Original Article

Relationship of right ventricular functions with in-hospital and 1 year later mortality in patients hospitalized for COVID-19 pneumonia

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Abstract:

BACKGROUND: The aim of this study was to determine the association of right ventricular function with in-hospital mortality and mortality 1 year after discharge in patients hospitalized for COVID-19 pneumonia.

METHODS: The study was conducted in Van Yuzuncu Yil University Faculty of Medicine hospital between February 10, 2021 and August 10, 2022. A total of 156 patients hospitalized in intensive care and wards due to COVID-19 pneumonia were included in this study. Echocardiography was performed in all patients.

RESULTS: Among the demographic findings of the patients included in the study, male gender, patients hospitalized in the intensive care unit (ICU), patients receiving O_2 support, and smokers were found to have higher mortality rates during hospitalization. At the end of 1 year, the mortality rate was higher in patients who were hospitalized in the ICU received O_2 support and had diabetes mellitus. Among echocardiographic findings, those with a low left ventricular ejection fraction had higher early and 1-year mortality rates. Of the right ventricular functions, low fractional area change, high systolic pulmonary artery pressure (SPAP), shortened pulmonary acceleration time, low right ventricle systolic wave S' velocity, increased right atrium area, and inferior vena cava diameter were found to be associated with high mortality. Increased right atrial area and inferior vena cava diameter, increased SPAP, and shortened pulmonary acceleration time were found to be significant in 1-year mortality. The presence of pericardial effusion was associated with mortality during hospitalization but not with 1-year mortality. B-type natriuretic peptide, D-dimer, and hemoglobin levels were significantly correlated with both hospital mortality and 1-year mortality.

CONCLUSIONS: In the follow-up of COVID-19 pneumonia, right ventricular function is considered to be an important factor in early and late mortality. It could be helpful to establish a follow-up program for discharged patients from the parameters involved in mortality.

Keywords:

COVID-19, mortality, right, transthoracic echocardiography, ventricular function

As of today, 763 million cases of coronavirus disease (COVID-19) have been reported worldwide, resulting in 6.9 million deaths.[1]

SARS-CoV-2 infection can progress in a wide spectrum from mild and even asymptomatic to high morbidity and mortality. Despite the well-known clinical manifestations and imaging characteristics of COVID-19, there are still many questions surrounding its pathophysiology.[2]

The variables of sex, age, smoking, and comorbidities have been found to affect mortality and morbidity in

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COVID-19 patients.[3] The disease is more severe and unfortunately more lethal in individuals who suffer from hypertension, cardiovascular diseases, and lung disease with chronic hypoxia. Previous studies have revealed that patients hospitalized due to COVID-19 have cardiac involvement, especially in right ventricular functions.[4] Morbidity and mortality rates have been found to be higher in patients with clinical, laboratory, and echocardiographic evidence of cardiac involvement.[5] Most studies on COVID-19 initially focused on acute infection effects and treatments to maximize patient survival. However, patients who were hospitalized and discharged after their infection were treated, later developed various problems, and some patients even died. Millions of people have experienced long-term morbidity and sequelae following recovery, and clinicians are trying to elucidate these conditions. It has been argued that pro-inflammatory response, mitochondrial dysfunction, and amyloids are involved in long-term morbidity and mortality.[6] Accurate scoring systems and markers to predict early and late mortality and morbidity will help physicians screen patients during the COVID-19 pandemic, quickly select the right strategies, and maximize treatment success. The number of studies investigating the late mortality rates of patients with cardiac involvement following hospital discharge and the factors affecting these rates is still limited. In this study, we tried to determine the epidemiological, clinical, laboratory, and echocardiographic characteristics of patients who had COVID-19 infection and were hospitalized, and the factors affecting mortality. The same patients were followed up for 1 year. We aimed to compare patients who survived and those who died from all causes during this period.

Methods

Population

The study was conducted at Van Yuzuncu Yil University Faculty of Medicine hospital between February 10, 2021 and August 10, 2022. The study was approved by the local ethics committee of Yuzuncu Yil University Faculty of Medicine. Informed consent was obtained from all patients included in the study. Patients older than 18 years of age with a laboratory-confirmed diagnosis of COVID-19 were included in the study. A total of 179 patients hospitalized in intensive care and wards due to COVID-19 pneumonia were evaluated. Demographic information of all patients was recorded. Laboratory results were obtained from hospital records. Electrocardiogram and radiological findings of the patients were examined. Patients with heart failure, significant valvular heart disease, severe coronary artery disease, atrial fibrillation, and other arrhythmias were excluded. In addition, patients with chronic obstructive pulmonary diseases (COPDs), asthma, and other chronic hypoxia and comorbidities that may affect right heart function were excluded. Patients with pregnancy, malignancy, and patients with poor image quality were excluded from the study. The study was continued with 156 patients. Data from patients who lived and died during hospitalization were compared. Periodic examinations were conducted for patients who were discharged after recovery. At the end of the 1st year, patients who could not attend periodic examinations for other reasons or their relatives were contacted by phone. At the end of the 1st year, living and deceased patients were identified and the data were analyzed. A statistical analysis of factors affecting mortality was conducted.

Transthoracic echocardiography

Each patient underwent transthoracic two-dimensional (2D) echocardiography at rest under standardized procedures. Vivid 9 echocardiography (Vivid 9; GE Vingmed Ultrasound AS, Horten, Norway) was used for this purpose. Standard M-mode, 2D echo, pulse Doppler, and tissue Doppler measurements were recorded. Diameters, wall thicknesses, and mass calculations of the heart chambers were performed on parasternal long-axis imaging. In apical four-chamber imaging, volumes, ejection fraction (EF), structure, and function of the valves were evaluated. Pulse and tissue Doppler imaging recordings were also obtained.

Statistical method

Descriptive statistics for the studied variables were presented as mean ± standard deviation for normally distributed variables, whereas median, minimum and maximum value for nonnormal distributed variables. In addition, frequency and percentage (%) were used as descriptive statistics for the quantitative (categorical) data. Binary logistic regression analysis was performed to determine the risk factors that could possibly affect mortality during hospitalization and mortality 1 year later. To avoid complexity and ensure simplicity in interpreting the results as well as to determine only main effect of the variables, all variables were included into logistic regression analysis. Thus interaction effects of the variables were ignored in the models. Statistically significance level was considered 5% and SPSS software version 23.0 (IBM Corp., Armonk, NY, USA) statistical program was used for all statistical computations.

Results

A total of 156 patients, 63 females (40.4%) and 93 males (59.6%), were included in the study. Of the patients, 67 (42.9%) were hospitalized in the intensive care unit (ICU), and 89 (57.1%) were hospitalized in the ward. Forty patients (25.6%) were receiving O_2 support. While the rate of survivors in the mortality category was 62.2%, the mortality rate was 31.4% during

Table 1: Descriptive statistics for the studied parameters

		Frequency (%)
Sex		
Female		63 (40.4)
Male		93 (59.6)
Hospitalization		
Service		89 (57.1)
ICU		67 (42.9)
Mortality		
Alive		97 (62.2)
Mortality during hospitalization		49 (31.4)
1 year later mortality		10 (6.4)
O_2		
Not requiring supplement		116 (74.4)
Requiring supplement		40 (25.6)
Hypertension		
No		93 (59.6)
Yes		63 (40.4)
Diabetes mellitus		
No		117 (75)
Yes		39 (25)
Smoking		
No		121 (78.1)
Yes		34 (21.9)
	Mean±SD	**Median (minimum–maximum)**
Demography		
Age (year)	62.56±14.58	64.00 (24.00–88.00)
Height (cm)	169.00±9.01	169.00 (150.00–195.00)
Weight (kg)	78.68±12.51	79.50 (50.00–112.00)
BMI (kg/m^2)	27.66±4.41	27.40 (18.40–40.60)
Heart rate (bpm)	89.39±18.29	90.00 (48.00–167.00)
Length of hospital stay (day)	11.72±6.96	10.00 (1.00–38.00)
Echocardiography		
LA (cm)	3.60±0.57	3.50 (2.50–6.30)
LVDd (cm)	4.75±0.45	4.70 (2.90–6.10)
LVSd (cm)	3.20±0.36	3.10 (2.20–4.40)
IVS (cm)	1.00±0.18	1.00 (0.60–1.70)
PWd (cm)	0.89±0.15	0.90 (0.40–1.30)
LVEF (%)	60.67±5.38	60.00 (50.00–73.00)
E/e' ratio	7.70±4.25	7.26 (0.66–50.00)
RV basal diameter (cm)	3.98±0.77	3.90 (2.30–6.70)
RV mid diameter (cm)	3.34±0.72	3.30 (1.80–5.60)
RV length (cm)	6.09±4.44	5.70 (3.50–60.00)
Right ventricular wall (cm)	0.42±0.13	0.40 (0.20–0.90)
RV FAC (%)	44.48±12.97	45.00 (10.00–67.00)
RA area (cm^2)	17.79±5.88	17.00 (7.60–38.00)
RA volume (cm^3)	56.38±30.49	50.00 (14.00–191.00)
IVC max (cm)	1.81±0.47	1.80 (1.00–3.00)
IVC min (cm)	1.08±0.50	1.00 (0.30–2.60)
PAd (cm)	2.19±0.43	2.10 (1.10–3.50)
TAPSE (cm)	2.16±0.52	2.10 (1.10–3.50)
PASP (mmHg)	49.21±16.38	47.00 (21.00–121.00)
PAAT (ms)	97.90±18.97	102.00 (50.00–140.00)
RVS' TDI (cm/s)	15.83±4.25	15.50 (6.00–32.00)
RV Tei index	52.68±16.11	48.00 (23.00–96.00)
Laboratory		
Troponin (µg/L)	0.18±0.40	0.01 (0.00–3.18)
BNP (pg/mL)	169.10±262.11	54.00 (10.00–2003.00)
WBC (10^3/uL)	11.77±16.93	9.13 (2.36–162.00)
Hemoglobin (g/dL)	12.54±2.28	12.85 (6.60–20.60)
D-dimer (µg/mL)	2.71±5.01	1.05 (0.11–39.50)
CRP (mg/L)	61.77±63.73	35.85 (2.98–295.00)

Values of quantitative parameters are presented in detail in the table. LA=Left atrium, LVDd=Left-ventricular diastolic diameter, LVSd=Left-ventricular sistolic diameter, IVS=Interventricular septum, PWd=Left-ventricular posterior wall depth, LVEF=Left-ventricular ejection fraction, PAd=Pulmonary artery diameter, TAPSE=Tricuspid annular plane systolic excursion, IVC max=Maximum diameter of the inferior vena cava, IVC min=Minimum diameter of the inferior vena cava, RV=Right ventricle, RV FAC=Right ventricular fractional area change percentage, RA=Right atrium, RVS'=RV systolic wave S' velocity, TDI=Tissue doppler imaging, PAAT=Pulmonary artery acceleration time, WBC=White blood cell count, BNP=B-type natriuretic peptide, BMI=Body mass index, SD=Standard deviation, CRP=C-reactive protein, ICU=Intensive care unit, O_2=Oxygen, PASP: Systolic pulmonary artery pressure

hospitalization and 6.4% after 1-year survival. Of the hospitalized patients, 39 (16 Female, 33 Male) died during their hospitalization, while 10 (7 Female, 3 Male) died within 1 year of their discharge. Of the hospitalized patients, 40.4% had hypertension and 25% had diabetes mellitus. Twenty-one percent of the patients were smokers. Descriptive statistics for the studied parameters are presented in Table 1.

Risk factors affecting mortality during hospitalization were analyzed by binary logistic regression. When the demographic data of patients hospitalized due to COVID-19 pneumonia were analyzed, it was observed that mortality was higher in male patients than in female patients [$P = 0.018$, Table 2]. The mortality risk of patients hospitalized in the ICU and requiring O_2 support was 62.79 times higher than those hospitalized in the ward ($P < 0.001$). The mortality risk increased 4-fold in smokers ($P = 0.001$). Mortality increases with increasing age, heart rate, and the length of hospitalization [$P = 0.001$, $P = 0.002$, $P = 0.011$, respectively, Table 2].

When laboratory parameters during hospitalization were analyzed, it was found that increased troponin, B-type natriuretic peptide (BNP), D-dimer, and C-reactive protein (CRP) increased mortality (all $P < 0.001$), and anemia and elevated white blood cell (WBC) in blood counts increased mortality [$P = 0.001$ and $P < 0.001$, respectively, Table 2].

Echocardiographic data during hospitalization were analyzed. Mortality increased as the left ventricular EF (LVEF) decreased [$P = 0.049$, Table 3]. When the right heart was evaluated, an increase in baseline and mid-diameters of the right ventricle (RV) and right atrium (RA) area and volume was associated with

Table 2: Results of binary logistic regression for mortality during hospitalization

	Mortality during hospitalization		OR (95% CI)	*P*
	Alive (*n*=107)	Dead (*n*=49)		
Sex				
Female	47 (74.6)	16 (25.4)	Reference	
Male	60 (64.5)	33 (35.5)	1.62 (0.795–3.282)	0.185
Hospitalization				
Service	86 (96.6)	3 (3.4)	Reference	
ICU	21 (31.3)	46 (68.7)	62.79 (17.784–221.725)	0.001
O_2				
Not requiring supplement	91 (78.4)	25 (21.6)	Reference	
Requiring supplement	16 (40)	24 (60)	5.46 (2.523–11.816)	0.001
Hypertension				
No	62 (66.7)	31 (33.3)	Reference	
Yes	45 (71.4)	18 (28.6)	0.80 (0.399–1.605)	0.530
Diabetes mellitus				
No	77 (65.8)	40 (34.2)	Reference	
Yes	30 (76.9)	9 (23.1)	0.58 (0.25–1.334)	0.199
Smoking				
No	92 (76)	29 (24)	Reference	
Yes	15 (44.1)	19 (55.9)	4.02 (1.814–8.901)	0.001
Age (year)	59.79±14.28	68.61±13.48	1.05 (1.02–1.079)	0.001
Height (cm)	168.13 8.73	170.90±9.41	1.04 (0.996–1.076)	0.077
Weight (kg)	78.41±13.00	79.27±11.46	1.01 (0.979–1.033)	0.691
BMI (kg/m^2)	27.87±4.72	27.21±3.65	0.97 (0.892–1.045)	0.382
Heart rate (bpm)	86.12±15.29	96.53±22.08	1.03 (1.012–1.055)	0.002
Length of hospital stay (day)	11.22±6.95	12.80±6.93	1.03 (0.984–1.082)	0.193
Laboratory parameters				
Troponin (µg/L)	0.07±0.34	0.43±0.41	36.48 (7.624–174.54)	0.001
BNP (pg/mL)	61.61±101.05	403.83±342.48	1.01 (1.007–1.016)	0.001
WBC (10^3/uL)	8.47±3.47	18.99±28.66	1.30 (1.177–1.433)	0.001
Hemoglobin (g/dL)	12.96±1.97	11.62±2.64	0.76 (0.65–0.896)	0.001
D-dimer (µg/mL)	1.30±1.80	5.80±7.73	1.68 (1.366–2.077)	0.001
CRP (mg/L)	44.58±49.43	99.29±74.98	1.01 (1.008–1.021)	0.001

WBC=White blood cell count, BNP=B-type natriuretic peptide, BMI=Body mass index, CRP=C-reactive protein, OR=Odds ratio, CI=Confidence interval, ICU=Intensive care unit, O_2=Oxygen

mortality (P = 0.016, P = 0.039, P = 0.004, P = 0.006, respectively). Mortality increases as the right ventricular fractional area change (FAC) decreases (P < 0.001). Increased systolic pulmonary artery pressure (SPAP) is associated with higher mortality (P < 0.001). Mortality increased with decreasing tissue Doppler tricuspid annular systolic velocity (RV systolic [RVS']) (P = 0.002). The increase in diastolic and systolic diameters of the inferior vena cava was also found to be significant (P = 0.023, P = 0.027). RV myocardial performance index (Tei index) was also found to be significant (P = 0.001). Pericardial effusion was detected in 25% of patients. The presence of pericardial effusion on echocardiography was also directly associated with mortality [P = 0.003, Table 3].

Risk factors affecting mortality 1 year later were analyzed by binary logistic regression analysis. Data of patients who survived and died at the end of the 1st year were analyzed. Those hospitalized in intensive care during acute infection had a 5-fold increased risk of mortality (P = 0.019). Patients requiring O_2 support had a 7.8-fold (P = 0.004) increased risk of mortality, while patients with diabetes mellitus had a 7.5-fold (P = 0.006) increased risk. Mortality risk increased with increasing age and length of hospitalization [P = 0.034, P = 0.03, respectively, Table 4]. When laboratory parameters affecting mortality at the end of the 1st year were evaluated, high BNP and D-dimer values were associated with mortality (P = 0.009, P = 0.04, respectively). As the hemoglobin level increased, the mortality risk decreased [P = 0.012, Table 4]. Echocardiographic findings of patients who died and survived at the end of the 1st year, taken during their hospitalization, were compared. Decreased LVEF was associated with increased mortality at the end of the 1st year (P = 0.029). Among the right ventricular measurements, only the increase in RA area and RA volume were significant (P = 0.038 and P = 0.017, respectively). High SPAP and low pulmonary artery acceleration time measured during hospitalization are directly associated with 1st-year

Table 3: Results of binary logistic regression analysis with echocardiographic characteristics for mortality during hospitalization

	Mortality during hospitalization		OR (95% CI)	*P*
	Alive (*n*=107)	Dead (*n*=49)		
LA (cm)	3.56±0.52	3.71±0.65	1.60 (0.879–2.904)	0.124
LVDd (cm)	4.78±0.41	4.68±0.54	0.63 (0.293–1.338)	0.227
LVSd (cm)	3.21±0.36	3.20±0.37	0.93 (0.365–2.369)	0.879
IVS (cm)	0.99±0.19	1.00±0.17	1.18 (0.187–7.471)	0.859
PWd (cm)	0.88±0.15	0.89±0.14	1.49 (0.15–14.82)	0.733
LVEF (%)	61.25±5.61	59.41±4.65	0.94 (0.88–1)	0.049
E/e' ratio	7.72±4.84	7.65±2.57	1.00 (0.918–1.081)	0.926
RV basal diameter (cm)	3.88±0.66	4.21±0.93	1.75 (1.112–2.758)	0.016
RV mid diameter (cm)	3.25±0.67	3.51±0.79	1.66 (1.026–2.684)	0.039
RV length (cm)	5.75±0.92	6.85±7.82	1.07 (0.916–1.26)	0.377
Right ventricular wall (cm)	0.41±0.12	0.45±0.13	7.26 (0.529–99.588)	0.138
RV FAC (%)	47.53±11.73	37.82±13.16	0.94 (0.914–0.969)	0.001
RA area (cm^2)	16.85±5.07	19.86±6.96	1.09 (1.028–1.158)	0.004
RA volume (cm^3)	51.58±25.91	66.88±36.83	1.02 (1.005–1.028)	0.006
IVC max (cm)	1.76±0.45	1.94±0.50	2.36 (1.126–4.956)	0.023
IVC min (cm)	1.02±0.47	1.21±0.54	2.14 (1.09–4.217)	0.027
PAd (cm)	2.17±0.44	2.25±0.42	1.58 (0.728–3.415)	0.249
TAPSE (cm)	2.18±0.47	2.11±0.62	0.76 (0.39–1.459)	0.403
PASP (mmHg)	43.91±14.66	60.78±13.88	1.08 (1.05–1.111)	0.001
PAAT (ms)	103.43±17.40	85.82±16.63	0.95 (0.926–0.968)	0.001
S' TDI (cm/s)	16.56±4.01	14.24±4.36	0.85 (0.773–0.945)	0.002
RV Tei index	53.56±16.70	50.76±14.74	0.99 (0.968–1.011)	0.313
Pericardial effusion				
No	88 (75.2)	29 (24.8)		
Yes	19 (48.7)	20 (51.3)	3.19 (1.501–6.798)	0.003

LA=Left atrium, LVDd=Left-ventricular diastolic diameter, LVSd=Left-ventricular sistolic diameter, IVS=Interventricular septum, PWd=Left-ventricular posterior wall depth, LVEF=Left-ventricular ejection fraction, PAd=Pulmonary artery diameter, TAPSE=Tricuspid annular plane systolic excursion, IVC max=Maximum diameter of the inferior vena cava, IVC min=Minimum diameter of the inferior vena cava, RV=Right ventricle, RV FAC=Right ventricular fractional area change percentage, RA=Right atrium, S' TDI=Systolic wave S' velocity tissue Doppler imaging, PAAT=Pulmonary artery acceleration time, OR=Odds ratio, CI=Confidence interval, PASP: Systolic pulmonary artery pressure

mortality (both $P < 0.001$). RV Tei index was also found to be significant ($P = 0.007$). The increase in diastolic and systolic diameters of the inferior vena cava was also significant in 1st-year mortality [$P = 0.048$, $P = 0.007$, respectively, Table 5].

Discussion

COVID-19 has emerged as the most serious health issue the world has experienced for many years. It has been well-documented that COVID-19 causes multi-organ involvement and the presence of cardiac dysfunction is associated with worse outcomes.[7] In echocardiographic studies conducted in the early days of the pandemic, it was reported that LV functions were less affected, whereas the RV was more affected, and this was in parallel with poor clinical indicators.[5] Various mechanisms have been proposed to explain the underlying causes of RV damage associated with COVID-19. Factors such as acute respiratory distress syndrome, alveolar and capillary damage caused by severe hypoxia, pulmonary vascular thrombosis, direct viral myocardial involvement, inflammatory response, and autoimmune damage may lead to increased right ventricular afterload and decreased right ventricular contractility.[8] It has been shown that RV functions are worse, especially in patients with myocardial damage, and this leads to a poor prognosis.[9] Impaired right ventricular function leads to a vicious cycle by increasing respiratory distress.[10]

Mortality rates in the acute phase of infection have been demonstrated in many studies. During the first wave of the pandemic, different studies showed in-hospital mortality between 20.5% and 53.4%. The general average in-hospital overall mortality is accepted as 31.1%.[11] Similarly, in our study, consistent with these data, we found in-hospital mortality to be 31.4%. Other demographic characteristics affecting mortality in our patients are consistent with the data in different studies. Mortality was higher in older men who were hospitalized in the ICU and needed O_2 support [Table 1]. Deaths typically occurred in the 1st week following hospitalization. As reported in different studies, mortality is high in patients with cardiovascular and chronic respiratory diseases with hypoxia. In our

Table 4: Results of binary logistic regression for mortality 1 year later

	1 year later mortality		OR (95% CI)	*P*
	Alive (*n*=97)	Dead (*n*=10)		
Sex				
Female	40 (85.1)	7 (14.9)	Reference	
Male	57 (95)	3 (5)	0.30 (0.073–1.234)	0.095
Hospitalization				
Service	81 (94.2)	5 (5.8)	Reference	
ICU	16 (76.2)	5 (23.8)	5.06 (1.312–19.54)	0.019
O_2				
Not requiring supplement	86 (94.5)	5 (5.5)	Reference	
Requiring supplement	11 (68.8)	5 (31.3)	7.82 (1.948–31.37)	0.004
Hypertension				
No	57 (91.9)	5 (8.1)	Reference	
Yes	40 (88.9)	5 (11.1)	1.425 (0.387–5.249)	0.594
Diabetes mellitus				
No	74 (96.1)	3 (3.9)	Reference	
Yes	23 (76.7)	7 (23.3)	7.507 (1.794–31.407)	0.006
Smoking				
No	85 (92.4)	7 (7.6)	Reference	
Yes	12 (80)	3 (20)	3.04 (0.69–13.355)	0.142
Age (year)	58.81±14.33	69.30±10.03	1.07 (1.005–1.137)	0.034
Height (cm)	168.36±8.97	165.90±5.84	0.97 (0.894–1.045)	0.396
Weight (kg)	78.95±13.27	73.20±8.93	0.97 (0.916–1.017)	0.185
BMI (kg/m^2)	28.00±4.82	26.67±3.54	0.97 (0.805–1.089)	0.396
Heart rate (bpm)	86.33±14.90	84.10±19.56	0.99 (0.948–1.034)	0.659
Length of hospital stay (day)	10.72±6.42	16.10±10.01	1.09 (1.008–1.173)	0.030
Laboratory parameters				
Troponin (µg/L)	0.06±0.34	0.16±0.32	1.73 (0.497–6.037)	0.389
BNP (pg/mL)	43.72±45.78	235.10±247.0	1.01 (1.003–1.024)	0.009
WBC (10^3/uL)	8.32±3.36	9.86±4.36	1.12 (0.945–1.335)	0.186
Hemoglobin (g/dL)	13.13±1.87	11.38±2.28	0.67 (0.49–0.917)	0.012
D-dimer (µg/mL)	1.14±1.69	2.80±2.27	1.34 (1.013–1.764)	0.040
CRP (mg/L)	43.36±50.43	56.39±38.50	1.01 (0.993–1.017)	0.430

WBC=White blood cell count, BNP=B-type natriuretic peptide, BMI=Body mass index, CRP=C-reactive protein, OR=Odds ratio, CI=Confidence interval, ICU=Intensive care unit, O_2=Oxygen

study, meanwhile, individuals with these diseases were excluded since they might affect our echocardiographic data. Biomarkers indicating cardiac damage and elevated inflammation markers are associated with mortality.[5,12] In our study, cardiac troponin, CRP, D-dimer, and WBC were found to be significant during hospitalization, while elevated BNP and D-dimer were found to be significant in mortality at the end of the 1st year [Tables 2-5].

In the aftermath of the pandemic, echocardiographic studies were widely conducted, and data were presented.[4] Considering that right heart functions will be more affected due to the nature of the disease, more research has been conducted in this field.[13,14] As expected, right heart involvement is more common than left. This has also been demonstrated in studies with different modalities and right heart involvement has been shown to be an independent predictor of mortality.[15] As in similar studies, the echocardiographic findings of hospitalized patients were similar in our study. The low LVEF was found to be significant in mortality. The RV was dilated and the baseline and mid diameters have increased. RA area and volume, inferior vena cava, and diameters were measured high. RV FAC was measured lower in deceased patients. In tissue Doppler examination, mortality increases as RVS' velocity decreases. Systolic pulmonary artery elevation and pulmonary artery acceleration time shortening were found to be significantly correlated with mortality [Table 3]. The development of pericardial effusion increases in parallel with cardiac damage.[16] In our study, pericardial effusion was detected in 25% of patients and was considered to be a significant factor in mortality [Table 3].

At first, clinicians sought to understand the pathophysiology of the disease and to apply the most appropriate treatment. Millions of people have recovered and been discharged. However, over time, various morbidities and disease sequelae started to appear in discharged patients. This situation also paved the way for some other diseases.[17] Some patients were also

Table 5: Results of binary logistic regression analysis with echocardiographic characteristics for mortality 1 year later

	1 year later mortality		OR (95% CI)	*P*
	Alive (*n*=97)	Dead (*n*=10)		
LA (cm)	3.56±0.52	3.47±0.59	0.69 (0.188–2.567)	0.584
LVDd (cm)	4.78±0.41	4.74±0.34	0.77 (0.151–3.92)	0.752
LVSd (cm)	3.21±0.37	3.22±0.29	1.111 (0.185–6.678)	0.908
IVS (cm)	0.98±0.18	1.12±0.23	24.35 (1.202–493.3)	0.038
PWd (cm)	0.88±0.15	0.96±0.15	37.30 (0.534–2603.254)	0.095
LVEF (%)	61.65±5.70	57.40±2.46	0.87 (0.773–0.986)	0.029
E/e' ratio	7.81±5.02	6.78±2.35	0.91 (0.693–1.18)	0.461
RV basal diameter (cm)	3.86±0.65	4.02±0.76	1.42 (0.544–3.693)	0.475
RV mid diameter (cm)	3.25±0.66	3.29±0.77	1.09 (0.413–2.889)	0.858
RV length (cm)	5.78±0.93	5.39±0.77	0.60 (0.28–1.299)	0.197
Right ventricular wall (cm)	0.42±0.12	0.40±0.15	0.34 (0.001–91.174)	0.708
RV FAC (%)	48.13±11.89	41.70±8.54	0.96 (0.907–1.009)	0.106
RA area (cm^2)	16.50±4.92	20.21±5.52	1.12 (1.007–1.25)	0.038
RA volume (cm^3)	49.47±24.66	72.00±30.11	1.03 (1.005–1.047)	0.017
IVC max (cm)	1.73±0.43	2.03±0.53	4.25 (1.016–17.803)	0.048
IVC min (cm)	0.97±0.44	1.43±0.58	5.69 (1.592–20.352)	0.007
PAd (cm)	2.14±0.43	2.41±0.53	3.23 (0.89–11.696)	0.075
TAPSE (cm)	2.21±0.47	1.91±0.31	0.21 (0.041–1.06)	0.059
PASP (mmHg)	41.57±11.44	66.60±22.40	1.13 (1.054–1.2)	0.001
PAAT (ms)	105.90±15.40	79.50±18.30	0.92 (0.883–0.962)	0.001
S' TDI (cm/s)	16.73±4.10	14.90±2.56	0.87 (0.721–1.056)	0.161
RV Tei index	52.06±15.73	68.10±19.60	1.06 (1.015–1.098)	0.007
Pericardial effusion				
No	82 (93.2)	6 (6.8)	Reference	
Yes	15 (78.9)	4 (21.1)	3.64 (0.917–14.482)	0.066

LA=Left atrium, LVDd=Left-ventricular diastolic diameter, LVSd=Left-ventricular sistolic diameter, IVS=Interventricular septum, PWd=Left-ventricular posterior wall depth, LVEF=Left-ventricular ejection fraction, PAd=Pulmonary artery diameter, TAPSE=Tricuspid annular plane systolic excursion, IVC max=Maximum diameter of the inferior vena cava, IVC min=Minimum diameter of the inferior vena cava, RV=Right ventricle, RV FAC=Right ventricular fractional area change percentage, RA=Right atrium, S' TDI=Systolic wave S' velocity tissue Doppler imaging, PAAT=Pulmonary artery acceleration time, OR=Odds ratio, CI=Confidence interval, PASP: Systolic pulmonary artery pressure

lost. Long-term data on patients who recovered after treatment for COVID-19 infection is still quite limited. The aim of our study was to investigate the outcomes of long-term mortality in COVID-19 patients requiring hospitalization, with a particular focus on postdischarge mortality. First-year mortality figures were different in various studies. Those hospitalized in the ICU, elderly patients, and those with different comorbidities are at a higher risk of death.[18,19]

Based on our study results, 10 patients died at the end of the 1st year (7Feamle, 3 Male). The mortality rate was 6.4%. Five patients, including two patients requiring hospitalization, died of cardiovascular causes (50%), three died of respiratory failure (30%) and one patient died of recurrent infections (10%). Plus, the cause of death in one of our patients could not be determined. The characteristics of deceased patients are summarized as follows: (1) Patients who were elderly, hospitalized in the ICU and receiving O_2 support, had diabetes mellitus, and had a longer hospitalization period had a higher mortality rate, (2) The mortality rates of patients with anemia and high BNP and D-dimer levels in laboratory parameters were significantly higher, (3) Echocardiographic findings revealed the following factors as contributing to mortality: Low LVEF, increased RA area, and volume, inferior vena cava diameter, increased SPAP, shortened pulmonary artery acceleration time and increased RV Tei index [Tables 4 and 5].

In the study of Novelli *et al*., the 1-year mortality rate after discharge was found to be 3.7%.[20] Similarly, Ramzi's systematic review and meta-analysis focusing specifically on postdischarge all-cause mortality rates have reported the overall 1-year mortality rate as 7.5%.[21]

Ceccato *et al*. found that only 1% of discharged patients died in the 1st year of follow-up.[18] Upon reviewing the literature on long-term outcomes in survivors of other viral cases of pneumonia, it was noted that 1-year mortality, although variable, is higher than for COVID-19 pneumonia.[22] Advanced age, intensive care admission, and preexisting comorbidities, especially malignancy, COPD, and cardiovascular disease, have been listed as predictors of postdischarge mortality in survivors. In our study, meanwhile, patients with cardiac and respiratory

diseases that may affect cardiac function, specifically the RV, were excluded.

There is a paucity of data examining the long-term impact of right ventricular function on mortality. In a study in which patients who were followed up for a shorter period were included, results close to the data obtained in our study were found.[23]

Study limitations

(1) Our study was conducted in a single center and the number of patients was limited. (2) Hospitalized patients were included in our study. Since a large proportion of patients are not hospitalized, rates of cardiac effects of the disease may not reflect exact Figures. (3) Due to the nature and risks of the pandemic, echocardiography was not performed in every patient at the same time of illness. As a result, we may have been unable to observe the effects of the disease at different points in time. (4) We excluded patients with previously known or newly detected cardiovascular and respiratory diseases. Thus, we have eliminated confounding factors that may affect right ventricular function.

Conclusions

There is no doubt that COVID-19 infection has significant cardiac effects, albeit to varying degrees. Numerous studies have also suggested that cardiovascular involvement is associated with a poor prognosis. Our study also supports this information. In future, we will undoubtedly see the late effects of cardiac involvement in recovered patients. This sequelae should be accurately defined in larger studies, and a follow-up and treatment program should be prepared for patients in light of these data. We believe that this will enable faster and more effective follow-up of the millions of patients who have recovered and been discharged. This could be a guideline not only for COVID-19 but also for other potential pandemics that may break out.

Author contributions

All authors contributed to the conception and design of the study, analysis and interpretation of the data, and critical revision of the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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