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Case Report

Cardiac Magnetic Resonance in Times of COVID-19: A Disease with Many Cardiac Faces

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Abstract

Although cardiac magnetic resonance (CMR) may proof useful in the diagnosis of myocardial injury triggered by COVID-19, limited experience has yet been published. We report several cases presenting its utility at various COVID-19 disease stages in diagnosing different cardiac manifestations. The current COVID-19 crisis will undoubtedly transform CMR imaging Units.

Keywords: Covid-19; Cardiac magnetic resonance; Cardiomyopathy; Imaging

Abbreviations: ARDS- Acute Respiratory Distress Syndrome; CMR- Cardiac Magnetic Resonance; TTE- Transthoracic Echocardiography; LGE- Late gadolinium enhancement; LV- Left ventricle; LVEF- Left ventricular ejection fraction

1. Introduction

Cardiac Magnetic Resonance (CMR) provides valuable clinical information in the characterization of myocardial injury secondary to COVID-19 infection. CMR not only provides reliable function quantification, but it can also detect acute inflammatory changes and necrotic damage [1]. Moreover, CMR results may have prognostic implications and hence guide clinical management of COVID-19 patients. However, information on the clinical use of CMR to date is limited, possibly due to a misperception of increased risk of infection to health workers, despite not involving direct contact with patients, as do other imaging modalities as, for example, echocardiography. Given that the health crisis will last, CMR Imaging Units will have to adapt the way they operate and redefine indications in times of COVID. Initial reports identified myocarditis as the main cardiac lesion triggered by COVID-19 and, less frequently, cases of a Tako-Tsubo-like syndrome [2,3]. Early diagnosis has proven key in initiating appropriate medical treatment, including aggressive anti-inflammatory therapy with corticosteroids and IL-6 inhibitors [4] or antiplatelet management. Here, we present several COVID-19 clinical cases where CMR plays a role in the differential diagnosis of various forms of cardiac damage at different stages of the disease, both during hospitalization and at follow up after discharge, with prognostic implications. Furthermore, the risk of misdiagnosis of non-COVID cardiomyopathies is yet another challenge we should be attentive to, as represented by two of the following cases. Demographic data, clinical symptoms, PCR test results, blood testing, imaging modalities, and clinical management for each are shown in Table 1.

	During Hospitalization (acute)			**After Discharge (subacute)**	**Non-Covid cardiomyopathies**	
	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Age and sex	70 y, male	35 y, male	21 y, male	41 y, male	29 y, male	70 y, male
Comorbidity	Dyslipemia	Smoker	None	None	Alport syndrome	Aortic insufficiency
Covid-19 symptoms	ARDS	Fever, discomfort	Dyspnea, ageusia	Exanthema, ARDS	ARDS, fever and cough	Fever, discomfort
Cardiac symptoms	Dyspnea and atypical chest pain	Chest pain	Pleuritic chest pain, dyspnea	Chest pain	Dyspnea	Dyspnea
EKG	negative T wave V4-V5	Normal	Normal	Normal	QTC 520ms	Normal
Echo	Moderate LV dysfunction	Normal LVEF, HK inferolateral	Severe LV dysfunction	Normal	Moderate LV dysfunction	Moderate aortic insufficiency

Covid-19 PCR	+	-	-	+	-	+
Troponin	+	+	+	+	+	NA
IgM/IgG	-	+	+	-	-	NA
Thoracic CT	BPI	Normal	Unilateral consolidation	Bilateral diffused in glass with blotted peripheral infiltrates	BPI	NA
Treatment	Lopinavir, corticosteroid, tocilizumab, anakinra	Corticosteroid, colchicine	AZT, AMX, HCQ, corticosteroid, colchicine	Kaletra, HCQ, corticoide, tocilizumab	HCQ, AZT Meropenem, linezolid	NA

AZT: Azithromycin; AMX: Amoxiclavulanic; ARDS: Acute respiratory distress syndrome; CT: Computed tomography; BPI: Bilateral pulmonary infiltrates. EKG: Electrocardiogram; HCQ: Hydroxychloroquine; LV: Left ventricular. NA: No available.

Table 1: Demographic data, symptoms, PCR and blood testing, imaging modalities results and clinical management for each case.

2. Cases

2.1 CMR in hospitalized COVID-19 patients (acute phase)

2.1.1 Case 1: A 70-year-old man with positive PCR for COVID-19 was admitted to the Intensive Unit Care with acute respiratory distress syndrome (ARDS) and moderately reduced left ventricular (LV) ejection fraction (LVEF) on transthoracic echocardiography (TTE). During hospitalization, the patient had atypical chest pain and elevated troponin levels. CMR was performed at 2 weeks showing normal LVEF, absence of edema, and negative late gadolinium enhancement (LGE) (Figure 1A-C). These results indicate a transient myocardial dysfunction possibly induced by excessive catecholaminergic stimulation or cytokine storm with full recovery of LVEF within a short period of time, suggestive of stress cardiomyopathy.

2.1.2 Case 2: A 35-year-old male with positive Ig-G anti-COVID-19 antibodies, presented with acute chest pain worsening with decubitus. TTE showed a normal LVEF with inferolateral hypokinesis. Troponin levels were increased. CMR showed increased mild signal intensity on T2-STIR sequences in the basal segment of the inferolateral wall. On LGE, there was subepicardial delayed enhancement in the inferior and inferolateral walls at the basal and mid segments (Figure 1D-F). Diagnosis was compatible with acute myocarditis.

2.1.3 Case 3: A 21-year-old man consulted for dyspnea, chest pain and ageusia. Test results were positive for Ig-G anti-COVID-19 antibodies, negative PCR and positive troponins. ECG was normal and TTE showed severe left ventricular dysfunction. CMR was performed at day 7 of admission, which showed normal LVEF (online video 1), mild involvement of the apical lateral wall with subepicardial hyperintensity on T2-STIR and LGE, coincident with mild pericardial effusion (Figure 1G-I). Although these findings suggest mild subacute inflammation as the main diagnosis, they cannot explain the severity of the acute event. Therefore, additional cardiac damage may be explained by other mechanisms such as sepsis or excessive catecholaminergic stimulation.

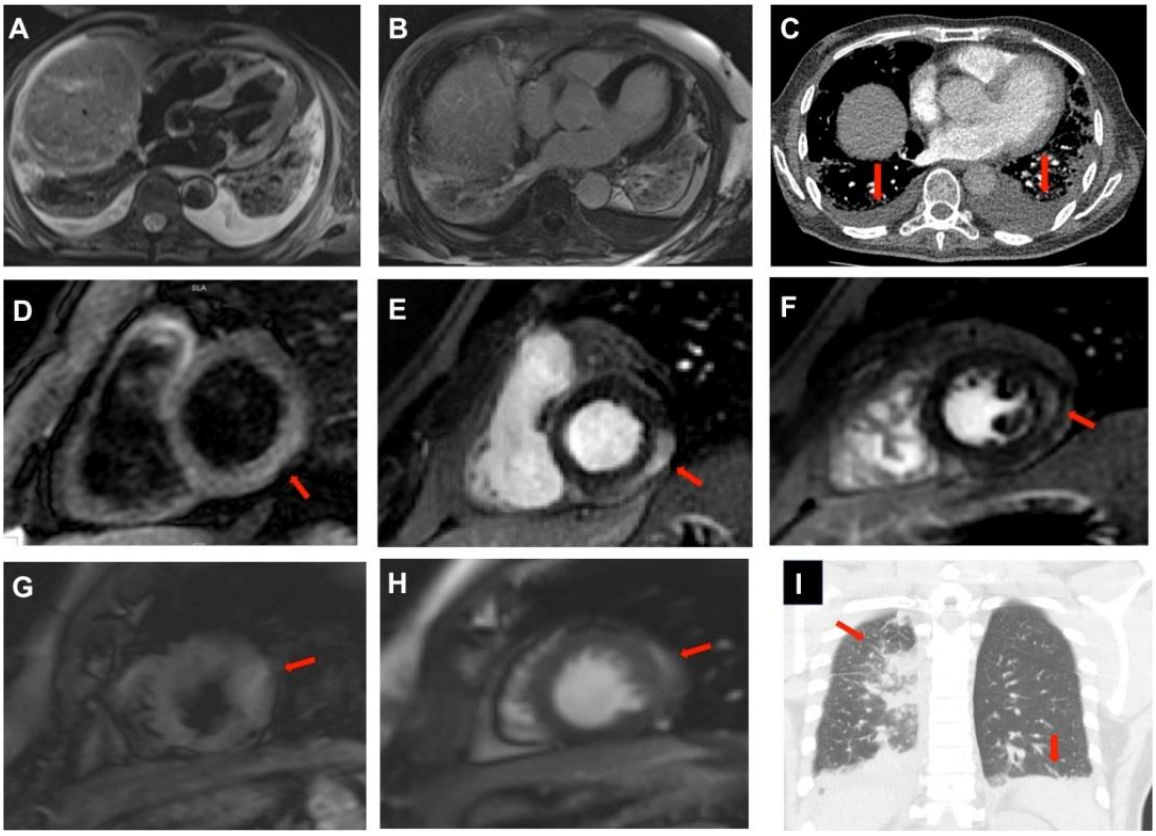

Figure 1: Imaging in hospitalized COVID-19 patients (acute phase). **Top Panels (Case 1).** T2-STIR (A) and LGE (B) CMR images without pathological cardiac findings. Chest CT showing bilateral pulmonary infiltrates and pleural effusion (arrows) (C); **Middle Panels (Case 2)**. T2-STIR showing mild epicardial increased signal intensity in the basal inferolateral wall (D), coincident with subepicardial enhancement in the inferior and inferolateral walls on LGE (arrows) (E-F); **Bottom Panels (Case 3)**. T2-STIR images showing mild subepicardial hyperintensity at the apical lateral wall (G) coincident with subepicardial enhancement on LGE (arrows) (H). Chest CT showing bilateral pleural effusion and upper right lung consolidation (arrows) (I).

2.2 CMR in a COVID-19 patient recently discharged from the Hospital (subacute phase)

2.2.1 Case 4: Two weeks after hospital discharge, a 41-year-old man with positive PCR and previous ARDS, presented in the Emergency Room with atypical chest pain and positive troponin levels. Due to a poor acoustic window on TTE, a CMR study was requested. CMR showed a normal-size LV with global hypokinesia causing mild dysfunction (LVEF of 50%), and absence of edema and LGE (Figure 2A-C). In this case, CMR allowed accurate quantification of LV volume and function, overcoming a poor-quality TTE. Although the initial clinical suspicion was myocarditis, CMR did not show any evidence of acute inflammation or fibrosis. Coronary artery disease hence needs to be ruled out as a cause of the episode.

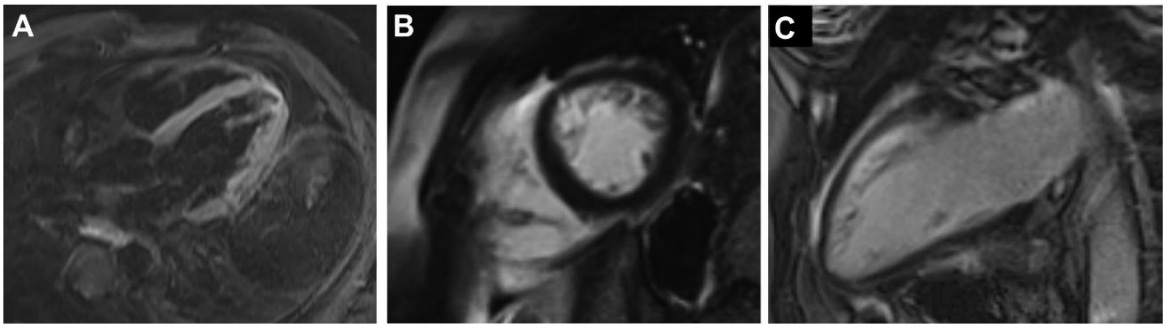

Figure 2: CMR imaging in a COVID-19 patient recently discharged from the Hospital (subacute phase) (Case 4). STIR (A) and LGE (B-C) images with normal myocardial signal.

2.3 CMR diagnosis of non-COVID-19 cardiomyopathies in times of COVID-19

2.3.1 Case 5: A 29-year-old man with Alport syndrome on hemodialysis was admitted to the Intensive Care Unit with ARDS under the suspicion of COVID-19 cardiac injury. Initial testing showed increased cardiac enzymes, normal ECG and biventricular dysfunction on TTE with limited visualization. CMR accurately quantified biventricular volumes and function, showing severe LV dysfunction and dilatation (online video 2), compatible with chronic cardiomyopathy. Tissue characterization with T1 and T2 mapping sequences were performed showing prolonged native T1 values (1386 ± 18 ms, normal range 1232 ± 51 ms), with normal T2 mapping and T2-STIR. LGE was not performed due to severe renal failure. Prolonged native T1 mapping with normal T2 mapping and T2-STIR images suggest the presence of diffuse myocardial fibrosis, possibly due to uremic cardiomyopathy secondary to the underlying chronic kidney disease (Figure 3A-C). During hospitalization, both PCR and antiCOVID-19 test results were negative.

2.3.2 Case 6: A 70-year-old man was referred to a routine CMR for aortic insufficiency evaluation in our Center. CMR incidentally showed changes in signal intensity at posterior lung parenchyma, suggestive of ground glass pattern and subepicardial /intramyocardial fibrosis in the basal inferolateral on LGE (Figure 3D-F). On clinical

history the patient reported a recent history of COVID-19 infection in clinical remission, compatible with pulmonary and cardiac CMR incidental findings.

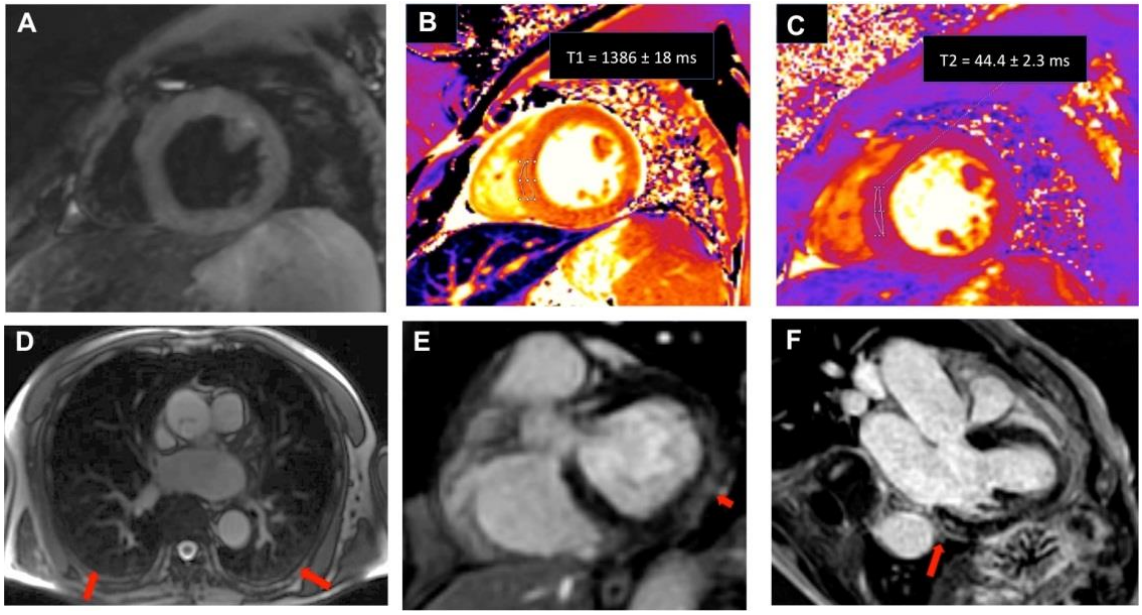

Figure 3: CMR diagnosis of non COVID-19 cardiomyopathies in times of COVID-19. **Top Panels (Case 5)**. T2-STIR images with normal signal intensity (A). T1 (B) and T2 mapping (C) images showing prolonged native T1 (1386 ± 18 ms, normal range 1232 ± 51 ms), and normal T2 mapping (44.4 ± 2.3 ms, normal range from 39.9 to 50.1 ms). **Botton Panels (Case 6)**. Pulmonary CMR incidental findings at posterior lung parenchyma. (arrows) (D)**.** LGE images showing subepicardial/intramyocardial enhancement in the basal inferolateral wall (E-F).

3. Discussion

COVID-19 era entails an important diagnostic challenge for cardiac imaging. CMR may help in the characterization of myocardial injury at different phases of the disease, as we have shown in cases 1 to 4, including acute/subacute myopericarditis and stress cardiomyopathy, in agreement with previous studies [5,6]. Interestingly, two patients presented with significant left ventricular dysfunction in the acute phase followed by a rapid LVEF recovery without evidence of myocardial scarring on follow-up-CMR, probably in the context of systemic inflammation, hypoxic damage, and a coexisting procoagulant state. Thus, CMR may be particularly useful in providing a differential diagnosis for COVID-19 cardiac damage and hence, guide clinical management [7]. As shown in cases 4 and 5, CMR overcome echocardiographic limitations, such as poor echocardiographic window or limited echo quality by the inconvenience of performing an echo in a COVID setting, because it provides accurate LVEF quantification. Furthermore, CMR can improve diagnostic accuracy by tissue characterization over troponin levels, which may proof to be less specific in a complex, multisystemic disease such as COVID-19 (as shown by the poor correlation

between troponin levels and CMR findings). It is important to note that chronic cardiac diseases unrelated to COVID-19 may be underdiagnosed during the current health crisis, as was the case in 5. Under normal circumstances, diagnosis may have been clear but clinical suspicion of COVID-19 infection challenges its assessment. Finally, CMR must be able to diagnose extracardiac and cardiac incidental findings compatible with COVID-19 infection, past or current. Case 6 shows the presence of pulmonary involvement compatible with previous COVID-19 infection and myocardial fibrosis in probable relation to the disease. The wide variety presented in these cases reflects the importance of CMR in the COVID-19 era. CMR units should keep in mind that any patient might be potentially infected and hence, safety and protection measurements must be implemented. Also, specialists must receive proper equipment and training to ensure safety in managing patients. In this context, the Society of CMR has recently provided guidance for the practice of CMR during the COVID-19 era [3]. Recommendations include the use of a single scanner and implementing shortened protocols. Organizational changes to attend both COVID and non-COVID patients and updated in CMR protocols of each CMR Unit are needed. Carrying out CMR scans for COVID patients at specific time during the day, selecting ambulatory cases, carrying out exhaustive sanitizing of facilities between scans, applying shorter acquisition protocols which should ideally be planned in advance, as well as carrying out remote imaging supervision and offline CMR analysis are among some of the measures that we have implemented in our Center.

In conclusion, the current COVID-19 pandemic has imposed a new reality, which has affected all areas of healthcare, including the CMR field. We have observed different CMR patterns of cardiac involvement at different phases of COVID-19 infection, each representing different diagnostic challenges. CMR can help understanding the cardiac involvement of this novel disease in terms of diagnosis, clinical management and will most probably be key in understanding mid-long term cardiac damage.

4. Take-Home Messages

- CMR has an important role in characterizing the various presentations of cardiac involvement of COVID-19, which may inform clinical treatment and prognosis.
- A wide differential diagnosis should be considered while characterizing myocardial injury in COVID-19 patients, including transient LV dysfunction secondary to direct and indirect, systemic mechanisms.
- CMR acquisition protocols, patients and staff safety and pre-procedural planning must be revised and updated to meet the challenges imposed by the COVID era.
- Extracardiac findings, such as pulmonary infiltrations on CMR, are key in asymptomatic patients in the diagnosis of current or past covid-19 infection.

5. Learning Objectives

- These clinical cases demonstrate the various clinical presentations of cardiac damage in COVID-19, characterized by CMR, both during hospitalization and ambulatory settings.
- CMR studies inform diagnosis, clinical management, and prognosis, and will be key in understanding longer-term cardiac involvement of COVID-19.
- Cardiac imaging Units need to adapt to meet the challenges imposed by COVID-19, including case selection, adapted acquisitions protocols, and safety procedures to guarantee patient and healthcare professional safety.

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Conflict of Interest

None of the authors have conflict of interest relevant to the subject material in this paper without financial relationships.

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