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Cardiovascular complications of COVID-19 with severe and critical illness diagnosed by comprehensive echocardiography

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Abstract

Background: Cardiac injury is common in COVID-19 patients and is associated with increased mortality. Many patients in the hospital suffering from unexplained deterioration of their conditions, one of the common causes of the deterioration is cardiovascular complications like IHD, pulmonary embolism, myocarditis, pericardial effusion, cardiac arrhythmias, valvular dysfunction, pulmonary hypertension and worsening of pre-existent heart disease.

Aim of study: to evaluate the cardiovascular complications of COVID-19 with severe and critical symptoms diagnosed by comprehensive transthoracic echocardiography.

Patient and Method: This cross-sectional cohort study analyzed COVID-19 patients who had an echocardiogram during hospitalization between May 2021 to August 2021.

Result: The mean age 66±12, and most of patients age more than 60 years old, and 61% is male and 39% is female, 82% of patients was hypertensive and 30% is DM, other co-morbidity is seen with lesser extent, 68% of patients with O₂ saturation between 80-89%, and most of them (61%) on CPAP, the echocardiographic study shows 85% of patients with mild increase LVWT, and 65% of patients have no WMA, most of patients has normal chamber dimension except dilatation in RV in 22% of patients with significant P-value, and 79% of patients with normal LVEF and there is 12% with mild impaired LVEF with significant P-value, and 80% of patients with grade I diastolic dysfunction, also there is 70% of patients with mild MR, and 23% of patients with mild AR with significant P-value, there is also 68% of patients with normal PASP, and 23% with mild pulmonary hypertension, other echocardiographic features were looked for, and it shows about 38% of patients with small pericardial effusion, 11% of patients with pulmonary embolism, and 15% of patients with myocarditis, and 39% of patients with sinus tachycardia.

Conclusion: From study, Echocardiography is necessary for COVID-19 patients, and usually shows some abnormality such as increase LVWT, WMA, dilatation of RV and pulmonary artery hypertension, pericardial effusion, myocarditis, arrhythmia and pulmonary embolism also significant cardiac complication of COVID-19.

Keywords: Echocardiography, COVID-19, arrhythmias, pulmonary hypertension, myocarditis, pericardial effusion

Introduction

At the end of 2019, a number of patients with fever and clinical pneumonia of unknown origin were found in Wuhan, Hubei, China. Through virus isolation, gene detection and the analysis of protein structure in the laboratories, the disease was identified as 2019 novel coronavirus pneumonia caused by a new kind of coronavirus. Researchers have found that this new coronavirus belongs to the severe acute respiratory syndrome coronavirus (SARS-CoV), This novel coronavirus is currently named severe acute respiratory syndrome coronavirus 2 (SARSCoV-2) [1].

Although the reported case fatality rates have been variable, in-hospital mortality has been reported to be as high as 21% [2, 3]. While much of the morbidity and mortality associated with COVID-19 has been due to respiratory failure, cardiovascular complications of the SARS-CoV-2 virus, as well as primary cardiovascular presentations of COVID-19, have become increasingly reported [5]. This infectious illness may provoke a multitude of

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cardiovascular events including acute coronary syndromes, arrhythmias, thromboembolism, myocarditis, sudden cardiac death, heart failure, cardiogenic and mixed shock states. The primary mechanism (s) underlying the development of each of these pathologies is unknown but is likely multifactorial, possibly involving vascular insufficiency, direct viral injury, tissue hypoxemia, systemic inflammation, and cytokine release [6].

High-risk group: An individual with high risk for complications from COVID-19 includes [11, 12]

- Age above 60 years old.
- Smoker.
- Cardiovascular disease.
- Diabetes.
- Hypertension.
- Obesity with BMI \geq 35.
- Immune deficiency and or suppression (HIV/AIDS, long-term steroid therapy, post-transplant cases, chemotherapy, immune modulator therapy)
- Pre-existing pulmonary disease (uncontrolled Asthma, COPD, bronchiectasis).
- Other chronic disease such as chronic kidney disease, Chronic Respiratory disease, Sickle cell...etc.

The clinical spectrum of SARS-CoV-2 infection includes asymptomatic or presymptomatic infection and mild, moderate, severe, and critical illness. Figure -2- provides guidance for clinicians on the therapeutic management of non-hospitalized adult patients. This includes patients who do not require hospitalization or supplemental oxygen and those who have been discharged from an emergency department or a hospital. Figure -3- provides guidance on the therapeutic management of hospitalized adult patients according to their disease severity and oxygen requirements [19].

Patients and methods: About 206 Patients with severe and critical cases of COVID 19 were admitted to the Iraqi Economic Council Hospital in Baghdad from 1st of May 2021 to 31 of August, 2021. Were included in this cross-sectional study. These patients were diagnosed by PCR + and CT chest with lung involvement mostly more than 70% and SPO2 from 70% to 90% on CPAP and NRM.

Inclusion criteria

1. All patients were 18 years and older.
2. These patients included in this study suffered from severe and critical illness.
3. These patients meet any of the following criteria, a- Respiratory distress (respiratory rate more than 30/minute b- Blood oxygen, SPO2 is less than 92%. c- Lung involvement more than 50%. d- Critical individuals in addition of above criteria who have respiratory failure, septic shock, and /or multiorgan dysfunction.
4. Any patients who have any prognostic factors and markers for severe COVID 19 disease including in this study like:
 - a) Age $>$ 55 years.
 - b) Pre-existing pulmonary disease.
 - c) Diabetes mellitus.
 - d) History of hypertension e-chronic kidney disease.

- e) History of cardiovascular disease g- Obesity with BMI $>$ 35
- f) History of other immunosuppression like malignancy, connective tissue disease, chemotherapy and steroid.

Exclusion criteria

Age less than 18 years, as well as Mild and moderate illness who have not indication for hospital admission.

Instruments

Transthoracic echocardiographic studies were performed by standard techniques with a P4-2E transducer with commercially available ultrasound system (mindray DC-8).

Echocardiographic Evaluation

All of the 169 patients underwent echocardiography to record LV dimensions and LV systolic function, wall motion abnormality, ejection fraction (EF), RA and LA dimensions, valves, RV dimension and function by TAPSE, and presence of thrombus and pericardial effusion. Assessment of pulmonary hypertension by PASP which equal to (TR PG +RAP). A PASP value equal to or higher than 35 mm Hg was considered PAH

Many patient with severe dyspnea, chest pain, tachypnea, tachycardia were diagnosed as case of acute coronary syndrome by global or segmental hypokinesia and LV systolic dysfunction and troponin +. Myocarditis was diagnosed mostly in young patients by presence of ECG changes (T.inversion in inferior leads), and echo findings like inferior wall segment edema and hypokinesia with or without LV systolic dysfunction, LV dilatation, mitral regurgitation and pericardial effusion.

Pulmonary embolism was diagnosed in addition to clinical symptoms and signs with severe dyspnea and low SPO2 and ECG changes like sinus tachycardia, S1Q3T3, right axis deviation, right bundle branch block, atrial fibrillation. Echocardiographic findings in pulmonary embolism include dilatation of RA, RV and pulmonary artery and sometime visualization of thrombus in IVC, RA, RV and main pulmonary artery. Meconells sign. (hyperkinesia in the apex of RV with hypokinesia of mid and base of RV). Presence of pulmonary hypertension by assessment of PASP which is not exceed 60 mmHg and pulmonary artery acceleration time (PAAT) is less than 60ms, sign of 60/60 which is 94% sensitive in diagnosis of pulmonary embolism.

Statistical analysis

All collected patients' data was fed to a computer software; Statistical Package for Social Sciences (SPSS) version 26.

The described statistical results were presented as value and frequency percentages.

Histograms and pie charts were exploited to clarify these statistical results.

(p) value of ≤ 0.05 was considered as level of significance in all statistical analysis.

Results

Total number of patients enrolled in this study were 206, they admitted to Iraqi economic council hospital, with the period extending from 1/3/ 2020 to 1/9/2021, with moderate to severe and critical symptoms of COVID 19, the number male patient is 127 (61%), and female patients is 79 (39%), according to the age, the most patient admitted is more than 60 years for both male and female. The data is shown in Table - 1.

Table 1: Distribution of COVID-19 patients according to age and gender

Criteria		Number and percent	
Gender	Male	127 (61%)	
	Female	79 (39%)	
Age (year)	Less 30	Zero (0)	
	30-40	26 (13%)	
	40-50	15 (7%)	
	50-60	53 (26%)	
	More 60	112 (54%)	
Age for gender	Male	Less 30	0 (0%)
		30-40	19 (14%)
		40-50	9 (7%)
		50-60	27 (21%)
		More 60	72 (58%)
	Female	Less 30	0 (0%)
		30-40	5 (6%)
		40-50	9 (11%)
		50-60	23 (29%)
		More 60	42 (54%)

Table 2: Shows the comorbidity of patients, O₂ saturation and O₂ supplementation methods, most of patients are hypertensive, and DM, with O₂ saturation below 90%

Table 2: Co-morbidity of patients, O₂ saturation and O₂ supplementation methods

Criteria	Number and percent (%)	
Co-morbidities	No co-morbidity	35 (17%)
	Hypertension	170 (82%)
	Diabetes mellitus	63 (30%)
	Ischemic heart disease	21 (10%)
	Cerebrovascular disease	1 (0.5%)
	Heart failure	2 (1%)
	Chronic kidney disease	2 (1%)
	Obesity	42 (20%)
	Pregnancy	2 (1%)
	carcinoma	2 (1%)
O ₂ saturation	More than 90%	37 (18%)
	80-89%	141 (68%)
	70-79%	26 (13%)
	Less than 70%	2 (1%)
O ₂ supplementation method	CPAP	126 (61%)
	Non-rebreathing mask	71 (34%)
	Face mask	9 (5%)

Table 3: Some echocardiographic criteria of the patients

Criteria		Number and percent (%)	
LVWT	Normal	31 (14%)	
	Increased	175 (86%)	
WMA	Normal	135 (65%)	
	Abnormal	71 (35%)	
Chamber dimension	LV	Normal	180 (87%)
		Dilated	26 (13%)
	RV	Normal	153 (78%)
		Dilated	44 (22%)
	LA	Normal	190 (92%)
		Dilated	16 (14%)
	RA	Normal	184 (89%)
		Dilated	22 (11%)
LVEF	Less than 30%	(2%) 5	
	30-45%	14 (7%)	
	46-53%	26 (12%)	
	More than 53%	161 (79%)	

Table 3. Shows some echocardiographic parameters, concludes that most of patients had LVH, with normal heart chamber dimension and normal EF.

Table 4. Shows other echocardiographic criteria of patients, illustrate most of patients was a grade I diastolic

dysfunction, and majority of patients with mitral regurgitation, and tricuspid regurgitation, with normal pulmonary artery systolic pressure.

Table 4: Some echocardiographic criteria

Criteria		Number and percent (%)	
LVDD	Normal	19 (9%)	
	GI	165 (80%)	
	GII	17 (8%)	
	GIII	5 (3%)	
valves	MV	Normal	49 (23%)
		regurgitation	157 (77)%
	AV	Normal	141 (68%)
		regurgitation	65 (32%)
	TV	Normal	2 (1%)
		regurgitation	204 (99%)
PASP (mmHg)	Less than 35	142 (68%)	
	35-50	49 (23%)	
	50-60	9 (6%)	
	More than 60	6 (3%)	

Table -5- shows the cardiac complications seen during admission in the hospital, it declare there is 11% of patients develops pulmonary embolism, and 38% had pericardial

effusion, and myocarditis seen in most patient, and different forms of cardiac rhythms abnormality was seen

Table 5: Cardiac complications of COVID 19

Feature	No	(%)
Pulmonary embolism	Non	183
	Yes	23
Presence of pericardial effusion	No effusion	127
	Small effusion	79
	Moderate effusion	0
	Large effusion	0
Myocarditis	non	175
	present	22
Heart rhythm status	Normal	67
	Sinus tachycardia	112
	AF	11
	Ventricular ectopic beats	4
	SVT	2
	Ventricular tachycardia	2

Table -6- illustrate some patient, was re-examined after 10-14 days of admission, and some clinical, and echocardiographic criteria is taken, including SPO₂ (shows significant reduction) mode of O₂ administration (shows increase number of patients on CPAP), and increase

significantly wall motion abnormalities after 3-5 days, also increase patients with impaired LVEF, also there is 6 patients develops severe pulmonary artery hypertension, and there is increase number of patients with pulmonary embolism, and pericarditis, myocarditis and arrhythmia,

Table 6: Echocardiographic criteria of re-examined patients

Criteria	1 st eho. Findings, no (%)	After10-14 days no (%)	p- value
SPO ₂	>90%	27(20%)	14(10%)
	80-89%	82 (60%)	82 (60%)
	70-79%	20 (15%)	27 (20%)
	70% <	0 (0%)	14 (10)
O ₂ administration	CPAP	55 (40%)	82 (60%)
	NRM	48 (35%)	41(30%)
	Face mask	27 (20%)	14 (10%)
Wall motion abnormality	Non	96 (70%)	69 (50%)
	yes	41 (30%)	69 (50%)
Ejection fraction (EF %)	52% >	92 (67%)	55(40%)
	45-52%	26 (19%)	48 (35%)
	30-45%	14 (10%)	27 (20%)
	30% <	5 (4%)	7 (5%)
PASP (mmHg)	<35 mmHg	123 (90%)	73 (53%)
	35-50mmHg	12 (9%)	49 (35%)
	50-60mmHg	2 (1%)	9 (7%)
	60 mmHg>	0 (0%)	6 (4%)
Pulmonary embolism	Non	132 ((96%)	114 (83%)
	yes	5 (4%)	23 (17%)

Pericardial effusion	Non	110 (80%)	89 (65%)	0.0031
	Small	27(20%)	41 (30%)	0.004
	Moderate	0 (0%)	7 (5%)	0.0012
	large	0 (0%)	0 (0%)	0.50
Myocarditis	Non	130 (95%)	115 (84%)	0.0032
	yes	7 (5%)	22 (16%)	0.0048
Arrhythmia	non	131 (96%)	122 (89%)	0.027
	yes	6 (4%)	15 (11%)	0.0134

Discussion

In current study, the number of male patient (61%) admitted to hospital is significantly greater than female patient (39%). This finding can be explained because of higher exposure of male to the virus and because most male not stay at home and most of them leaving home to their job, and other explanation can be introduce is the hormonal factors may protect the female from infection, and this may needs further study to improve it, and this finding is resemble what we seen in (Xiong, Shiqiang *et al.*)^[9] with 62% is male and 38% is female and also similar finding in (Giustino, Gennaro *et al.*)^[10] with 58% male and 42% female.

In our study, no patient admitted to hospital at age less than 30 year, and most of patient admitted to hospital is older than 60 years old, this finding may be explained as with increasing age the immune system of patient will be less effective in resisting infection due to chronic illness such as diabetes, his finding is resemble of (Xiong, Shiqiang, *et al.*)^[9] which find the mean age of admitted patients is 67+/- 14 years old also near the finding of (Hua Fan Lin *et al.*, 2020)^[11] who find the mean age is 58+/- 14 year and 41% of patients between 60-74 years old and 19% of patients below 44 years.

On the other hand, the age group distributed according to gender, and we notice, there is no difference between the age of admitted patient between both sexes, so about 58% of male patients and 54% of female patients is more than 60 years old and that finding prove there is no sex hormonal effects on the disease morbidity, this finding resemble (Xiong, Shiqiang, *et al.*)^[9] and (Hua Fan Lin *et al.*)^[11].

Also, our study show most of admitted patients was hypertensive 170 (82%), and about 63 (30%) of admitted patients was diabetes, and this finding may described as most of diabetes mellitus DM and hypertensive are old aged and the DM may reduce immunity strength against infection and increase risk of infection in such population, and the is finding is resemble of (Inciardi, Riccardo M., *et al.* 2020)^[12], which is say there is an 64% of patients is hypertensive and 30% of patients is diabetes, but the finding not totally similar the finding of (Dweck, Marc *et al.*)^[13], who find about 37% is hypertensive and 19% are DM, this difference in finding may be described as of (Dweck, Marc *et al.*)^[13] study assess the COVID 19 infection globally for all population not only the admitted patients.

In our study most of patients (141 (68%) oxygen saturation is between 80-89%, and this is usually the main indication of admission to hospital and this oxygen level may cause myocardial muscle hypoxia and cardiac dysfunction. While in (Inciardi, Riccardo *et al.*, 2020)^[12], the oxygen saturation for patients with cardiovascular disease is 90+/- 12%, and in patients without cardiovascular disease is 91+/- 89% without significant difference between two groups and this discrepancy between our results and results of Inciardi, Riccardo *et al.*, 2020^[12] result can be described that most patients admitted to hospital is moderate to severe symptoms while the samples of Inciardi, Riccardo^[12] is

taken from general population. We notice most of patients admitted to hospital 126 (61%) administer oxygen by CPAP, and about 71 (34%) of patients on NRM, and that is very sense because all admitted patients was moderate or severe symptoms^[12].

Also, most of patient 173 (85%) has mild increase septal wall thickness (SWT), with mild left ventricle hypertrophy, and this is acceptable finding may be related with their co-morbidity rather than COVID 19 infection... i.e. about 82% of patients is hypertensive which is considered most common cause of increase SWT, and this finding is similar to Xiong, Shiqiang *et al.*)^[9] who said that 78% of patient admitted to hospital had increase SWT.

In current study, there is 135 (65%) of patients without wall motion abnormality seen at time of examination, and about 35% of patient present with abnormal wall motion in certain segment or segments of the myocardial muscle, this finding can be explained as most of our patient is old age with chronic diseases and some of them has past history of ischemic heart disease (IHD), in association of myocardial hypoxia due to COVID 19 infection these factors may cause wall motion WMA of myocardium, this finding is support what is seen in results of Fan, Hua *et al.*, 2020^[14] who says about 20% of admitted patient shows IHD by echocardiographic study and about 80% of patients had no WMA.

So, chamber dimensions were measured, the most common chamber was dilated is the right ventricle (RV). Other chambers was dilated with lesser extent, the RA dilatation can explained as the moderate to severe COVID pneumonia may cause increase pulmonary artery systolic pressure and due to poor compliance of the RV wall may cause dilatation, other contributing factors may cause chamber dilatation such as heart failure, ischemic heart disease, hypertension. etc. this finding may be resemble of Xiong, Shiqiang *et al.*,^[9] who find that 7% of hospitalized patient shows LV dilatation and 10% of them shows RV dilatation.

The left ventricle ejection fraction (LVEF) was measured for all patients understudy, the finding shows most of patient (79%), has normal LVEF and (12%) of patients with mild impairment LVEF, with lesser extend moderate to severe LVEF impairment, with insignificant P- value. Most of our patient has risk factors that may cause impairments LVEF such as IHD, hypertension, DM. etc., instead of myocardial injury because of COVID 19 infection may contribute in the impairments of LVEF, this finding is similar what is seen in (Fan, Hua, *et al.* 2020)^[14] who find about (79%) of patients had normal LVEF, and (Xiong, Shiqiang, *et al.*)^[9] who find about (77%) of admitted patients had normal LVEF.

In our study, most of the patient 165 (80%) was examined had grade I LV diastolic dysfunction, and this is acceptable finding because most of our patients is old aged with different cardiac co-morbidity such as hypertension and DM. this finding is correlate (Xiong, Shiqiang, *et al.*)^[9] who find that about 76% of patients with diastolic dysfunction,

and (Wei, Xiaohan *et al.* 2021) ^[15] who find about 65% of patients is with grade I diastolic dysfunction.

In current study, about 157 (77%) of patients had mild mitral regurgitation MR, and this finding may be acceptable according to the age of the patients and their associated clinical conditions, and there is 65 (32%) with mild aortic regurgitation (AR), and this is because most of our patient is old aged, where calcification and some degree of AR was seen, and also there are 204 (99%) with mild tricuspid regurgitation, which seen normally in most of populations. This valvular changes mostly unrelated with COVID 19 infection, and it is the same what is find by (A Shafi, Ahmed MA, *et al.* 2021) ^[16] who find that 64% of admitted patients had MR, and 18% of admitted patients with mild AR.

The pulmonary artery systolic pressure (PASP), was measured for all admitted patient depending on TR pressure gradient add with it right atrial pressure assessed depending on dimension and compressibility of inferior vena cava (IVC), about 68% of our patients had normal PASP, and this may explained that most of our patients was examined at 1st or 2nd day of admission, and that's why the PASP have no time to increase due to high compliance of RV, and there is 49 (23%) of patients had mild pulmonary artery hypertension, and this occurs due to COVID pneumonia or may be other underlying co-morbidity. This finding is supported by other study Xiong, Shiqiang, *et al.* ^[9] who find there is 16% of admitted patients has mild increase id PASP, and (Xia, Peng, *et al.* 2020) ^[17] who find about 18% of patients understudy has increase PASP.

In this study 137 patients deteriorated after 10 days, reassessed these patients by another echocardiography, and considered mostly as a directed complication of COVID 19 infection, there were 28 (13.5%) patients developed IHD, 37 (18%) patients had decrease in EF, 50 (24%) patients developed pulmonary hypertension, 18 (9%) patients had pulmonary embolism, 21 (10%) patients had pericardial effusion, 15(7%) patients had myocarditis and 9(4%) patients had arrhythmia. overall acute cardiac injury is significant in patients with severe and critical cases of COVID19 (66.5%)

Conclusion

1. Cardiovascular complications are a common finding in COVID-19, it is vital to remember that cardiovascular complications remain the leading cause of death.
2. The current study suggests that the most common cardiovascular complications of COVID-19 are myocardial injury like myocarditis and IHD, pulmonary hypertension, pulmonary embolism, valvular heart disease and cardiac arrhythmias.
3. The COVID 19 is more common in male than female and more common in patients more than 60 years.
4. 4-the COVID 19 is more common in patients with comorbidities like HT, DM, obesity, pre existent IHD.

Conflict of Interest

Not available

Financial Support

Not available

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