



EKG Abnormalities in a Youth Athlete Following COVID-19: It's Not Always Myocarditis!

Adam W. Powell^{1,2} · Elaine M. Urbina^{1,2} · William B. Orr³ · Jesse E. Hansen⁴ · Shankar Baskar^{1,2}

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Abstract

COVID-19 associated myocarditis following mild infections is rare while incidental findings may be more common. A young athlete fully recovered from a mild COVID-19 infection presented with inferolateral T-wave inversions and left ventricular hypertrophy on imaging. Exercise testing aided in correctly diagnosing the patient with masked systolic hypertension.

Keywords Cardiopulmonary exercise test · Return-to-play guidelines · Masked hypertension · COVID-19

Case Report

An obese 14-year-old Caucasian male presented to his pediatrician for cardiac clearance to resume football and basketball after a mild COVID-19 infection, as recommended by the American Academy of Pediatrics [1]. He was referred to cardiology for evaluation and EKG secondary to concern for COVID-associated myocarditis. Past medical and family history were unremarkable. In the cardiology clinic, he was asymptomatic, and his physical exam and vital signs were unremarkable with the exception of elevated weight (103.9 kg; height 176 cm; BMI 34 kg/m²) and elevated blood pressure (126/58; compared to the 120/80 mmHg cut-point defining hypertension in adolescents) [2]. An EKG demonstrated ectopic atrial rhythm with a rate of 60 bpm and T-wave inversion in the inferolateral leads (see Fig. 1).

Based on the EKG and history of COVID-19, the primary diagnoses of concern were cardiomyopathy or COVID-19 associated myocarditis. Other differential diagnoses included

abnormal coronary artery origins, ischemic heart disease, systolic hypertension, and normal athletic remodeling. Secondary to this differential diagnosis, an echocardiogram was obtained that demonstrated normal coronary artery origins, mild concentric hypertrophy of the left ventricle with no ventricular outflow tract obstruction, and normal systolic ventricular function. High-sensitivity troponin was negative. A cardiac MRI was performed for myocardial characterization, which demonstrated normal native T1 and T2 values without late gadolinium enhancement. There was mild concentric left hypertrophy, consistent with the echocardiogram (see Fig. 2). A cardiopulmonary exercise test (CPET) was performed to evaluate exercise capacity and T-wave morphology dynamics. The stress EKG tracings demonstrated persistent lateral precordial T-wave inversion throughout exercise without ectopy or arrhythmias. There were no pathologic changes in the QT interval. Indirect calorimetry demonstrated normal predicted peak oxygen consumption (87% of predicted normal) using the Wasserman prediction equation for obesity. His exercise vital signs demonstrated a normal heart rate response (peak HR 194 bpm) without exertional hypoxia. His baseline blood pressure was consistent with his clinic measurements (124/62) and with an exaggerated systolic blood pressure response with exercise (226/64). Ambulatory blood pressure monitoring demonstrated 24-h systolic hypertension with a mean SBP of 131 mmHg (greater than 95% of predicted for his age and size), meeting criteria for masked hypertension (see Table 1).

The concerns for cardiomyopathy and myocarditis were lessened based on the normal CMR tissue characterization and normal exercise capacity. The persistently abnormal

✉ Adam W. Powell
Adam.Powell@cchmc.org

¹ Department of Pediatrics, University of Cincinnati College of Medicine, 3333 Burnett Avenue, MLC 2003, Cincinnati, OH 45229-3026, USA

² The Heart Institute, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA

³ Division of Pediatric Cardiology, Department of Pediatrics, Washington University School of Medicine, St. Louis, USA

⁴ Division of Pediatric Cardiology, Department of Pediatrics, C.S. Mott Children's Hospital, Ann Arbor, MI, USA

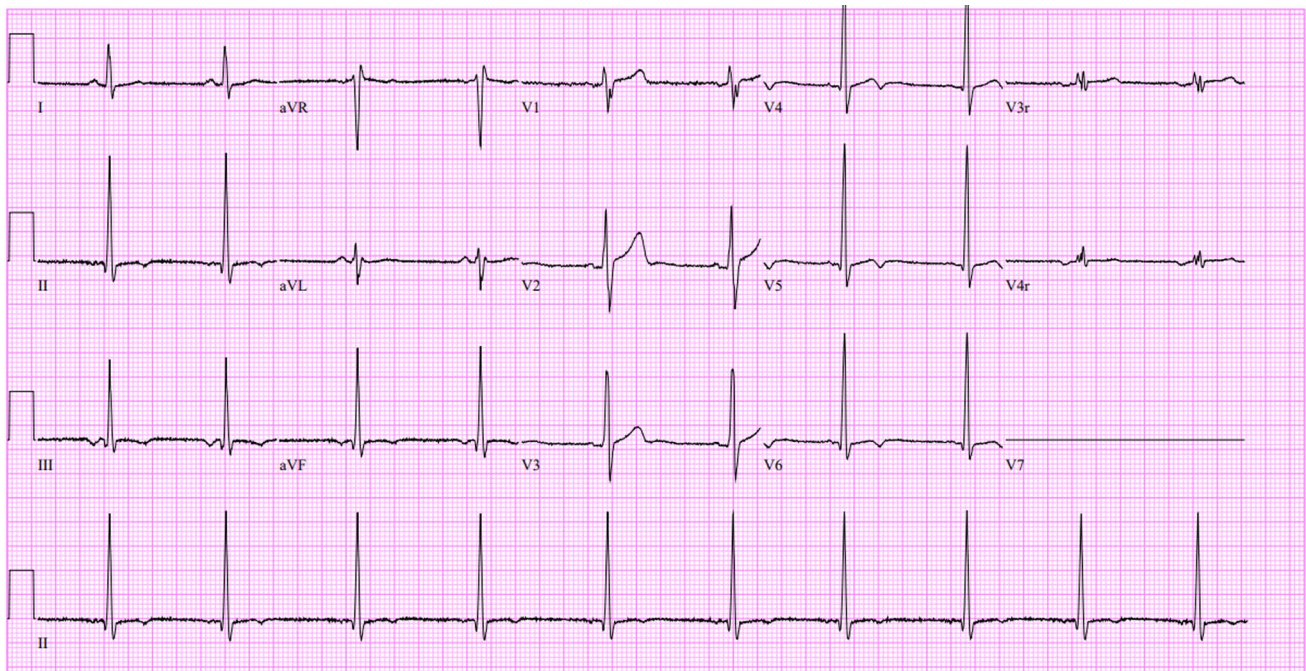


Fig. 1 Electrocardiogram on 14-year-old patient who presented for cardiac evaluation prior to resuming sports following a mild COVID-19 infection showing T-wave inversion in the inferolateral leads

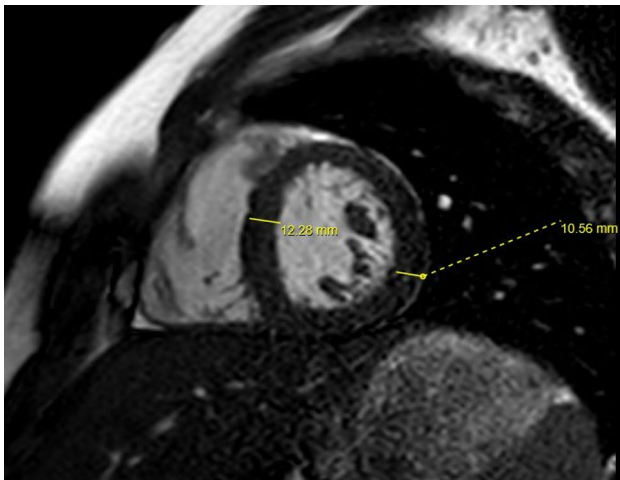


Fig. 2 Cardiac MRI demonstrating mild concentric left ventricular hypertrophy

T-waves, mild concentric left ventricular hypertrophy, and hypertensive response to exercise were all consistent with masked systolic hypertension, which was confirmed by ambulatory blood pressure monitoring. The patient was started on an ACE-inhibitor and allowed to return to full sports participation. The patient responded well to the ACE-inhibitor with a normal blood pressure in follow-up clinic (108/52) without medication side-effects. He will be followed every 6 months with repeat echocardiogram after

Table 1 Summary table of normative blood pressure data in adults and children based on method and location

	Age	Normal	Elevated
Office	Adult and child ≥ 3 y	$< 120/80$	$\geq 120/80$ – $129/89$
	Child	< 95 th percentile	≥ 95 th percentile
ABPM (day)	Adult	$< 135/85$	$\geq 135/88$
	Child	< 95 th percentile	≥ 95 th percentile
ABPM (night)	Adult	$< 120/70$	$\geq 120/70$
	Child	< 95 th percentile	≥ 95 th percentile
ABPM (mean)	Adult	$< 130/80$	$\geq 130/80$
	Child	< 95 th percentile	≥ 95 th percentile

Adult data adapted from O’Brien et al. [10] and pediatric data adapted from Flynn et al. [2] ABPM (ambulatory blood pressure monitor)

12 months of adequate blood pressure control. Additionally, he has resumed basketball without issue.

Discussion

Widely publicized reports of myocardial injury in patients with COVID-19 has resulted in high levels of patient, parent, and primary care provider anxiety. In response multiple national pediatric organizations have issued return to play guidelines for pediatric athletes [1, 3]. Differing and

evolving guidelines and recommendations has resulted in occasional confusion by referring pediatricians as illustrated in this case. Fortunately, the prevalence of clinically significant cardiac damage secondary to COVID-19 is low in both pediatric and collegiate athletes but additional cardiovascular evaluation has frequently led to incidental findings [4, 5]. This case illustrates one of these incidental findings.

Certain isolated T-wave findings such as early repolarization, ST-inversion in VI-V3 in athletes < 16-years-old, and domed ST-segment elevation followed by inversion of leads V1-V4 in African-American athletes may represent normal findings of athletic remodeling [6]. Inferolateral T-wave inversions are more concerning and should prompt additional investigation for potentially life-threatening conditions, such as myocarditis and cardiomyopathy [6]. Cardiac MRI is helpful in the evaluation of ventricular size and function as well as to assess myocardial tissue characteristics [7]. As this case demonstrates, imaging alone does not always reveal the diagnosis. CPET is often performed in conjunction with imaging to evaluate for potential abnormal responses seen in myocardial disease, such as stagnation or fall in systolic blood pressure during exercise or the presence of high-grade ectopy [8]. Additionally, patients with phenotype-positive cardiomyopathy will often have an abnormal peak oxygen consumption with this being a useful prognostic indicator in these patients [8]. Lastly, CPET is often used to assess for pathologic ST-segment or T-wave changes during exercise, which is important in this case as there were already baseline T-wave abnormalities present [6, 8]. This patient had a generally reassuring exercise test with regards to myocardial disease, but the exaggerated systolic blood pressure response and the persistent T-wave changes along with the mild left ventricular hypertrophy on cardiac imaging helped point towards the eventual diagnosis of masked systolic hypertension.

Masked systolic hypertension, as defined by normal in-office blood pressures but abnormal out-of-office blood pressure measurements, can be challenging to diagnose in the pediatric population but may be present in as much as 5.8% of children [9]. This has increased importance as untreated masked hypertension can progress to sustained systolic hypertension and is associated with end-organ damage including increased left ventricular mass and abnormal vascular function [2, 9]. Ambulatory blood pressure monitoring is an important tool to help make the diagnosis. It consists of a blood pressure cuff attached to a small device and it obtains two to three recordings every hour for a 24-h period [10]. In this case, while there were abnormal findings indicative of untreated systolic hypertension (left ventricular hypertrophy), the patient did not meet criteria for essential systolic hypertension based solely on his in-office blood pressure measurements (see Table 1). However, the exaggerated blood pressure response elicited during the CPET

prompted additional ambulatory blood pressure monitoring confirming the diagnosis and allowing for appropriate treatment.

Conclusions

Concerns for COVID-19 related myocardial damage often results in incidental cardiovascular findings more than the discovery of true COVID-related pathology. CPET continues to be an excellent non-invasive tool in the diagnosis and clinical management of many of these incidentally discovered pathologies. Masked systolic hypertension in pediatric patients is not a rare phenomenon and can cause end-organ damage that can manifest in unusual ways, included isolated left lateral T-wave inversions.

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Declarations

Conflict of Interest The authors have no significant financial disclosures.

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