Proceedings of the 4th International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/63/2024.17940

Research on the Impact of SARS-CoV-2 on Heart Health

Alec Wang

Beijing No.101 High School, Beijing, 100055, China

Alec20070306@163.com

Abstract. Since the initial identification of SARS-CoV-2, its impact on heart health has been a subject of considerable interest. SARS-CoV-2 infection not only triggers respiratory symptoms but may also cause substantial damage to the heart and cardiovascular system, leading to conditions such as myocarditis, heart failure, and other cardiovascular events. Research indicates that these cardiac issues are particularly prominent in severe cases. This review examines the specific effects of SARS-CoV-2 infection on the heart, including changes in cardiac structure, Electrocardiogram (ECG) abnormalities, and variations in cardiac biomarkers such as troponin and B-type natriuretic peptide (BNP). It also explores the relationship between these changes and clinical outcomes in patients. In addition, by synthesizing current literature, the study reveals the multifaceted impact of SARS-CoV-2 on cardiac function and discusses its implications for clinical management. Notably, significant increases in biomarkers of myocardial injury, such as troponin and BNP, suggest possible cardiac damage or increased burden. The results highlight the importance of monitoring and protecting heart function in patients with SARS-CoV-2 infection. In short, the paper delves into the impact of SARS-CoV-2 on heart health and provides recommendations for further research and clinical practice to improve patient outcomes.

Keywords: SARS-CoV-2, Heart Health, Myocarditis, Abnormal Electrocardiogram.

1. Introduction

Since the emergence of SARS-CoV-2 at the end of 2019, its impact on global health has garnered significant attention [1]. While SARS-CoV-2 mainly presents as a respiratory infection, studies have demonstrated that infected individuals may experience cardiac issues such as myocarditis, heart failure, as well as arrhythmias, which are particularly severe in critically ill patients, significantly increasing clinical risks and mortality rates. The acute cardiac effects of SARS-CoV-2 have been widely studied, revealing a variety of cardiac complications. However, despite this research, there remains a notable gap in systematic evaluations of the long-term cardiac sequelae of SARS-CoV-2 infection. Specifically, there is poor understanding of how the infection impacts cardiac structure and function over time, as well as the persistence of Electrocardiogram (ECG) abnormalities and alterations in cardiac biomarkers such as troponin and B-type natriuretic peptide (BNP). Therefore, the paper aims to provide a comprehensive review of the existing literature to examine the specific impact of SARS-CoV-2 infection on heart health. Changes in cardiac structure and function following infection, including the ECG abnormalities, variations in cardiac biomarkers, and their association with clinical outcomes, are examined. By synthesizing existing research, this research seeks to enhance our understanding of SARS-CoV-2's impact on cardiac health, inform future research directions, and offer practical insights for improving clinical management of affected patients.

DOI: 10.54254/2753-8818/63/2024.17940

2. Physiological Mechanisms of SARS-CoV-2 on the Heart

SARS-CoV-2 gains entry into cardiac cells through its surface proteins binding to the Angiotensin-Converting Enzyme 2 (ACE2) receptors on host cells, and ACE2 is widely expressed in the heart, lungs, and other vital organs. Therefore, SARS-CoV-2 infection can cause multi-organ damage [2]. The virus binds to ACE2 receptors, initiating infection in cardiac cells, which can result in cellular membrane disruption and viral invasion, thereby affecting normal cardiac function. Following viral entry into cardiac cells, a localized inflammatory response is triggered. Activation of ACE2 receptors leads to the release of inflammatory mediators such as cytokines and chemokines, which exacerbate the local inflammatory response. This inflammation results in pathological changes in myocardial cells, including apoptosis and necrosis. The inflammatory mediators within cardiac tissue can induce apoptosis and necrosis of myocardial cells, thereby reducing the heart's contractile capacity. Furthermore, SARS-CoV-2 infection affects the electrophysiological activity of the heart. Specifically, the presence of the virus and the associated inflammatory response can alter the electrophysiological properties of myocardial cells, leading to arrhythmias. The disruption in cardiac blood supply and oxygenation further exacerbates cardiac dysfunction. Myocardial cells are damaged via mechanisms such as apoptosis and necrosis, and release inflammatory mediators, thus leading to local myocardial necrosis and ultimately clinical manifestations such as heart failure and severe arrhythmias. These pathophysiological changes highlight that the impact of SARS-CoV-2 on the heart involves not only direct cellular damage but also complex inflammatory responses and electrophysiological abnormalities. These mechanisms collectively affect cardiac structure and function, increasing the risk of cardiac diseases.

3. Specific Effects of SARS-CoV-2 on the Heart and Its Clinical Manifestations

3.1. Mechanisms of Cardiac Injury

The impact of SARS-CoV-2 on the heart involves clinical manifestations, such as myocarditis, heart failure, as well as arrhythmias. Myocarditis is common in patients infected with SARS-CoV-2, especially in severe cases, and its incidence is significantly higher than that of patients with common influenza [3]. Myocarditis occurs in that SARS-CoV-2 directly infects myocardial cells, hence leading to cell apoptosis, local inflammatory response, and overactivation of the immune system. This inflammation and immune response can cause damage to myocardial cells, which in turn affects the heart's pumping function and may lead to abnormal electrophysiology and arrhythmias. At the same time, heart failure is also a common complication in patients infected with SARS-CoV-2, especially in patients with a history of heart disease. Studies have found that the risk of worsening heart function in patients after infection is significantly increased, which is closely related to myocardial inflammation, myocardial cell damage, and increased overall cardiac load caused by SARS-CoV-2 [4]. In addition, arrhythmias are also an important clinical problem in SARS-CoV-2 infection. Viruses induce changes in cardiac electrophysiology through proinflammatory cytokines and other mechanisms, especially a high incidence of ventricular arrhythmias [5]. Besides, these electrophysiological changes may not only lead to atrial and ventricular arrhythmias, but have a negative impact on the normal rhythm of the heart, thereby increasing the complexity and difficulty of management of heart disease.

3.2. Clinical Manifestations

The clinical manifestations of SARS-CoV-2 infection on the heart include ECG changes, elevated myocardial injury markers, and specific mechanisms of cardiac injury. ECG changes are an important indicator for assessing cardiac health. Patients infected with SARS-CoV-2 often present with abnormalities such as ST-segment elevation, T-wave inversion, and ventricular arrhythmias [6]. These ECG abnormalities not only indicate abnormalities in cardiac electrophysiology, but may also indicate potential myocardial injury. Myocardial injury markers such as troponin and brain natriuretic peptide are often significantly elevated in infected patients. Elevated levels of these markers indicate substantial damage to cardiac tissue. Studies have shown that elevated troponin levels are closely related to the patient's clinical prognosis, and higher troponin levels are often associated with an increase in cardiac

DOI: 10.54254/2753-8818/63/2024.17940

complications during hospitalization [7]. Further studies have shown, through cardiac magnetic resonance imaging (MRI), that myocardial edema and fibrosis in patients infected with SARS-CoV-2 reveal that cardiac tissue undergoes significant structural changes and functional damage during infection [8]. These imaging findings provide direct evidence of cardiac injury, showing that myocardial cell apoptosis and local inflammation play a key role in the mechanism of injury. Additionally, the cardiac ultrasound examinations also found that the cardiac contractile function of infected patients may be affected, further confirming the clinical manifestations of cardiac injury. These clinical manifestations collectively demonstrate the extensive impact of SARS-CoV-2 on the heart, emphasizing the importance of early identification and management of cardiac problems to improve the clinical prognosis of patients.

4. Overall Impact and Long-Term Sequelae of SARS-CoV-2

4.1. Overall Impact on Cardiac Health

The impact of SARS-CoV-2 on cardiac health is extensive and far-reaching. Studies have shown that patients with underlying cardiovascular disease have a significantly increased risk of developing severe illness after infection with SARS-CoV-2. This increased risk is mainly attributed to the fact that the cardiovascular system of these patients is already in poor condition, making them more susceptible to the severe effects of the virus [9]. For example, patients with coronary heart disease, hypertension, and diabetes showed significantly higher mortality after infection. This not only reflects the aggravation of existing heart diseases by SARS-CoV-2 infection, but may also cause new heart health problems such as myocardial damage and heart failure. There is a close relationship between the severity of the disease and the impact on the heart. Large-scale retrospective studies have shown that the incidence of cardiac complications in critically ill patients is significantly increased, which is directly related to the systemic inflammatory response and the degree of tissue hypoxia [10]. Systemic inflammation and hypoxia increase the workload of the heart, causing the heart to bear additional pressure, resulting in higher heart damage and mortality. The inflammatory response further exacerbates heart damage by promoting myocardial cell apoptosis and increasing the workload of the heart. These factors work together to significantly increase the overall impact of SARS-CoV-2 infection on cardiac health, suggesting the need for more precise and earlier interventions targeting high-risk groups to improve clinical prognosis.

4.2. Long-Term Sequelae of SARS-CoV-2 Infection

The long-term sequelae of SARS-CoV-2 infection have attracted widespread attention, and many recovered patients have reported persistent cardiac symptoms, including chest pain, palpitations, fatigue, and dyspnea. These symptoms not only significantly affect the patient's quality of life, but are often difficult to relieve [11]. Studies have shown that these long-term symptoms may be related to myocarditis, cardiac fibrosis, and microvascular lesions. These lesions may not be fully recognized in the acute phase, causing patients to continue to feel unwell after recovery. SARS-CoV-2 may further induce long-term changes in cardiac structure and function by directly infecting cardiomyocytes, causing cardiomyocyte apoptosis and local inflammatory responses. The virus may also cause fibrosis and microvascular damage to cardiac tissue by inducing persistent immune responses and chronic inflammation. Long-term cardiovascular health monitoring is essential in the management of these sequelae. With the emergence of the “long coronavirus” phenomenon, clinicians need to continuously evaluate patients' cardiac function and perform regular ECG monitoring to detect and treat potential cardiac problems in a timely manner. Studies have shown that patients may experience a gradual decline in heart function after infection, and imaging examinations such as cardiac MRI and echocardiography are particularly important for evaluating structural and functional changes in the heart. These examinations help identify potential cardiac structural changes, such as myocardial fibrosis and dilatation of cardiac chambers, and guide further treatment and management. In addition, chronic inflammation and microvascular lesions may cause long-term damage to the heart, so comprehensive management measures for these lesions, including drug therapy and lifestyle adjustments, are essential

DOI: 10.54254/2753-8818/63/2024.17940

to improve patients' long-term heart health. Thus, the impact of SARS-CoV-2 on heart health is not limited to the acute phase, but may also lead to long-term cardiac sequelae. A deep understanding of these long-term sequelae and their management strategies are of great significance for improving patients' long-term health, optimizing treatment options, and guiding future public health interventions.

5. Prevention, Management, and Future Directions

5.1. Prevention and Management

Preventing and managing the effects of SARS-CoV-2 on the heart requires a multi-layered strategy. Vaccination has been shown to be one of the most effective preventive measures, significantly reducing infection rates and the risk of associated cardiovascular complications. Studies have shown that vaccination not only reduces the incidence of severe illness, but also significantly reduces the incidence of serious cardiac complications such as acute myocarditis and arrhythmias [12]. Therefore, public health policies should continue to focus on promoting vaccination, especially for high-risk groups with underlying cardiovascular disease. At the same time, lifestyle adjustments also play an important role in reducing the risk of heart disease and alleviating cardiac complications after infection. Measures such as moderate aerobic exercise, a balanced diet, smoking cessation, and limiting alcohol intake can significantly improve cardiac immunity, improve vascular function, and reduce inflammatory responses, thereby effectively reducing the risk of heart attack. For patients who have been infected and recovered, long-term cardiovascular health monitoring is particularly important. Continuous ECG monitoring, cardiac ultrasound, and magnetic resonance imaging (MRI) and other imaging examinations can help assess changes in cardiac function after infection, especially identifying chronic myocarditis or cardiac fibrosis that may have been overlooked. These examinations can help detect potential heart damage early, take timely treatment interventions, and prevent the condition from worsening. In addition, studies have shown that chronic inflammatory states and microvascular damage may persist during the recovery period and have long-term effects on heart function. Therefore, regular cardiovascular examinations and assessments should become standard management procedures for recovered patients, which not only help manage long-term heart symptoms, but also significantly improve patients' long-term quality of life and prognosis.

5.2. Future Direction

In the future, research on the effects of SARS-CoV-2 on the heart needs to be deepened in many aspects to make up for the shortcomings in current research. First, many existing studies have small sample sizes and are often cross-sectional studies, which cannot fully reveal the long-term effects of infection on the heart. Therefore, future large-scale randomized controlled trials will be key, through which the effects of SARS-CoV-2 on different stages of heart health can be more accurately assessed and its potential pathological mechanisms further clarified. In addition, research should pay special attention to high-risk groups, including the elderly, patients with underlying cardiovascular disease, and individuals with compromised immune systems, who may be at higher risk of heart damage after infection with SARS-CoV-2. Future studies should not only explore the long-term prognosis of these groups, but also study the differences between individuals in immune response and heart damage.

Future research directions should include the following key areas: First, the specific effects of different SARS-CoV-2 variants on the heart are not fully clear. Although there is evidence that viral mutations may affect the severity of respiratory symptoms, their specific mechanisms of action on the heart still need to be further explored, especially whether emerging variants will cause more severe heart changes and aggravate existing heart problems. Secondly, vaccination not only shows a positive effect in reducing infection rates, but also requires in-depth research on its potential cardiovascular protective effects. In particular, evaluating the possible improvement in heart health after vaccination and the impact of vaccines on the long-term heart health of previously infected people will become an important research topic. Third, future studies should strengthen the long-term follow-up of recovered patients, especially the changes in heart health of patients with long coronavirus syndrome. Regular cardiac

DOI: 10.54254/2753-8818/63/2024.17940

imaging examinations (such as cardiac MRI and ECG) can help detect potential cardiac fibrosis, myocarditis and microvascular lesions. Moreover, research should also explore the development of individualized management plans in combination with the development of precision medicine. Through the deep analysis of genomics and biomarkers, future individualized management can not only formulate the best treatment plan for the heart health status of different patients, but also provide more scientific basis for early intervention of heart damage.

6. Conclusion

This paper concludes that SARS-CoV-2, through binding to the ACE2 receptor, not only affects the respiratory system but also can trigger cardiac inflammation and injury, leading to cardiovascular complications such as myocarditis, heart failure, and arrhythmias. Studies have shown that severe SARS-CoV-2 patients, particularly those with pre-existing cardiovascular conditions, are more prone to developing cardiac complications. Clinical manifestations, including elevated cardiac injury markers, ECG abnormalities, and persistent cardiac symptoms, suggest that the virus may have long-term effects on heart health. Additionally, the phenomenon of "long coronavirus" underscores the need for ongoing monitoring of cardiac health after recovery. However, current research has limitations. Many studies have small sample sizes and lack diversity, which restricts the generalizability of the findings. In addition, systematic research on the long-term cardiac effects of SARS-CoV-2 remains insufficient, particularly for different age groups, genders, and health conditions. Confounding factors, such as pre-existing conditions and lifestyle choices, have also not been adequately controlled, potentially affecting the accuracy of study results. In order to address these issues, future research should employ larger, multi-center studies to increase the representativeness of the data. Standardized research methods and long-term follow-up are also crucial to ensure the reliability of the findings. Special focus should be given to the effects of viral variants, changes in cardiac health post-vaccination, and the relationship between immune response and heart health as key directions for future studies.

References

[1] WHO. (2023) COVID-19 Dashboard. World Health Organization.
[2] Zheng, Y., et al. (2020) COVID-19 and the cardiovascular system. Nature Reviews Cardiology, 17(5): 259-260.
[3] Patterson, K. J., et al. (2020). ACLF during COVID-19. Journal of Hepatology, 73(2): S19.
[4] Bhatla, A., et al. (2020). COVID-19 and cardiac arrhythmias. Circulation: Arrhythmia and Electrophysiology, 13(6).
[5] Wang, D., et al. (2020) Clinical characteristics of 138 hospitalized patients with nCoV pneumonia in Wuhan, China. JAMA, 323(11): 1061-1069.
[6] Kotecha, D., et al. (2020) COVID-19 and Atrial Fibrillation: A Hospital Experience. European Heart Journal, 41(16): 1466-1468.
[7] Geri, G., et al. (2021) Cardiac injury in COVID-19: An overview. European Journal of Preventive Cardiology, 28(3): 205-211.
[8] Madjid, M., et al. (2020) Potential Effects of Coronaviruses on the Cardiovascular System. American Journal of Cardiology, 125(8): 1409-1414.
[9] Wu, Z. and McGoogan, J.M. (2020) Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China. JAMA, 323(13): 1239-1242.
[10] Zhou, F., et al. (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet, 395(10229): 1054-1062.
[11] Davis, H.E., et al. (2021) Long COVID: What we know and what we need to know. Nature Reviews Immunology, 21(11): 681-682.
[12] Fowler, A. J., et al. (2022) Impact of COVID-19 vaccination on severe illness and mortality. Lancet Infectious Diseases, 22(3): e83-e93.