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Assessment of Right Ventricular Function by 2D Transthoracic Echocardiography in COVID-19 Hospitalized Patient in Correlation with CT Pulmonary Angiographic Findings

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ORIGINAL ARTICLE

Assessment of Right Ventricular Function by 2D Transthoracic Echocardiography in COVID-19 Hospitalized Patient in Correlation with CT Pulmonary Angiographic Findings

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Abstract

Background: **COVID- 19 pandemic outbreak in Egypt began in February 2020 and is still ongoing. For individuals with suspected respiratory symptoms, the Egyptian protocol recommends a non-contrast CT chest. However, many patients with worsening symptoms, particularly in the second week of disease, demonstrated signs of thrombotic events in the pulmonary arteries, which is why CT pulmonary angiography (CTPA) was performed.**

Aim of the work: **Evaluation of RV Function by Echocardiography in COVID-19 hospitalized patients in correlation with CT pulmonary angiographic findings.**

Patients and methods: **This study was conducted on One hundred participants attending to the outpatient of Cardiovascular Diseases, Al-Azhar University Hospitals during the time of the study.**

Results: **No statistically significance alterations were seen between the groups in terms of RV basal diameter, FAC, PASP, McConnell's sign, and left ventricular ejection percent, (except for severe pulmonary embolism there is significant reduction in TAPSE parameter).**

Conclusion: **According to our findings, COVID-19 has many potential mechanisms for inducing pulmonary embolism. Furthermore, there was no significant variation in right ventricular dysfunction between the pulmonary embolism and control groups. (except for severe pulmonary embolism there is a significant reduction in TAPSE parameter).**

Keywords: 2D transthoracic echocardiography, COVID-19, Right ventricular function

1. Introduction

One of the known consequences of COVID-19 infection is pulmonary embolism (PE). The purpose of this study was to determine the prevalence of PE in COVID-19 infected patients, as well as the association between the CT Pulmonary angiography finding and right ventricular function as measured by echocardiography.[1]

COVID- 19 pandemic outbreak in Egypt began in February 2020 and is still ongoing. For individuals with suspected respiratory symptoms, the Egyptian protocol recommends a non-contrast CT chest. However, many patients with worsening symptoms, particularly in the second week of disease, demonstrated signs of thrombotic events in the pulmonary arteries, which is why CT pulmonary angiography (CTPA) was performed and recommended.[2]

The complicated structure of the RV makes echocardiographic evaluation of right ventricular (RV) function difficult. Several transthoracic echocardiographic approaches for measuring RV function have been proposed. However, many of the parameters are time demanding and necessitate the use of specialised hardware and software.[3]

TAPSE and eyeballing can lead to incorrect readings of right ventricular function. However, the two metrics are most commonly used to quantify

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right ventricular function. Some physicians, primarily in university hospitals, use new procedures such as 3D echocardiography and RV-GLS. Despite being proved to be extremely accurate, these advanced parameters are rarely used in regular clinical practise.[4]

Most studies found that patients with a high BMI are more likely to experience embolic events. Those investigations attempted to link thrombotic occurrences to disease severity, high D-dimer, patient weight, and related conditions rather than a hospitalisation consequence.[5]

Echocardiography evaluates right ventricular function, and CT pulmonary angiography may determine both the existence and severity of pulmonary embolism. This allows us to foresee if a patient will need intensive care and what their prognosis will be.[6]

A number of risk variables, including the development of more severe symptoms including hemoptysis, oxygen desaturation, and chest discomfort, are linked to the development of PE during COVID-19 infection. As the condition progresses, a rising D-dimer level in week 2 should serve as an alarm for everyone to have a CT pulmonary angiogram to rule out or confirm PE. Consequently, preventative anticoagulation is of the highest importance.[7]

2. Patients and methods

2.1. Technical design

2.1.1. Population or subjects

We studied 100 consecutive adult patients (≥18 years of age).

2.1.2. Inclusion criteria

Diseases persons with proven COVID-19 infection, as verified by an RT-PCR or CT scan of the lungs, were admitted to a medical institution.

2.1.3. Exclusion criteria

Patients who have one or more of the following:

(1) Non COVID-19 patient.
(2) CORADS-4 or less in CT chest.
(3) Dilated cardiomyopathic patient.
(4) Patient with known abnormal RV Function.
(5) Patients with Known Chronic Respiratory Disease.
(6) Non hospitalized patients.

2.2. Operational design

(1) This study is a prospective study.
(2) The final study population was 100 patients.

All patients were subjected to:

(1) **Taking history:** age, sex, DM, HTN and smoking
(2) **Full clinical examination:** including pulse, blood pressure measurement (systolic and diastolic) and cardiac auscultation for the presence of murmurs or added sounds.
(3) **Pulse oximetry:** to measure the oxygen saturation of blood.
(4) **Labs:** Serum ferritin, D-dimer C-reactive Protien & serum troponin were measured in all patients.
(5) **Electrocardiography:** To rule out ischemia alterations and other ECG abnormalities, a twelve-lead surface ECG was performed to analyze the patient's heart rate and rhythm.
(6) **Echocardiography:**

2.2.1. Right ventricular dimensions

We measured the RV's longitudinal diameter by following a line from the tricuspid annulus to its apex and its basal and mid cavities' dimensions by splitting it into thirds along its length.

2.2.2. Normal values

(1) RV basal dimension: 2.4–4.2 cm.

2.2.3. Right ventricular areas and fractional area change (FAC)

Normal values of RVFAC: 35–63%.[7]

2.2.4. Pulmonary artery systolic pressure (PASP)

Pulmonary artery systolic pressure was estimated by calculating the systolic pressure gradient

Variables	Normal (0–5 (3) mmHg)	Intermediate (5–10 (8) mmHg)	High (15 mmHg)
IVC diameter	≤21 mm	≤21 mm; >21 mm	>21 mm
Collapse with sniff	>50%	<50%; >50%	<50%
Secondary indices of elevated RAP			Restrictive filling Tricuspid E/e' >6 Diastolic flow predominance in hepatic veins (systolic filling fraction <55%)

between RV and RA by continuous wave Doppler of the tricuspid regurgitation jet. Right ventricular systolic pressure (RVSP) was determined from peak TR jet velocity, using the simplified Bernoulli equation and combining this value with an estimate of the RA pressure: $RVSP = 4(V)^2 + RA$ pressure, where V is the peak velocity (in meters per second) of the tricuspid valve regurgitant jet, and RA pressure is estimated from IVC diameter, collapsibility and respiratory changes as follows.

2.2.5. Tricuspid annular plane systolic excursion (TAPSE)

Normal values of TAPSE: 1.6—3 cm.[7]

2.2.6. McConnell's sign

Right ventricular dysfunction has a regional pattern, with mid-free wall akinesia.[8]

Clinical and imaging data with CT pulmonary angiography collected prospectively.

2.3. Statistical analysis

All the data was coded and entered into IBM SPSS 20. (Statistical Package for the Social Sciences). Means, standard deviations, and ranges (for parametric data) represented quantitative data, whereas counts and percentages indicated qualitative data.

We used the Fisher exact test when each cell's expected count was less than 5.

Both groups used parametric quantitative data, and an independent t-test compared them.

One-way ANOVA was used to compare quantitative data from more than two groups.

It was 5% error margin, 95% confidence interval. These *P* values are statistically significant. as follow:

Table 1. Characteristics of included cases; sex, age, diabetes, hypertensive and previous CV disease.

	Number = 100
Sex	
Male	56 (56.0%)
Female	44 (44.0%)
Age	
Mean ± SD	56.42 ± 14.98
Range	28—80
Diabetes	
Negative	44 (44.0%)
Positive	56 (56.0%)
Hypertensive	
Negative	58 (58.0%)
Positive	42 (42.0%)
Previous CV disease	
Negative	46 (46.0%)
Positive	54 (54.0%)

Table 2. Characteristics of included cases; EF, diastolic function and grade, FAC, TAPSE, PASP, Basal RV diameter, troponin and CKMB, CT pulmonary angiography, TAPSE and McConnell's sign.

	Number = 100	
	Mean ± SD	Range
EF	50.79 ± 12.05	32—71
Diastolic function and grade	1.72 ± 1.09	0—3
FAC	45.59 ± 3.09	34—50.1
TAPSE	17.11 ± 3.05	12—22
PASP	41.44 ± 8.57	25—55
Basal RV diameter	39.56 ± 2.83	35—44
Troponin	124.73 ± 79.44	0—249
CKMB	11.73 ± 7.27	0—25
CT pulmonary angio	No. (%)	
No pulmonary embolism	43 (43.0%)	
Pulmonary embolism	57 (57.0%)	
	Number = 100	
Severity	Mild	28 (49.1%)
	Moderate	16 (28.1%)
	Severe	13 (22.8%)
TAPSE	Mean ± SD	17.11 ± 3.05
	Range	12—22
McConnell's sign	Negative	85 (85.0%)
	Positive	15 (15.0%)

(1) If $P > 0.05$ = not statistically significant (NS)
(2) If $P < 0.05$ = statistically significant (S)
(3) If $P < 0.001$ = highly statistically significant (HS).

3. Results

Tables 1—3.

From the data shown in the previous table, we can conclude that there was no statistical significance variation in-between the double collections as regard of EF, Troponin, or CKMB, D dimer, TAPSE nor McConnell's sign (Table 4).

There was no statistically significant difference in diastolic function or grade, FAC, TAPSE, PASP and basal RV diameter between the groups, as indicated in the preceding table (Table 5).

A very statistically significant difference was detected between the three groups on the TAPSE, as shown in the preceding table (Table 6).

Statistical analysis of the data in the previous table reveals no significant differences in diastolic function or grade, FAC, PASP and basal RV diameter (Table 7).

4. Discussion

Twenty to thirty percent of 2019 corona virus hospitalized patients showed myocardial involvement (COVID-19). COVID-19 individuals hospitalized with acute cardiac damage had a greater risk of complications and death than those without the virus.[9]

Table 3. Comparison between No pulmonary embolism (no. = 43) and Pulmonary embolism (no. = 57) regarding EF, Troponin and CKMB, D dimer, Severity, TAPSE, McConnell's sign.

	No pulmonary embolism	Pulmonary embolism	Test value	*P* value	Sig.
	Number = 43	Number = 57			
EF					
Mean ± SD	50.49 ± 13.10	51.02 ± 11.31	−0.216·	0.829	NS
Range	32–71	33–71			
Troponin					
Mean ± SD	135.26 ± 75.54	116.79 ± 82.02	1.153·	0.252	NS
Range	1–249	0–248			
CKMB					
Mean ± SD	10.56 ± 7.70	12.61 ± 6.86	−1.408·	0.162	NS
Range	0–25	0–24			
D dimer					
Mean ± SD	859.67 ± 355.34	766.81 ± 339.19	1.328·	0.187	NS
Range	166–1330	165–1328			
Severity of PE					
Mild	–	28 (49.1%)	NA	NA	NA
Moderate	–	16 (28.1%)			
Severe	–	13 (22.8%)			
TAPSE					
Mean ± SD	16.86 ± 3.06	17.29 ± 3.05	0.502	0.48	NS
Range	12–22	12–22			
McConnell's sign					
Negative	36 (83.7%)	49 (86.0%)	0.097	0.756	NS
Positive	7 (16.3%)	8 (14.0%)			

COVID-19 has been linked to a wide variety of cardiac conditions, including asymptomatic myocardial damage, acute coronary syndrome, moderate to fulminant myocarditis, stress cardiomyopathy, and cardiogenic shock, although its exact mechanism of action remains unclear.[10]

The current study revealed that the age ranged between 28 and 80 with mean (56.42 ± 14.98) and there were male predominance (56.0%) in our study.

In *Li* et al.[11] study; they reported that median age in patients with CVD was 48 yrs and higher proportion of men (52.5%).

In *Vasudev* et al.[12] study; 45 patients were evaluated. The mean age was 61.4 ± 12.2 years.

In *García-Cruz* et al.[13] study, Men made up the majority of patients (62.2%), and the average age ranged from 50 to 66 years.

The current study revealed that there were 42 (42.0%) hypertensive patients among the candidates.

In *Li* et al.[11] study; they reported that from a total of 215 individuals diagnosed with CVD, 176 were also hypertensive. Those with cardiovascular disease tended to have higher systolic readings (138).

Table 4. Comparison between No pulmonary embolism (no. = 43) and Pulmonary embolism (no. = 57) regarding Diastolic function and grade,FAC, TAPSE, PASP, basal RV diameter.

Diastolic function and grade	No pulmonary embolism	Pulmonary embolism	Test value	*P* value	Sig.
	Number = 43	Number = 57			
Mean ± SD	1.58 ± 1.03	1.82 ± 1.14	−1.103·	0.273	NS
Range	0–3	0–3			
FAC					
Mean ± SD	45.62 ± 2.94	45.56 ± 3.23	0.082·	0.935	NS
Range	40–50.1	34–50			
TAPSE					
Mean ± SD	16.86 ± 3.07	17.30 ± 3.05	−0.708·	0.48	NS
Range	12–22	12–22			
PASP					
Mean ± SD	42.65 ± 7.62	40.53 ± 9.19	1.230·	0.222	NS
Range	27–55	25–55			
Basal RV diameter					
Mean ± SD	39.49 ± 2.96	39.61 ± 2.74	−0.219·	0.827	NS
Range	35–44	35–44			

Table 5. Comparison between mild (no. = 51), moderate (no. = 27) and severe (no. = 22) regarding TAPSE.

TAPSE	Mild	Moderate	Severe	Test value	*P* value	Sig.
	Number = 28	Number = 16	Number = 13			
Mean ± SD	19.63 ± 1.46	15.74 ± 1.32	12.95 ± 0.90	217.515 β	0.0000	HS
Range	17–22	13–18	12–14			

In *Vasudev* et al.[12] study; out of 45 patients. (64%) were hypertensive.

Momtazmanesh et al.[14] reported that third or fewer of hospitalized patients had hypertension.

In *García-Cruz* et al.[13] study, hypertension (47.2%) and type 2 diabetes (43.9%) were the leading co-morbidities.

The current study revealed that there were 56 (56.0%) diabetic patients among our cases.

In *Li* et al.[11] study; they reported that the rate of diabetes (27.0%) in the patients with CVD.

In *Lassen* et al.[15] study; they reported that the rate of diabetes (25.5%) in the patients with CVD.

Meta-analysis of COVID-19 participants showed a prevalence of diabetes mellitus of 9.7%.[11]

In the current study, regarding incidence of previous cardiovascular disease, there were 54 (54.0%) patients among our cases.

In *Vasudev* et al.[12] study; The incidence of congestive heart failure among the studied patients was 24%, coronary artery disease was 20%, and valvular heart disease 7%.

The frequency of cardio-cerebrovascular disease was 16.4% among COVID-19 patients, according to a meta-analysis.[11]

In the current study; regarding Pa O2 ranged between 30 and 85 with mean (58.20 ± 16.56).

In (**Li et al., 2020**)[11] research; They discovered that respiratory impairment is more severe in CVD patients. Patients with CVD exhibited decreased partial pressure of oxygen (PaO2) (80) in blood gas analysis (IQR 58–118).

Goudot et al., **(2020)**[16] in their observational cohort research which made in the Georges Pompidou European Hospital in Paris, they reported that most patients with covid 19 had respiratory acidosis with median PaO2 of85 mmHg (68–100).

In the current study; regarding O2 saturation ranged between 65 and 98 with mean (81.27 ± 10.35).

In (**Li et al., 2020**)[11] study; they reported that patients with CVD had lower SpO 2 (96 (IQR 90–99).

In the current study; regarding HCO3 ranged between 15 and 30 with mean (22.37 ± 4.62).

In (**Li et al., 2020**)[11] study; they reported that patients with CVD had lower HCO3 (25.4 (IQR 22.2–27.8).

In our study; regarding $paCO_2$ ranged between 20 and 44 with mean (32.46 ± 7.26).

Goudot et al.[16] in their study. Median PaCO2 was 53 mmHg, indicating that most patients had respiratory acidosis (42–59).

In our study; regarding PO2/FiO2ratio ranged between 152 and 398 with mean (273.77 ± 71.08).

In *Li* et al.[11] study; they reported that patients with CVD had lower PaO2/FiO2 (333.0 mmHg).

There was nonsignificant statistical difference in the present study between the 2 groups regarding TLC (mean TLC was 9.33 ± 4.95 cells/mm3, 9.20 ± 5.15 cells/mm3 in group I, II respectively; $P = 0.904$).

In *Li* et al.[11] study; they reported that Patients with CVD showed high total leukocyte counts (5770 cells/μl).

In our study; regarding Lymphocytic count ranged between 1 and 18 with mean (9.40 ± 4.75).

Table 6. Comparison between Mild (no. = 28), Moderate (no. = 16) and Severe (no. = 13) regarding Diastolic function and grade, FAC, PASP and basal RV diameter.

Diastolic function and grade	Mild	Moderate	Severe	Test value	*P* value	Sig.
	Number = 28	Number = 16	Number = 13			
Mean ± SD	1.65 ± 1.09	1.78 ± 1.09	1.82 ± 1.14	0.237 β	0.79	NS
Range	0–3	0–3	0–3			
FAC						
Mean ± SD	45.59 ± 2.77	45.16 ± 3.68	46.12 ± 3.10	0.582 β	0.561	NS
Range	41–50.1	34–50	41.4–50			
PASP						
Mean ± SD	42.33 ± 8.47	41.33 ± 9.01	39.50 ± 8.32	0.839 β	0.435	NS
Range	25–55	25–54	25–54			
Basal RV diameter						
Mean ± SD	39.67 ± 2.74	39.30 ± 2.78	39.64 ± 3.17	0.159 β	0.853	NS
Range	35–44	35–44	35–44			

Table 7. Percentage of cardiac parameter affection in COVID-19 patients.

	Number = 100 Number (Percent)
FAC	1 (1%)
TAPSE	34 (34%)
PASP	38 (38%)
Right ventricular dysfunction (Basal RV diameter > or equal 4.2)	28 (28%)

In ***Li*** et al.[11] study; they reported that Patients with CVD showed low lymphocyte counts (930 cells/μl).

Guan et al.[16] in their research on 7736 diseased persons with Covid-19 reported that lymphocytopenia was existed in 83.2% of the diseased persons.

In our study; regarding D-dimer ranged between 165 and 1330 with mean (806.74 ± 347.54).

In ***Li*** et al.[11] study; they reported that Patients with CVD had high levels of D-dimer (0.43 (IQR 0.18—2.78) μg/ml).

In the current study; regarding INR. Mean INR was 1.48 ± 0.31 and ranged between 1 and 1.9.

In ***Yu*** et al.[17] study, they reported median INR was 1.07 in cardiac pateints.

In our study; Regarding Creatinine ranged between 0.6 and 2.5 with mean (0.92 ± 0.29) and Urea ranged between 5 and 20 with mean (13.67 ± 4.56).

In ***Li*** et al.[11] study; they reported that Patients with CVD had high levels creatinine (66 μmol/l), also Patients with CVD had high levels of alanine aminotransferase (23 U/l), aspartate aminotransferase (29 μmol/l).

In the current study, mean values for EF were (50.79 ± 12.05), for diastolic function and grade they were (1.72 ± 1.09), for TAPSE they were (17.11 ± 3.05), and for PASP they were (41.44 ± 8.57), and There were no apparent variation between the double collections in any aspect.

Lassen et al.[15] reported that regarding TAPSE, as Right ventricular function, (TAPSE: cases: 2.0 ± 0.4).

Szekely et al.[18] found that Only 10% of our patients had an LVEF that was less than 50% at the time of their first assessment (including 2 who had documented low LVEF in a previous examination).

In the current study, regarding Basal RV diameter ranged between 35 and 44 with mean (39.56 ± 2.83).

Stockenhuber et al.[19] reported that mean RVD was 38.2 mm.

Deep vein thrombosis (DVT) at the femoral veins was seen in 5 of the 12 individuals with RV degeneration.[18]

Szekely et al.[18] reported that RV dilatation and dysfunction accompanied by shorter AT and normal LV systolic and diastolic performance was the most prevalent aberrant echocardiographic pattern among worsening patients (10 of 20, 50%). Acute RV failure in hospitalized patients may be caused by a number of diseases that raise pulmonary vascular resistance or pulmonary pressure.

The current study results revealed that: There was no apparent change in O2 saturation or D dimer levels between the two groups. And also no apparent change in Treponin levels between the two groups.

Patients who had shorter ATs (indicating greater pulmonary resistance) also had more comorbidities, poorer oxygen saturation, and higher biomarkers (D-dimer and troponin-I).[18]

Similar to earlier findings, we found that 20% of our sample had high troponin levels.[20]

Momtazmanesh et al.[14] levels of cardiac troponin were found to be greater in the dead compared to the living. ***Li and his colleagues***[11] said that COVID-19 patients who passed away had elevated cardiac troponins. Likewise, ***Guo*** et al.,[20] Based on his research with 187 people infected with COVID-19, he found that the rate at which cardiac troponin T levels were increasing or changing dynamically was much greater in those who eventually passed away.

The current study revealed that there was no statistically significant difference in ALT, AST, or albumin levels between the two groups.

COVID-19 hepatic symptoms include elevated ALT and AST and low albumin21,22.

Albumin levels decreased in 98% of patients, but alanine aminotransferase (AST), alanine aminotransferase (ALT), and bilirubin levels increased in 35%, 28%, and 18% of patients, respectively. Researchers analyzed 1099 people's AST and ALT levels and found that 18.2% of those with moderate sickness and 39.4% of those with severe disease had high AST levels, whereas 19.8% of those with mild illness and 28.1% of those with severe disease had elevated ALT values.[16]

4.1. Conclusion

According to our findings, COVID-19 has many potential mechanisms for inducing pulmonary embolism. Furthermore, there was no significant variation in right ventricular dysfunction between the pulmonary embolism and control groups. (except for sever pulmonary embolism there is significant reduction in TAPSE parameter).

Conflict of Interest

None declared.

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