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Research Article

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The diagnostic utility of cardiac imaging (echocardiogram and cardiac magnetic resonance) in covid 19 patients and cardiac complications: retrospective cohort study in Saudi Arabia

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Abstract

Objectives: *Coronavirus disease (COVID-19) continues to cause considerable morbidity and mortality worldwide. The complication in patients with severe COVID-19 disease include arrhythmias, peri-myocarditis (PM), and heart failure (HF). The important role of echocardiogram (ECHO) and cardiac MRI (CMRI) in the diagnosis of myocarditis in COVID-19 patients in Saudi Arabia has not been assessed. The objective is to assess the diagnostic value of ECHO and CMRI and define phenotypes patterns in the COVID 19 subgroup.*

Methods: *In this retrospective study, adults with suspected COVID-19 presented with dyspnea and cardiovascular comorbidities were studied between January 2021 and December 2021. We collected 329 patients, (LVEF by ECHO was 44±11%). Fifty-two percent (173/329), had HF (HFrEF or HFpEF), thirty-six percent presented with acute coronary syndrome ACS (120/329), and four percent had adult congenital heart disease (ACHD). CMRI was performed in 160 patients (LVEF is 40±11%), and fifty-two were COVID-19 positive. Based on the Lake Louis criteria, CMRI was performed at siemens 3 T can identify myocardial function and damage using Late Gadolinium Enhancement (LGE) images phenotypes pattern were described as normal, ischemic, or nonischemic (peri-myocarditis). LVEF was divided by CMRI as (EF≥50 or EF<50%). Comparison of Cardiac MRI LGE in the COVID 19 subgroups according to the LVEF was analyzed. The average time interval from diagnosis to CMRI was 4-8weeks.*

Results: *Sixty percent of patients (221/329) were confirmed COVID-19 infection, the mean age is 54±13 years. Ten patients were diagnosed with pulmonary embolism (2/10 were ACHD). Peri-myocarditis patterns were found in sixty percent of COVID-19 patients (31/52), five percent (3/52) had an ischemic pattern, and thirty- five percent (18/52) had normal LGE (X^2=21.8 and P value<0.001). However, in COVID-19 negative patients, Eighty percent (85/108) had an ischemic pattern, and twenty percent (23/108) had normal LGE. (X^2=37.7 and P value<0.001).*

Conclusion: *In this observational study, CMRI confirms its high diagnostic tool in evaluating myocarditis activity. In COVID-19 patients, two third of the population were found to have peri-myocarditis, with half of them reporting LVEF was ≥50 %. (X^2=67.1 and P value<0.001).*

Keywords: (CMRI) Cardiac Magnetic Resonance Imaging, (DCM) Dilated Cardiomyopathy, (COVID-19) Coronavirus Disease 2019, (ACHD) Adult Congenital Heart Disease, (ACS) Acute Coronary Syndrome.

Abbreviations

ACS: Acute Coronary Syndrome; ACHD: Adult Congenital Heart Disease; CCTA: Coronary Computed Tomography Angiography; CMRI: Cardiac Magnetic Resonance Imaging; DORV: Double Outlet RV; LGE: Late Gadolinium Enhancement; NYHA: New York Heart Association Classification; PS: Pulmonary Stenosis; PDA : Patent Ductus Arteriosus; PM: Perimyocarditis; RTOF: Repaired Tetralogy of Fallot.

Introduction

Coronavirus disease 2019 (COVID 19) continues to cause considerable morbidity and mortality worldwide [1-4]. A major complication in patients with severe disease included arrhythmias (AT), perimyocarditis (PM) and heart failure (HF) [5-6-7-8]. The important role of echocardiogram (ECHO) and cardiac MRI (CMRI) in the diagnosis of myocarditis in COVID 19 patients in Saudi Arabia has not been utilized. The objective of the study is to assess the diagnostic value of ECHO and CMRI for clinically suspected PM, and compare the CMRI phenotypes between the patients with and without COVID 19.

Methods

This is a single-center, retrospective, observational study was performed at KFH, Saudi Arabia with total number of 329 adult patients. In this retrospective study the inclusion criteria are: data of adults>18 years of age, with suspected COVID 19 patients and admitted with angina, palpitations or dyspnea, clinical, laboratory, radiological, cardiopulmonary complications (HF, ACS, AT, PM) were included and analyzed over 12 months period (Jan 2021 to Dec 2021) in tertiary cardiac center. Cardiopulmonary complications are: Acute or decompensated heart Failure HFrEF and HFpEF, Peri myocarditis (PM), and acute ischemic events (ACS) (STEMI or NSTEMI&UA) and Arrythmia (AT) diagnosed according to the previous published guidelines [1-4]. Patients younger than 18 years, with pregnancy or contraindications to CMRI are excluded.

Informed consent was waived because of the retrospective nature of this study and the analysis used anonymous clinical data. Cardiac injury was defined if the serum levels of cardiac biomarkers (troponin I) were above the 99th percentile upper reference limit or new abnormalities were shown in electrocardiography and echocardiography [1-5].

Utilized cardiac imaging with ECHO and CMRI were performed according to the standard international protocol (ASE and ACC guidelines) [6-8].

SARS-CoV-2 RNA is detected by reverse-transcription polymerase chain reaction (RT-PCR) [9]. Baseline characteristics are seen in Table 1. Protocols used in patients who have known/suspected active COVID-19 or post COVID-19 was performed based on the specific clinical question with an emphasis on cardiac function and myocardial tissue characterization. Short and dedicated protocols are recommended [8]. Cardiac MRI scans were performed within 4-8 weeks' time interval from diagnosis, in a 3T MRI system using protocols consistent with Society for Cardiovascular Magnetic Resonance recommendations for patients with COVID-19 [8]. This included anatomic imaging, long- and short-axis cine scans, and myocardial tissue characterization including and late gadolinium enhancement.

Variable mean ± SD	Total Patients (329) N (%)
Age	54±13 (18-78 y)
Male /Female	285/71
NYHA ≤ 2 >2	 181(55%) 148(45%)
O2 saturation	95± 2% (85-97 %)
Heart Rate	84±9 bpm
Blood Pressure	131±11/85±4 mmHG
Risk factors DM HTN CKD Hypoxia None	 130(39%) 138(41%) 14(4%) 14(4%) 33(10%)
Diagnosis group ACS● HF Arrythmia Structural or ACHD* Pericardial	 120(36%) 173(52%) 14(4%) 15(4.6%) 7(2%)
CXR+CT Chest severity Mild Mild to moderate Severe	 35(10%) 266(80%) 28 (8%)
Covid 19 positive/Covid 19 negative	221(67%)/108
ECHO LVEF (n=329)	44±11%
CMRI LVEF (n=160) (52 in COVID 19 positive/108 in COVID 19 Negative)	40±10%
Creatinin	1.19±0.3

Troponins I	0.59±0.02
Pulmonary embolism	10 (2 with ACHD)

Table 1: Baseline Characteristics: ACS patients: 14 with ST Elevation (STEMI), 32 NSTEMI, 72 unstable anginas with acute chest pain (UA); ACHD patients: four with Eisenmenger syndrome, 3 Down syndrome, 3 Pulmonary Stenosis, 2 r-TOF, one Patent Ductus arteriosus, one Double Outlet RV with arterial switch, one with Fontan repair.

Based on the Lake Louis criteria, CMRI was performed at siemens 3 T can identify myocardial function and damage using Late Gadolinium Enhancement (LGE) images phenotypes pattern, subgroups as normal, ischemic, or nonischemic peri myocarditis) [10,11].

Ischemic: Subendocardial or transmural scar conforming to a coronary territory; nonischemic: subepicardial or intramyocardial scar [a category that included most myocarditis-related scars. Left ventricular ejection fraction were analyzed using a clinically validated artificial intelligence analysis platform and verified by 2 experts, Impairment was defined as below age- and sex-specific reference ranges, CMRI LVEF was divided into two groups by as (EF≥50 or EF<50%) [5,7,8]. CCTA was performed according to the previous trials in COVID 19 patients [10-15].

Analysis of the mean, median and SD and the comparison of the subgroups are performed using SPSS 25 software. Normally distributed variables were expressed as mean ± standard deviation; CMRI LGE pattern and Covid 19 patients' group are analyzed and reported. Cardiac MRI LGE pattern in the COVID 19 subgroups is compared according to the MRI LVEF and analyzed in cross tables using Chi-square. Student's t-tests (two-tailed) and the Mann-Whitney U test was used to compare normal and non-normally distributed data between two groups. Statistical significance level was set to P<0.05.

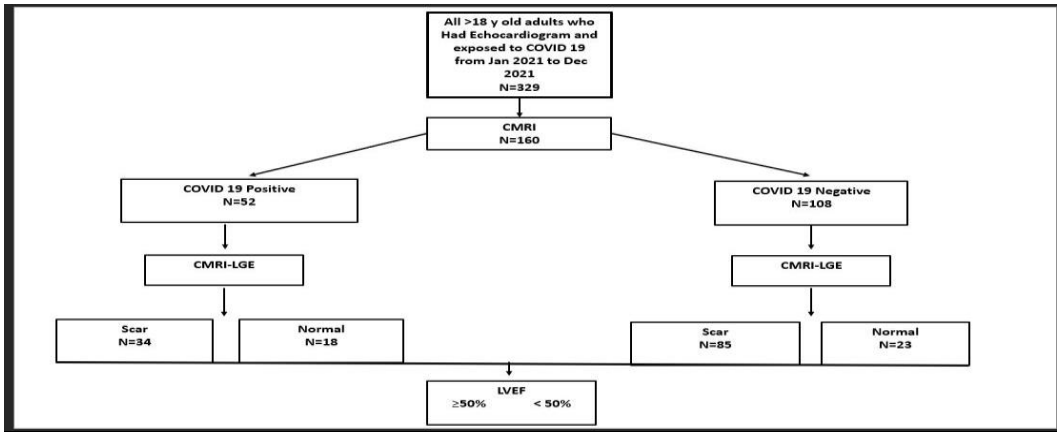
Results

In this retrospective study, adults with suspected COVID-19 and symptomatic with cardiovascular comorbidities were studied between January 2021 and December 2021. Forty percent (148/329) of patients has Cardiopulmonary symptoms NYHA class>II. Mean age was 54±13 years and patients were predominantly male (285/239, 78%). (Figure 1-Flow chart) We collected 329 patients, (LVEF by ECHO was 44±11%). Fifty-two percent (173/329), had HF (HFrEF or HFpEF), thirty-six percent presented with acute coronary syndrome ACS (120/329), and four percent had adult congenital heart disease (ACHD). 10 patients underwent Coronary computed tomography angiography (CCTA), showed pulmonary embolism with Right ventricular dysfunction in echocardiogram (Two of them with ACHD patients). Baseline characteristics and comorbidity are summarized in Table1. The prevalence of COVD 19 cardiac complications in the total number of 329 cases in our study are as follow: HF is 23%, ACS is 8%, arrythmia is 3% and Perimyocarditis in 9%. In our cohort, Sixty percent of patients (221/329) were confirmed COVID-19 infection. In CMRI peri-myocarditis patterns were found in sixty percent of COVID-19 patients (31/52), five percent (3/52) had an ischemic pattern, and thirty-five percent (18/52) had normal LGE (X^2=21.8 and P value<0.001). However, in COVID-19 negative patients, Eighty percent (85/108) had an ischemic pattern, and twenty percent (23/108) had normal LGE. (X^2=37.7 and P value<0.001). In COVID-19 patients, two third of the population were found to have peri-myocarditis, with half of them reporting LVEF was ≥50 % (X^2=67.1 and P value <0.001) (Table 2, Figure 2-3).

LGE pattern classifications are shown in Figure 4 with multiple examples.

COVIDGRUOP			LGE PATTERN			Total	Chi-square	
			Normal	Ischemic	Non-ischemic		X^2	P-value
COVID 19 POSITIVE	EF>=50%	N	3	1	26	30	21.845	<0.001*
		%	10.00	3.33	86.67	100.00		
	EF<50%	N	15	2	5	22		
		%	68.18	9.09	22.73	100.00		
	Total	N	18	3	31	52		
		%	34.62	5.77	59.62	100.00		
COVID 19 NEGATIVE	EF>=50%	N	14	5		19	37.753	<0.001*
		%	73.68	26.32	0.00	100.00		
	EF<50%	N	9	80		89		
		%	10.11	89.89	0.00	100.00		
	Total	N	23	85		108		
		%	21.30	78.70	0.00	100.00		

Total	EF>=50%	N	17	6	26	49	67.109	<0.001*
		%	34.69	12.24	53.06	100.00		
	EF<50%	N	24	82	5	111		
		%	21.62	73.87	4.50	100.00		
	Total	N	41	88	31	160		
		%	25.63	55.00	19.38	100.00		



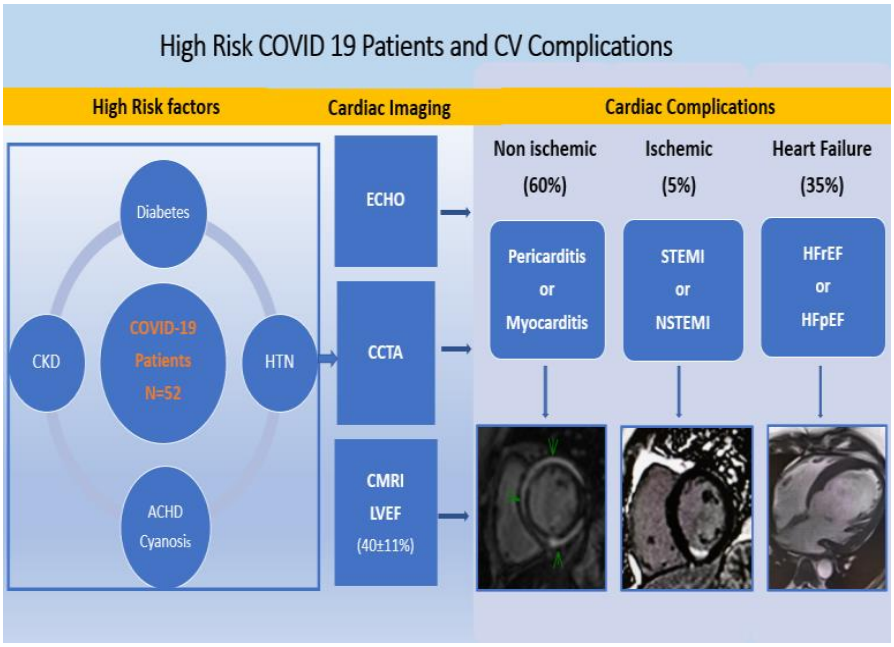


Figure 1: Graphical Illustration: High Risk COVID 19 Patients and Cardiovascular Complications. HTN, Hypertension; CV, Cardiovascular; CKD, Chronic kidney Disease; CCTA, Coronary computed tomography angiography; ACHD, Adult Congenital Heart Disease; MI, Myocardial infarction; CMRI Cardiac MRI.

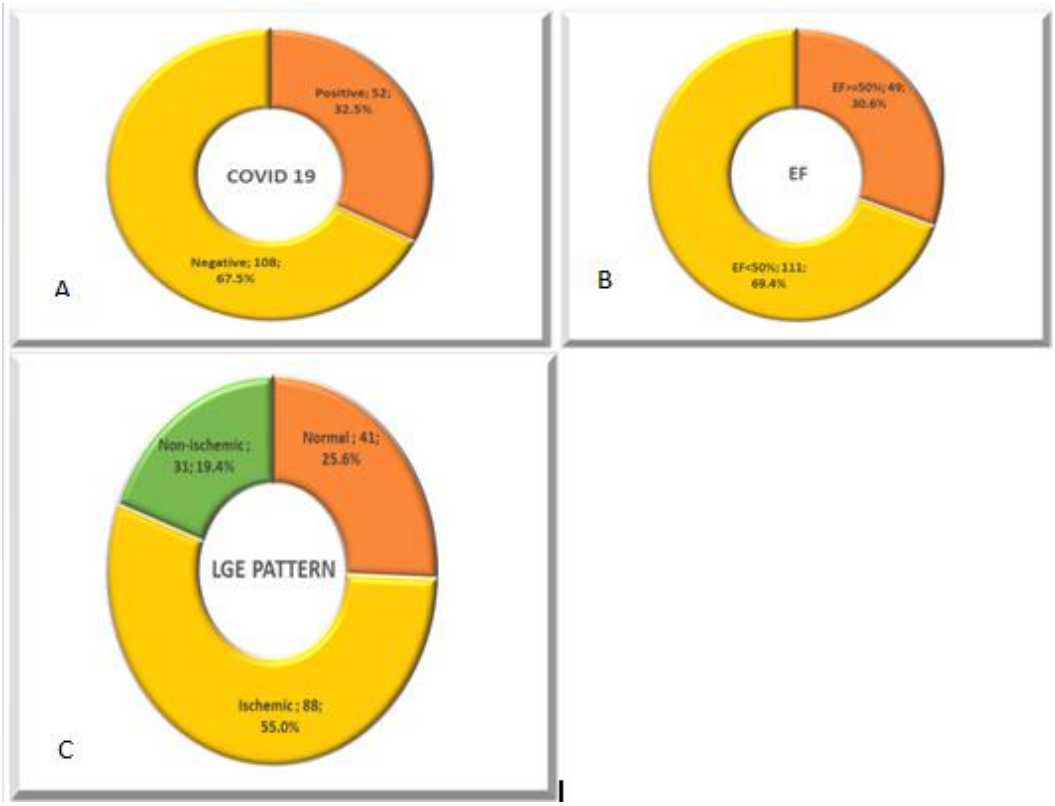


Figure 2: A) Total patients with CMRI (n 160); B) Total patients with CMRI and LVEF Group; C) CMRI Late gadolinium enhancement (LGE) pattern in all patients

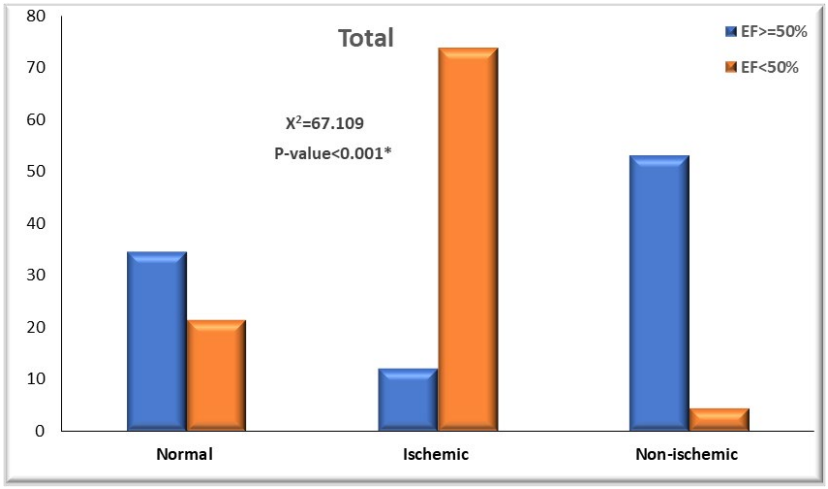


Figure 3A: All patients and CMRI Late gadolinium enhancement (LGE) Pattern.

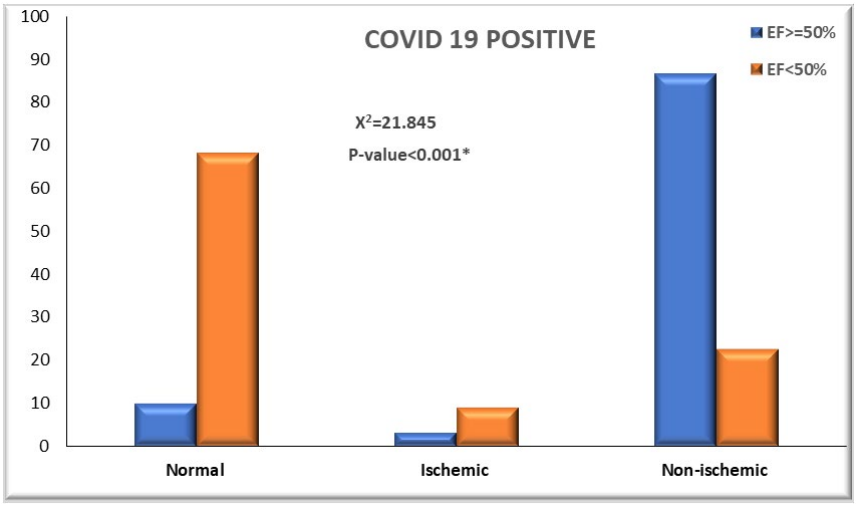


Figure 3B: COVID 19 Positive patients and LVEF group.

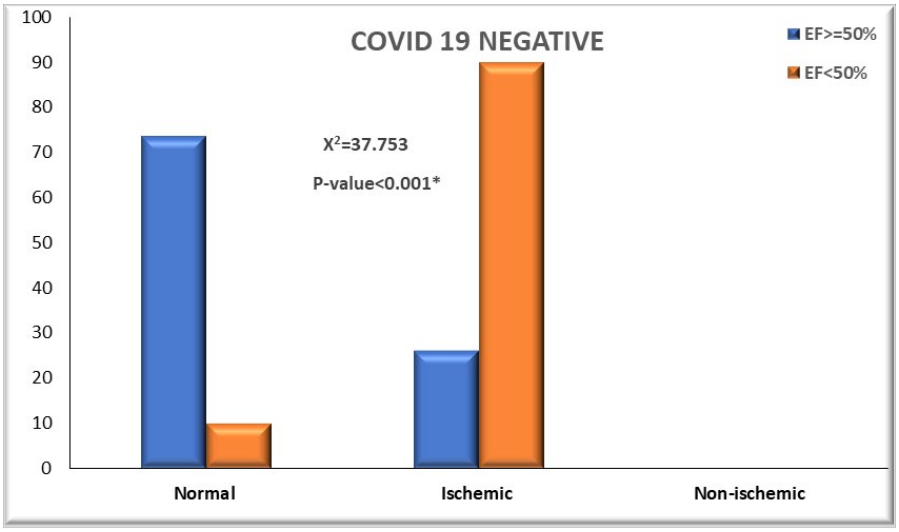


Figure 3C: Covid 19 negative patients and LVEF group.

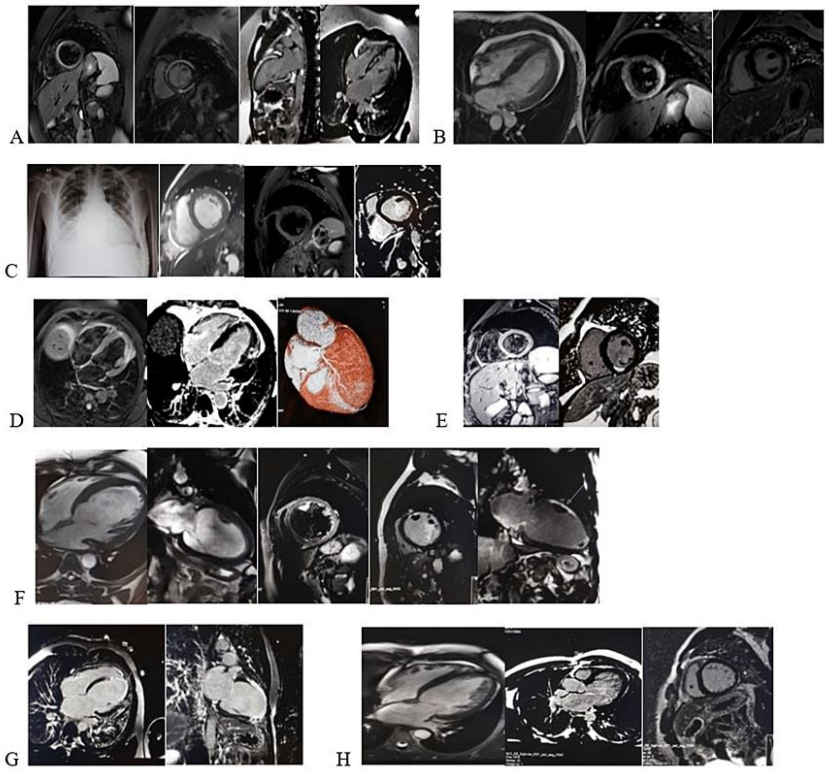


Figure 4: Selected Cardiac MRI cases (Cine, T2-weighted Edema, LGE images. Covid 19 Positive patients:
A) Peri myocarditis: EF47% with high signal intensity in Edema images and subepicardial hyperenhancement; LGE)Pericarditis: EF 55% with edema; C) Cardiomyopathy: EF 30% with HF, Edema images with Normal LGE; D) Ischemic pattern: EF 45% with focal transmural infarction in LGE; E) Ischemic pattern: EF 45% STEMI (Transmural) in LGE; F) Ischemic pattern: EF 23% with NSTEMI (subendocardial) and LV thrombi. Covid 19 Negative patients: G) Covid 19 Negative Ischemic pattern: EF 35% with transmural infarction-ICM; H) Covid 19 Negative: EF 30% with DCM N LGE.

Discussion

In this retrospective Comparative study of high risk symptomatic COVID 19 patients, ECHO and CMRI are noninvasive diagnostic tools in evaluating the myocarditis activity and severity. Cardiac involvement, as measured by CMRI, is common in 60% of our patients with COVID-19 and comparable to previous studies (range: 30%-78%) [1-4]. EMB and autopsy sample analysis suggests that myocarditis is an uncommon diagnosis occurring in 4.5% of highly selected cases [1-4]. The Centers for Disease Control and Prevention revealed that the risk for myocarditis is 0.146% among inpatients and outpatients with COVID-19 [1-4]. The prevalence of myocardial injury as a consequence of COVID-19 remains uncertain, however estimation of definite/probable acute myocarditis prevalence among patients with COVID-19 is 2.4 per 1000 hospitalizations [5,6].

There are multiple mechanisms proposed: (1) direct cardiac damage mediated by stimulation of the angiotensin converting enzyme 2 (ACE2), which is expressed on myocytes and vascular endothelial cells and involved as receptor for SARS-CoV-2; (2) myocardial damage induced by hypoxia; (3) damage related to systemic inflammatory response mediated by release of cytokines, the so-called “cytokine storm”; and (4) macro and microcirculatory thrombosis, correlated to a state of hypercoagulability [9-12]. The damage is generally diagnosed by troponin increase or the appearance of new electrocardiographic or echocardiographic abnormalities. Definitive COVID-19 diagnosis requires a positive reverse transcription-polymerase chain reaction test [9]. The diagnosis can be made by chest computed tomography; which is useful in assessing for a possible COVID-19 pneumonia, which usually is bilateral and with basal or multi-lobar distribution. Quickly progressive ground glass opacities, sometimes with consolidation, are the typical features [9-10,13-15]. The existence of Comorbidities and ACHD in Our cohort group, with Cardiopulmonary symptoms NYHA class>II, one third are diabetics, one third are diagnosed with HTN and other comorbidities are CKD, hypoxia. According to Wang et al. hypertension, diabetes, and cardiovascular diseases were the most common coexisting conditions. Furthermore, patients with underlying comorbidities were admitted to ICU and showed more signs of cerebrovascular accidents in comparison with patients who were non comorbid [13,14] (Graphical illustration).

Total ACHD patients in our study are fifteen: 4 patients with Eisenmenger syndrome, 3 with Down syndrome, 3 with PS, 2 with r-TOF, one PDA, one with DORV with arterial switch, 1 Fontan repair. Adults with congenital heart disease (ACHD) have been considered potentially high risk for (COVID-19) mortality or

morbidity [16]. Pulmonary arterial hypertension, Fontan palliation and cyanotic heart disease were widely considered as risk factors for poor outcome in COVID-19 [16]. Broberg CS et al, concluded that, most vulnerable patients are those with worse physiological stage, such as cyanosis and pulmonary hypertension [17].

Perimyocarditis in COVID 19 Patients

Perimyocarditis , is defined by the presence of 1) cardiac symptoms (eg, chest pain, dyspnea, palpitations, syncope); 2) an elevated cTn; and 3) abnormal electrocardiographic (eg, diffuse T-wave inversion, ST- in 5 of 10 segment elevation without reciprocal ST-segment depression, prolongation of the QRS complex duration), echocardiographic (eg, left ventricular (LV) wall motion abnormalities, often noted in a noncoronary distribution), or pericarditis, CMR (eg, nonischemic late gadolinium enhancement (LGE) pattern with prolonged native T1 and T2 relaxation times), and/or histopathologic findings on biopsy or postmortem evaluation (eg, inflammatory myocardial infiltrates associated with myocyte degeneration and necrosis) in the absence of flow-limiting epicardial coronary artery disease [1-3,6-8,18].

Transthoracic Echocardiography (ECHO) remains the first-line imaging modality for the assessment of COVID-19-associated myocarditis [10-12]. It provides rapid, non-invasive assessment of cardiac structure and function. Echocardiographic findings characteristic to fulminant myocarditis includes severely reduced biventricular function with preserved diastolic chamber dimensions, the increased ventricular wall thickness in the setting of myocardial edema, pericardial effusion, and potential intracavitary thrombus formation [12]. In Our study, patients with PM reported mild impairment of LVEF in the majority of cases, consistent with previous studies, in which patients with myocarditis may have a normal echocardiogram [11,19-20]. Ten patients from our study have pulmonary embolism with right ventricle (RV) dysfunction in ECHO two of them are ACHD patients. clinically suspected myocarditis, in SARS-CoV-2 pandemic, had a variety of presentations, LV-EF could be normal or mildly, moderately, or severely reduced [20,21]. The spectrum of cardiac manifestations in hospitalized patients with COVID-19 was first described by the group of Szekely and Lichter, who performed a complete echocardiographic evaluation in 100 consecutive patients [21]. Thirty-two percent of the patients had a normal echocardiogram, the most common pathological finding was RV dilation and dysfunction (39% of patients), followed by LV diastolic dysfunction (16%) and LV systolic dysfunction expressed by a reduced EF (10%) [11,20,21]. In some studies, RV systolic dysfunction was more common than LV systolic dysfunction in COVID-19 patients. The etiology of this dysfunction could be related to pulmonary embolism, a common complication in this type of patients or to ARDS and its well-known sequelae, such as secondary pulmonary fibrosis [13,20-22]. However, echocardiographic findings are non-specific, and therefore have a limited role in identifying the underlying etiology.

The diagnostic gold standard for the diagnosis of myocarditis is endomyocardial biopsy [20]. CMRI allows characterization of myocardial tissue, which can be of great help in identifying the etiology of the cardiomyopathy [21,22]. As few interstitial mononuclear inflammatory infiltrates were described at a COVID-19 patient's heart [10,22].

CMRI can provide a noninvasive, biopsy like method for identifying the imaging features of myocardial inflammation [1-2,10]. CMRI has been utilized frequently in COVID-19 to objectively assess the prevalence of myocarditis and to determine the extent of myocardial injury. This provides invaluable information complementing clinical, biomarker and ECHO data [10-12,18-22]. Cardiac MRI is the non-invasive gold standard imaging modality for myocardial tissue characterization owing to its ability to reliably detect edema and fibrosis [10-12]. The diagnosis of myocarditis by MRI may be established based on the 2018 Lake Louise Criteria (LLC) with 88% sensitivity and 96% specificity [11-21]. Based on the Lake Louis criteria, CMR can identify myocardial damage with a diagnostic accuracy of 78%. Lake Louise criteria include detection of regional edema on T2-weighted CMR images, detection of hyperemia and early capillary leakage on the basis of T1-weighted early gadolinium enhancement, and detection of necrosis and fibrosis by late gadolinium enhancement (LGE), with high specificity and positive predictive value when 2 out of 3 CMR characteristics are present [11]. Supportive findings include the presence of T1 and T2 mapping abnormalities. Pericardial effusion and left ventricular systolic dysfunction [10-12].

Consistent with our cohort, Puntmann et al performed a prospective study of 100 recovered patients, the majority (49%) of whom had mild to moderate COVID19 infection. Abnormal CMR findings were present in 78% of patients and ongoing myocardial inflammation in 60%. Native T1 and T2 mapping provided the best discriminatory ability to detect COVID-19-associated myocardial disease. Pericardial enhancement was frequent (22%). There were greater proportions of patients with ischemic (32% vs 17%) and nonischemic (20% vs 7%) LGE patterns than the risk factor-matched control group [18].

Long et al. reported that myocardial injuries may occur in 7-31% patients, Other cardiac complications observed were heart failure (23%) and arrhythmias (7%), COVID-19 can trigger acute myocardial infarction and This might be due plaque rupture, coronary spasm or hypercoagulability with development of microthrombi [2-3,19]. In other studies, reports of CMR-identified abnormalities in patients hospitalized caused by COVID-range from 26% to 60% of individuals at 1 to 5 months after hospital discharge. Reassuringly, patients with mild COVID-19 and asymptomatic individuals are reported to have low rates of CMR abnormalities [18,23,24] (Figure 3,4).

COVID 19 with Ischemic Pattern in CMRI

It will be important to establish diagnostic criteria specific for COVID-19-associated myocarditis in order to differentiate this entity from other cardiac complications of the viral infection, such as stress cardiomyopathy, myocardial ischemia due to underlying

coronary disease or thrombotic events, or sepsis related myocardial dysfunction [24-27]. In our population, ACS was reported in five percent (3/52) of Covid 19 patients (Figure 3,4). We identified a new pattern of microinfarction on CMRI, highlighting the prothrombotic nature of this disease. COVID-19 is linked to an increased risk of ST-elevation myocardial infarction (STEMI) and myocarditis during the acute, hospitalized phase; even myocardial injury has been associated with higher morbidity and mortality for patients with COVID-19 [23-29]. Multiple hypotheses for the higher incidence and greater adverse outcomes in ACS have been proposed, including arterial direct viral infection of the endothelial cell or vascular injuries [27,28] or (macrovascular and microvascular) and venous thrombosis mediated by an endothelial inflammatory response, microvascular dysfunction, sepsis hypoxia, sympathetic nervous system overactivity, and cytokine and possible bradykinin release [1-10,27,28]. Our data was consistent with previous groups regarding the pattern of CMRI in covid 19 patients, where PM patients are diagnosed with associated mild LV systolic dysfunction [23]. In a multicenter UK study of 140 patients hospitalized with the COVID-19, Kotecha et al. characterized myocardial injury using (CMRI). They identified myocarditis-like myocardial injury in 26% of patients, myocardial ischemia and infarction in 22% of patients, and dual pathology (ischemic and non-ischemic) in 6% of patients. Also, the large majority of patients (89%) has a normal left ventricular (LV) systolic function (ejection fraction (EF) 67±11%), providing evidence that myocardial injury during the COVID-19 infection can be detected but it has limited extent and minimal functional consequence [23].

COVID 19 and Cardiomyopathy

Generally, ECHO is used as a first approach to evaluate cardiac dysfunction in patients with COVID-19, but, in some cases, this approach may be silent and more advanced cardiac imaging techniques, such as myocardial strain imaging or cardiac magnetic resonance, are necessary to document alterations in cardiac structure or function [25-26]. One third of our patients has HF symptoms with cardiomyopathy (CM) with or without scar in LGE images by CMRI. The pattern of CMRI in patient with Non ischemic inflammatory CM is different from Ischemic CM. The following three different enhancement patterns can be recognized using LGE: subendocardial, transmural, or subepicardial. LGE located within the perfusion territory of an epicardial coronary artery can be classified as ischemic type, and abnormal enhancement not confined to a known vascular distribution is consistent with nonischemic causes [3-10,20,30] (Figure 3,4).

Inflammatory cardiomyopathy is defined as myocarditis in association with cardiac dysfunction and/or ventricular remodeling. It is characterized by inflammatory cell infiltration into the myocardium [10-11,20-21]. Myocarditis-induced alterations may present with several patterns of LGE typically localized at the subepicardial and/or intramural regions of the left ventricle and frequently located in the basal to mid inferolateral walls [10,11,20,21,23,24]. Others reported patterns of residual myocardial abnormalities in post-COVID-19 syndrome includes myocardial edema, myopericarditis, and isolated pericarditis. [10,20,21]. Some patients will have persistent myocardial scar on late gadolinium enhancement images with persistent T1 and T2 mapping abnormalities [25]. The cases of clinically suspected myocarditis, published so far in reference to the current COVID 19 pandemic, had a variety of presentations. LV-EF could be normal or mildly, moderately, or severely reduced [26]. Left, right, and bi-ventricular dysfunction have been reported in the acute phase of the disease, not necessarily related to an ischemic origin. The aetiology of LV dysfunction can be divided into ischemic and non-ischemic. In the context of non-ischemic LV dysfunction, some specific pictures in COVID-19 patients can be distinguished: stress-induced ventricular dysfunction, cytokine ventricular dysfunction, and myocarditis [26,27]. Stress-induced ventricular dysfunction (also known as tako-tsubo cardiomyopathy) has been observed in patients with COVID-19, the first published by Meyer et al. [4,5,10,26]. Nonischemic Dilated Cardiomyopathy Patients either show no enhancement or linear mild myocardial enhancement. However, McCrohon et al showed different patterns of enhancement, at 28%, it was a linear mild myocardial pattern, subendocardial pattern at 13%, and no enhancement at 59% [28,29,30].

Limitations

First, the study is retrospective study and the sample size was small, limited to one regional center. Second, Although LV-EF is the most widely used measure of LV systolic function, global longitudinal strain (GLS) obtained by two-dimensional STE is considered a more accurate method for early detection and screening of subclinical LV dysfunction in COVID 19 patients was not used in this study. Third, CCTA and diagnostic catheterization was not performed in all cases. Fourth, Advanced CMR features such as T1/T2 mapping were not routinely acquired in all patients in this study .With these limitations, the reported proportion of cardiac involvement is limited to the present study and cannot be extrapolated to a larger population. However, an important extension of this work will be to evaluate the importance of late gadolinium enhancement and quantitative cardiac CMR mapping in the risk assessment of long term Covid 19 patients. Whether these additional features could improve patient classification remains to be evaluated.

Conclusion

The prevalence of myocardial injury as a consequence of COVID-19 remains uncertain. COVID 19 related. In this retrospective Comparative study of high risk COVID 19 patients, ECHO and CMRI are important noninvasive diagnostic tools in evaluating the myocarditis activity and severity. Myocarditis-induced alterations may present with several patterns of LGE in CMRI typically localized at the sub-epicardial and/or intramural regions of the left ventricle and frequently located in the basal to mid inferolateral walls. Prospective studies using CMRI are required to evaluate diagnostic and prognostic role of tissue characterization risk stratification in long term COVID 19 patients.

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Institutional Review Board Statement
IRB-Ministry of Health- King Abdulaziz City for Science and Technology Kingdom of Saudi Arabia issued approval A01282. Approved by the IRB-Ministry of Health-King Abdulaziz City for Science and Technology Kingdom of Saudi Arabia, The Diagnostic Utility of Cardiac Imaging (Echocardiogram and Cardiac MRI) in COVID 19 Patients and Cardiac Complications: Retrospective Cohort Study in Saudi Arabia.

Informed Consent Statement
Informed consent was waived because of the retrospective nature of this study and the analysis used anonymous clinical data.

Data Availability Statement
The data presented in this study are available on request from the corresponding author.

Conflicts of Interest
The authors declare no conflict of interest.

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