

## REVIEW ARTICLE

# Cardiovascular Complications Associated with COVID-19 Vaccination: A Review of Current Evidence

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## Abstract

**Background:** Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), has created an unprecedented global health challenge. Vaccination campaigns have played a crucial role in reducing infection rates, severe disease, hospitalizations, and mortality worldwide. Although COVID-19 vaccines have demonstrated high efficacy and an overall favorable safety profile, rare cardiovascular adverse events have been reported through post-vaccination surveillance systems.

Reported cardiovascular events following COVID-19 vaccination include myocarditis, pericarditis, cardiac arrhythmias, myocardial infarction, blood pressure changes, and stress-induced cardiomyopathy (Takotsubo syndrome). Among these, myocarditis and pericarditis have been the most frequently documented conditions, particularly after mRNA vaccines and predominantly among young males following the second dose. Most cases described in the literature have been mild and self-limiting with favorable clinical outcomes. Large epidemiological studies consistently demonstrate that the risk of cardiovascular complications following SARS-CoV-2 infection is significantly higher than the risk observed after vaccination. Although rare cardiovascular adverse events have been documented after COVID-19 vaccination, current evidence indicates that these events occur infrequently and are generally associated with mild clinical courses. The benefits of vaccination in preventing severe COVID-19 and its cardiovascular complications clearly outweigh the potential risks. Continued pharmacovigilance and long-term epidemiological studies remain essential to further clarify the mechanisms and incidence of these complications.

**Keywords:** COVID-19 vaccines, Cardiovascular complications, Myocarditis, Pericarditis, Arrhythmia, Myocardial infarction, Takotsubo cardiomyopathy, SARS-CoV-2.

## Introduction

The emergence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) in late 2019 resulted in a global pandemic that has had profound effects on healthcare systems and societies worldwide. Initially identified as a respiratory illness, coronavirus disease 2019 (COVID-19) was later recognized as a systemic disease affecting multiple organ systems, including the cardiovascular, neurological, and immune systems (Chang et al., 2020).

Since the beginning of the pandemic, hundreds of millions of confirmed infections and millions of deaths have been reported globally. Vaccination has been widely recognized as the most effective strategy for controlling the spread of the virus and reducing the severity of disease outcomes (World Health Organization, 2023).

In response to the urgent need for protection against COVID-19, several vaccines were rapidly developed using different technological platforms, including messenger RNA (mRNA) vaccines, viral vector vaccines, and inactivated virus vaccines. Among the most widely used vaccines worldwide are Pfizer-BioNTech (BNT162b2), Moderna (mRNA-1273), AstraZeneca (ChAdOx1-S), Johnson & Johnson (Ad26.COV2.S), Sinopharm (BBIBP-CorV), Sinovac (CoronaVac), Sputnik V (Gam-COVID-Vac), and Covaxin (BBV152).

Large clinical trials and real-world observational studies have confirmed the safety and effectiveness of these vaccines in preventing severe COVID-19, hospitalization, and death (Harris, 2022). Nevertheless, as vaccination programs expanded globally, post-marketing surveillance systems

began detecting rare adverse events that had not been observed during initial clinical trials.

Among these events, certain cardiovascular complications have attracted particular attention from the scientific community. Reports of myocarditis, pericarditis, arrhythmias, thrombotic events, and other cardiac conditions following vaccination have prompted further investigation into potential associations between vaccination and cardiovascular outcomes.

Understanding these potential complications is essential for clinicians and public health authorities. Accurate evaluation of vaccine safety helps guide clinical decision-making, improve patient management, and maintain public confidence in vaccination programs. Moreover, comparing the cardiovascular risks associated with vaccination with those related to COVID-19 infection itself is crucial for evaluating the overall benefit-risk balance.

This review provides a comprehensive overview of cardiovascular complications reported following COVID-19 vaccination, discusses possible pathophysiological mechanisms, and highlights the importance of ongoing surveillance and research.

### **Cardiovascular Complications Following COVID-19 Vaccination**

#### *Myocarditis and Pericarditis*

Myocarditis and pericarditis have been the most frequently reported cardiovascular conditions following COVID-19 vaccination. Myocarditis refers to inflammation of the heart muscle, whereas pericarditis involves inflammation of the pericardial membrane surrounding the heart.

Initial reports of vaccine-associated myocarditis were observed in Israel during large-scale vaccination campaigns using the Pfizer-BioNTech vaccine. Epidemiological data indicated that the incidence was highest among young males aged 16–24 years, particularly following the second vaccine dose (Witberg et al., 2021).

Clinical presentation commonly includes chest pain, elevated cardiac biomarkers such as troponin, electrocardiographic abnormalities, and cardiac magnetic resonance imaging findings consistent with myocardial inflammation. Symptoms typically develop within several days after vaccination.

Importantly, the majority of reported cases have been mild and self-limiting. Patients generally recover with conservative treatment, including nonsteroidal anti-inflammatory drugs and short periods of clinical monitoring (Paknahad et al., 2022).

#### **Cardiac Arrhythmias**

Cardiac rhythm disturbances have also been reported following COVID-19 vaccination. These include palpitations,

atrial fibrillation, supraventricular tachycardia, and ventricular arrhythmias.

Pharmacovigilance databases have documented a number of arrhythmia-related symptoms after vaccination (Cocco et al., 2022). However, arrhythmias are relatively common in the general population, particularly among individuals with pre-existing cardiovascular disease. Therefore, establishing a direct causal relationship between vaccination and arrhythmias remains challenging.

In some studies involving patients with implanted cardiac electronic devices, researchers observed transient increases in arrhythmic events following vaccination, possibly related to immune activation or autonomic nervous system responses.

#### **Myocardial Infarction**

Cases of myocardial infarction occurring shortly after COVID-19 vaccination have been described in the medical literature. However, current evidence does not strongly support a direct causal relationship between vaccination and acute coronary events.

Many individuals reported in case studies had established cardiovascular risk factors such as hypertension, diabetes mellitus, dyslipidemia, and advanced age. These underlying conditions may explain the occurrence of myocardial infarction independently of vaccination (Demir et al., 2021).

Possible mechanisms that have been proposed include transient inflammatory responses, increased sympathetic activity, and pro-thrombotic changes associated with immune activation.

#### **Blood Pressure Changes**

Some individuals have experienced temporary increases in blood pressure following COVID-19 vaccination. In a prospective study involving healthcare workers receiving the Pfizer-BioNTech vaccine, approximately 5% of participants experienced a short-term increase in systolic blood pressure within the first few days after vaccination (Zappa et al., 2021).

The exact mechanism remains unclear but may involve sympathetic nervous system activation, stress responses, or immune-mediated effects on the renin-angiotensin system. These changes are generally transient and resolve without medical intervention.

#### **Takotsubo Cardiomyopathy**

Takotsubo cardiomyopathy, also known as stress-induced cardiomyopathy, is another rare cardiac condition reported following COVID-19 vaccination.

This syndrome is characterized by temporary left ventricular dysfunction that mimics acute coronary syndrome but occurs in the absence of significant coronary artery obstruction. It is most commonly observed in postmenopausal women and is often triggered by emotional or physical stress.

Systematic reviews analyzing reported cases suggest that most patients recover completely with supportive treatment and normalization of cardiac function within several weeks (Stewart et al., 2022; Ahmed et al., 2022).

### **Cardiovascular Risks Associated with COVID-19 Infection**

Although rare cardiovascular events have been reported following vaccination, SARS-CoV-2 infection itself poses a much greater threat to cardiovascular health.

COVID-19 has been strongly associated with numerous cardiovascular complications, including myocarditis, myocardial infarction, heart failure, arrhythmias, thromboembolic events, and stroke (Chang et al., 2020).

Large observational studies have demonstrated significantly increased risks of cardiovascular disease following infection. The CVD-COVID-UK study reported elevated risks of myocardial infarction, heart failure, and arrhythmias among patients diagnosed with COVID-19 (British Heart Foundation Data Science Centre, 2022).

Similarly, the PCORnet COVID-19 study, which analyzed data from millions of individuals, found that the risk of myocarditis and pericarditis was substantially higher after SARS-CoV-2 infection compared with vaccination.

These findings highlight that vaccination not only prevents severe respiratory illness but also reduces the likelihood of serious cardiovascular complications associated with COVID-19 infection.

### **Conclusion**

COVID-19 vaccination has proven to be a critical tool in controlling the global pandemic and reducing severe disease outcomes. Extensive clinical trials and post-marketing surveillance data have confirmed the strong safety profile of currently authorized vaccines.

Although rare cardiovascular events such as myocarditis, arrhythmias, myocardial infarction, blood pressure changes,

and Takotsubo cardiomyopathy have been reported following vaccination, these events occur infrequently and are generally associated with favorable clinical outcomes.

Importantly, the risk of cardiovascular complications associated with SARS-CoV-2 infection is substantially greater than the risk observed after vaccination. Consequently, the overall benefits of COVID-19 vaccination clearly outweigh the potential risks.

Future research should focus on identifying potential risk factors, understanding the biological mechanisms underlying vaccine-associated cardiovascular events, and conducting long-term population studies to further evaluate vaccine safety.

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