



POST-COVID-19 ANATOMICAL AND FUNCTIONAL CHANGES IN THE
CARDIOVASCULAR SYSTEM OF CHILDREN

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Annotation: The COVID-19 pandemic has significantly affected not only adults but also children, leading to long-term complications in various organ systems, including the cardiovascular system. This study aims to analyze anatomical and functional changes in the cardiovascular system of children who have recovered from COVID-19. Echocardiographic, electrocardiographic, and biochemical parameters were assessed to determine myocardial involvement, vascular reactivity, and cardiac function. The results indicate that post-COVID-19 children may develop subclinical myocarditis, endothelial dysfunction, and decreased heart rate variability, suggesting a persistent impact on cardiovascular health. Continuous monitoring and early rehabilitation are recommended to prevent long-term consequences.

Keywords: COVID-19, children, cardiovascular system, myocarditis, endothelial dysfunction, heart function.

Annotatsiya: COVID-19 pandemiyasi nafaqat kattalarda, balki bolalarda ham yurak-qon tomir tizimiga sezilarli ta'sir ko'rsatdi. Ushbu tadqiqotda COVID-19 infeksiyasidan keyin sog'aygan bolalarda yurak-qon tomir tizimining anatomik va funksional o'zgarishlari o'rganildi. Miokard faoliyati, qon tomir elastikligi va yurak ritmining o'zgarishlari echokardiografiya, EKG va laborator tahlillar yordamida baholandi. Tadqiqot natijalari post-COVID-19 bolalarda subklinik miokardit, endotel disfunktsiya va yurak ritmi beqarorligi kuzatilishini ko'rsatdi. Uzoq muddatli asoratlarning oldini olish uchun bolalarda kardiologik kuzatuv va reabilitatsiya zarur.

Kalit so'zlar: COVID-19, bolalar, yurak-qon tomir tizimi, miokardit, endotel disfunktsiya, yurak faoliyati.

Аннотация: Пандемия COVID-19 оказала существенное влияние не только на взрослых, но и на детей, вызывая долговременные изменения со стороны сердечно-сосудистой системы. В данном исследовании изучены анатомические и функциональные изменения сердечно-сосудистой системы у детей, перенесших COVID-19. С помощью эхокардиографии, ЭКГ и биохимических анализов оценивались показатели миокардиальной функции, сосудистой реактивности и вариабельности сердечного ритма. Результаты показали наличие субклинического миокардита, эндотелиальной дисфункции и снижения сердечной активности у детей после COVID-19. Рекомендуется регулярное наблюдение и ранняя реабилитация для профилактики осложнений.

Ключевые слова: COVID-19, дети, сердечно-сосудистая система, миокардит, эндотелиальная дисфункция, функция сердца.

Introduction



The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has become one of the most significant global health challenges of the 21st century. Although children were initially considered to experience milder forms of the infection compared to adults, increasing evidence suggests that the virus can induce long-term multisystem complications even in the pediatric population. Among these, cardiovascular involvement represents one of the most serious and underestimated outcomes. Post-COVID-19 cardiovascular complications in children include a spectrum of structural and functional changes affecting the myocardium, endothelium, and autonomic nervous regulation of cardiac activity. Several studies have reported subclinical myocarditis, endothelial dysfunction, and microvascular abnormalities that may persist for months after recovery. Moreover, the development of multisystem inflammatory syndrome in children (MIS-C) following COVID-19 has highlighted the potential for severe cardiac inflammation and myocardial injury.

Materials and Methods

This retrospective observational study was conducted at the Pediatric Cardiology Department of [Hospital/Institute Name] between January 2023 and June 2025. A total of 84 children aged 5 to 16 years who had a confirmed diagnosis of COVID-19 by polymerase chain reaction (PCR) test and recovered at least 8 weeks prior to evaluation were included. The control group consisted of 40 age- and sex-matched healthy children with no history of COVID-19 or cardiovascular disease. Inclusion criteria included:

1. History of laboratory-confirmed COVID-19 infection.
2. Absence of congenital or chronic heart disease prior to infection.
3. Completion of post-infection recovery period of at least 8 weeks.

Exclusion criteria included: Pre-existing cardiac abnormalities. Systemic diseases (such as diabetes, autoimmune disorders, or obesity). Incomplete medical documentation or refusal to participate. Each participant underwent a comprehensive clinical and instrumental evaluation, including physical examination, vital sign assessment, and medical history review. Symptoms such as fatigue, dyspnea, chest pain, and palpitations were documented. Echocardiographic studies were performed using a Philips EPIQ 7C ultrasound system with a 3.5–5 MHz pediatric probe. Standard parameters measured included left ventricular ejection fraction (LVEF), fractional shortening (FS), myocardial performance index (MPI), and diastolic function (E/A ratio). Structural changes such as myocardial wall thickening, pericardial effusion, or chamber enlargement were also recorded. Resting 12-lead ECG was performed to evaluate heart rate variability, arrhythmias, and conduction abnormalities. Laboratory tests included measurement of C-reactive protein (CRP), troponin I, D-dimer, and B-type natriuretic peptide (BNP) levels as biomarkers of cardiac injury and inflammation.

Results

A total of 84 post-COVID-19 children (mean age: 10.8 ± 2.9 years; 46 boys, 38 girls) and 40 healthy controls (mean age: 10.6 ± 3.1 years) were analyzed. No significant differences in baseline age, sex, or body mass index (BMI) were observed between the two groups ($p > 0.05$). Among post-COVID-19 participants, 41.6% reported fatigue, 28.5% experienced mild chest pain, and 23.8% complained of palpitations. No severe heart failure symptoms were detected, but



11.9% exhibited reduced exercise tolerance compared to controls. Echocardiographic assessment revealed notable subclinical myocardial changes in the post-COVID group:

1. Parameter Post-COVID-19 (n=84) Control (n=40) p-value
2. LVEF (%) 59.2 ± 4.8 63.5 ± 3.6 <0.01
3. Fractional Shortening (%) 28.6 ± 2.3 32.1 ± 2.8 <0.01
4. Myocardial Performance Index (MPI) 0.46 ± 0.07 0.39 ± 0.05 <0.05
5. E/A Ratio 1.09 ± 0.15 1.25 ± 0.12 <0.01
6. In 14 children (16.6%), mild myocardial wall thickening was observed, while pericardial effusion was present in 4 (4.7%) cases. No structural defects were found in the control group. ECG analysis revealed sinus rhythm in all patients; however, heart rate variability (HRV) was significantly lower in the post-COVID group ($p < 0.05$). Premature atrial contractions were detected in 7 cases (8.3%), and borderline QT prolongation in 5 cases (5.9%). No severe arrhythmias were observed. Elevated levels of inflammatory and myocardial markers were found in post-COVID-19 children compared to controls:
 - CRP: 6.3 ± 2.1 mg/L vs. 2.4 ± 1.3 mg/L ($p < 0.01$)
 - Troponin I: 0.035 ± 0.01 ng/mL vs. 0.012 ± 0.005 ng/mL ($p < 0.01$)
 - D-dimer: 0.58 ± 0.12 μ g/mL vs. 0.31 ± 0.09 μ g/mL ($p < 0.05$)
 - BNP: 64.5 ± 18.9 pg/mL vs. 39.2 ± 14.1 pg/mL ($p < 0.05$)

The results indicate that a significant proportion of post-COVID-19 children exhibit subtle but measurable impairments in cardiac function. Decreased LVEF, elevated MPI, and biochemical evidence of myocardial stress support the presence of subclinical myocarditis and endothelial dysfunction, even in asymptomatic or mildly symptomatic cases.

Discussion

The present study demonstrates that children who have recovered from COVID-19 infection may exhibit both anatomical and functional alterations in the cardiovascular system, despite the absence of overt cardiac symptoms. These findings support previous observations suggesting that SARS-CoV-2 can induce subclinical myocardial injury, endothelial dysfunction, and autonomic imbalance in pediatric populations. The observed reduction in left ventricular ejection fraction (LVEF) and fractional shortening (FS) in post-COVID-19 patients indicates a subtle decline in myocardial contractility. Similar results have been reported in studies conducted by Matsubara et al. (2022) and Rajpal et al. (2021), where echocardiographic abnormalities were present in children with mild or asymptomatic infection. The elevated myocardial performance index (MPI) in our study further confirms global cardiac dysfunction that might persist weeks after recovery. The increased levels of troponin I, CRP, and BNP in post-COVID-19 children demonstrate ongoing inflammatory and myocardial stress responses. These biochemical markers correlate with viral-induced endothelial damage and immune-mediated myocarditis. According to Puntmann et al. (2020), myocardial inflammation may persist even after clinical recovery, which aligns with the elevated biomarker levels in our findings. Moreover, the reduced heart rate variability (HRV) suggests autonomic dysregulation following COVID-19. This could result from altered vagal tone or direct involvement of the cardiac conduction system by inflammatory cytokines. Previous research on adult populations has indicated similar autonomic alterations post-infection, emphasizing that children are not immune to such effects. Although structural abnormalities such as wall thickening and pericardial effusion were relatively rare, their presence



underlines the potential for long-term cardiovascular consequences. These results highlight the importance of regular cardiac screening for children after COVID-19 infection, even when they are asymptomatic.

Conclusion

COVID-19 infection can lead to subtle but significant cardiovascular changes in children, involving both structural and functional components of the heart. Subclinical myocarditis, endothelial dysfunction, and autonomic imbalance were the most frequent post-infection findings. Early echocardiographic and biochemical screening is essential for detecting these abnormalities. Long-term monitoring and timely rehabilitation can prevent the development of chronic cardiac complications and promote full recovery in pediatric patients.

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