## PREDICTION AND PREVENTION OF THE RISK OF DEVELOPING CARDIOVASCULAR COMPLICATIONS IN PATIENTS WITH COVID-19

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***Abstract:*** *this article examines methods for identifying and preventing the risk of developing cardiovascular diseases in patients who have recovered from COVID-19 infection. Possible complications in the cardiovascular system in the final stage of the disease, their pathophysiology, diagnostics and treatment strategies are analyzed. Modern approaches to assessing risk factors and implementing preventive measures are also presented. The article provides recommendations for timely detection and effective prevention of cardiovascular diseases in patients with COVID-19.*

***Keywords:*** *COVID-19, cardiovascular diseases, complications, risk prediction, prevention, diagnostics.*

## COVID-19 O‘TKAZGAN BEMORLARDA YURAK QON-TOMIR ASORATLARI RIVOJLANISH XAVFINI PROGNOZLASH VA OLDINI OLISH

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***Annotatsiya:*** *ushbu maqolada COVID-19 infektsiyasidan sog‘aygan bemorlarda yurak qon-tomir kasalliklari rivojlanish xavfini aniqlash va oldini olish usullari ko‘rib chiqilgan. Kasallik so‘nggi bosqichida yurak-tomir tizimida yuzaga kelishi mumkin bo‘lgan asoratlar, ularning patofiziologiyasi, diagnostikasi va davolash strategiyalari tahlil qilingan. Shuningdek, xavf omillarini baholash va profilaktika choralarini joriy etish bo‘yicha zamonaviy yondashuvlar taqdim etilgan. Maqolada COVID-19 ga chalingan bemorlarda yurak-qon tomir kasalliklarini vaqtida aniqlash va samarali oldini olish uchun tavsiyalar berilgan.*

***Kalit so‘zlar:*** *COVID-19, yurak qon-tomir kasalliklari, asoratlar, xavfni prognozlash, profilaktik, diagnostika.*

## ПРОГНОЗИРОВАНИЕ И ПРОФИЛАКТИКА РИСКА РАЗВИТИЯ СЕРДЕЧНО-СОСУДИСТЫХ ОСЛОЖНЕНИЙ У БОЛЬНЫХ COVID-19

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***Аннотация:*** *в данной статье рассматриваются методы выявления и профилактики риска развития сердечно-сосудистых заболеваний у пациентов, перенесших инфекцию COVID-19. Проанализированы возможные осложнения со стороны сердечно-сосудистой системы в терминальной стадии заболевания, их патофизиология, диагностика и тактика лечения. Также представлены современные подходы к оценке факторов риска и проведению профилактических мероприятий. В статье даны рекомендации по своевременному выявлению и эффективной профилактике сердечно-сосудистых заболеваний у пациентов с COVID-19.*

***Ключевые слова:*** *COVID-19, сердечно-сосудистые заболевания, осложнения, прогнозирование риска, профилактика, диагностика.*

**Introduction.**

The COVID-19 pandemic has presented a significant challenge to health worldwide, not only because of acute respiratory illness but also because of its systemic complications, most notably cardiovascular involvement. Clearly, patients recovering from COVID-19 are at risk of a wide range of cardiovascular complications, including myocarditis, arrhythmias, thromboembolism, and heart failure. A good understanding of the underlying mechanisms, the identification of high-risk individuals, and the implementation of preventive strategies are vital to reduce morbidity and mortality related to these complications. The present article explores prediction and prevention in relation to cardiovascular risk among patients affected by COVID-19, with the aim of improving clinical outcomes and long-term health [1]. Despite the containment of the pandemic caused by the SARS-CoV-2 virus, more than 70% of patients who have experienced COVID-19 have symptoms of post-COVID syndrome (PCS). Common symptoms of PCS include shortness of breath, decreased exercise tolerance, fatigue, cognitive impairment, and cardiovascular disease. According to statistics, more than 50% of patients with PCS have various disorders of the cardiovascular system [2]. Therefore, the treatment of PCS occurring against the background of cardiovascular disease without medication, through physical rehabilitation, is of particular importance.

**Main part.**

COVID-19 is not merely a respiratory disease; it has significant systemic effects, especially on the cardiovascular system. The virus uses the angiotensin-converting enzyme 2 (ACE2) receptor to enter human cells, highly expressed in heart muscle cells and vascular endothelial cells. This facilitates direct viral invasion and damage. The resulting endothelial dysfunction, combined with an intense inflammatory response characterized by a cytokine storm, creates a pro-thrombotic environment. This hyperinflammatory and hypercoagulable state contributes to myocardial injury, microvascular thrombosis, and arrhythmias. Therefore, understanding this pathophysiology is crucial for predicting which patients are more likely to develop cardiovascular complications post COVID-19 and tailoring preventive strategies effectively. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV 2), or coronavirus disease 2019 (COVID-19), virus pandemic has drastically changed the health service and has paralyzed medical services. Recent growing evidence suggests that COVID-19 can disrupt several systems and results in a variety of clinical symptoms [3]. The mechanisms behind how COVID-19 affects the cardiovascular system are currently being discovered. The size of the viral inoculum, the intensity of the host immune response, and the existence of underlying comorbidities may all influence the cardiovascular involvement in COVID-19, and frequently, these patients present newly discovered or worsening cardiovascular disease, hypertension, arrhythmia, myocardial infarction, heart failure, and sudden cardiac arrest. Post-COVID-19 syndrome is a public health concern that has emerged as a result of the COVID-19 pandemic, and has long-lasting impacts on those who have already contracted COVID-19. The Royal College of General Practitioners (RCGP) has thus divided COVID-19 infection into three timeframe points: signs and symptoms that last for up to four weeks are referred to as acute COVID-19, those that last for four weeks to twelve weeks are referred to as ongoing symptomatic COVID-19, and those that last for more than twelve weeks are referred to as post-COVID-19 syndrome. Since it affects COVID-19 survivors at all illness severity levels, post-COVID-19 syndrome is a poorly known condition. The condition is mostly characterized by post-discharge tiredness and dyspnea. The need to determine the persistent symptoms and clinical consequences has been driven by the limited understanding of its clinical course. The aim of

this review was to explore the most common cardiovascular (CV) complications of COVID-19 [4].

The spectrum of cardiovascular complications related to COVID-19 is broad and can manifest during the acute infection or later in recovery. Myocarditis—an inflammation of the heart muscle—is one of the most serious outcomes. Patients may also experience arrhythmias like atrial fibrillation, acute coronary syndromes, stress-induced cardiomyopathy, and thromboembolic events such as deep vein thrombosis and pulmonary embolism. Importantly, persistent symptoms like chest pain, palpitations, and fatigue in post-COVID syndrome are often linked to underlying cardiovascular issues. These complications increase morbidity and mortality and complicate long-term recovery, reinforcing the need for ongoing surveillance.

Identifying patients at high risk of cardiovascular complications requires a comprehensive evaluation of clinical risk factors and biomarkers. Older age, male gender, and comorbidities such as hypertension, diabetes, obesity, and pre-existing cardiovascular diseases significantly raise the likelihood of adverse outcomes. Additionally, laboratory markers such as elevated cardiac troponins, D-dimer levels, and C-reactive protein reflect myocardial injury and systemic inflammation, serving as important predictors [5]. Combining these clinical and biochemical indicators into risk assessment models enables healthcare providers to stratify patients and allocate resources efficiently by focusing preventive care on those most vulnerable.

Effective prediction must be coupled with robust preventive strategies to decrease the incidence and severity of cardiovascular complications. Pharmacological interventions play a pivotal role; for example, anticoagulants reduce the risk of thrombosis in hospitalized and high-risk post-discharge patients. Similarly, the use of ACE inhibitors or beta-blockers may help control cardiac workload and limit remodeling in patients with myocardial involvement. Anti-inflammatory treatments, both during acute illness and recovery phases, may mitigate cytokine-driven damage. However, therapy should be individualized, balancing benefits against risks such as bleeding or adverse drug interactions, emphasizing the need for vigilant monitoring

Beyond medication, lifestyle modification and rehabilitation are critical components of prevention. Structured cardiac rehabilitation programs offer supervised exercise, nutrition counseling, and psychological support, all contributing to improved cardiovascular outcomes and quality of life. Encouraging patients to maintain physical activity, quit smoking, manage weight, and control blood pressure and glucose levels can alleviate underlying risk factors exacerbated by COVID-19. These interventions foster cardiovascular resilience and help reverse or limit long-term damage, highlighting the importance of multidisciplinary care and patient education in managing the cardiovascular aftermath of COVID-19 [6].

1. Pathophysiology of Cardiovascular Complications in COVID-19

SARS-CoV-2 enters cells through the ACE2 receptor, which is highly expressed in the heart and vascular endothelium. The interaction promotes an inflammatory cascade, including endothelial dysfunction and a hypercoagulable state leading to myocardial injury and vascular damage. Cytokine storms and immune-mediated effects further contribute to cardiovascular stress, leading to the onset of complications.

2. Common Cardiovascular Complications in the Aftermath of COVID-19

The most common cardiovascular complications reported include myocarditis, acute coronary syndrome, arrhythmias, myocardium fibrosis, and thromboembolic events. These may occur either during acute illness or even after recovery, thus complicating the convalescent period and affecting quality of life.

3. Risk Factors for Cardiovascular Complications

Advanced age, previous cardiovascular diseases such as hypertension and coronary artery disease, diabetes mellitus, obesity, and severity of initial COVID-19 infection enhance the possibility of developing cardiovascular sequelae. Laboratory markers of risk include high levels of troponin, D-dimer, and CRP.

4. Early Detection Diagnostic Tools

The early recognition depends on clinical assessment along with cardiac biomarkers, electrocardiography, echocardiography, and, if indicated, cardiac MRI. Regular follow-up visits after COVID increase the chances for early detection and timely management.

5. Predictive Models and Risk Stratification

A number of clinical features and laboratory parameters-based risk prediction models have been developed for the stratification of patients. These risk prediction models help clinicians in the identification of high-risk individuals who deserve intensified surveillance and preventive interventions. Pharmacological Prevention Strategies Anticoagulants, anti-inflammatory agents, and medications like ACE inhibitors or beta-blockers may be indicated for certain patients to prevent thrombotic events and mitigate cardiac stress. Treatment should be tailored individually and based on risk assessment. Lifestyle and Rehabilitative Measures Encouraging healthy lifestyle changes post-COVID, such as proper nutrition, regular physical activity, quitting smoking, and sufficient stress management, are essential in the maintenance of cardiovascular health. Cardiac rehabilitation improves functional capacity and reduces complications [8]. Future Directions and Research Needs Long-term cardiovascular outcomes need further research to better understand them and to refine the prediction tools. Large-scale prospective studies and clinical trials will enable the establishment of evidence-based guidelines on prevention and management in this population [9].

ECG is widely available and a basic tool for the detection of acute myocardial injury, ischemia, new-onset arrhythmias, conduction abnormalities, ST-T segment deviations, or QT prolongation [10], which may be early critical markers of cardiac distress. Cardiac biomarkers, especially high-sensitivity troponin and N-terminal pro-B-type natriuretic peptide, play an indispensable role in defining myocardial injury and ventricular dysfunction, respectively. High levels of troponin are associated with an increased risk of unfavorable outcomes, including death, whereas an elevated level of NT-proBNP indicates cardiac strain and might suggest further development of heart failure [11].

The imaging techniques play a central role in characterizing the extent and nature of cardiovascular damage. Echocardiography assesses ventricular function, valvular abnormalities, pericardial effusions, and pulmonary hypertension, identifying subtle signs of myocardial dysfunction even in patients with preserved ejection fraction, and can guide management decisions. Cardiac computed tomography (CT) can be used to assess coronary arteries, check for pulmonary embolism, and identify pericardial effusions. COVID-19 patients are at an increased risk for future CV events, and in this setting, coronary CT has demonstrated a more rapid progression of coronary atherosclerosis with increased risk of target lesion failure [12].

On the other hand, CMR has the capability of precisely delineating the area of myocarditis, targeting myocardial scarring, and providing insights into diffuse myocardial injury that may go unnoticed by other modalities. The multi-parametric capabilities of CMR make it particularly useful both in the acute and post-acute phase, although the COVID-19 pandemic has determined a disproportion between the number of CMR requested and positive results. The cardiovascular implications for outcomes in COVID-19 patients are severe. Acute cardiac injury and the development of major adverse cardiovascular events (MACE)

during hospitalization significantly increase the risk of in-hospital mortality. Beyond the acute phase, a considerable number of individuals, including those with mild initial infections, experience “Long COVID” or Post-Acute Sequelae of SARS-CoV-2 infection (PASC), with persistent cardiovascular symptoms such as palpitations, chest pain, and exercise intolerance. This suggests a long-term burden on cardiovascular health, necessitating ongoing monitoring and potential intervention. The cumulative impact of direct viral effects, systemic inflammation, and prolonged recovery can lead to a significant increase in the prevalence of cardiovascular morbidity and mortality in the years following the pandemic. Therefore, a multidisciplinary approach encompassing early diagnosis, risk stratification, and long-term cardiovascular follow up is crucial to mitigate the lasting impact of COVID-19 on global cardiovascular health [13].

Post-COVID syndrome leads to serious impairment of respiratory and cardiovascular functions. This condition is even more severe in patients with existing heart disease [14]. However, a 12-week cardiopulmonary rehabilitation program not only reduces shortness of breath, but also helps restore cardiac function, reduce fatigue, and increase exercise tolerance. Rehabilitation also has a positive effect on psychological well-being. These results provide the basis for recommending physical rehabilitation as the main alternative, without medication, in post-COVID patients [15].

**Conclusion.**

Cardiovascular complications in COVID-19 patients are an important health concern and require early prediction and prevention. The identification of high-risk subjects by clinical and laboratory assessments, followed by pharmacological and lifestyle interventions, will minimize adverse outcomes. Further research and a multidisciplinary approach to care are urgently needed to optimize cardiovascular health among post-COVID populations and reduce burdens on health systems.

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