ESC European Society of Cardiology

European Heart Journal - Case Reports (2020) **4**, 1–5
doi:10.1093/ehjcr/ytaa180

CASE REPORT
Cardiac imaging

Case report of an isolated myocarditis due to COVID-19 infection in a paediatric patient

Quentin Fischer [1], Nina Brillat-Savarin[2], Grégory Ducrocq[1], and Phalla Ou [2]*

[1]Department of Cardiology, Hôpital Bichat, Assistance Publique-Hôpitaux de Paris, DHU FIRE, INSERM U-1148, Université de Paris, Paris, France; and [2]Department of Radiology, Hôpital Bichat, Assistance Publique-Hôpitaux de Paris, DHU FIRE, INSERM U-1148, Université de Paris, Paris, France

Received 2 May 2020; first decision 6 May 2020; accepted 27 May 2020; online publish-ahead-of-print 3 July 2020

Background Cardiovascular complications of COVID-19 have been reported in the adult population including myocarditis. However, less is known about the myocardial involvement in paediatric patients.

Case summary A 15-year-old boy was admitted to our intensive cardiac care unit with COVID-19 and an isolated acute myocarditis, confirmed on cardiac magnetic resonance imaging. No pulmonary lesion was observed on the chest CT scan. We report here the initial presentation, medical care, and clinical course of this patient.

Discussion In the context of the acute COVID-19 outbreak, screening for COVID-19 infection should be performed in children presenting with myocardial injury in an inflammatory context.

Keywords Case report • Myocarditis • COVID-19 • Children

Learning points

- Cases of multisystem inflammatory disease with myocardial injury are increasing in children tested positive for COVID-19.
- Acute myocarditis without pulmonary lesion can be observed in COVID-19 children.
- In the context of the acute COVID-19 outbreak, screening for COVID-19 infection should be performed in patients presenting with myocardial injury in an inflammatory context.

Introduction

Coronavirus disease-2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The outbreak of COVID-19 appeared in China in December 2019 and, since then, has spread worldwide at a rapid pace and has been declared a global pandemic by the World Health Organization as of 11 March 2020.[1]

Several cardiovascular complications of COVID-19 have been described in the adult population, and acute myocarditis appears to be relatively frequent.[2] Younger patients with COVID-19 infection can present with few or no symptoms or with atypical symptoms.[3]

On 27 April 2020, the Paediatric Intensive Care Society launched an alert concerning an increased number of reported cases of multisystem inflammatory disease with myocardial injury in children tested positive for COVID-19.[4] We report here the initial presentation, medical care, and clinical course of a paediatric patient presenting with an isolated myocarditis due to COVID-19 infection.

*Corresponding author. Department of Radiology, Bichat Hospital, 46 rue Henri Huchard, 75018 Paris, France. Email: phalla.ou@aphp.fr
Handling Editor: Monika Arzanauskaite
Peer-reviewers: Inga Voges and Erica Tirr
Compliance Editor: Christian Fielder Camm
Supplementary Material Editor: Ross Thomson
The videos are available in the online version of this article.
© The Author(s) 2020. Published by Oxford University Press on behalf of the European Society of Cardiology.
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com

Timeline

Time	Events
7 April	First symptoms: persistent chest pain with mild fever (38°C)
10 April 10:00 h	The patient presented to the emergency department. Despite apyrexia and the absence of respiratory signs, a nasopharyngeal swab was performed.
10 April 14:00 h	Nasopharyngeal swab returned positive for SARS-CoV-2.
	Chest CT scan showed no lung anomalies.
	Blood tests revealed a slight increase in C-reactive protein level (41 mg/L, normal <6 mg/L) with normal leucocytes (6.1 × 10^9/L), and elevated cardiac troponin 6.1 µg/L (99th upper reference limit 0.045 µg/L).
	Transthoracic echocardiography showed a mild diffuse hypokinesia with left ventricular ejection fraction at 50%, mild pericardial effusion around the lateral wall of the left ventricle (maximum, 5 mm) without signs of tamponade.
10 April 14:30	The patient was admitted to the cardiologic intensive care unit with a diagnosis of suspected myocarditis.
10 April 15:30	CMR showed moderate left ventricle dysfunction with LVEF of 48% and normal right ventricular function. It showed abnormal hyperintensity on T2-weighted image involving the posterolateral wall of the left ventricle, related to acute myocardial oedema. There was also late subepicardial post-gadolinium enhancement in the corresponding area. CMR fulfilled all the Lake Louise criteria and was typical of acute myocarditis
10 April 18:00 h	Beta-blockers and angiotensin-converting enzyme inhibitors were started.
13 April	High-sensitivity troponin I peaked at 13.1 µg/L (99th upper reference limit 0.045 µg/L).
15 April 11:30 h	The haemodynamics of the patient remained stable without indication for inotropic support.
	Patient was discharged from the hospital.
	The echocardiography performed at discharge showed a preserved LVEF at 55% with normal cardiac output.

Case presentation

A 15-year-old boy without cardiovascular risk factors or previous history of cardiovascular disease presented to the emergency department in our institution for persistent chest pain with mild fever (<38°C) for the last 3 days. The patient reported no respiratory tract signs.

The physical examination revealed blood pressure of 100/60 mmHg, heart rate of 75 b.p.m., oxygen saturation of 98% while breathing ambient air, and body temperature of 36.9°C. The electrocardiogram showed diffuse ST elevation without reciprocal changes (*Figure 1*).

Blood tests revealed a slight increase in C-reactive protein level (41 mg/L, normal <6 mg/L) with normal leucocytes (6.1 × 10^9/L, normal 4–10 × 10^9 cells/L) and elevated cardiac troponin 6.1 µg/L (99th upper reference limit 0.045 µg/L). N-terminal probrain natriuretic peptide (NT-proBNP 65 ng/L, normal <300 ng/L) and D-dimer (259 ng/mL, normal <500 ng/mL) remained normal.

Because of systematic suspicion of COVID-19 in patients with unexplained fever, a PCR was performed on a nasopharyngeal swab and resulted positive for SARS-CoV-2. A multiplex real-time PCR was also performed and resulted negative, allowing the exclusion of viral co-infections. Chest CT scan showed no lung anomalies (Supplementary material online). There were no other family members tested positive for SARS-coV-2.

Transthoracic echocardiography showed a mild diffuse hypokinesia with left ventricular ejection fraction (LVEF) at 50%, preserved cardiac output, normal right ventricular function, no significant valvular disease, and normal pulmonary pressure without lower vena cava dilatation. There was a mild pericardial effusion around the lateral wall of the left ventricle (maximum, 5 mm) without signs of tamponade (Supplementary material online).

The patient was admitted to the cardiology intensive care unit with a diagnosis of suspected myocarditis. Given the echocardiography changes and elevated markers of myocardial injury in a low cardiovascular risk patient, emergent cardiac magnetic resonance (CMR) imaging was performed on the day of admission.

CMR showed moderate left ventricular dysfunction with LVEF of 48% and normal right ventricular function. Tissue characterization based on T2-weighted and late gadolinium enhancement sequences revealed interstitial oedema and myocardial damage involving the subepicardial layer in the posterolaterobasal wall of the left ventricle. First-pass perfusion was normal. There was a mild pericardial effusion with an enhancement of the pericardium adjacent to the posterolaterobasal segment. Diagnosis of acute myocarditis was thus confirmed based on the classic Lake Louise criteria[5] (*Figure 2*; Supplementary material online)

According to the reliable CMR findings, typical of acute myocarditis, no subsequent coronary angiography and no endomyocardial biopsy were done.

The haemodynamics of the patient remained stable without indication for inotropic support. He remained afebrile and the biological inflammatory syndrome gradually decreased. No ventricular arrythmia was observed during his hospitalization. High-sensitivity troponin I peaked at 13.1 µg/L (99th upper reference limit 0.045 µg/L) on day 3. The patient was treated with beta-blockers (bisoprolol 2.5 mg daily) and angiotensin-converting enzyme inhibitors (ramipril 2.5 mg daily). Due to this favourable clinical course, no specific treatment of COVID-19 was introduced.

The patient was discharged from hospital on day 5 with a CMR scheduled control at 6 months. The echocardiography performed at

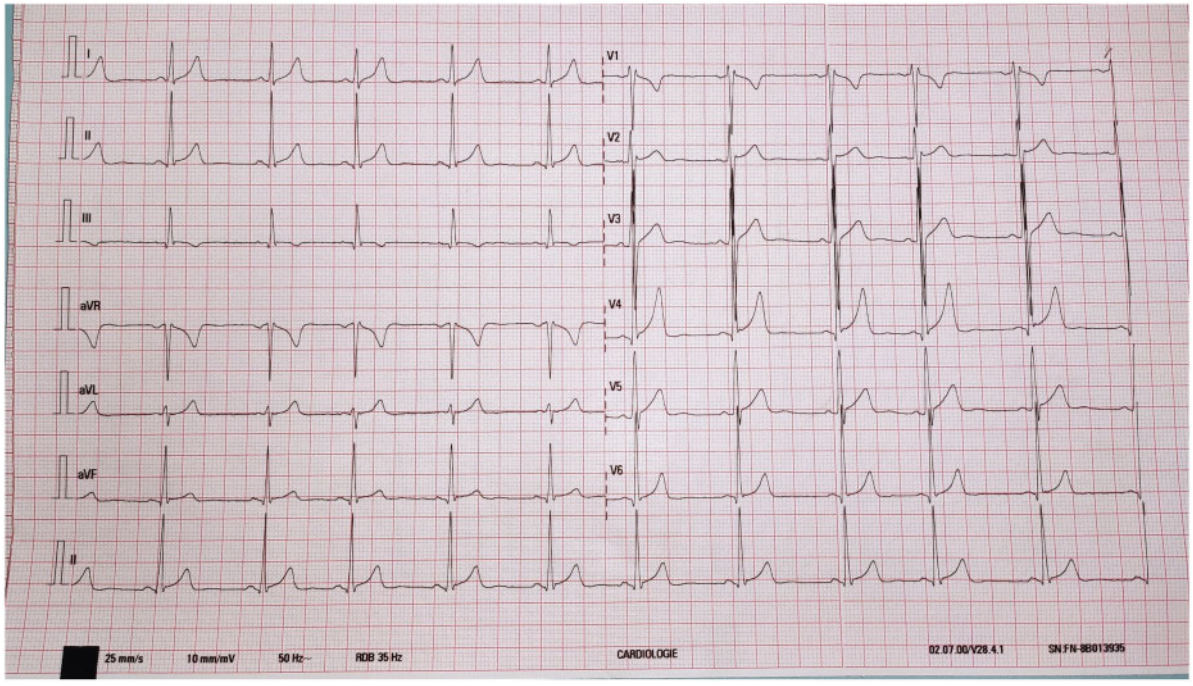

Figure 1 Electrocardiogram recorded at admission showed diffuse ST elevation without reciprocal changes.

discharge showed a preserved LVEF at 55% with normal cardiac output.

Discussion

Herein, we describe a 15-year-old boy without a history of cardiovascular disease admitted to the hospital with COVID-19 and an acute myocarditis. While the spectrum of clinical manifestation is highly related to the inflammation process of the respiratory tract, this case provides evidence of isolated cardiac involvement in a teenager at low cardiovascular risk without respiratory symptoms and a normal chest CT scan. There are several salient points from this case report.

First, although children are less likely than older adults to become severely ill, there are subpopulations of at-risk children including those with an underlying pulmonary pathology or immunocompromising conditions. Nevertheless, no risk factor was found in our patient, including the absence of family history of cardiomyopathies. Recently, an alert was launched concerning an increased number of reported cases of multisystem inflammatory disease with myocardial injury in children tested positive for COVID-19.[4]

Secondly, infection with viral pathogens, such as influenza and parvovirus B-19, has been widely described as the most common infectious cause of acute myocarditis.[6] However, less is known about the cardiac involvement as a complication of SARS-CoV-2 infection. The attributable risk for severe disease from COVID-19 in children is challenging to discern. Previous studies have revealed that children in whom coronaviruses are detected from the respiratory tract can have viral co-infections in up to two-thirds of cases.[7] In order to exclude viral co-infections, a multiplex real-time PCR was performed and resulted negative.

Thirdly, determination of the presence of myocardial injury in the COVID-19 population should be performed in all symptomatic patient. Shi *et al.*[8] reported the importance of myocardial injury in COVID-19 mortality in 416 patients hospitalized with COVID-19, of whom 57 died. Approximately 20% of patients had cardiac injury defined as high-sensitivity troponin I greater than the 99% percentile upper reference limit. Unlike our patient, patients with elevated cardiac troponin in that study were older, had more comorbidities, and had higher levels of leucocytes, NT-proBNP, C-reactive protein, and procalcitonin, but lower lymphocyte counts. Patients with cardiac injury had a higher incidence of acute respiratory distress syndrome (ARDS) (58.5% vs. 14.7%; $P < 0.001$) and a higher mortality rate (51.2% vs. 4.5%; $P < 0.001$) than those without cardiac injury. In multivariable adjusted models, cardiac injury and ARDS were significantly and independently associated with mortality, with hazard ratios of 4.26 and 7.89, respectively.

Fourthly, patients presenting with myocardial injury may be susceptible to proarrhythmic effects of COVID-19-related issues such as fever, stress, electrolyte disturbances, and use of antiviral drugs. Our patient did not present with any ventricular arrhythmia during his hospitalization. Moreover, immune injury observed in COVID-19 patients may be the main cause of myocardial injury. A study showed that after SARS-CoV infection, interferon-related cytokine storms may be involved in the immunopathology of SARS patients.[9] Cytokine storms may lead to increased vascular wall permeability and myocardial oedema.[10] However, in view of the patient's rapid recovery, low increase of C-reactive protein,

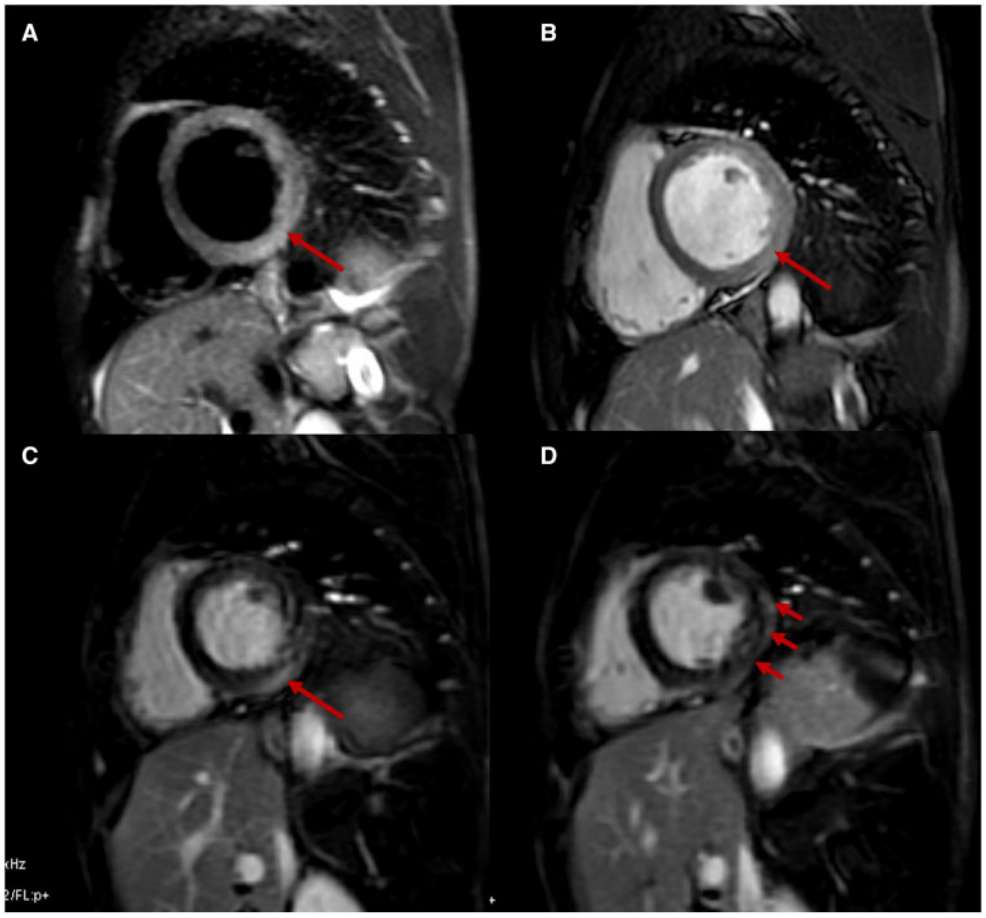

Figure 2 CMR confirming the diagnosis of myocarditis. Black blood T2-weighted with fat saturation image (*A*) and post-gadolinium SSFP image (*B*) in short-axis view showed diffuse myocardial signal hyperintensity involving the posterolaterobasal wall of the left ventricle, suggesting interstitial oedema. Myocardial damage was confirmed on the late gadolinium enhancement involving the subepicardial layer of the myocardium (*C* and *D*). Pericardial enhancement (*D*) and pericardial effusion were seen around the laterobasal wall of the left ventricle (Supplementary material online, *Video S1*), suggesting pericardial oedema.

and the early presentation of the acute myocarditis, myocardial injury was considered to be transient damage from viral infection rather than from the cytokine storm. In addition, the clinical outcome of the patient was favourable, without use of corticosteroids, antiviral drugs, or chloroquine.

Conclusion

We report here the case of a paediatric patient presenting with an isolated acute myocarditis as the sole manifestation of COVID-19 infection and without pulmonary lesion.

In the context of an acute COVID-19 outbreak, screening for COVID-19 infection should be performed in children presenting with myocardial injury in an inflammatory context.

Lead author biography

Dr Quenitn Fischer is a 31-year-old interventional cardiologist working in Bichat Hospital, Paris, France.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient and his parents in line with COPE guidance.

Conflict of interest: none declared.

References

1. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-mission-briefing-on-covid-19 (12 March 2020).
2. Driggin E, Madhavan MV, Bikdeli B, Chuich T, Laracy J, Bondi-Zoccai G, Brown TS, Der Nigoghossian C, Zidar DA, Haythe J, Brodie D, Beckman JA, Kirtane AJ, Stone GW, Krumholz HM, Parikh SA. Cardiovascular considerations for patients, health care workers, and health systems during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Cardiol* 2020;**75**:2352–2371.
3. Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, Tong S. Epidemiology of COVID-19 among children in China. *Pediatrics* 2020;**145**:e20200702.
4. Paediatric Intensive Care Society Statement: Increased number of reported cases of novel presentation of multisystem inflammatory disease. https://picsociety.uk/wp-content/uploads/2020/04/PICS-statement-re-novel-KD-C19-presentation-v2-27042020.pdf
5. Friedrich MG, Sechtem U, Schulz-Menger J, Holmvang G, Alakija P, Cooper LT, White JA, Abdel-Aty H, Gutberlet M, Prasad S, Aletras A, Laissy JP, Paterson I, Filipchuk NG, Kumar A, Pauschinger M, Liu P; International Consensus Group on Cardiovascular Magnetic Resonance in Myocarditis. Cardiovascular magnetic resonance in myocarditis: a JACC White Paper. *J Am Coll Cardiol* 2009;**53**:1475–1487.
6. Fung G, Luo H, Qiu Y, Yang D, McManus B. Myocarditis. *Circ Res* 2016;**118**:496–514.
7. Heimdal I, Moe N, Krokstad S, Christensen A, Skanke LH, Nordbø SA, Døllner H. Human coronavirus in hospitalized children with respiratory tract infections: a 9-year population-based study from Norway. *J Infect Dis* 2019;**219**:1198–1206.
8. Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F, Gong W, Liu X, Liang J, Zhao Q, Huang H, Yang B, Huang C. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. *JAMA Cardiol* 2020;doi:10.1001/jamacardio.2020.0950
9. Huang KJ, Su IJ, Theron M, Wu YC, Lai SK, Liu CC, Lei H-Y. An interferon-gamma-related cytokine storm in SARS patients. *J Med Virol* 2005;**75**:185–194.
10. Sawamura A, Okumura T, Ito M, Ozaki Y, Ohte N, Amano T, Murohara T; CHANGE PUMP Investigators. Prognostic value of electrocardiography in patients with fulminant myocarditis supported by percutaneous venoarterial extracorporeal membrane oxygenation—analysis from the CHANGE PUMP Study. *Circ J* 2018;**82**:2089–2095.