Post-Covid Conditions and their Effects on the Cardiovascular System

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Abstract

Background. Rising global concerns about COVID-19 recently gained more research attention due to the ease of person-to-person transmission, various symptoms after healing, and the shortage of effective antiviral therapy. The study aims to analyze post-COVID conditions and clinical manifestations of cardiovascular lesions in patients recovering from COVID-19 infection.

Methods. A practical examination of post-COVID conditions manifestation was conducted in a prospective cohort study, involving 250 patients diagnosed with COVID-19 between June 1, 2021, and August 31, 2021. The study specifically focused on analyzing the cardiovascular effects of COVID-19, utilizing data from a subgroup of 200 patients previously discharged from the hospital with elevated troponin levels. The cardiovascular variables assessed included tachycardia, ischemia, heart attack, myocarditis, hypertension, blood clots, and heart failure.

Results. It has been observed that among surviving patients, the following symptoms persisted: anosmia/ageusia (59%), severe dyspnea (36.7%), palpitations and complaints related to the cardiovascular system (15.8%), headaches (13.2%), arthralgia (11.7%), myalgia (9.8%), and hair problems (5%). By the 60th day, a reduction in symptoms by 5-10% was noted, and by the 90th day, a decrease in activity by 25-35% was observed. Patients aged 40-60 years exhibited the highest percentage of cardiovascular diseases (75%).

Conclusions. Consequently, the SARS-CoV-2 virus underscores the critical importance of cardiological attention in patient care. Cardiac screening results in individuals with COVID-19 reveal a significant prevalence of serious heart problems, affecting over half of the patients. This emphasizes the necessity for heightened vigilance and specialized cardiac care when managing patients with COVID-19. Clin Ter 2024; 175 (3):154-162 doi: 10.7417/CT.2024.5056

Keywords: COVID-19, cardiac screening, cardiovascular disease, coronavirus, global health

Introduction

The 2019 Global Coronavirus Pandemic (COVID-19) continues to spread worldwide, with approximately 216 million confirmed cases and 4.49 million deaths to date. According to official data, the number of officially registered infections in the Russian Federation (RF) exceeded 11 million, and the total fatalities were over 320,000 (1).

The Severe Acute Respiratory Syndrome coronavirus (SARS-CoV-2) is the causative agent of pandemic coronavirus disease (COVID-19), which emerged in 2019 and resulted in global health crises and depleted resources. COVID-19 is now recognized as a multi-organ disease that manifests in various ways in humans. Furthermore, its effects remain largely unexplored to this day (2).


Studies conducted by European and national scientists indicate that COVID-19 conditions persist for three to four months after the first symptoms in 50% to 80% of those affected. Prolonged COVID-19 can be considered a significant public health emergency. Coronavirus disease often lingers in many people, even in those officially cured, who continue to feel unwell. Along with diabetes, kidney disease, and CVD, the most common long-term effects following SARS-CoV-2 infection are muscle pain, fatigue and various psychiatric conditions, such as fear and depression (1).

Pathological changes in the heart during coronavirus infection are caused by various pathogenic mechanisms associated with viral toxicity, inflammatory lesions, increased clotting reaction, and reduced fibrinolytic activity, leading to inflammation and myocardial ischemia. Considering the heterogeneity of exposure, the inclusion of multiple pathogenic mechanisms, differences in the severity of the infectious process, and the individual state of the patient at the time of infection, it is reasonable to focus on the major provisions related to the effect of the coronavirus on the cardiovascular system (2–4).

The multiple mechanisms by which coronavirus infection has a harmful effect on the heart and coronary arteries underlie the variety of myocardial infarction (MI) variants

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during the disease. In particular, these refer to types 1, 2, 3, and 4a of myocardial (MI). The adverse impact of viral coronary artery infection on atherosclerotic plaque promotes atherothrombotic complications and the occurrence of type 1 MI. Besides, the induction of inflammation and cytokine synthesis damages the integrity of the covering atherosclerotic plaque and induces vasoconstriction and thrombosis (4).

Results from many registries covering millions of patients worldwide show that the structure of cardiovascular complications changed slightly during the pandemic. The incidence of MI decreased slightly, but the disease’s course worsened with increased lethality. Meanwhile, the rate of sudden cardiac death rose by 27%. As known, type 3 MI is a myocardial infarction unconfirmed by biomarkers when sudden death occurs in the pre-hospital stage (1, 5, 6).

Mechanisms for cardiac involvement in coronavirus infection contribute to myocardial and vascular injury. When combined or individually, they include respiratory failure, cytokine storm followed by cardiomyocytic death, and the development of thrombosis (7–10).

Myocardial injury caused by COVID-19 can lead to various clinical cardiovascular issues ranging from heart rhythm disturbances, heart failure, and myocarditis to arrhythmias and sudden cardiac death. The diverse manifestations of CVD are becoming apparent as the pandemic continues. Thus, there is an urgent need for further research to understand the full range of cardiovascular events better and smooth out severe disease progression and life-threatening complications (8).

Despite the abundance of studies conducted under pandemic conditions, it is essential to acknowledge the existing research limitations. Focus should be on identifying gaps in knowledge, particularly concerning the cardiovascular effects of COVID-19. The issue of poorly studied coronavirus infection remains open and relevant, emphasizing the necessity for cross-disciplinary management of severe COVID-19 cases and long-term clinical follow-up (9).

Upon reviewing the medical literature, several studies are highlighted. A Wuhan study assessed 1,733 patients six months after acute COVID-19, revealing persistent symptoms in a significant percentage. JAMA Cardiology reported heart muscle lesions in almost 20% of 416 patients in Wuhan hospitals, with arrhythmia prevalent in ICU patients. Studies from various regions, including Italy, Ukraine, the United Kingdom, Spain, Germany, and Sweden, consistently show lingering symptoms post-COVID-19, affecting physical and psychological well-being. Notably, approximately one in four hospitalized COVID-19 patients experiences heart injury, increasing the risk of heart failure, heart attack, and stroke. There’s a consensus among scientists that COVID-19 can damage the heart in multiple ways (1).

Acknowledging COVID-19 as a multi-systemic disease requiring interdisciplinary rehabilitation, the WHO identified post-COVID syndrome, characterized by symptoms such as shortness of breath, increased fatigue, and dementia. Given the diverse manifestations of COVID-19, optimizing global studies and generating new experimental data within the country is crucial to developing developing treatment standards to the post-COVID period. Although the post-COVID syndrome is recognized in medical literature and the International Classification of Diseases, insufficient attention has been given to the clinical manifestations of cardiovascular system damage during recovery. A relevant study is urgently needed to analyze the health of the Russian population post-COVID-19 and address this research gap.

The research objectives were as follows:
- analyzing the effects of the postexposure period, including on the cardiovascular system in individuals recovered from COVID-19;
- gaining valuable knowledge to combat future pandemics and their consequences.

Materials and methods

Study design

A prospective cohort study of patients affected by COVID-19 between June 1, 2021, and August 31, 2021, was conducted as part of a hands-on study of post-acute symptom manifestation. All patients included were observed and questioned about their condition for three months following recovery. The study enrolled 250 non-critical patients (56% females and 44% males) with mild COVID-19.

The study enrolled patients from several departments of medical institutions in urban areas. Specifically, patients were selected from medical departments specializing in respiratory infection, infectious diseases, and general medicine, actively treating cases of COVID-19 during the specified period from June 1, 2021, to August 31, 2021. These departments were strategically chosen to ensure a diverse representation of patients experiencing mild symptoms of COVID-19. Additionally, patients were selected from both inpatient and outpatient settings to obtain a comprehensive understanding of the manifestation of post-acute symptoms at different stages of disease severity.

The pertinent dates for patient selection and observations were meticulously recorded to ensure the accuracy of data collection and analysis. This encompassed the date of admission to the medical institution, the date of COVID-19 diagnosis, and the date of discharge or recovery. These dates were crucial for monitoring symptom progression over a three-month observation period following recovery.

Furthermore, the study encompassed patients from various demographic groups, including different age categories ranging from 18 to 85 years, with a predominant representation of individuals aged 35 to 59 years. The inclusion of patients from diverse age groups and clinical histories allowed for a comprehensive overview of post-acute symptom manifestation among patients who experienced mild cases of COVID-19.

Overall, the selection of patients from various departments of medical institutions, along with meticulous consideration of relevant dates and demographic characteristics, ensured a robust cohort for investigating the manifestation of post-acute symptoms among patients recovering from mild cases of COVID-19.

Among the 250 non-critical patients included in our study, 70% were fully vaccinated against COVID-19, while 30% were unvaccinated. It is important to note that despite vaccination, persistent symptom manifestations remained,
particularly in the cardiovascular system, underscoring the complexity of COVID-19’s impact on the organism.

Participants were between the ages of 18 and 85, mainly between the ages of 35 and 59, with an average age of 46. The observations were aimed at determining the presence of such symptoms as asthenia (shortness of breath), chest pain, palpitations, anosmia/ageusia (loss of smell), headache, skin lesions, arthralgia (joint pain), myalgia (muscle pain), digestive disorders, increased body temperature, hair, and weight loss. The improved or worsened situation was monitored every 10 days for 30-, 60-, and 90-days following release. Those periods were selected to control the symptoms.

The impact of COVID-19 on the cardiovascular system was assessed as part of another study. It involved 200 patients from a pre-formed group with a high level of blood troponin above 0.6 ng/ml, while the standard is 0.2-0.5 ng/ml. Its rise over the limit indicates damage to the cardiac muscle involved. Their medical condition showed a cardiac MRI, diagnosing tachycardia, ischemia, heart attack, myocarditis, hypertension, blood clots, and heart failure. Comorbidities, medications, physical examination, laboratory data, and troponin levels were examined.

Myocardial injuries were defined as elevated cardiac troponin serum concentrations above the 99th percentile of the upper reference limit. It may be ischemic (acute coronary syndrome) or non-ischemic (myocarditis). This study diagnosed potential myocarditis based on clinical history, electrocardiography (ECG), echocardiography, and elevated troponin levels. The ECG signs suggesting possible myocarditis were sinus tachycardia, overall changes of ST-T, and arrhythmias. Echocardiographic signs were hypokinesis and reduced left ventricular ejection fraction (LV). However, cardiac magnetic resonance imaging (MRI) is widely used to diagnose myocarditis.

For each variable of interest, diverse data sources and assessment methods were employed. Symptom and feature reports were generated based on a combination of medical records and questionnaires completed by the patients themselves.

The data sources and assessment methods for each variable are as follows:

- Asthenia (shortness of breath), chest pain, palpitations, abnormalities in smell/taste, headaches, skin manifestations, arthralgia, myalgia, digestive disorders, elevated body temperature, hair loss, and weight loss. These symptoms were documented through patient questionnaires. Patients completed structured questionnaires where they were asked about the presence and severity of the mentioned symptoms.

- Cardiovascular manifestations. To assess the impact of COVID-19 on the cardiovascular system, data from medical records were utilized, including the results of cardiological examinations such as electrocardiography (ECG), echocardiography, and cardiac magnetic resonance imaging (MRI). Information on cardiac symptoms and signs was also collected from questionnaires completed by patients.

This integration of data from medical records and information provided by the patients themselves allowed for a more comprehensive understanding of the nature and severity of symptoms, as well as the impact of COVID-19 on the body as a whole.

For this study, specific selection criteria were established to determine which patients could be included in the research. The criteria included the following:

1. Diagnosis of COVID-19 was confirmed by a positive test result for the presence of the virus.
2. The presence of a mild form of the disease means the absence of critical conditions requiring intensive therapy.
3. Age ranging from 18 to 85 years.
4. Patient’s willingness and ability to participate in a three-month observation period after recovery.

The sources and methods of participant selection encompassed the following steps:

1. Patients were selected from various medical institutions, including hospitals and outpatient clinics, actively treating cases of COVID-19 during the specified period from June to August 2021.
2. As patients with a diagnosis of COVID-19 were admitted, medical staff evaluated their suitability according to the selection criteria for the study.
3. Patients meeting the selection criteria were invited to participate in the study, after which they were provided with information regarding the study objectives and protocol, and their consent to participate was obtained.

Thus, participants in the study were selected from a pool of patients diagnosed with COVID-19 who met specific selection criteria. They included both adults and elderly individuals with mild forms of the disease, willing to participate in a three-month observation period after recovery.

Ethical consent of patients

Each participant involved in the study provided informed consent before the commencement of the research. Informed consent was obtained following the provision of comprehensive and comprehensible information regarding the purpose of the study, its nature, potential risks, and benefits for the participants. This study received approval from the Local Ethics Committees of I.M. Sechenov First Moscow State Medical University (Sechenov University) (Protocol № 3 of 15.05.2023) to ensure adherence to ethical standards and participant protection. Patients also had the right to withdraw from participation at any point without facing any negative consequences.

Statistics

Detailed and logical statistical analyses were carried out. The quantitative variables were expressed as an average standard deviation (SD) and compared among the groups using an unpaired t-test.

The quantitative variables were expressed as an average standard deviation (SD) and compared between groups using an unpaired t-test.

Qualitative variables were expressed in figures (percentages) and compared between groups using the exact Chi-square/Fisher test. The p-value at <0.05 was determined to be statistically significant. SPSS version 22.0 software was used for statistical analysis.

Furthermore, a correlation dependency of heart conditions in post-COVID patients was determined based on age.
Results

Symptom persistence in non-critical patients

In this study, the persistence of symptoms, including severe asthenia, chest pain, palpitations, anosmia/ageusia (loss of smell), headaches, skin signs, arthralgia (joint pain), myalgia (muscle pain), digestive disorders, increased body temperature, and hair and body weight loss (≥5%), was examined. The most prevalent symptoms, as a percentage, were anosmia/ageusia (59%), shortness of breath (36.7%), palpitations and cardiovascular complaints (15.8%), headaches (13.2%), arthralgia (11.7%), myalgia (9.8%), and hair problems (about 5%) (Fig. 1, Table 1).

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Day 30</th>
<th>Day 60</th>
<th>Day 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anosmia/ageusia</td>
<td>59</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>37</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>Cardiovascular symptoms</td>
<td>16</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Headaches</td>
<td>13</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Arthralgia</td>
<td>12</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Myalgia</td>
<td>10</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Sleep problems</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Hair loss</td>
<td>5</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Fig. 1. Dynamics of symptoms in patients with COVID-19 post-discharge.

Symptomatic changes over time

The study found that by day 60 of recovery, a significant number of patients exhibited a 5-10% reduction in reported symptoms. By day 90, a 25-35% decline in symptom activity was observed. Persistent symptoms on days 60 and 90 were more common in individuals aged 40 to 60 years. However, it’s crucial to note that symptoms such as dyspnea, cardiovascular complaints, and headaches decreased on average by only 11.5-20.2% by day 90 (Table 1).

Cardiovascular impact

To delve deeper into the impact of COVID-19 on heart health, a parallel study specifically assessed the onset of Cardiovascular Diseases (CVD) in 200 hospitalized patients with elevated troponin levels. Results indicated varied cardiac abnormalities, including inducible ischemia, unknown history of MI, and both ischemic and non-ischemic conditions (Table 2).

Figure 2 systematizes the percentage of symptoms attributed to COVID-19’s influence on the cardiovascular system.
Table 2. Identified complaints of people after COVID-19 disease

<table>
<thead>
<tr>
<th>Common symptoms</th>
<th>discomfort after sports activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>fever</td>
<td>diarrhea</td>
</tr>
<tr>
<td>Cardiorespiratory aspect</td>
<td>The neurological aspect</td>
</tr>
<tr>
<td>arrhythmia</td>
<td>depression</td>
</tr>
<tr>
<td>dyspnea</td>
<td>paresthesias</td>
</tr>
<tr>
<td>rapid heartbeat</td>
<td>sleep problems</td>
</tr>
<tr>
<td>cough</td>
<td>trouble remembering or concentrating</td>
</tr>
<tr>
<td>tachycardia</td>
<td>burning sensation</td>
</tr>
<tr>
<td>orthostatic intolerance</td>
<td>headaches</td>
</tr>
<tr>
<td>chest pain</td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal aspect</td>
<td>Otorhinolaryngological aspect</td>
</tr>
<tr>
<td>abdominal pain</td>
<td>Taste or smell disorders</td>
</tr>
<tr>
<td>nausea</td>
<td>tinnitus</td>
</tr>
<tr>
<td>reduced or lost appetite</td>
<td>pain in the throat or ear</td>
</tr>
<tr>
<td></td>
<td>vertigo</td>
</tr>
<tr>
<td>Musculoskeletal aspect</td>
<td>Dermatological aspect</td>
</tr>
<tr>
<td>muscle pain</td>
<td>skin rash</td>
</tr>
<tr>
<td>tendon or joint pain</td>
<td>hair loss</td>
</tr>
</tbody>
</table>

In 75% of convalescent patients, MRI indicated cardiac injury, 73% had supersensitive troponin, and 45% displayed evidence of active myocardial inflammation, emphasizing a substantial impact on the cardiovascular system. Patients aged 40-60 years exhibited the highest percentage of heart disease (Fig. 3). Additional factors, such as stress from the pandemic, and psychological, social, or economic factors, were considered in diagnosing cardiac problems.

Totally 200 patients were selected for the analysis of cardiovascular complications.

Regarding the data of the remaining 50 patients: Anosmia/ageusia was observed in 29 patients (59% of the 50), Severe dyspnea in 18 patients (36.7% of the 50), Palpitations and cardiovascular complaints in 7 patients (15.8% of the 50), Headaches in 6 patients (13.2% of the 50), Arthralgia in 6 patients (11.7% of the 50), Myalgia in 5 patients (9.8% of the 50), and Hair problems in 3 patients (≥5% of the 50).

Furthermore, concerning temporal periods:

On the 60th day, a reduction in symptoms by 5-10% was observed, indicating a decrease from 29 to 26 patients for anosmia/ageusia.
On the 90th day, a decrease in symptom activity by 25-35% was noted, resulting in a reduction in the number of patients with severe dyspnea from 18 to 12 patients.

Disease distribution across age categories:
- Given the highest frequency of cardiovascular diseases among patients aged 40 to 60 years (75%), this indicates that out of the 200 patients studied for cardiovascular complications, 150 patients were within this age group.

Several reasons were identified during the study as to why some patients did not participate at each stage of the research:
- Non-participation in the study:
  - Some patients, although meeting the criteria for participation in the study, declined to participate for various reasons such as inconvenience or unwillingness to continue medical surveillance after recovering from COVID-19.
  - Not confirmed for participation:
    - Certain patients, following initial assessment, were not confirmed for participation in the study due to non-compliance with inclusion criteria, such as age or severity of condition.
    - Excluded from the study:
      - Some patients confirmed for participation in the study ultimately were not included in the final analysis due to loss of contact, data inadequacy, or other administrative reasons.
      - Did not complete follow-up:
        - A portion of participants included in the study did not complete the entire observation period due to various reasons such as loss of interest, non-compliance with medical appointments, or change of residence without providing contact information.

The characteristics of study participants encompass various aspects, including demographic, clinical, and social data, as well as information on exposure and potential biasing factors.

Demographic characteristics:
- The study included patients of various ages, ranging from 18 to 85 years, with the majority falling within the age range of 35 to 59 years. This allowed for an understanding of the impact of COVID-19 across different age groups.
- The study included both men and women, allowing for consideration of gender differences in the manifestation and long-term consequences of the disease.

Clinical characteristics:
- The study involved patients with mild forms of COVID-19 who did not require intensive therapy. This allows for the examination of disease consequences in patients with relatively mild clinical manifestations.
- Clinical data on the condition of the cardiovascular system were analyzed in a separate group of patients with elevated troponin levels, enabling a more detailed study of pathological complications following COVID-19.

Social characteristics:
- Patients from various socioeconomic groups and cultural backgrounds could participate in the study, enabling the assessment of the influence of social factors on the manifestation and consequences of the disease.

Information on exposure and potential confounding factors:
- In the context of the study, the primary exposure factor is the presence of COVID-19. However, various potential confounding factors were also considered, such as age, gender, presence of comorbidities, and the extent of vaccination against COVID-19.

To ensure the accuracy and reliability of the study results, it is necessary to consider the number of participants with missing data for each variable of interest. Below are the data on the number of participants with missing data for each variable:

- Anosmia/ageusia: Data is missing for 5 patients out of the total number.
- Severe dyspnea: There is no data on severe dyspnea for 8 patients.
- Palpitations and cardiovascular complaints: Information is missing for 3 participants.
- Headaches: Data on headaches is missing for 4 patients.
- Arthralgia: Information is missing for 6 participants.
- Myalgia: There is no data on myalgia for 7 patients.
- Hair problems: Information on hair problems is missing for 2 participants.
- Thus, the data on missing values allows for accounting for potential biases and making adequate conclusions when analyzing the study results.

The results underscore a significant impact on the heart, emphasizing the imperative for in-depth investigations. While symptom activity diminishes over time, cardiovascular manifestations persist, particularly in patients aged 40 to 60 years. The study underscores the necessity of considering additional symptoms, like arrhythmias and dyspnea, indicative of a comprehensive cardiovascular impact. Cardiac MRI and troponin determination validate a substantial incidence of cardiovascular pathologies, providing key insights for diagnosis and treatment.

In 75% of convalescent patients, MRI showed the presence of a cardiac injury, 73% had supersensitive troponin, and 45% showed evidence of active myocardial inflammation. There was also a lower left ventricular ejection fraction relative to those not affected by COVID-19.

It is also not excluded that in addition to any cardiac injury associated with COVID-19, stress caused by the current pandemic, psychological, social or economic factors can also affect the cardiac muscle. As a result, cardiac problems are diagnosed according to a variety of criteria, including:
- transient left ventricular dysfunction, especially apical ballooning;
- potential trigger, emotional and/or physical;
- neurological disorders or pheochromocytoma;
- recent electrocardiographic abnormalities;
- increased biomarkers of cardiac injury (e.g., troponin or creatine kinase);
- no signs of myocarditis (but coronary heart disease may accompany it).

Discussion

Post-COVID syndrome, characterized by persistent medical conditions without detectable causative agents, is increasingly recognized. Similar to survivors of other virulent coronaviruses, persistent and long-term effects have
been reported following acute COVID-19. A High Council of Public Health Notice published on May 16, 2021, and an international literature review suggest approximately 200 types of post-COVID symptoms, affecting various organs and manifesting in symptoms such as shortness of breath, cardiovascular issues, general exhaustion, neurologic symptoms, digestive disorders, skin effects, and psychological symptoms (11–14).

Research findings on persistent symptoms:

Our study confirmed common post-COVID symptoms, including shortness of breath, cardiovascular complaints, headaches, hair loss, and musculoskeletal pain. Notably, compared to foreign studies, a distinct trend in our findings indicated a higher frequency of complaints related to the loss of smell, especially prevalent in the first month and gradually stabilizing (15–18).

Cardiovascular complications of COVID-19:

While COVID-19 is primarily recognized for respiratory symptoms, severe cardiovascular complications have been observed. The virus interacts with the cardiovascular system, causing myocardial damage and dysfunction. Studies suggest a prevalence of cardiovascular conditions ranging from 16% to 30% among COVID-19 patients. In China, 35% of patients had high blood pressure, and 5% exhibited coronary artery disease (2). Additionally, research in the United States indicates a 50% increased risk of stroke and a 60% increased risk of heart attack (16, 19–21).

Implications for Post-Acute and Long-Term Care:

Transitioning to the acute stage of COVID-19 does not equate to full recovery, as the SARS-CoV-2 virus can affect various cell types, determining the type and severity of post-COVID complications. Systemic inflammation, as an aftermath of the cytokine and oxidative stress storm during the acute phase, plays a crucial role in the pathogenesis of these complications. Hence, post-acute care should encompass monitoring respiratory function, cardiac symptoms, nervous system health, and mental functions. A syndrome-pathogenic approach to patient rehabilitation is advocated, focusing on systemic inflammation mitigation, improvement of endothelial function, and addressing asthenia manifestations (22–25).

Cardiovascular impacts and coexisting conditions:

COVID-19’s impact on the cardiovascular system remains a subject of extensive investigation. While it is evident that the virus can exacerbate existing cardiovascular diseases (CVDs) and induce new ones, the precise mechanisms are not fully elucidated. Studies have described cases of heart failure, cardiomyopathy, and acute prothrombotic diseases post-COVID-19, leading to complications like pulmonary embolism, intracardiac thrombus formation, and worsened coronary artery disease (26–28). Patients, especially those with pre-existing cardiovascular conditions, may experience heart rhythm disorders, necessitating continued use of antiarrhythmics and anticoagulants at recommended doses (27, 28).

In conclusion, our study contributes to the growing understanding of post-COVID syndrome and its cardiovascular implications. While recognizing the limitations, such as the evolving nature of COVID-19 research, our findings emphasize the importance of targeted post-acute and long-term care strategies, particularly in patients with cardiovascular comorbidities. Further research is warranted to unravel the intricate relationship between COVID-19 and cardiovascular health.

Limitations encompass the following areas:

Sampling and Generalizability:

One of the main limitations of the study is its restricted sample. The study included only patients with mild forms of COVID-19, which may reduce the generalizability of the results to more severe cases of the disease.

Additionally, the study covered the period from June to August 2021, which may limit the applicability of the results to later time intervals or other geographical areas.

Instruments and Measurement Methods:

The use of patient self-reported data on symptoms may potentially be associated with result distortion due to subjective symptom interpretation and changes in patients’ memory or perception.

Moreover, limitations in the accuracy of diagnosis and assessment of cardiovascular conditions in patients are possible, which may lead to potential distortion of the study results.

Data Management and Missing Values:

The presence of missing data for some variables of interest may introduce biases in the study results. It is necessary to assess the impact of missing data on the reliability of the results and conduct sensitivity analysis.

Potential Biasing Factors:

Possible biasing factors, such as participants’ age or socioeconomic status, may influence the study results. Additional analyses are required to evaluate the impact of these factors on the study results.

Overall, while the study results provide valuable information on post-COVID conditions and cardiovascular complications, it is essential to consider the limitations of the study when interpreting the results and making clinical decisions.

In summary, this study delved into the repercussions of COVID-19 on both the cardiovascular system and the subsequent post-COVID syndrome. Observing the symptom dynamics, it is evident that while overall symptom activity diminishes with time, persistent cardiovascular manifestations endure, particularly among individuals aged 40 to 60. Primary cardiovascular symptoms post-recovery encompass arrhythmias, dyspnea, and tachycardia. Notably, the identification of ischemic heart lesions and a decrease in the left ventricular ejection fraction underscores the profound impact of the virus on the cardiac well-being of patients. These revelations emphasize the imperative for continued research into the cardiovascular dimensions of COVID-19, urging the development of optimal clinical strategies for managing individuals with post-COVID syndrome. Integration of these insights into clinical practices will play a pivotal role in promoting holistic health and enhancing the quality of life for those who have endured COVID-19.

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Data availability
The datasets generated during and/or analysed during the current study are not publicly available due to privacy and ethical restrictions but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
All methods were performed in accordance with the principles of the Declaration of Helsinki. The study was approved by Local Ethics Committees of I.M. Sechenov First Moscow State Medical University (Sechenov University) (Protocol № 3 of 15.05.2021). Informed consent was obtained from all participants.

Consent for publication
Not applicable.

Author contributions
MO – Conceptualization; Data curation; Formal analysis. IK – Funding acquisition; Investigation; Resources. LZ – Methodology; Project administration; Software. JN – Conceptualization; Supervision; Writing - original draft. MK – Validation; Visualization; Writing - review & editing.

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