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Implementation of a practice plan for the outpatient cardiac evaluation of children after acute SARS-CoV-2 infection and a report of outcomes

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SARS-CoV-2 infection has been associated with cardiovascular disease in children, but which children need cardiac evaluation is unclear. We describe our experience evaluating 206 children for cardiac disease following SARS-CoV-2 infection (one of whom had ventricular ectopy) and propose a new guideline for management of these children. Routine cardiac screening after SARS-CoV-2 infection in children without any cardiac signs or symptoms does not appear to be high yield. (Am Heart J 2021;241:83–86.)

Although children tend to have excellent short-term outcomes when infected with SARS-CoV-2, there is growing concern regarding their long-term outcomes after apparent recovery from the acute illness. In particular, data suggest that cardiovascular disease can be a common sequela following SARS-CoV-2 infection, even among non-MISC patients.^{1,2} This has led to concerns regarding cardiac clearance for return to activity after SARS-CoV-2 infection, with varying recommended protocols.^{3,4} These protocols have different guidelines determined by patient age, degree of symptoms during SARS-CoV-2 infection, and presence of cardiac symptoms during or after SARS-CoV-2 infection. However, due to the paucity of data in pediatric patients, these protocols are based primarily on expert opinion derived from experience with other forms of viral myocarditis and the experience with athletes and young adults.

The objective of this report is to describe the experience of evaluating children following SARS-CoV-2 infection (non-MISC) in a large, outpatient pediatric cardiology practice. Furthermore, we propose a new protocol for future evaluations of children following SARS-CoV-2 infection based on available data.

Methods

In August 2020 we created a pediatric-specific guideline for the referral of children to pediatric cardiology following SARS-CoV-2 infection (Figure 1A). This guideline was disseminated widely to pediatric providers in the state via webinars, newsletters, and in-person visits. Our referral guideline recommended that severe cases (required hospitalization) be referred to pediatric cardiology, and that moderate cases (fever or symptoms >3 days) be referred if any concerning physical exam findings or if an electrocardiogram (ECG) was needed. Asymptomatic or mild cases (no fever and <3 days of symptoms) did not have to be referred. Moreover, providers could also refer any post-SARS-CoV-2 cases at their own discretion. An abnormal screening ECG prompted a standard clinical evaluation, with further testing determined by the pediatric cardiologist. No extramural funding was used to support this work.

In this quality improvement study, we reviewed the records of all patients ≤ 21 years of age referred and seen in one of our 22 outpatient cardiology clinics after SARS-CoV-2 infection, from August 6, 2020 to October 30, 2020. Patients were included if they were referred by their primary care provider during the study period to our pediatric cardiology practice for an ECG or a full clinic visit with a screening ECG after recovery from SARS-CoV-2 infection. We excluded patients who had Multisystem Inflammatory Syndrome in Children (MIS-C) and those with unrepaired congenital heart disease. Descriptive and summary statistics were performed.

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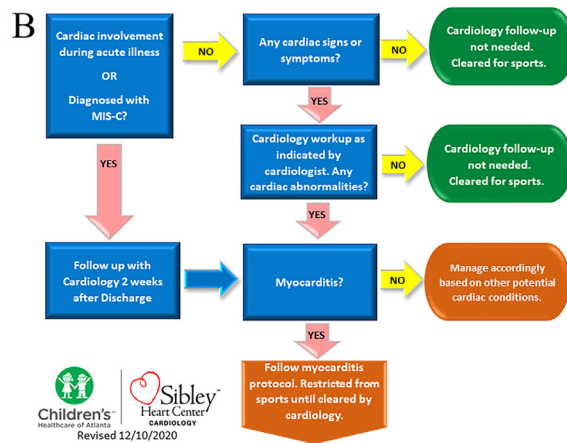
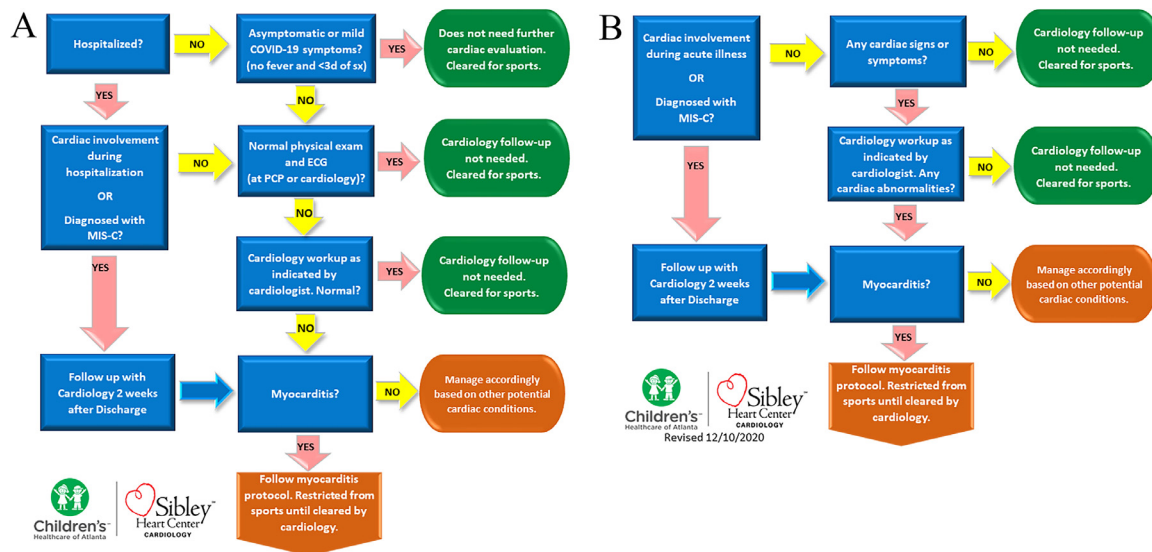
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Figure 1.



Recommended algorithms for screening children for cardiac involvement after SARS-CoV-2 infection. Panel A illustrates the initial algorithm implemented. Panel B illustrates the revised algorithm after review of the experience using the initial algorithm.

Results

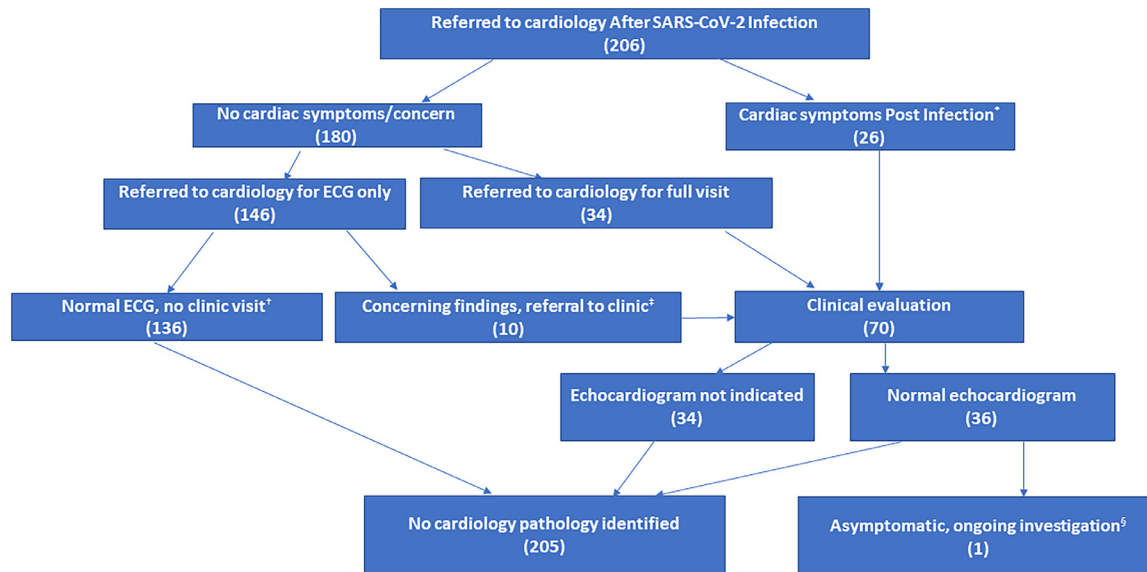
Of the 253 patients referred following SARS-CoV-2 infection, 206 met inclusion criteria (Figure 2). Among the 47 patients not included, there were 31 patients excluded due to a diagnosis of MIS-C, 9 due to referral prior to the release of our guideline, 6 that did not have a screening ECG at the time of the clinical assessment, and 1 due to unrepaired congenital heart disease. Two patients with surgically repaired congenital heart disease and no residual defects were included in the cohort; a child with repaired atrial and ventricular septal defects, and another with a repaired ventricular septal defect.

The median age was 16 years, range 3 to 21 years. The majority identified as White Non-Hispanic (84%), 12% as Black or African American, 3.5% Hispanic, and 0.5% Asian. Four children (2%) had severe COVID-19 infections, 23 (11%) had a moderate illness, and 179 (87%) had mild or asymptomatic infection. Cardiac symptoms were present in 26 patients at the time of referral, including chest pain (12), fatigue (6), syncope/dizziness (4), dyspnea (3) and palpitations (3). Of 146 patients referred for a clearance ECG only, 136 had no concerning pathology, including 57 patients with sinus bradycardia for age. Ten patients had concerning ECG findings which led to a standard clinical evaluation, including: left ventricular hypertrophy (5), right ventricular hypertrophy (1), biventricular hypertrophy (1), first degree atrioventricular block (1), single pre-

mature ventricular beat (1), and frequent ventricular ectopy (1).

Among the 70 in-person clinical evaluations (60 directly referred and 10 after concerning ECG findings), 36 echocardiograms were performed. All 10 patients with concerning ECG findings had an echo completed, all of which were normal. Of the remaining 26 echocardiograms that were completed, the majority were in patients with post-infectious cardiac symptoms. However, the decision to perform an echocardiogram on a patient was deferred to the evaluating cardiologist. Therefore, not all patients with post-infectious symptoms had an echocardiogram and some were completed on asymptomatic patients with normal ECGs (as in the case of 1 patient who exhibited a new murmur on exam). Regardless, all 36 echocardiograms demonstrated normal cardiac findings. Overall, 99.5% (205/206) were cleared from a cardiovascular standpoint for full sports participation without further clinical follow-up. The 1 patient not fully cleared was a 19-year-old female who had been hospitalized with severe COVID-19. She had no known cardiac signs or symptoms during her acute illness and was asymptomatic at the time of cardiac outpatient evaluation. However, she had frequent ventricular ectopy on physical exam, ECG, and Holter monitoring, although her ventricular ectopy dissipated at higher heart rates. She had a normal echocardiogram; cardiac magnetic resonance imaging (cMRI) was pursued but was not able to be performed due to lack of insurance.

Figure 2.



*Patients referred for evaluation for: Chest Pain (12), Fatigue (6), Syncope/Dizziness (4), Dyspnea (3), Palpitations (3)

†Includes 57 pts with Sinus Bradycardia for Age

‡Left ventricular hypertrophy (5), Right ventricular hypertrophy (1), Biventricular hypertrophy (1), Premature Ventricular Contraction (1), Significant Ventricular Ectopy (1), 1st degree AVB (1)

§One patient had notable ventricular ectopy on exam and ECG, referred for cardiac MRI.

Flow diagram of 206 children evaluated for cardiac sequelae following SARS-CoV-2 infection. Only 1 patient was noted to have significant findings (ventricular ectopy).

Discussion

In our experience of evaluating children following SARS-CoV-2 infection, routine referral for ECG or clinical evaluation rarely led to new concerning cardiac findings. In the lone instance in which a concerning cardiac abnormality was identified, the patient had clear abnormalities on physical exam. The majority of children were referred after mild or asymptomatic infection, contrary to the recommend guideline. No cardiac abnormalities were found in these cases. Based on our experience, routine cardiac evaluation following SARS-CoV-2 infection, including screening ECG, is not indicated in the absence of concerning symptoms.

Myocarditis can be a leading contributor of sudden death among athletes and children.⁵ The gold standard for diagnosing myocarditis is tissue biopsy, or cMRI if tissue biopsy is not available.⁵ Early studies of young adults following SARS-CoV-2 infection suggested that myocarditis may be a frequent complication based on cMRI evaluations.^{2,6} However, subsequent studies using cMRI have not found a high rate of myocarditis in young adults following SARS-CoV-2 infection, particularly in those who are asymptomatic.^{1,7} While there have been news reports of myocarditis in adolescents and young adults fol-

lowing SARS-CoV-2 infection, these have been rare, particularly in the absence of MIS-C.

It is unclear whether the finding of frequent premature ventricular contractions in one 19-year-old patient is related to the SARS-CoV-2 infection or not. Typically, frequent premature ventricular contractions are benign and do not require treatment, although monitoring is recommended.⁸ Unfortunately in this instance cMRI was unable to be attained to determine whether this was a manifestation of myocarditis, although the normal echocardiogram and dissipation of ectopy at high heart rate on Holter were reassuring. Nevertheless, the patient will be monitored as able.

Interestingly, sinus bradycardia was a common finding in our patients. Sinus bradycardia can commonly be seen in athletes, and it is possible that athletes seeking cardiac clearance for sports were preferentially referred for evaluation. Sinus bradycardia is not typically associated with myocarditis, and in the absence of other symptoms is felt to be benign. Therefore, further workup was not pursued on the basis of sinus bradycardia. However, this finding is consistent with other studies that have noticed elevated rates of sinus bradycardia in adults following SARS-CoV-2 infection.⁹ These findings are similar to the

experience seen in patients with SARS in 2003, in which sinus bradycardia was commonly seen and typically resolved after 2 to 3 weeks.¹⁰

Our findings are not without limitations. First, this is a review of outcomes from clinically indicated care delivery, not a comprehensive evaluation and workup for all patients. Thus, not all patients received all testing. Laboratory testing, including troponins, was neither indicated nor obtained in all patients and cMRI was not recommended except in 1 case. However, the absence of clinically relevant findings on ECG and/or echo argues against the value of additional blood work, and cMRI screening is not a feasible public health intervention for the general population.⁷ Second, these findings may be subject to selection bias as a result of referral patterns. Notably, there was a relatively low percentage of minorities referred for evaluation, despite the underlying population in the area and the fact that minorities tend to have higher rates of SARS-CoV-2 infection.¹¹ Future work is needed to address potential disparities. Finally, by the nature of this study there is a lack of systematic long-term follow-up for patients cleared from a cardiovascular standpoint. However, given the fact that our practice provides care at the primary institution where children with a sudden cardiac event would be referred, it is likely that we would learn of any such cases. To our knowledge, none of the children in this study had subsequent serious cardiac events in the more than 7 months since initial evaluation.

Given these findings and other published experiences, we have modified our referral guideline to more closely resemble that of routine pre-participation screening recommended by the American Heart Association before the COVID-19 pandemic.¹² Our new guideline, which was distributed to area providers in December 2020, recommends a pediatric cardiology evaluation for any child with new cardiac involvement during SARS-CoV-2 infection or recovery, regardless of the severity of illness (Figure 1B). Routine cardiac screening is no longer recommended in the absence of any concerning signs or symptoms. Furthermore, given the lack of any clear association in the literature between severity of SARS-CoV-2 infection and subsequent outcomes, particularly in children, the severity of SARS-CoV-2 infection should not be considered. This is not to say that children are not at risk of developing cardiac outcomes after SARS-CoV-2 infection. Rather, the new protocol emphasizes the importance of new signs and symptoms and discourages routine screening. Future evaluations are planned on the impact of this revision, including whether this revision helps decrease potentially unnecessary resource utilization.

In conclusion, cardiac abnormalities following SARS-CoV-2 infection in children are rare. A screening program in our practice identified only 1 individual with potentially concerning pathology, and this finding was present on exam. Future cardiac evaluations of children following SARS-CoV-2 should emphasize the presence of new cardiac signs or symptoms.

Disclosures

None reported.

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