International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-Jun-2026, ISSN (Online): 2395-566X

Covid-19 Vaccination and Cardiac Arrest: A Review

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Abstract- COVID-19 vaccination has been a major public health intervention, significantly decreasing the incidence of severe infection, hospitalization, and death caused by SARS-CoV-2. The safety of currently authorized vaccines has been confirmed through extensive clinical trials and post-marketing surveillance. However, uncommon cardiovascular complications, including myocarditis and pericarditis, have been identified in a small number of vaccinated individuals, especially after administration of mRNA-based vaccines. In very rare situations, vaccine-associated myocarditis can progress to serious cardiac complications such as arrhythmias, impaired ventricular function, and, in exceptional cases, cardiac arrest. This review provides an overview of the available literature on cardiac arrest occurring after COVID-19 vaccination, focusing on potential pathophysiological mechanisms, clinical presentation, diagnostic evaluation, treatment strategies, and patient outcomes.

Keywords- COVID-19 Vaccine, Cardiac Arrest, Myocarditis, Pericarditis, SARS-CoV-2, Vaccine Safety.

I. INTRODUCTION

Mass immunization programs against Coronavirus Disease 2019 (COVID-19) have significantly contributed to lowering disease burden, reducing hospital admissions, and decreasing mortality rates across the globe. (1) Data obtained from large-scale pharmacovigilance systems and post-authorization safety monitoring have consistently shown that COVID-19 vaccines are generally safe and well tolerated. (2) Despite their strong safety record, infrequent cardiovascular complications such as myocarditis and pericarditis have been documented, most notably after administration of messenger RNA (mRNA) vaccines. (3)

These conditions are reported more commonly among adolescent and young adult males and are usually characterized by mild clinical manifestations, with the majority of patients recovering fully following supportive or conservative therapy. (3,4) Occurrences of cardiac arrest after COVID-19 vaccination are extremely uncommon and, when reported, are often linked to severe myocarditis, malignant ventricular arrhythmias, or previously existing cardiovascular disease. (4,5) Available scientific evidence continues to demonstrate that the protective benefits of vaccination against severe COVID-19 outcomes greatly exceed the risk of these rare cardiac adverse effects. (1,2,5) Ongoing safety monitoring, early detection of cardiovascular complications, and prompt clinical intervention remain important components of vaccine safety programs and public health efforts. (1,2)

II. EPIDEMIOLOGY

Myocardial inflammation occurring after COVID-19 immunization has been recognized as an uncommon adverse event. Reports have primarily involved adolescent and young adult males who received mRNA vaccines. (6,7) Available clinical data suggest that symptoms usually appear shortly after vaccination, most often within the first week and frequently after the second vaccine dose. (6) Individuals may experience chest pain, breathing difficulty, awareness of an irregular heartbeat, and laboratory evidence of cardiac injury demonstrated by increased cardiac biomarker levels. (3)

Although vaccine-associated myocarditis has attracted significant scientific and public attention, its overall incidence remains very low compared with the enormous number of COVID-19 vaccine doses administered globally. (7,5) The majority of reported cases follow a benign clinical course and respond well to supportive management, resulting in complete recovery without long-term complications. (5,8) Serious manifestations, including sustained impairment of ventricular function, potentially fatal ventricular arrhythmias, or cardiac arrest, are exceedingly uncommon. (3,5)

Population-based studies have consistently demonstrated that SARS-CoV-2 infection carries a substantially greater risk of myocarditis than vaccination. (7,5,8) Moreover, COVID-19 illness itself has been linked to numerous cardiovascular

complications, including rhythm disturbances, thrombotic events, myocardial damage, and heart failure. (5,8) Consequently, the protective effect of vaccination against severe infection and its cardiovascular consequences greatly outweighs the small likelihood of vaccine-related myocarditis. (5,7,8) Continuous safety monitoring, detailed case evaluation, and long-term follow-up investigations remain essential for further strengthening evidence regarding rare cardiac events associated with COVID-19 vaccines. (6,7)

III. PATHOPHYSIOLOGY

1. Immunopathological Mechanisms of Vaccine-Related Myocarditis

The biological processes responsible for myocarditis following COVID-19 vaccination have not yet been completely elucidated. Current research indicates that the condition is most likely the result of an abnormal immune response rather than direct toxic effects on cardiac tissue. (3,7) Vaccination stimulates both innate and adaptive immunity, and in a small subset of susceptible individuals, this activation may trigger an exaggerated inflammatory reaction involving cytokine-mediated myocardial injury. (3) An additional hypothesis involves immune cross-reactivity, in which antibodies or immune cells generated against the SARS-CoV-2 spike protein may inadvertently recognize similar antigens present within cardiac tissue. (7,9) Findings from endomyocardial biopsies and imaging studies have demonstrated myocardial edema and inflammatory infiltration, further supporting an immune-mediated origin. (3,9)

2. Development of Cardiac Rhythm Disturbances

Inflammatory changes affecting the myocardium can interfere with the heart's normal electrical activity and increase susceptibility to rhythm abnormalities. (3,10) Tissue swelling, inflammatory cell accumulation, and localized myocardial damage may disrupt electrical conduction pathways and alter impulse propagation. (10) As a consequence, patients may develop conduction abnormalities, premature ventricular beats, supraventricular arrhythmias, or other disturbances of cardiac rhythm. (9,10) In uncommon circumstances, severe ventricular tachyarrhythmias such as ventricular tachycardia or ventricular fibrillation may occur, producing significant hemodynamic instability and increasing the likelihood of sudden cardiac arrest. (10,5)

3. Impact on Ventricular Function

Most reported cases of vaccine-associated myocarditis are mild and resolve without permanent cardiac impairment. Nevertheless, extensive myocardial inflammation can occasionally compromise ventricular contractile performance. (3,5) Reduced myocardial function may diminish cardiac output and result in manifestations of acute heart failure, including low blood pressure, pulmonary fluid accumulation, and inadequate tissue perfusion. (5) Temporary enlargement of the ventricles and a decline in left ventricular ejection fraction have also been observed in some patients, although these abnormalities typically improve as inflammation subsides. (3,9)

4. Pathways Contributing to Cardiac Arrest

Instances of cardiac arrest reported after COVID-19 vaccination are exceptionally uncommon and are generally attributed to severe secondary cardiac complications rather than a direct vaccine effect. (7,5) Potential pathways include fulminant myocarditis with profound myocardial dysfunction, malignant ventricular arrhythmias precipitated by inflammation, and cardiogenic shock resulting in circulatory failure. (10,5) In rare and severe presentations, deterioration of the heart's electrical or mechanical function may progress to pulseless electrical activity, ventricular fibrillation, or asystole. (5) Available epidemiological data consistently indicate that these outcomes occur at substantially lower rates than cardiovascular complications observed following SARS-CoV-2 infection. (7,5)

5. Clinical Implications

Evidence accumulated to date suggests that myocarditis associated with COVID-19 vaccination is an infrequent adverse event with generally favorable clinical outcomes. (3,7) Most affected individuals recover completely with supportive management, and persistent cardiac complications are uncommon. (3,9) Ongoing surveillance programs, long-term outcome studies, and continued investigation into the underlying biological mechanisms are important for improving risk assessment and enhancing understanding of these rare vaccine-associated events. (7,5)

IV. CLINICAL PRESENTATION

Cardiac complications associated with COVID-19 vaccination generally become apparent within a few days after immunization, although the onset and intensity of symptoms

can differ between patients. (6,7) Early manifestations are often related to myocardial inflammation and may include chest pain, palpitations, shortness of breath during activity or at rest, fatigue, dizziness, and occasional syncopal episodes. (6,3)

Most documented cases follow a mild clinical course and resolve without significant long-term consequences. Nevertheless, a minority of patients may develop signs of extensive myocardial involvement requiring urgent medical attention. (7,3) Features suggestive of severe disease include persistent ventricular arrhythmias, hemodynamic instability, low blood pressure, evidence of impaired organ perfusion, and marked reduction in left ventricular contractile function. (3,14) Such complications may progress to acute heart failure, cardiogenic shock, or, in very rare circumstances, sudden cardiac arrest. (14)

Prompt identification of high-risk clinical features is critical for improving outcomes. Individuals experiencing persistent chest discomfort, recurrent fainting episodes, worsening breathlessness, significant ECG abnormalities, or evidence of ventricular dysfunction should undergo immediate cardiovascular evaluation. Recommended investigations include electrocardiography, measurement of cardiac biomarkers, echocardiographic assessment, and advanced imaging studies when clinically appropriate. (6,7) Early diagnosis and timely management play an important role in limiting disease progression and reducing complications. (6,14)

Diagnostic Evaluation

The diagnosis of vaccine-associated myocarditis and related cardiovascular complications relies on a combination of clinical assessment, laboratory testing, electrocardiographic analysis, and multimodality cardiac imaging. A systematic evaluation is essential for confirming the diagnosis, estimating disease severity, and guiding treatment decisions.

Laboratory Assessment

Biochemical investigations provide important evidence of myocardial injury and inflammation. Elevated serum cardiac troponin levels are among the most reliable indicators of myocardial damage and are commonly detected in affected patients. (11,13) Increased CK-MB concentrations may provide additional support for the presence of cardiac muscle injury. Assessment of BNP or NT-proBNP levels can help identify ventricular dysfunction and assess the severity of heart failure when present. (13,14)

Markers of systemic inflammation, including CRP and ESR, are frequently elevated during active myocardial inflammation. Although these laboratory parameters lack specificity, they contribute valuable supportive information when interpreted alongside clinical findings and imaging results. (11,14)

Electrocardiographic Findings

Electrocardiography remains a fundamental component of the initial diagnostic workup and may reveal a variety of abnormalities. Frequently reported findings include ST-segment alterations, T-wave abnormalities, sinus tachycardia, and nonspecific repolarization disturbances. (11,12) Conduction system involvement may result in atrioventricular block or bundle branch block in certain cases. Severe myocardial inflammation can also predispose patients to QT prolongation, frequent ventricular ectopy, ventricular tachycardia, or ventricular fibrillation, thereby increasing the potential risk of sudden cardiac arrest. (12)

Echocardiography

Transthoracic echocardiography is a readily available, noninvasive imaging technique that provides valuable information regarding cardiac anatomy and function. It enables evaluation of ventricular systolic performance, regional wall motion abnormalities, chamber size, and pericardial fluid accumulation. (13,12) Patients with mild disease may demonstrate normal echocardiographic findings, whereas more severe cases can exhibit reduced left ventricular ejection fraction, diffuse hypokinesia, or other abnormalities consistent with acute myocarditis. (14,12) Serial echocardiographic examinations are useful for monitoring recovery and assessing response to therapy.

Cardiac Magnetic Resonance Imaging

Cardiac magnetic resonance imaging (CMR) is considered the preferred noninvasive modality for confirming myocarditis because of its superior ability to characterize myocardial tissue. (11,3) CMR can identify edema, inflammation, necrosis, and fibrotic changes within the myocardium. The updated Lake Louise Criteria have enhanced the diagnostic accuracy of CMR and facilitate reliable identification of active myocardial inflammation. (3) Beyond diagnosis, CMR contributes to risk assessment, determination of disease extent, and evaluation of myocardial recovery during follow-up.

Additional Investigations

Further diagnostic testing may be warranted in selected patients with severe presentations, persistent arrhythmias, circulatory instability, or uncertain diagnoses. Potential investigations include coronary angiography, CT coronary angiography, ambulatory ECG monitoring, and endomyocardial biopsy. (14,3) Although endomyocardial biopsy remains the histological gold standard for diagnosing myocarditis, its invasive nature limits routine application, and it is generally reserved for fulminant or diagnostically challenging cases. (3)

Overall, accurate diagnosis and risk stratification require an integrated approach that combines clinical evaluation with laboratory biomarkers, ECG findings, echocardiography, and cardiac magnetic resonance imaging. This comprehensive strategy facilitates early detection and appropriate management of suspected vaccine-associated myocarditis.

V. MANAGEMENT

The management of vaccine-associated myocarditis and related cardiac complications is primarily determined by the severity of clinical presentation, extent of myocardial involvement, and the presence of hemodynamic instability or arrhythmias. Most patients experience a favorable clinical course with appropriate supportive care; however, severe cases require prompt hospitalization and intensive monitoring. (11,13)

Management of Mild Cases

Patients presenting with mild symptoms and stable hemodynamic status are generally managed conservatively. Physical activity restriction and adequate rest are recommended during the acute inflammatory phase to minimize cardiac workload and facilitate myocardial recovery. (11,13) Symptomatic relief may be achieved with nonsteroidal anti-inflammatory drugs (NSAIDs), particularly in individuals with associated pericardial involvement. Regular clinical follow-up, serial electrocardiograms, and monitoring of cardiac biomarkers are important to assess disease progression and ensure complete recovery. (13,14)

Management of Moderate to Severe Cases

Individuals with evidence of significant myocardial injury, ventricular dysfunction, persistent chest pain, arrhythmias, or elevated cardiac biomarkers often require hospital admission for close observation and treatment. (11) Continuous electrocardiographic monitoring is essential for the early detection of conduction abnormalities and potentially life-threatening arrhythmias. Supportive management may include oxygen therapy, fluid optimization, and treatment of heart failure symptoms when present. (13)

Patients who develop clinically significant arrhythmias may require anti-arrhythmic medications and individualized electrophysiological management. In selected cases characterized by extensive myocardial inflammation or fulminant myocarditis, immunomodulatory therapies such as corticosteroids, intravenous immunoglobulin (IVIG), or other immunosuppressive agents may be considered based on clinical judgment and evolving evidence. (11,14)

Management of Fulminant Myocarditis

Although uncommon, fulminant myocarditis represents a medical emergency associated with severe ventricular dysfunction and cardiogenic shock. Such patients require intensive care unit admission and advanced hemodynamic support. (14,3) Vasopressor and inotropic agents may be necessary to maintain adequate organ perfusion. In refractory cases, mechanical circulatory support devices, including intra-aortic balloon pumps, ventricular assist devices, or extracorporeal membrane oxygenation (ECMO), may be utilized as bridging therapies until myocardial recovery occurs. (3)

Management of Cardiac Arrest

Cardiac arrest following vaccine-associated myocarditis is exceedingly rare but requires immediate and aggressive intervention. (13,3) Successful outcomes depend on rapid recognition and adherence to established resuscitation protocols. Initial management should include prompt initiation of high-quality cardiopulmonary resuscitation (CPR) and activation of emergency response systems. Advanced Cardiac Life Support (ACLS) guidelines should be followed throughout the resuscitation process. (3)

For patients presenting with shockable rhythms such as ventricular tachycardia or ventricular fibrillation, early defibrillation is critical and significantly improves survival outcomes. Following return of spontaneous circulation, patients should be transferred to an intensive care setting for comprehensive post-resuscitation care, including hemodynamic stabilization, neurological assessment, arrhythmia surveillance, and evaluation of underlying myocardial injury. (3)

Long-Term Follow-Up

Patients recovering from myocarditis should undergo periodic cardiovascular evaluation to document normalization of cardiac function and resolution of inflammation. Exercise restriction is generally advised for several months, particularly in individuals with significant myocardial involvement or documented arrhythmias. (11,14) Long-term follow-up may include repeat electrocardiography, echocardiography, cardiac biomarker assessment, and cardiac magnetic resonance imaging when clinically indicated. Most patients experience complete recovery with minimal long-term sequelae. (11,13)

VI. OUTCOMES AND PROGNOSIS

The prognosis of vaccine-associated myocarditis is generally favorable, with the majority of affected individuals experiencing complete clinical recovery and minimal long-term complications. (11,15) Available evidence from observational studies, post-marketing surveillance programs, and follow-up investigations indicates that most patients present with mild disease, require only short periods of hospitalization, and demonstrate rapid improvement in symptoms following supportive treatment. (11,15)

Clinical recovery is typically accompanied by normalization of cardiac biomarkers, resolution of electrocardiographic abnormalities, and restoration of ventricular function on follow-up imaging. (4,15) In many cases, myocardial inflammation resolves within weeks to months, and patients are able to return to normal daily activities after appropriate medical evaluation and monitoring. (11)

Longitudinal studies assessing medium- and long-term outcomes have provided reassuring data regarding the safety profile of COVID-19 vaccines. Most individuals with vaccine-associated myocarditis show preserved cardiac function during follow-up, with only a small proportion exhibiting residual imaging abnormalities or persistent symptoms. (15,5) Importantly, clinically significant long-term complications such as chronic heart failure, progressive cardiomyopathy, recurrent malignant arrhythmias, or persistent ventricular dysfunction appear to be uncommon. (5)

Mortality associated with vaccine-related myocarditis remains exceedingly low. (4,5) Although isolated cases of severe myocarditis, cardiogenic shock, and cardiac arrest have been reported, these events are exceptionally rare when considered against the vast number of vaccine doses administered worldwide. (11,15) Current evidence indicates that the incidence of serious adverse cardiovascular outcomes following vaccination is substantially lower than the risk associated with SARS-CoV-2 infection itself. (4,5)

Furthermore, large population-based studies and national surveillance systems have not identified an increased risk of sudden cardiac death among healthy adolescents or young adults following COVID-19 vaccination. (15) These findings reinforce the overall favorable benefit-risk profile of vaccination and support its continued use as an effective public health measure for preventing severe COVID-19 and its cardiovascular complications. (4)

Continued long-term follow-up and pharmacovigilance efforts remain important to further characterize rare adverse events and ensure ongoing vaccine safety. However, the currently available evidence consistently demonstrates that vaccine-associated myocarditis is typically self-limiting and associated with excellent clinical outcomes. (11,4,5)

VII. CONCLUSION

COVID-19 vaccine-associated cardiac arrest is an extremely rare event, generally occurring secondary to severe myocarditis or malignant arrhythmias. Current evidence indicates that myocarditis after vaccination is uncommon, usually mild, and associated with favorable outcomes. Importantly, the risk of myocarditis, cardiac complications, and sudden cardiac death is significantly higher following COVID-19 infection than after vaccination. Ongoing surveillance and research continue to support the favorable benefit-risk profile of COVID-19 vaccines. (World Health Organization)

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