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Case Report

Cardiac magnetic resonance findings in acute myocarditis after mRNA COVID-19 vaccination

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ABSTRACT

There is increasing evidence for myocarditis as a complication of the mRNA coronavirus disease 2019 (COVID-19) vaccination. We report the case of a 20-year-old previously healthy man who presented with fever and chest pain 2 days after the second dose of mRNA-1273 vaccine. Electrocardiogram and laboratory studies showed extensive ST-segment elevation accompanied by elevated cardiac biomarkers. Cardiac magnetic resonance (CMR) revealed late gadolinium enhancement (LGE) characteristics of myocarditis. The patient rapidly improved with conservative management and was discharged on hospital day 6. As an advantage over previous reports, we performed a 1-month follow-up CMR. It showed improvement in myocardial edema but persistence of LGE which may indicate irreversible fibrosis. CMR may be useful not only for diagnosis but also for prognostic evaluation of myocarditis after COVID-19 mRNA vaccination.

<**Learning objective:** With the expansion of coronavirus disease 2019 (COVID-19) vaccine administration, the number of cases of myocarditis as a complication has been increasing. Cardiac magnetic resonance imaging can be useful for the diagnosis and follow-up of patients with myocarditis after mRNA COVID-19 vaccination. Persistent late gadolinium enhancement may indicate irreversible myocardial fibrosis, and it is also associated with poor prognosis, similar to previously reported cases of other acute myocarditis.>

Introduction

Coronavirus disease 2019 (COVID-19) has become a pandemic and affected millions of people since December 2019. With the development of novel mRNA based vaccines for COVID-19, a variety of possible vaccine-related adverse events have been reported [1]. Here, we report a case of mRNA-1273 (Moderna, Cambridge, MA, USA) vaccine-associated myocarditis in a previously healthy young man. Some previous reports showed the diagnostic value of cardiac magnetic resonance (CMR). In this case, we also had special attention to CMR findings of 1-month follow-up.

Case report

A previously healthy 20-year-old man presented to his primary physician with fever and chest pain 2 days after the second dose of mRNA-1273 vaccination. He had no history of recent viral illness or known COVID-19 exposure. His vital signs were stable, except for body temperature that indicated a high-grade fever (38.9 °C). Physical examination, chest radiography, and computed tomography images were normal. His electrocardiogram (ECG) showed extensive ST-segment elevation with PR-segment depression. Initial blood tests revealed that creatine kinase (CK) and CK-MB isoforms were within the normal range. High-sensitivity troponin T (0.104 ng/mL, normal range: <0.016 ng/mL), C-reactive protein (CRP) (1.9 mg/dL, normal range: <0.50 mg/dL), and white blood cell (WBC) (12,030/μL, normal range: 3,300–9,000/μL) were elevated. Acute myocarditis was suspected, and the patient was referred to our hospital the next day. ECG abnormalities remained unchanged (Fig. 1). His blood tests were remarkable with elevated cardiac and inflammatory markers with high-sensitivity troponin I (76.8 ng/L, normal range: <0.028 ng/L), CK (1,488 U/L, normal range: 60–250 U/L), CK-MB (99.7 U/L, normal range: <12 U/L), CRP (5.33 mg/dL, normal range: <0.50 mg/dL), N-terminal pro-B-type natriuretic peptide (595 pg/mL, normal range: <125 pg/mL). Transthoracic echocardiography (TTE) showed a mildly reduced left ventricular ejection fraction (LVEF) of 42.4% with inferolateral hypokinesis and no significant valve disease. Coronary angiography revealed no obstructive coronary artery disease, and right heart catheterization revealed a preserved cardiac index (3.83 L/min/m^2 of body surface area as measured by the thermo dilution method)

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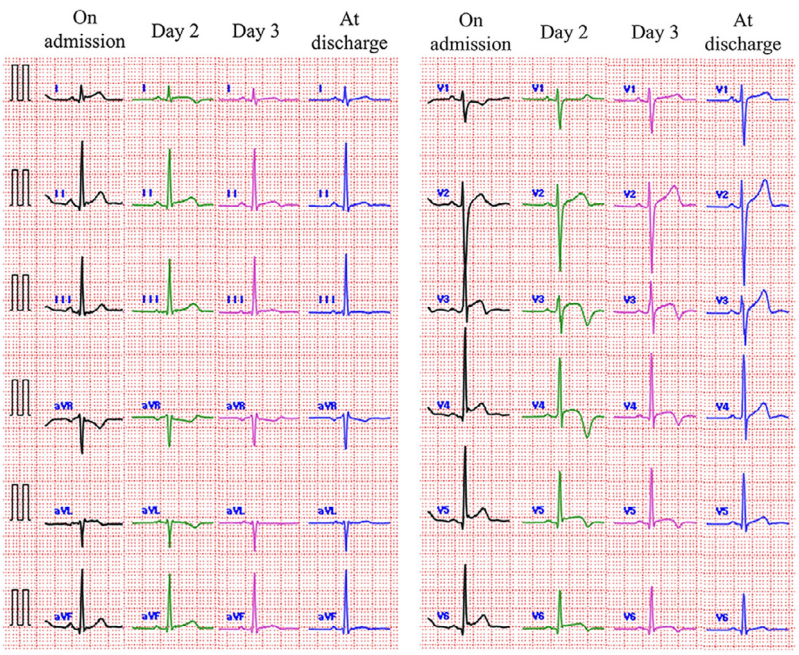

Fig. 1. **ECG changes during hospitalization.** ECG shows diffuse ST segment elevations on admission. Terminal T inversions are seen at day 2–3, and ST changes are normalized at discharge. ECG, electrocardiogram.

and normal pulmonary capillary wedge pressure (11 mmHg). An endomyocardial biopsy obtained from the mid-septum of the right ventricle showed myocardial edema but no inflammatory infiltrate. CMR revealed reduced LVEF (38.3%) and native T1-map (Fig. 2A) and T2-map (Fig. 2B) images showed hyperintense signals in the anterolateral to inferolateral wall, indicating myocardial hyperemia and edema. Sub-epicardial and mid-myocardial late gadolinium enhancement (LGE) was present in the anterolateral to inferolateral walls (Fig. 2C, D), which is consistent with the wall-motion abnormality in TTE. A nasopharyngeal viral panel and serological tests showed no evidence of active infection with severe acute respiratory syndrome coronavirus 2 and other potential cardiotropic viruses. He did not present with any other symptoms suggestive of autoimmune disorders and had unremarkable autoimmune serologies. Although a direct causal relationship could not be definitively established, the patient was diagnosed with vaccine-associated myocarditis because of the temporal association between vaccination and the onset of symptoms. He developed atrial fibrillation during cardiac catheterization on hospital day 1, and intravenous aprindine was administered, which restored sinus rhythm within several hours. He remained hemodynamically stable and was successfully managed with supportive therapies. Cardiac biomarkers (CK, CK-MB, and troponin I) and CRP peaked on the admission day, and ST-segment resolution was noted on ECG in the following days (Fig. 1). TTE performed on hospital day 5 showed a normal LVEF with no wall motion abnormalities. He was discharged on hospital day 6, without any symptoms. CK and CK-MB were normalized, and CRP and troponin I declined to 0.55 mg/dL (normal range: <0.50 mg/dL) and 23.0 ng/L (normal range: <0.028 ng/L) respectively. At the 1-month follow-up visit, the patient was completely asymptomatic, and his ECG and laboratory tests including high-sensitivity troponin I and CRP were normalized. CMR performed 1 month after discharge showed improved T1 (Fig. 3A) and T2 (Fig. 3B) elevation, but sub-epicardial LGEs were persistent (Fig. 3C, D), which may indicate irreversible myocardial fibrosis.

Discussion

As the COVID-19 outbreak has spread all over the world, mRNA vaccines have been approved for human use. The mRNA vaccines demonstrated excellent safety and clinical efficacy profiles in phase 3 clinical trials in adults [2,3]. Although no cases of myocarditis have been reported in clinical trials, with the expansion of vaccine administration, there are a growing number of reports of myocarditis after mRNA COVID-19 vaccination [1,4–6]. mRNA COVID-19 vaccination is associated with an elevated risk of myocarditis [1]. It predominantly occurs in young male adolescents within a few days after a second dose of vaccination [4]. While endomyocardial biopsy remains the confirmatory test in the diagnosis of myocarditis, it is an invasive test with risk of complications and carries the limitation of tissue sampling errors due to the focal nature of myocardial inflammation [7]. CMR is an established noninvasive modality for the diagnosis of myocarditis based on Lake Louise Criteria revised in 2018: increased myocardial signal intensity ratio or increased myocardial relaxation times or visible myocardial edema in T2-weighted images, increased myocardial relaxation times or extracellular volume fraction, or LGE in T1-weighted images [8]. The myocardial tissue characteristics observed in our patient were similar to those observed in acute viral myocarditis. CMR is considered useful for the diagnosis of COVID-19 mRNA vaccine-related myocarditis. The mainstay of management is supportive care, including arrhythmia management and treatment of heart failure [4]. Although some fatal cases have been reported [5], the clinical course is typically self-limited [4].

Herein, we report a patient with myocarditis after the administration of the mRNA COVID-19 vaccine. Our patient was a young man who had symptoms 2 days after the second dose of vaccination. He had typical symptoms, elevated biomarkers, and an ECG profile. Although the endomyocardial biopsy was negative, CMR led to the diagnosis of acute myocarditis. His LVEF was reduced after admission, but he developed no symptoms of heart failure and recovered within a few days.

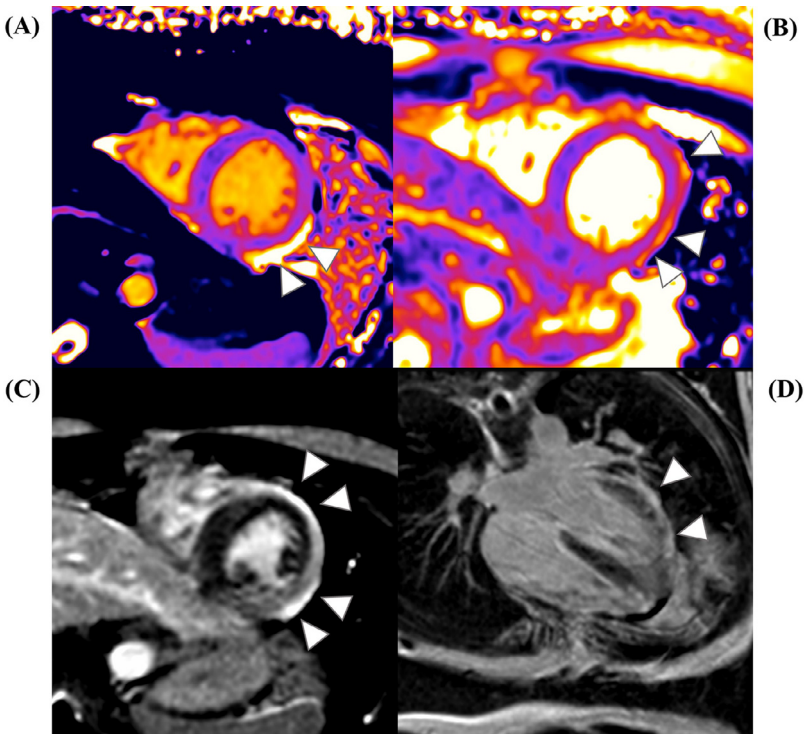

Fig. 2. **Cardiac magnetic resonance images on the admission day.** Native T1-map (A) and T2-map (B) images in the short-axis view show a hyperintense signal in the anterolateral to inferolateral walls. Late gadolinium enhancement imaging in short-axis view (C) and four-chamber view (D) show subepicardial and mid-myocardial enhancement in the corresponding regions.

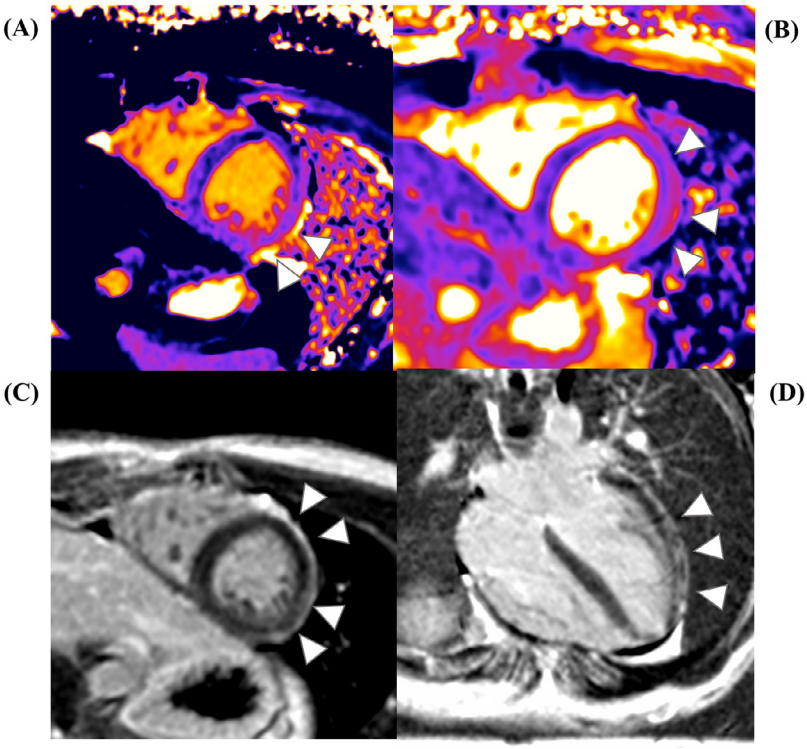

Fig. 3. **Cardiac magnetic resonance images at 1 month follow-up.** Native T1-map (A) and T2-map (B) images in the short-axis view reveal improvement of hyperintense signal in the anterolateral to inferolateral walls. Late gadolinium enhancement imaging in short-axis view (C) and four-chamber view (D) shows persistent subepicardial and mid-myocardial enhancement in the corresponding regions.

The clinical utility of CMR for the diagnosis of myopericarditis after the mRNA-1273 vaccine has also been reported [6]. As an advantage over previous reports, we performed a 1-month follow-up CMR in addition to acute-phase CMR. Follow-up CMR revealed persistent LGE, which may indicate irreversible fibrosis and association with worse prognosis in myocarditis, even if left ventricular function and cardiac biomarkers are normalized [9,10]. The prognostic significance of these CMR findings in myocarditis after COVID-19 mRNA vaccination is unknown at this time, and further follow-up is needed.

In conclusion, acute myocarditis should be considered in patients who present with chest pain or dyspnea within a few days of receiving mRNA COVID-19 vaccination, especially after the second dose. CMR may be useful for diagnosis and follow-up. Further studies are needed to elucidate long-term clinical outcomes.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

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