

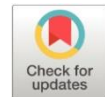
Immunization-associated myocarditis post mRNA COVID-19 vaccination: a review article

Miocarditis asociada a la vacunación del COVID-19 como efecto secundario: un artículo de revisión

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Palabras

claves: COVID-19, miocarditis, vacunación, biomarcadores, informes de casos.

Keywords:

COVID-19, myocarditis, vaccination, biomarkers, case reports.

Resumen

Introducción: Miocarditis ha sido reportada como un efecto secundario de la vacuna del COVID-19 de ARNm. En este artículo de revisión, 15 casos clínicos confirmados de miocarditis asociados con la vacuna del COVID-19 de diferentes lugares del mundo fueron resumidos. **Objetivos:** El objetivo principal de este artículo es de críticamente analizar y resumir la información existente sobre la asociación de la vacunación del COVID-19 y el desarrollo de miocarditis como efecto secundario de la vacuna. **Metodología:** Google Académico fue usado para buscar casos confirmados de miocarditis relacionados a la vacuna del COVID-19 desde el 2021 hasta el 2022. **Resultados:** existe mayor predominancia de miocarditis en jóvenes adultos, especialmente en pacientes de sexo masculino (94%). Defectos genéticos, aspectos ambientales y hábitos alimenticios, fueron encontrados como otros posibles factores que pudieron haber estimulado el desarrollo de miocarditis. Los niveles de troponina y la proteína C-reactiva estuvieron elevados en la mayoría de los casos (93%). **Conclusiones:** Los casos de miocarditis asociados con la vacuna del COVID-19 son muy escasos y representan una mínima fracción de toda la población vacunada. Los beneficios que ofrece la vacuna del COVID-19 son mucho mayores a los efectos que una infección por COVID-19 podría causar. Se recomienda seguir administrando la vacuna del COVID-19 para hacer frente a la pandemia del coronavirus.

Abstract

Introduction: Vaccination-related myocarditis has been reported as a major side effect of the mRNA COVID-19 vaccine. In this review article, a series of 15 global case reports of laboratory-confirmed myocarditis post COVID-19 vaccination were summarized. **Objectives:** The main objective of this article is to critically analyze and summarize published case reports on vaccination-associated myocarditis. **Methodology:** Google Scholar was used to search for confirmed cases of vaccination-associated myocarditis from 2021 to 2022. **Results:** It was found that there is a higher prevalence of immunization-related myocarditis in young adults, especially in male patients (94%). Genetic defects, environmental aspects and dietary habits were discovered as other factors that could have stimulated the development of myocarditis.

Troponin and C-reactive protein levels were elevated in most cases (93%). **Conclusions:** vaccination-associated myocarditis case reports are very rare and only represent a minimal fraction of the total population that has been vaccinated. The benefits offered by the COVID-19 vaccine far outweigh the effects a COVID-19 infection. It is recommended to continue administering the mRNA vaccine to manage the COVID-19 pandemic.

Introduction

The novel coronavirus disease (COVID-19) originated in Wuhan, China in 2019. The World Health Organization (WHO) declared the COVID-19 disease a pandemic in 2020. The SARS-CoV-2 virus is highly transmissible and spreads through respiratory droplets, including saliva, sneezing, and coughing (1). At the time of writing, there has been a total of 532,545,504 COVID-19 confirmed cases in the world according to the Johns Hopkins Coronavirus Research Center (2). Vaccination is often acknowledged as the most efficient approach to tackle infectious diseases caused by viruses. Nowadays, mRNA vaccines have become a powerful tool to fight the COVID-19 pandemic. In addition, mRNA vaccines offer more advantages than conventional vaccines such as rapid development and higher immune response (3). However, some medical reports suggest that COVID-19 mRNA vaccines may cause some rare side effects; it has been revealed that some patients may develop myocarditis after COVID-19 immunization. Myocarditis is a heterogeneous cardiac disease that is defined as the inflammation of the muscular layer of the heart, the myocardium, principally due to a viral infection (4). Moreover, the diagnosis of myocarditis is usually assessed under the Lake Louis criteria (CLL). Positron emission tomography/computed tomography (PET/CT), electrocardiography (ECG), echocardiography, plasma tests, endomyocardial biopsy (EMB) and cardiac magnetic resonance imaging (CMR) are among the modalities for diagnosis of myocarditis, the latter being the most preferred technique (4,5,6). Furthermore, viral myocarditis can be asymptomatic, mild, or severe (5). In cases where myocarditis is asymptomatic, this disease can remain undiagnosed. Whilst, mild symptoms of myocarditis may include chest pain, chest tightness, tachycardia, and fatigue (4,5). Whereas, the most severe cases of myocarditis may lead to dilated cardiomyopathy, cardiac arrest, arrhythmias, acute heart failure and even death (4,5). Acute myocarditis is a subclassification of the disease which can occur during a period of less than a month after diagnosis; acute myocarditis symptoms are mild. While fulminant myocarditis is more severe and can cause cardiogenic shock (4). Besides the viral pathogenesis of myocarditis, some other aetiologies also include bacterial infections, myocardial toxins, certain drugs, and autoimmune diseases (4). However, the pathogenic mechanism of vaccination-associated

myocarditis is yet to be discovered. Some researchers believe that the mRNA vaccine exposure might have caused this adverse response. Nevertheless, genetic defects, environmental aspects and dietary habits may be underlying factors responsible for the development of myocarditis. Additionally, evidence of direct myocardial involvement has not been found until now and some authors emphasize the importance to regularly monitor any adverse event that the mRNA vaccine could cause (7,8,9). The main goal of this review was to critically summarize published literature to clarify the association between myocarditis and COVID-19 vaccination, to provide a more in-depth insight of factors that could have influenced this adverse response and evaluate the risks between the mRNA vaccine and a COVID-19 infection.

Materials and Method

In this review article, I used Google Scholar search engine to find published literature about patients diagnosed with myocarditis after COVID-19 immunization. I selected case reports from different countries. However, my main preferences were articles written in English. All mRNA vaccine brands included in this review were Pfizer-BioNTech, Moderna and AstraZeneca. I used “COVID-19”, “myocarditis”, “vaccination”, “case report” keywords to select articles from 2021 to 2022. To obtain the results for this review, I only chose primary sources and excluded books, secondary papers, and other review articles. My results were narrowed down by gathering case reports of laboratory-confirmed myocarditis cases. I ended up selecting 15 articles that met the searching criteria. Some of the information that I gathered were demographics, ECG, CMR, ECHO, EMB, troponin and CRP laboratory results and all this data was collected into Microsoft Excel spreadsheets.

Results

The results evaluated in this review included case reports from: USA, South Korea, Japan, Germany, Iran, France, Morocco, and Israel. Furthermore, out of 50 hospitalized patients that took part in this review, only 3 were female (6%) and 47 patients were male (94%). Therefore, there seems to be a predisposition to suffer from vaccine-related myocarditis in males among this population dataset (8-22). Furthermore, the mean age was 25.6 years old, the mode was 23 years old, and the median age was 24.5 years old. Thus, vaccination-associated myocarditis tends to affect more young adults in general. Additionally, 77.5% of cases started presenting symptoms of myocarditis after receiving the 2nd dose, whereas patients who received the 1st dose (20.4%) started having symptoms such as chest pain and fever, and there was only one patient who had the 3rd dose (2.04%) and began noticing some adverse effects (8-22). Hence, most people are more propense to start developing symptoms for myocarditis after taking the 2nd dose of the COVID-19 vaccine. On the other hand, about 78% of individuals diagnosed with myocarditis were otherwise healthy, 20 of them have had elevated level of fitness, with neither previous history of cardiac

diseases nor family history of myocarditis. Nevertheless, 20 % of patients suffered from other comorbidities that consist of the following: obesity, high blood pressure, Crohn’s disease, Sjogren’s syndrome, gastroesophageal reflux disease, vasovagal syncope, and previous COVID-19 infection (8-22).

Table 1.

Demographics of patients diagnosed with vaccine-related myocarditis

Case report #	Author/Year of publication:	Country:	Gender and number of patients:	Age :	Type of COVID-19 vaccine:	Medical History:	Dosage:*	Symptoms:	Days to symptom onset:	Treatment:	Outcome:
1	Albert et al., 2021 (8)	USA	1 Male	24	Moderna	Healthy	2nd dose	Chest pain, fever, chills, body aches	4 days	beta-blocker medication, non-steroidal anti-inflammatory	Unknown
2	Montgomery et al., 2021 (9)	USA	23 Males	Median age 25	7 Pfizer-BioNTech and 16 Moderna	All were healthy except for 3 patients with prior COVID-19 infection	2nd dose in 20 patients and 1st dose in 3 cases	Chest pain, palpitations, dyspnea	4 days	unknown	16 patients recovered
3	Choi et al., 2021(10)	South Korea	1 Male	22	Pfizer-BioNTech	High blood pressure	1st dose	Chest pain	5 days	N/A	Deceased
4	Schmitt et al., 2021 (11)	France	1 Male	19	Pfizer-BioNTech	Healthy	2nd dose	Chest pain, dyspnea	3 days	No medication	Recovered
5	Nunn et al., 2022 (12)	Germany	3 Males and 1 Female	Median age 27.5	3 Pfizer-BioNTech and 1 Moderna	2 Healthy, 1 with family history of myocardial infarction and 1 with Sjogren syndrome + history of perimyocarditis	three 2nd doses and one 1st dose	Chest pain, fever, flue-like symptoms	Median 5 days	beta-blocker medication and ATI antagonist	Recovered
6	Ehrlich et al., 2021 (13)	Germany	1 Male	40	Pfizer-BioNTech	Healthy	1st dose	Chest pain, headache, fever, shortness of breath, dyspnea	6 days	beta-blocker medication, ACE inhibitor, unfractionated	Recovered
7	Onderko et al., 2021 (14)	USA	3 Males	Median age 28	2 Pfizer-BioNTech and 1 Moderna	1 Crohns disease case, 1 obesity case and 1 gastroesophageal reflux disease case	2nd dose in all cases	Chest pain	Median 3 days	beta-blocker and activity restriction nonsteroidal anti-inflammatory drug	Recovered
8	Nagasaka et al., 2022 (15)	Japan	1 Male	23	Pfizer-BioNTech	Healthy	2nd dose	Chest pain, fever	3 days	angiotensin-converting enzyme inhibitor	Recovered
9	Watanabe et al., 2022 (16)	Japan	4 Males	Median 24.5	1 Pfizer-BioNTech and 3 Moderna	Healthy	three 2nd doses and one 1st dose	Chest pain, fever, fatigue	Median 4 days	omeprazole, bisoprolol, ramipril,	Recovered
10	Mengesha et al., 2022 (17)	Israel	1 Female	43	Pfizer-BioNTech	Obesity	3rd dose	Palpitations and shortness of breath	2 days	Corticosteroid treatment,	Recovered
11	Mimouni et al., 2022 (18)	Morocco	1 Male	14	Pfizer-BioNTech	Healthy	unknown	Asthenia, headache, fever	10 days	Corticosteroid pulse treatment, intravenous immunoglobulin	Deceased
12	Hoshino et al., 2022 (19)	Japan	1 Male	27	Moderna	Healthy, no family history of heart disease	1st dose	Chest pain, fatigue	8 days	inflammatory drug and	Recovered
13	Mouch et al., 2021 (20)	Israel	6 Males	Median age 23	Pfizer-BioNTech	Healthy in all cases	5 cases and 1st in one	Chest pain	Median 3.5 days	Carvedilol, rivaroxaban, captopril,	Recovered
14	Hassanzadeh et al., 2022 (21)	Iran	1 Female	32	AstraZeneca	Vasovagal syncope	1st dose	Tachycardia, dyspnea, fatigue, palpitations	3 months	No medication	Recovered
15	Yamamoto et al., 2022 (22)	Japan	1 Male	13	Pfizer-BioNTech	Healthy	2nd dose	Chest pain	3 days	No medication	Recovered

* The dosage administered after the symptoms for myocarditis were first noticeable

* LVEF, Left ventricular ejection fractions

Table 1, summaries demographic characteristics of 50 patients who were hospitalized after being vaccinated against COVID-19. Two hospitalized patients died, and the rest recovered in a few days after hospital admission. Follow ups were requested and prescription medication were given in some cases to see how the cases evolve over time after discharge.

Table 2.

Laboratory results of hospitalized patients diagnosed with vaccination-related myocarditis

Case report #	Troponin Levels:	CRP Levels :	ECG:	PCR test for COVID-19 & other viruses:*	CMR:	ECHO:	EMB:
1	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	Normal	N/A
2	Elevated in all cases	N/A	19 abnormal and 4 normal cases	Negative in all cases	Abnormal in 8 cases, the rest were	19 patients had LVEF ≥50% and 4 had LVEF <50%	N/A
3	unknown	unknown	Abnormal	N/A	unknown	unknown	abnormal
4	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF ≥50%	N/A
5	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF ≥50% in all cases	abnormal in 2 cases
6	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF <50%	abnormal
7	Elevated in all cases	Elevated in all cases	Abnormal	Negative in all cases	Abnormal	LVEF ≥50% in all cases	N/A
8	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	unknown	abnormal
9	Elevated in all cases	Elevated in all cases	Normal in 3 cases and 1 abnormal case	Negative in all cases	Abnormal	3 cases of LVEF ≥50% and 1 case of LVEF <50%	N/A
10	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF <50%	abnormal
11	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF ≥50%	N/A
12	Elevated	N/A	Abnormal	Negative in all cases	N/A	LVEF <50%	abnormal
13	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF ≥50% in all cases	N/A
14	Normal	Normal	Normal	Negative in all cases	N/A	LVEF ≥50%	N/A
15	Elevated	Elevated	Abnormal	Negative in all cases	Abnormal	LVEF ≥50%	N/A

*Other additional PCR tests were performed for the following viruses: coxsackies virus, hepatitis A, B and C, parvovirus B19, Epstein-Barr virus, adenovirus, influenza, herpes simplex virus 1 and 2, and HIV.

Table 2 summarizes the laboratory results of 50 patients diagnosed with myocarditis after COVID-19 immunization. The two main biomarkers that are covered in this review were troponin and CRP levels. This table also includes electrocardiogram (ECG), echocardiogram (ECHO), cardiac magnetic resonance imaging (CMR) and endomyocardial biopsies (EMB) results.

Treatment for myocarditis included medication to improve the heart function; patients were treated with beta-blockers, non-steroidal anti-inflammatory drugs (NSAIDs), and corticosteroids drugs. Some other therapeutic treatment options were ACE inhibitors, angiotensin-converting enzyme inhibitor, omeprazole, bisoprolol, ramipril and activity restriction was also recommended (8-22). Even though prognosis is good with majority of patients have been recovered in a few days after hospital admission (96%), only 2 patients died (4%). On average, it takes approximately 4 days for patients to start showing symptoms of myocarditis after vaccination. In addition, hospitalized patients often had the following symptoms: chest pain, fever, palpitations, fatigue, and dyspnea (8-22). Moreover, PCR tests were performed and all of them were negative for SARS-COV-2 in all patients that took part in this review. Additional PCR test results for other viruses such as influenza and coxsackies virus were also negative, ruling out other possible aetiologies of myocarditis. In most cases, echocardiography (ECHO) results showed that the left ventricular ejection fraction (LVEF) was greater than or equal to 50% (8-22). While electrocardiogram (ECG) results revealed some abnormalities such as: paroxysmal atrioventricular block, lateral ST elevations in V3-V6 and in some cases there were no signs of acute ischemia. While most cardiac magnetic resonance imaging (CMR) results with late gadolinium enhancement showed a superimposed oedema. In most cases, myocarditis was confirmed after these results met the Lake Louis criteria for myocarditis. Most reports based their diagnosis of myocarditis based on the CMR results and troponin and C-reactive protein levels. Thus, CMR proved to be the most efficient technique for diagnosis, and it was conducted in most cases. Furthermore, endomyocardial biopsy (EMB) is still considered the gold standard for diagnosis but it is not a routine procedure; EMB was performed in only 6 out of 15 case reports that were analyzed in this review (8-22).

Discussion

In the literature data, many case reports rely on serological tests to evaluate biomarkers levels. Biomarkers have been particularly useful for research, management, diagnosis, and treatment of diseases. For this reason, this review article is focused on two biomarkers in particular; it appears that troponin I and C-reactive protein (CRP) levels are good inflammatory markers for the diagnosis of myocarditis. The rise in troponin I levels may suggest myocardial injury or damage which in turn can lead to myocarditis (5). For instance: as Albert et al., discusses in his study, a 24-year-old male patient with no previous history of heart disease was diagnosed with myocarditis after receiving the second dose of the Moderna COVID-19 vaccine. It was found that the patient had elevated levels of troponin I: 18.94 ng/mL, while normal levels of troponin I are between 0.01 to 0.04 ng/mL. In addition, it was also discovered that the patient had elevated levels of C-reactive protein (CRP): 26.4 mg/L, whereas normal levels of CRP are regularly <10.0 mg/L (8). As it can be seen from table 2., the same pattern was observed in the rest of the

other case reports that took part of this review where troponin and CRP levels were all elevated, except of only one case report where troponin and CRP levels were normal (8-22). For this reason, these two biomarkers could be extremely helpful for diagnosis of myocarditis. Even though myocarditis was accredited to the mRNA vaccine in this case, the research responsible for this study failed to evaluate other underlying factors. For instance: genetic and environmental factors were not taken into consideration. No information on dietary habits, physical activity, or other comorbidities were provided.

Some evidence suggests that genetic and environmental factors may induce the development of myocarditis in some clinical studies (23). It has been revealed that individuals with family history of heart disease will be more prone to suffer from a cardiac disease throughout their life span. In addition, defects in genes (such as TTN, DSP, and Dystrophin) that encode for structural proteins are strongly associated with cardiac diseases. These genetic mutations make individuals more susceptible to myocarditis. Moreover, environmental factors such as chemotherapy, pregnancy, physical activity, and alcohol consumption are linked to the development of myocarditis and cardiomyopathy (23). There is one case which was included in this review of a 27-year-old professional athlete who died suddenly of fulminant myocarditis after COVID-19 vaccination. This death was attributed to athlete's heart and fatal arrhythmia with myocarditis happening afterwards (19). Therefore, physical activity is a major factor for this adverse outcome. Besides, numerous studies using animal models have implied the key role of genetics in cardiac diseases. For instance: in a study by Wei et al., some mice were treated with immune checkpoint inhibitors (ICI), which is frequently used as a cancer treatment, as a result mice developed ICI-induced myocarditis as an adverse immune response to this treatment. From these results, it was discovered that the *Pdcd1* (which encodes for PD-1 protein) and *Ctla4* (which encodes for CTLA4 protein) alleles play a significant role in the development of fatal myocarditis due to interactions between CTLA4 and PD-1 proteins (24). Furthermore, another animal model-based study points out that the *M2* gene, which encodes for capsid protein, is another causal factor of fatal myocarditis in mice (25). In addition, human DSP variants have been associated with inherited acute myocarditis (4). Another important finding from this review was the gender inclination to vaccination-related myocarditis; most case reports suggests that side effects might appear to be more predominantly in young males. Thus, there might be a possibility that exhibiting the XY chromosome could be a predisposition to suffer from myocarditis. Since genetic testing is not a routine procedure for diagnosis of myocarditis, we will not know for certain if some of the case reports presented in this review may have had a genetic aetiology. Thus, vaccination-induced myocarditis may not be caused directly by the mRNA vaccine but could be indirectly caused by genetic predisposition.

The benefits of a certain type of diet might be effective for the treatment of myocarditis. Since gluten is one of the main components of processed foods and it has been associated

with autoimmune and chronic diseases due to its proinflammatory, cytotoxic and immunogenic properties. Following a gluten-free diet might be favorable to successfully treat patients with autoimmune-myocarditis (26). In a study by Marcolongo et al., three pediatric patients with autoimmune-induced myocarditis were treated with immunosuppressive therapy (IT) accompanied by a gluten-free diet. After following this treatment, patients showed some considerable improvement in their health (27). Moreover, another author also highlights the importance of diet in a case report where a patient was hospitalized after showing symptoms of myocarditis. As Myrmel et al. argues, a CD-associated myocarditis case was managed by making the patient follow a glute-free diet regimen and a heart failure treatment; after a 4-month follow-up, the patient stopped having chest pain and dyspnea was less frequent (28). On the other hand, some dietary deficiencies might be detrimental, and they could exacerbate the severity of the disease in some individuals. As discussed by Favere et al., a vitamin E and selenium-deficient diet might aggravate the severity of viral myocarditis in mice models; it was further revealed that diet may affect both the virus and the host by altering the virus genetic makeup (29). Furthermore, deficiency of vitamin D may influence the inflammation of the myocardium. Enayati et al., details the findings of a laboratory experiment using vitamin D in mice models with autoimmune-induced myocarditis. Consequently, vitamin D repressed cardiac inflammation while ameliorating cardiac function. These results could have been attributed to the vitamin D's anti-inflammatory properties (30). In addition, taking certain drugs may have a negative impact in certain cases. For example: non-steroidal medications were prescribed in two of the case reports that took part of this review. Non-steroidal anti-inflammatory drugs (NSAIDs) are not recommended for treatment of myocarditis because these drugs may have the potential to cause renal impairment that could aggravate the condition of the patients. Furthermore, anti-viral agents such as remdesivir and lopinavir have not shown any significant effect in reducing duration of hospital stay and mortality rates (7). Thus, dietary habits have an important impact in the prevention and treatment of myocarditis.

The results of this review also indicate that 26 individuals took the Pfizer-BioNTech vaccine (52%), whereas 23 patients were immunized with the Moderna vaccine (46%) and there is only one patient who received only one dose of the AstraZeneca vaccine (2%) (8-22). The BNT162b2-mRNA (Pfizer-BioNTech) vaccine proved to be highly effective in some medical reports. Polack et al, argues that the BNT162b2-mRNA vaccine is 95% effective in successfully providing protection against COVID-19 for everyone 16 years of age and older. Furthermore, clinical trials revealed that the vaccine is safe after a 2-month of postvaccination follow-up (31). These results were consistent with another study by Thomas et al, which emphasizes that the vaccine is safe, but it gradually loses its efficacy over time. On the other hand, there were a few cases where the vaccine showed some adverse effects, an equivalent ratio of deaths was found between the vaccinated group and the placebo group in a clinical study, and these adverse effects were not

attributed to the vaccine (32). Whereas the mRNA-1273 (Moderna) vaccine has an efficacy of 92.7% in preventing symptomatic COVID-19 for everyone 18 years of age and older. Adverse events of the Moderna vaccine were muscle pain, joint pain, and headache. The author of this study also points out that more severe cases with diagnosed myocarditis occurred with an incidence of 65.7 cases per 1 million doses of Moderna COVID-19 vaccine (33). Furthermore, in a study by Montgomery et al., it was detailed some clinical cases of vaccination-associated myocarditis in members of the US military where it was found that 23 male patients developed myocarditis after 2.8 million doses of the COVID-19 vaccine were administered (9). Hence, myocarditis cases are rare among vaccinated recipients and these few cases may not even be related to vaccine exposure.

The pathogenesis of vaccination-related myocarditis is not well known. However, some mechanisms were proposed by some researchers. For instance, Hassanzadeh et al., suggests that inflammation of the myocardium may have been caused by abnormal apoptosis and cross-reactive anti-idiotypic antibodies. It also has been theorized that the COVID-19 vaccine produces an immune response that could cause autoimmune-myocarditis (21). Moreover, Mengesha et al., argues the possibility of molecular mimicry between the SARS-CoV-2 virus spike protein and a cardiac protein that could have triggered an acquired or innate immune response (17). In addition, using animal models to design a study that could help us understand the pathogenic mechanism of vaccination-associated myocarditis might be extremely useful. Therefore, to better understand the pathogenesis of vaccination-induced myocarditis, more research must be done.

Finally, it is also important to compare and evaluate the possible risks between a COVID-19 infection and the risks of suffering from myocarditis as a side effect of vaccination. The risks of suffering from a COVID-19 infection are still very appalling; some patients with increased disease severity after being infected with COVID-19 are more likely to be hospitalized with mechanical ventilation support for several days, many others are left with some sequelae and some patients might have a higher risk of death. Furthermore, Nunn et al., argues that vaccination may increase the risk of developing myocarditis (12). On the contrary, as Wallace et al. discussed the vaccine significantly lowers the risk of COVID-19-related hospitalization by 95.9% and the probability of adverse effects is extremely low compared to a COVID-19 infection (33). Some of the most common adverse events after vaccination include muscle pain, headache, chills, fatigue, and fever. Myocarditis being far less common among vaccine recipients; according to a British study, there is an approximate incidence of 1 to 10 per 1,000,000 people who can develop myocarditis after vaccination, compared to an incidence of 40 per 1,000,000 cases with myocarditis after a COVID-19 infection which is a much higher ratio. Another study reveals that 136 individuals developed myocarditis out of 1.5 million people who were vaccinated against COVID-19 in Israel; this study also points out that the symptoms that people had were mostly mild (12). Therefore, the risks of a COVID-19 infection are by

far more catastrophic than the drawbacks of getting vaccinated. There is a higher chance to develop myocarditis because of a SARS-CoV-2 infection than after receiving the mRNA COVID-19 vaccine.

This review had some limitations. Since I did not have access to more databases, I only use Google Scholar to find my results. Most of the literature analyzed in this review was open-accessed and my results were limited to budget. Nonetheless, the use of Web of Science, PubMed and other search engines could have more helpful to increase the scope of my investigation. On the other hand, the clinical trials that monitored the efficacy of the COVID-19 vaccine were all blinded and selected their participants randomly. Hence, these results are reliable and excluded the possibility of bias. Furthermore, it could have been more advantageous to collaborate with other specialized researchers in the field to have a more in-dept analysis and evaluation of results. Therefore, a collaboration with other researchers, it is highly recommended.

Conclusion

- In conclusion, the benefits of vaccination against COVID-19 outweighs the adverse effects of a possible SARS-CoV-2 infection. Myocarditis is a rare complication which has a low incidence among vaccine recipients and this adverse event might not be directly associated with the mRNA vaccine. Several studies have shown that there are genetic, environmental, and dietary factors that we must take into consideration before deducting this disease aetiology. Moreover, it is suggested that we keep monitoring the vaccine efficacy and any side effects. Further research needs to be done to investigate the possible pathogenesis of vaccination-related myocarditis. The administration of the mRNA COVID-19 vaccine is still recommended to fight the COVID-19 pandemic.

Conflict of Interest

The author declares no conflict of interest.

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