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Review Article

Cardiac Magnetic Resonance Imaging in Patients with COVID-19

Ali Kemal Erenler^{1*}, Seval Komut¹ and Ahmet Baydin²

¹Department of Emergency Medicine, School of Medicine, Hitit University, Çorum, Turkey

²Department of Emergency Medicine, School of Medicine, Ondokuz Mayıs University, Samsun, Turkey

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ABSTRACT

In the beginning of December 2019, an outbreak of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was determined in Wuhan, Hubei, China. Besides its predominant respiratory system-related symptoms, cardiovascular involvement has also been described in adults with direct and indirect cardiac injury. Pre-existing cardiovascular disease and cardiac risk factors have been shown to increase the risk of cardiac complications of COVID-19 infection. However, it is also known that healthy and asymptomatic COVID-19 survivors suffer cardiac damage-related complications. Cardiac Magnetic Resonance Imaging (CMRI) is known to be the reference non-invasive standard to present cardiac function and tissue characterization. It is recommended as an effective and efficient diagnostic imaging choice to obtain critical information for clinical diagnosis and decision-making. In this article, we sought the usefulness of CMRI in cardiovascular complications related to COVID-19.

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Introduction

A series of unexplained pneumonia occurred in Wuhan, Hubei Province, China, in December 2019 and lately severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was officially identified as their underlying cause. Given the quick and steady viral spread, SARS-CoV-2 became such a big challenge for public health that Coronavirus Disease 2019 (COVID-19) was declared as a pandemic by the World Health Organization (WHO) on March 11th, 2020 [1, 2]. Although the disease was well-defined with its respiratory symptoms in the beginning, it was understood that it has also involved cardiovascular complications as a cause of morbidity and mortality. The risk of cardiac complications increases in patients with a history of cardiovascular disease, however, healthy and asymptomatic COVID-19 survivors may suffer cardiac complications [3]. Virus itself and the drugs used as therapeutics may have harmful cardiovascular side effects and interactions with other medications. Cardiac magnetic resonance imaging (CMRI) may be a promising non-invasive imaging method that indicates reversible and/or reversible tissue damage in patients with COVID-19 [4]. In this narrative review, we aimed to underline the diagnostic importance of CMRI in patients with COVID-19.

Material and Methods

This study was conducted by entering terms “coronavirus”, “COVID-19”, “cardiac” and “magnetic resonance imaging” into Pubmed[®] Database. Relevant original articles, reviews and case reports were involved into the study. Articles written in other languages than English and those without explanatory abstracts were excluded. A total of 74 articles were evaluated by two reviewers independently according to their relevance to the subject. Finally 54 articles were excluded and the remaining 20 articles were discussed by three reviewers.

Discussion

It is known that cardiac injury occurs up to 30% of the patients with COVID-19 and it is correlated with the severity of the disease [5]. The mechanism of myocardial injury as a result of COVID-19 is still unclear, however it is clear that cardiac complications are associated with poor prognosis. In order to improve outcomes, echocardiography and CMRI are both useful to make an early diagnosis. Echocardiography is used for early diagnosis and allows to perform at bedside. At the other hand, CMRI is used in refining diagnosis with a short protocol in the acute phase and complete protocol in late phase [4]. It was reported that CMRI

*Correspondence to: Ali Kemal Erenler, M.D., Associate Professor in Emergency Medicine, Department of Emergency Medicine, School of Medicine, Hitit University, Çorum, Turkey; E-mail: akerenler@hotmail.com

could be helpful in making a diagnosis, deciding therapeutics and predicting prognosis. It may also be helpful in differentiating between ischaemic and non-ischaemic acute myocardial injury [6].

Society for Cardiovascular Magnetic Resonance (SCMR) underlined the ability of CMRI in diagnosis of cardiovascular abnormalities during pandemic [7]. They declared: “CMRI is the reference non-invasive standard for cardiac function and tissue characterization and may offer an effective and efficient diagnostic imaging choice to obtain critical information for clinical decision-making. In patients with confirmed or suspected active COVID-19 and clinical evidence of myocardial injury, CMRI may provide important and clinically useful information regarding the presence, etiology, and severity of myocardial injury. Focused protocols that assess ventricular morphology and function, as well as myocardial tissue characterization, are recommended” [8]. Facilities must be prepared for imaging in terms of physical distancing and protective clothes and timing for imaging must be scheduled carefully. SCMR classified cardiovascular imaging studies into three groups as urgent, semi-urgent and elective, and advised to delay non-urgent ones [7].

In CMRI, late gadolinium enhancement (LGE) is an indicator of areas with necrosis and fibrosis. Fatal ventricular arrhythmias may arise from these areas. LGE-negative patients have more favorable outcomes [4]. Recently, Inciardi *et al.* revealed severe biventricular myocardial injury with edema and LGE in COVID-19 [9]. In another study, CMRI was performed to diagnose myocarditis based on Lake Louis Criteria [10]. The findings of myocarditis are signs of myocardial edema on T2-weighted imaging and myocardial injury on T1-weighted imaging with LGE. In a review with 31 studies on 51 patients, diffuse hypokinesis in the left and/or right ventricles was determined in 3 patients, and one patient had mild hypokinesis at basal and mid LV segments on T1-weighted imaging. On T2-weighted imaging, 6 patients had diffuse increase in signal uptake suggesting diffuse myocardial edema, one patient had localised edema in the apical region and another in the mid inferoseptal and inferior wall regions. Only one patient reported no edema on initial CMRI and 2 patients had resolution of edema within 2 weeks. Imaging with LGE found non-ischaemic patterns of enhancement in 8 patients. The inferolateral regions were most commonly affected, and LGE ranged from subepicardial to transmural patterns [11].

In a young patient with shock state due to COVID-19, diminished LVEF of 40% and regional hypokinesia were confirmed by CMRI demonstrating global biventricular systolic dysfunction, as well as a small area of T2 hyperintensity and mid-wall LGE [12]. In another study investigating athletes with a history of COVID-19, it was reported that 9% had LGE in CMRI. One patient met the criteria for myocarditis [13]. Cardiac damage such as myocardial edema, fibrosis, and impaired right ventricle function may also be determined by CMRI in patients recovered from COVID-19 [14]. In patients recovered from COVID-19, myopericardial inflammation or scarring were determined in 78% by CMRI [15]. In a primigravida with sudden cardiac death, early CMRI was performed for the diagnosis of peripartum cardiomyopathy and for the exclusion of virus-related myocarditis [16]. Besides, the only indicator of myocardial inflammation may be diffuse edema when LGE is absent or minimal in CMRI [17]. In an 18-year-old patient with COVID-19, CMRI revealed increased LV wall thickness, increased LV volumes with marked diffuse hypokinesis, mild pericardial effusion and

myocardial edema without perfusion defects [18]. By CMRI, regional wall motion abnormalities of the ventricles may also be determined [19].

Conclusion

Cardiac morphology and function may be determined by CMRI. It also has ability provide tissue characterization so that it is a good tool for cardiac study in patients with COVID-19. In the absence of epicardial coronary artery stenosis, sub-clinical myocardial dysfunction in COVID-19 may be a consequence of an impairment of microcirculatory endothelial function observed during the early stages of the systemic inflammatory response to the infection [20]. Also, as mentioned above, direct COVID-19-mediated infection of endothelial cells might contribute to cardiac injury [21]. Particularly virus-related myocarditis results from the interaction of the virus with the host's immune system [19]. It is well-documented in the literature that the gold standard in the diagnosis of myocarditis is histopathological evidence by endomyocardial biopsy (EMB) which is an invasive procedure. COVID-19 patients have a high risk for virus spread so that it is often not clinically performed. At that point, CMRI arises as an alternative tool [11].

Even though short and dedicated CMRI examinations that focus on the evaluation of cardiac morphology and function, as well as myocardial tissue characterization are recommended, to avoid transmission of the virus to the healthcare providers, CMRI studies may be postponed [22]. CMRI may indicate features of myocarditis (contractile dysfunction, inflammatory edema, necrosis) and its non-invasive nature makes it the gold standard in diagnosis. The diagnosis is based on conventional cine images, T2-weighted sequences, T1 and T2 parametric maps, and LGE images. LGE also helps to determine the degree of myocardial necrosis which is a strong predictor of prognosis [23].

Conflicts of Interest

None.

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