

# A report on short-term follow-up cardiac imaging and clinical outcomes of myocarditis after coronavirus disease 2019 vaccination

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## To the Editor,

Myocarditis as a rare complication after coronavirus disease 2019 (COVID-19) mRNA vaccination in adolescents and young adults has been recently reported;<sup>1,2</sup> however, follow-up data was lacking.

## Methods

This is an observational case series of patients who were diagnosed with myocarditis after mRNA COVID-19 vaccination. The clinical characteristics, short-term (4–6 months) follow-up cardiac imaging and clinical outcomes are described.

## Results

A total of six male patients with a median age of 16 years [interquartile range, (IQR) 14–18] were diagnosed with myocarditis after mRNA COVID-19 vaccination at our center. All patients presented with acute onset chest pain within 2–5 days of a second dose of COVID-19 mRNA vaccine (Pfizer/BioNTech). A majority of the patients (five of six) had no clinical history of past or active COVID-19 infection reported and one patient was tested positive for spike protein immunoglobulin G (IgG) antibody suggestive of past infection.

There was evidence of myocardial involvement with a median peak high-sensitivity troponin of 1502 ng/ml (IQR, 1094–2126). C-reactive protein was elevated in all patients with a median of 10.65 mg/dl (IQR, 2.69–47.75). Electrocardiogram (ECG) patterns varied with ST-elevations being the most common, present in four of six patients (67%). Transthoracic echocardiograms (TTE) showed normal left ventricular ejection fraction

(LVEF) with only one patient having depressed LVEF of 35% (did not have worse clinical presentation and no heart failure symptoms). Five out of six patients (83%) underwent cardiac magnetic resonance (CMR) during acute hospitalization. All patients met CMR modified Lake Louise Criteria for acute myocarditis.<sup>3</sup> All five patients had extensive late gadolinium enhancement (subepicardial and mid myocardial involving multiple segments). Our patient with depressed LVEF on the TTE showed an improved LVEF of 45% on the same hospitalization CMR. The median hospital length of stay was 3.5 days (IQR, 3–4 days). Treatment comprised ibuprofen for 2 weeks with complete resolution of symptoms at hospital discharge. All cases were reported to the vaccine adverse event reporting system and the Centers of Disease Control (CDC).

At a median outpatient follow-up of 159 days (IQR, 46–178) from discharge, no recurrence of chest pain or other cardiac symptoms such as palpitations or syncope were reported. ECGs were performed in five of six patients. Four patients had normalized ECGs while one patient had nonspecific early repolarization changes. All patients had normal Holter monitor studies and exercise stress testing. All patients completed repeat CMR imaging at a median follow-up of 117 days (IQR, 88–118). A significant reduction in LGE burden was observed in all patients along with normalization of native T1 and T2 parameters suggestive of resolution of myocardial edema and inflammation (Table 1). Based on the above findings, all patients were cleared for gradual return to physical activities.

## Comment

Multiple studies have shown that myocarditis after COVID-19 vaccination is extremely rare with a reported rate of approximately 12.6 cases per million doses of second-dose mRNA vaccine described among individuals 12–39 years of age, as per the CDC.<sup>4</sup> Short- and long-term studies looking at outcomes are lacking and likely in the pipeline. Based on our single-center cohort findings, all patients with myocarditis after mRNA COVID-19 vaccination had favorable short-term outcomes without any adverse events at outpatient follow-up. Weighing the increasing rates of hospitalization with acute COVID-19 infection in adolescents and young adults, with nearly a

Table 1 Short-term follow-up of patients recovering from myocarditis after COVID-19 vaccination

Patient no./age on presentation (years)	Presenting symptoms 2–5 days after second dose of mRNA COVID-19 vaccination	Prior heart disease/myocarditis/pericarditis	ECG on presentation	TTE on presentation	CMR on presentation	Follow-up ECG, median duration of follow-up 159 days (IQR, 46–178)	Follow-up TTE, median duration of follow-up 22 days (IQR, 18–38)	Follow-up CMR, median duration of follow up 117 days (IQR, 88–118)
1/15	Acute onset chest pain for 24 h	None reported	ST elevation in anterolateral leads	LVEF 63%, no RWMA, Borderline abnormal diastolic function (lateral E' velocity of 0.6 m/s)	Edema, patchy subepicardial late gadolinium enhancement	Resolved ST-T wave changes	LVEF 64%, no RWMA, normal diastolic function	Resolved edema, small focal areas of subepicardial late gadolinium enhancement
2/17	Fever [101 °C], malaise for 2 days; midsternal chest pain radiating to shoulders for 1 day	None reported	ST elevation in inferolateral leads	LVEF 65%, no RWMA, normal diastolic function	Edema, patchy mid-myocardial and subepicardial late gadolinium enhancement	Sinus arrhythmia	LVEF 68%, no RWMA, normal diastolic function	Resolved edema, Small patchy low intensity late gadolinium enhancement
3/14	Burning chest pain and shortness of breath for 24 h	None reported	ST elevation in anterolateral leads	LVEF 62%, no RWMA, normal diastolic function	Edema, patchy subepicardial late gadolinium enhancement	Early repolarization changes	LVEF 67%, no RWMA, normal diastolic function	Resolved edema, no late gadolinium enhancement
4/12	Substernal chest pain for 2–3 days	None reported	ST elevation in inferior leads	LVEF 64%, no RWMA, normal diastolic function	Edema, patchy subepicardial late gadolinium enhancement	Resolved ST-T wave changes	LVEF 65%, no RWMA, normal diastolic function	Small focal late gadolinium enhancement
5/20	Substernal pressure like chest pain for 4 days	None reported	Tall peaked symmetrical T waves, without QRS widening, P waves diminished	LVEF 35%, moderate global hypokinesis with LVEF 45%, edema, patchy subepicardial late gadolinium enhancement	NA	NA	NA	Global hypokinesis with LVEF 45%, resolved edema, persistent slightly reduced late gadolinium enhancement
6/16	Sharp substernal chest pain for 1 day	None reported	Sinus tachycardia	LVEF 66%, no RWMA, normal diastolic function	NA	Sinus arrhythmia	LVEF 69%, no RWMA, abnormal tissue Doppler suggestive of diastolic dysfunction	Absence of acute edema. Focal subepicardial late gadolinium enhancement. Imaging suggestive of history of acute myocarditis

COVID-19, coronavirus disease; CMR, cardiac magnetic resonance; IQR, interquartile range; LVEF, left ventricular ejection fraction; TTE, transthoracic echocardiograms; RWMA, regional wall motion abnormality.

third of them requiring intensive care, these findings help tip the balance scale further towards vaccination as a preferred risk prevention strategy.<sup>5</sup> Our study limitations include small patient number, difficult to prove causality, cases missed in outside care settings and missed subclinical myocarditis. Therefore, the investigators feel an urgent need for larger multicenter studies in order to establish formal guidelines on future vaccination strategies in these patients, long-term follow-up and return to sports and physical activities.

## Conclusions

In conclusion, myocarditis after mRNA COVID-19 vaccination must be considered in the differential diagnosis of patients who develop chest pain within 2–5 days after receiving the vaccine. Fortunately, most cases can be

expected to be self-limited with favorable short-term outcomes in this single-center cohort. Long-term outcome data remain to be studied.

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