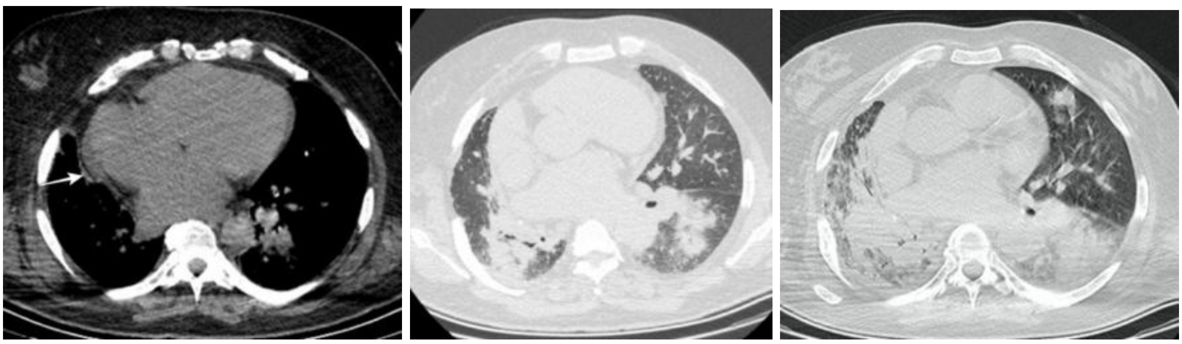

Fig. 3. A 52-year-old man with a history of chronic heart disease was admitted to our hospital with complaints of fever, cough and sore throat. His RT-PCR test was positive. He was hospitalized and treated in the service for 14 days and in the intensive care unit for 6 days. But he died in the intensive care unit. (a) Axial mediastinal window of non-contrast chest CT shows an excessive enlargement of cardiothoracic ratio with minimal pericardial effusion (white arrow), (b) Axial lung window of initial non-contrast chest CT shows bilateral consolidations and ground-glass opacities in the lower lobes. CT-SS = 9 and (c) Axial lung window of second non-contrast chest CT shows bilateral extensive consolidations and ground-glass opacities. Consolidations and CT-SS increased compared to previous CT. CT-SS = 21.

Table 1. Comparison of demographic and chest CT findings according to the presence of cardiomegaly

		Cardiomegaly			
		Absent n (%)	**Present n (%)**	**Total**	***p* value**
Gender	Male	136 (40.9)	148 (59.1)	284	**< 0.001**
	Female	61 (58.6)	139 (41.4)	200	
Mortality or surviving	Alive	157 (48.2)	180 (51.8)	337	**< 0.001**
	Death	40 (48.5)	107 (51.5)	147	
Intensive care unit	ICU	42 (31.1)	93 (68.9)	135	**0.008**
	Non-ICU	155 (44.4)	194 (55.6)	349	
Ground-glass opacities	Absent	42 (53.2)	37 (46.8)	79	**0.014**
	Present	155 (38.3)	250 (61.7)	405	
Consolidation	Absent	157 (46.9)	178 (53.1)	335	**< 0.001**
	Present	40 (26.8)	109 (73.2)	149	
Crazy paving pattern	Absent	131 (48.5)	139 (51.5)	270	**< 0.001**
	Present	66 (30.8)	148 (69.2)	214	
Pericardial effusion	Absent	184 (44.3)	231 (55.7)	415	**< 0.001**
	Present	13 (18.8)	56 (81.2)	69	
Pleural effusion	Absent	189 (44.4)	237 (55.6)	426	**< 0.001**
	Present	8 (13.8)	50 (86.2)	58	
Diabetes mellitus	Absent	139 (43.2)	183 (56.8)	322	0.120
	Present	58 (35.8)	104 (64.2)	162	
Chronic heart diseases	Absent	190 (43.5)	247 (56.5)	437	**< 0.001**
	Present	7 (14.9)	40 (85.1)	47	
Hypertension	Absent	123 (50.2)	122 (49.8)	245	**< 0.001**
	Present	74 (31)	165 (69)	239	
Hyperlipidemia	Absent	157 (44.4)	197 (55.6)	354	**0.007**
	Present	40 (30.8)	90 (69.2)	130	
Cardiovascular diseases	Absent	165 (44.1)	209 (55.9)	374	**0.005**
	Present	32 (29.1)	78 (70.9)	110	
Chronic pulmonary disease	Absent	169 (41.5)	238 (58.5)	407	0.398
	Present	28 (36.4)	49 (63.6)	77	
Neurological diseases	Absent	189 (41.3)	269 (58.7)	458	0.289
	Present	8 (30.8)	18 (69.2)	26	
Kidney diseases*	Absent	191 (40.3)	283 (59.7)	474	0.329*
	Present	6 (60)	4 (40)	10	

Pearson's chi-squared or Fisher tests (*) were used to compare categorical variables according to cardiomegaly groups. Fisher's test was used in the Chi-square analysis of categorical variables with less than 5 data in cells.

Table 2. Comparison of age, CT-SS and laboratory findings according to the presence of cardiomegaly

			Mean	Std. Deviation	Minimum	Maximum	*p* value
Age	Absent	197	57		47	68.50	**< 0.001***
	Present	287	70		62	78	
	Total	484	66		55	75	
Cardiothoracic ratio	Absent	197	0.45	0.03	0.34	0.50	**< 0.001**
	Present	287	0.57	0.05	0.51	0.73	
	Total	484	0.52	0.07	0.34	0.73	
CT severity score	Absent	197	10		3	16	0.473*
	Present	287	10		4	17	
	Total	484	10		4	17	
Length of stay in hospital	Absent	177	11		8	17.50	0.042*
	Present	276	13		8	20	
	Total	453	12		8	19	
Length of stay in ICU	Absent	42	10.50		6	20.25	0.803*
	Present	94	9.50		7	19	
	Total	136	10		6.25	19	
WBC (×10^9/L)	Absent	197	7.39	6.58	1.42	66.65	0.482
	Present	287	7.74	4.30	2.25	30.47	
	Total	484	7.60	5.34	1.42	66.65	
Neutrophil count (×10^9/L)	Absent	197	4.98	5.30	0.34	69	**0.025**
	Present	287	5.97	4.34	1.44	33.32	
	Total	484	5.57	4.77	0.34	69	
Lymphocyte count (×10^9/L)	Absent	197	1.45	0.70	0.29	4.52	**0.012**
	Present	287	1.28	0.77	0.14	5.60	
	Total	484	1.35	0.75	0.14	5.60	
Triglycerides (mg/dL)	Absent	188	151.95	99.74	42.00	881	0.111
	Present	276	138.09	85.77	3	822	
	Total	464	143.70	91.84	3	881	
Total cholesterol (mg/dL)	Absent	174	153.84	45.09	68	262	**0.004**
	Present	259	142.42	37.00	57	297	
	Total	433	147.01	40.78	57	297	
LDH (U/L)	Absent	195	290.46	135.81	140	1422	**< 0.001**
	Present	285	346.18	148.28	121	1167	
	Total	480	323.54	145.80	121	1422	
ALP (U/L	Absent	175	74.50	35.01	14	30	0.307

Table 2 contunied. Comparison of age, CT-SS and laboratory findings according to the presence of cardiomegaly

			Mean	Std. Deviation	Minimum	Maximum	*p* value
	Present	259	77.91	32.46	20	245	
	Total	434	76.53	33.51	14	309	
CRP (mg/L)	Absent	197	41.90	45.80	0.06	273.10	**< 0.001**
	Present	287	64.34	60.53	0.29	304.19	
	Total	484	55.20	56.05	0.06	304.19	
	Present	284	60.49	61.46	6.00	979.00	
	Total	479	53.46	50.97	6.00	979.00	
Fibrinogen (mg/dL)	Absent	194	498.76	137.58	30.70	987.00	**< 0.001**
	Present	282	551.28	155.97	216	985	
	Total	476	529.88	150.83	30.70	987	
INR	Absent	185	1.04	0.10	0.87	1.63	**0.028**
	Present	281	1.09	0.34	0.09	4.73	
	Total	466	1.07	0.27	0.09	4.73	
D-dimer (µg/mL)	Absent	194	0.88	1.67	0.02	16.79	**0.034**
	Present	283	1.50	3.85	0.05	46.60	
	Total	477	1.25	3.16	0.02	46.60	

WBC = White blood cell, LDH = lactate dehydrogenase, ALP = Alkaline Phosphatase, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate, INR = International Normalized Ratio. In the comparison of continuous variables according to cardiomegaly, the Student's t-test was used for those with normal distribution and the Mann-Whitney U test for those who were not normally distributed (*).

cardiomegaly with comorbidities such as hypertension ($p < 0.001$), hyperlipidemia ($p = 0.007$), cardiovascular diseases ($p = 0.005$), and chronic heart disease ($p < 0.001$) (Table 1).

The mean value of CTR was 0.57±0.05 in patients with cardiomegaly, there was a statistical difference between the groups with and without cardiomegaly ($p < 0.001$). The median value of CT- SS of the group with cardiomegaly was 10 (IQR 4-17), and without cardiomegaly was 10 (IQR 3-16). No statistical difference was found between the presence of cardiomegaly with the initial CT-SS ($p = 0.473$). In the total study population, the median value of the length of stay in service of the hospital was 12 (IQR 8-19), and the median value of the length of stay in ICU was 10 (IQR 6.25-19). No statistical difference was found between the presence of cardiomegaly with the length of stay in the hospital or ICU. Statistical associations were found between cardiomegaly with laboratory findings such as elevated C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) ($p < 0.001$), high coagulation factors such as fibrinogen ($p < 0.001$), D-Dimer ($p = 0.034$) and the other serum parameters that are shown in Table 2.

Multivariate analysis of risk factors for mortality

In multivariate analysis, older age 1.07-fold (95% CI: 1.043-1.097, $p < 0.001$), cardiomegaly 1.752-fold (95% CI: 1.114-2.756, $p = 0.015$), history of cerebrovascular diseases 2.929-fold (95% CI: 1.203-7.135, $p = 0.018$) and elevated serum LDH levels 1.003-fold (95% CI: 1.001-1.005, $p = 0.011$) associated with higher risks of mortality (Table 3).

DISCUSSION

In this retrospective analysis, we investigated the impact of the presence of cardiomegaly on ICU admission, and mortality rates of COVID-19 patients. Our

Table 3. Univariate- multivariate logistic regression analysis of predicting the risk of mortality in COVID-19 patients

Mortality	Univariate				Multivariate			
	p-value	OR	95% CI for OR		*p*-value	OR	95% CI for OR	
			Lower	Upper			Lower	Upper
Age	**< 0.001**	1.08	1.06	1.10	**< 0.001**	1.07	1.043	1.097
Gender	0.959	1.010	0.682	1.497				
CT Severity Score	0.466	0.991	0.967	1.016				
WBC	0.02	1.05	1.01	1.09	0.996	1.000	0.937	1.067
Hemoglobin	0.01	0.87	0.79	0.97	0.806	1.018	0.882	1.176
Neutrophil count	**< 0.001**	1.07	1.02	1.13	0.472	1.029	0.951	1.114
Lymphocyte count	**0.04**	0.74	0.56	0.99	0.287	1.423	0.743	2.727
GGT	0.90	1.00	1.00	1.00				
ALP	**0.01**	1.01	1.00	1.01	0.089	1.007	0.999	1.015
LDH	**< 0.001**	1.00	1.00	1.01	**0.011**	1.003	1.001	1.005
CRP	**< 0.001**	1.01	1.00	1.01	0.903	1.000	0.995	1.006
Ferritin	0.14	1.00	1.00	1.00	0.14	1.00	1.00	1.00
ESR	0.56	1.00	1.00	1.01	0.56	1.00	1.00	1.01
Diabetes mellitus	0.56	1.13	0.75	1.70	0.56	1.13	0.75	1.70
Hypertension	**< 0.001**	2.45	1.64	3.66	0.049	1.584	1.002	2.503
Asthma	0.12	1.64	0.88	3.04	0.12	1.64	0.88	3.04
Cardiomegaly	**< 0.001**	2.33	1.53	3.55	**0.015**	1.752	1.114	2.756
Hyperlipidemia	**< 0.001**	1.99	1.31	3.04	0.235	1.361	0.819	2.260
Chronic heart disease	**0.012**	2.462	1.22	4.97	0.110	1.843	0.871	3.900
Chronic obstructive pulmonary disease	0.611	1.217	0.571	2.594	0.611	1.217	0.571	2.594
Cerebrovascular diseases	**0.002**	3.84	1.62	9.08	**0.018**	2.929	1.203	7.135
Chronic kidney disease	0.063	2.525	0.951	6.703				

WBC = White Blood Cell, AST: aspartate aminotransferase, ALT = alanine transaminase, GGT = gamma-glutamyl transferase, LDH = lactate dehydrogenase, ALP = Alkaline Phosphatase, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate, INR = International Normalized Ratio. Hosmer and Lemeshow Test= 0.301 Accuracy= 73.8%

study found that the presence of cardiomegaly was associated with a higher risk of the requirement of an ICU treatment or mortality in patients with COVID-19. In multivariate analysis, cardiomegaly 1.752-fold had higher risks of mortality. Our results showed no association between the presence of cardiomegaly with CT-SS, since we only calculated CT-SS in CTs at the time of admission, and lung involvement increased mostly in follow-up CTs of the patients.

COVID-19 symptoms are more severe in patients with CVD. The probable reason for this is the increase in ACE-2 secretion in COVID-19 patients [18]. While pre-existing CVD appears to be associated with increased mortality and worse outcomes in COVID-19 patients [9, 10, 19–21]. COVID-19 itself can cause cardiovascular disorders, such as arrhythmia, acute coronary syndrome, venous thromboembolism, and myocardial injury [22-24]. Also, morbidity and mortality are higher in patients with COVID-19 and CV risk factors such as HT and DM [19, 22]. According to the literature, older patients with comorbidities including HT, CVD, and DM may have a severe prognosis in COVID-19 [25]. In our study, mortality rates of the study population statistically increased with older age, cardiomegaly, history of cerebrovascular disease, and elevated serum LDH levels.

Although there is insufficient evidence to establish a direct relationship between cardiac injury and underlying CVD in COVID-19 patients, it may be thought that patients with CAD or heart failure are more susceptible to heart damage. If severe pneumonia occurs in these patients, they are more prone to myocardial ischemia or heart failure. In addition, acute inflammatory responses may lead to ischemia in patients with pre-existing CVD. Also, inflammation may cause endothelial dysfunction, thereby increasing the procoagulant activity of the blood [26]. Based on these reasons, Shie *et al* speculated that an intensive inflammatory response superimposed on CVD may precipitate the observed heart damage in patients with COVID-19 [22]. Similar to the literature we found increased mortality risk for patients with cardiomegaly.

Previous studies have shown that imaging-based cardiac indices predict an increased risk of mortality and morbidity in various acute and chronic diseases. The increase in the CTR value in patients with non-COVID-19 respiratory diseases is associated with poor clinical outcomes and the severity of the disease [11, 12]. Cardiomegaly is related to an increased risk of CVD. Eslami V. *et al*. reported that a high CTR was associated with increased mortality in hospitalized COVID-19 patients with a small sample size [15]. In the study of Mehrabi Nejad *et al*. [27], cardiomegaly was significantly more common in the deceased group ($p = 0.005$). Our study is the most comprehensive study in the literature, with the largest number of patients, comparing CTR values measured on thorax CT with ICU admission and mortality rates in patients with COVID-19. In accordance with the literature, we also found that patients with cardiomegaly have a higher risk of mortality than patients with COVID-19. Unlike previous studies, we also investigated the effects of cardiomegaly on the need for ICU admission. More COVID-19 patients with cardiomegaly were admitted to ICU than those without cardiomegaly.

It is very important to evaluate COVID-19 patients for cardiomegaly as a risk factor at the time of the first admission to the emergency department. Since they are the first to encounter COVID-19 patients, emergency department health professionals have important contributions to the management of the diagnosis and treatment of their patients. It should be known that COVID-19 patients with cardiomegaly detected on CT or radiography may have a high risk of needing ICU treatment or mortality and more care should be taken in the follow-up, consultation, follow-up, and treatment of these patients.

Limitations

There were some limitations in our study. First, our study was a single-center, retrospective study. So, a multicenter study with large sample size is needed for more validation. Second, CTR was measured on chest CTs of patients in our study, and the measurements may be affected by changes in cardiac motion and breathing. Third, we evaluated the initial chest CT images of the patients. We did not use follow-up CTs, so we cannot review late period CT finding changes.

Key points

-Our study is the most comprehensive study in the literature, with the largest number of patients, comparing CTR values measured on chest thorax CT with ICU admission and mortality rates of COVID-19 patients.

-Presence of cardiomegaly was associated with a high risk of ICU admission and mortality.

-Evaluation of the presence of cardiomegaly on initial chest CT can provide useful prognostic information and assist physicians and nurses in the triage and follow-up of patients with COVID-19

CONCLUSION

We found that the presence of cardiomegaly is associated with the high risk of ICU admission and mortality and may predict survival in patients with COVID-19. Therefore, evaluation of the presence of cardiomegaly on thoracic CT can provide useful prognostic information and assist physicians in the triage and follow-up of patients with COVID-19.

Authors' Contribution

Study Conception: BA, ATK; Study Design: BA, ATK; Supervision: BA, ATK; Funding: N/A; Materials: BA, ATK; Data Collection and/or Processing: BA, ATK; Statistical Analysis and/or Data Interpretation: BA, ATK, ŞÇ; Literature Review: BA; Manuscript Preparation: BA and Critical Review: BA, ATK, ŞÇ.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

REFERENCES

1. Majumder J, Minko T. Recent developments on therapeutic and diagnostic approaches for COVID-19. AAPS J 2021;23:14.
2. Kanji JN, Zelyas N, MacDonald C, Pabbaraju K, Khan MN, Prasad A, et al. False negative rate of COVID-19 PCR testing: a discordant testing analysis. Virol J 2021;18:13.
3. Ding X, Xu J, Zhou J, Long Q. Chest CT findings of COVID-19 pneumonia by duration of symptoms. Eur J Radiol 2020;127:109009.
4. Wang Y, Dong C, Hu Y, Li C, Ren Q, Zhang X, et al. Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study. Radiology 2020;296:E55-64.
5. Nair AV, Kumar D, Yadav SK, Nepal P, Jacob B, Al-Heidous M. Utility of visual coronary artery calcification on non-cardiac gated thoracic CT in predicting clinical severity and outcome in COVID-19. Clin Imaging 2021;74:123-30.
6. Spoorthy MS, Pratapa SK, Mahant S. Mental health problems faced by healthcare workers due to the COVID-19 pandemic - A review. Asian J Psychiatr 2020;51:102119.
7. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020;323:1239-42.
8. Li B, Yang J, Zhao F, Zhi L, Wang X, Liu L, et al. Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. Clin Res Cardiol 2020;109:531-8.
9. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395:497-506.
10. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA 2020;323:1061-9.
11. Jotterand M, Faouzi M, Dédouit F, Michaud K. New formula for cardiothoracic ratio for the diagnosis of cardiomegaly on post-mortem CT. Int J Legal Med 2020;134:663-7.
12. Ogata H, Kumasawa J, Fukuma S, Mizobuchi M, Kinugasa E, Fukagawa M, et al. The cardiothoracic ratio and all-cause and cardiovascular disease mortality in patients undergoing maintenance hemodialysis: results of the MBD-5D study. Clin Exp Nephrol 2017;21:797-806.
13. Zouk AN, Gulati S, Xing D, Wille KM, Rowe SM, Wells JM. Pulmonary artery enlargement is associated with pulmonary hypertension and decreased survival in severe cystic fibrosis: a cohort study. PLoS One 2020;15:e0229173.
14. Wells JM, Morrison JB, Bhatt SP, Nath H, Dransfield MT. Pulmonary artery enlargement is associated with cardiac injury during severe exacerbations of COPD. Chest 2016;149:1197-204.
15. Eslami V, Abrishami A, Zarei E, Khalili N, Baharvand Z, Sanei-Taheri M. The association of CT-measured cardiac indices with lung involvement and clinical outcome in patients with COVID-19. Acad Radiol 2021;28:8-17.
16. Pan F, Ye T, Sun P, Gui S, Liang B, Li L. Time course of lung changes at chest CT during recovery. Radiology 2020;295:715-21.
17. Menard S. Applied logistic regression analysis. Quantitative Applications in Social Sciences, Vol. 106, 2nd ed., Sage Publications, Inc., 2002.
18. Zheng Y-Y, Ma Y-T, Zhang J-Y, Xie X. COVID-19 and the cardiovascular system. Nat Rev Cardiol 2020;17:259-60.
19. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020;382:1708-20.
20. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;395:1054-62.
21. Ruan Q, Yang K, Wang W, Jiang L, Song J. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. Intensive Care Med 2020;46:846-8.
22. Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. JAMA Cardiol 2020;5:802-10.
23. Guo T, Fan Y, Chen M, Wu X, Zhang L, He T, et al. Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19). JAMA Cardiol 2020;5:811-8.
24. Shi S, Qin M, Cai Y, Liu T, Shen B, Yang F, et al. Characteristics and clinical significance of myocardial injury in patients with severe coronavirus disease 2019. Eur Heart J 2020;41:2070-9.
25. Wei PF. Diagnosis and treatment of pneumonia caused by novel coronavirus (trial version 7). General office of the Chinese health commission 2020. Chin Med J 2020;133:1087-95.
26. Corrales-Medina VF, Musher DM, Shachkina S, Chirinos JA.

Acute pneumonia and the cardiovascular system. Lancet 2013;381:496-505.
27. Mehrabi Nejad M-M, Abkhoo A, Salahshour F, Salehi M, Gity M, Komaki H, et al. Chest CT scan features to predict COVID-19 patients' outcome and survival. Radiol Res Pract 2022;2022:4732988.