Guidance on Myocarditis and Pericarditis after mRNA COVID-19 Vaccines

The following guidance was initially developed by the Australian Technical Advisory Group on Immunisation (ATAGI), the Cardiac Society of Australia and New Zealand (CSANZ), the Royal Australian College of General Practitioners (RACGP), the Australian College of Rural and Remote Medicine (ACRRM), the Australasian College for Emergency Medicine (ACEM) and the Paediatric Research in Emergency Departments International Collaborative (PREDICT). Updates have been endorsed by ATAGI and all groups above.

Updated 29 April 2022

Vaccine-associated heart disease is very rare and usually mild. ATAGI emphasise that the overwhelming benefits of vaccination in protecting against COVID-19 greatly outweigh the rare risk of these conditions.

What has been updated:

- Updated information on the risk of myocarditis and pericarditis associated with mRNA and non-mRNA COVID-19 vaccine brands, dose schedules and age groups
- Updated recommendations for primary dose schedules of mRNA vaccines to potentially improve vaccine effectiveness and reduce the risk of myocarditis and pericarditis.
Key Points

Understanding the benefits and risks of vaccination

- The overwhelming benefits of vaccination in protecting against COVID-19 greatly outweigh the rare risk of myocarditis and/or pericarditis. Vaccination continues to be recommended for all people aged 5 years and above.

mRNA vaccines

- A small increased risk of myocarditis and/or pericarditis has been observed in real-world settings in people vaccinated with Pfizer or Moderna, compared with unvaccinated people.
- The risk appears higher with Moderna than with Pfizer.
- Pericarditis and myocarditis after COVID-19 vaccines have been reported most commonly in males under 40 years of age, and most commonly after the second vaccine dose. However, these conditions can occur in any gender, and after any dose, including a third dose.
- Early evidence suggests the risk in children aged 5-11 years is significantly lower than in adolescents aged 12-17 years.
- Providers should consider the potential risk of myocarditis and pericarditis when selecting a COVID-19 vaccine brand and dose interval, considering the individuals age, preferences and any precautions to specific vaccine brands.

Non mRNA vaccines

- AstraZeneca may also be associated with a small increased risk of myocarditis and pericarditis, though this risk appears lower than with Moderna or Pfizer.
- The risk after Nuvaxovid (Novavax) is not yet known. A small number of cases of myocarditis were reported in the clinical trial, though it is not yet known if these were causally linked with the vaccine.

Precautions

- People with a history of any of the following conditions can receive a COVID-19 vaccine but should consult a GP, immunisation specialist service or cardiologist about the best timing of vaccination and whether any additional precautions are recommended:
  - Recent (i.e., within the last 3 months) myocarditis or pericarditis
  - Acute rheumatic fever or acute rheumatic heart disease (i.e., with evidence of active inflammation)
  - Acute decompensated heart failure

Dose intervals

- ATAGI recommends an 8-week interval between dose one and dose two for Pfizer and Moderna for people aged 5 years and older, particularly for males ages 12 to 39 years. A shorter interval (down to three weeks for Pfizer; four weeks for Moderna) between the first and second doses could be utilised for people who are moderately to severely immunocompromised [see Box on Immunocompromising Conditions]; those at risk of severe disease [see Medical Conditions Table] and adults ages 65 years and older. The extended interval has been shown to improve the immune response to vaccination and therefore may improve effectiveness. The longer dose interval may also reduce the risk of myocarditis and pericarditis. Providers should consider the potential risk of myocarditis and pericarditis when selecting a COVID-19 vaccine brand and dose interval, taking into account an individual’s age, preferences and any precautions to specific vaccine brands.

Symptoms and outcomes

- Symptoms of myocarditis or pericarditis typically appear within 1-5 days of a COVID-19 vaccine dose and may include chest pain, palpitations (irregular or rapid heartbeat),
syncope (fainting) or shortness of breath. People who experience any of these symptoms after having a COVID-19 vaccine should seek prompt medical attention.

- Most myocarditis cases linked to COVID-19 vaccination have been mild, with brief periods of hospitalisation required for the majority of patients. The symptoms usually settle quickly, noting they need to have a period of limitation of exercise.

**Assessment and management**

- Initial assessment and investigation can be done in a general practice or an ambulatory outpatient cardiology setting for patients who are not acutely unwell and when initial investigation results can be obtained and reviewed within 12 hours. Based on a clinical severity and risk assessment, some patients may require review in an emergency department.
- Initial investigations should include ECG, serum troponin levels, and inflammatory markers. A chest X-ray, and other investigations for other differential diagnoses should be undertaken as clinically indicated.

**Future vaccine dose recommendations:**

- Further doses of COVID-19 vaccine can be given to people who have been investigated for pericarditis but who had normal ECG, troponin, and inflammatory makers, and who have been symptom-free for at least 6 weeks. This includes people with a clinical diagnosis of pericarditis despite normal investigations.
- For people with suspected or proven pericarditis and abnormal investigation results, the need and choice of further doses is informed by age and sex (see Figure 2).
- For people who have had confirmed myocarditis attributed to a COVID-19 vaccine, further doses should be considered on a case-by-case basis, and usually deferred until recovery from symptoms. For those ≥18 years, Novavax or AstraZeneca may be suitable.

**Recommendations**

ATAGI, CSANZ, RACGP, ACRRM, ACEM and PREDICT emphasise that the overwhelming benefits of COVID-19 vaccination to protect individuals from COVID-19 and its serious outcomes such as hospitalisation and death, as well as the wider benefits of reducing spread of the disease in the community, greatly outweigh the rare risk of myocarditis or pericarditis after vaccination.

- Vaccination continues to be recommended for all people aged ≥ 5 years with no preferential vaccine related to minimising risk of myocarditis or pericarditis.
- ATAGI recommends an 8-week interval between dose one and dose two for Pfizer and Moderna for people aged 5 years and older, particularly for males aged 12 to 39 years. A shorter interval (down to three weeks for Pfizer; four weeks for Moderna) between the first and second doses could be utilised for people who are moderately to severely immunocompromised [see Box on Immunocompromising Conditions]; those at risk of severe disease [see Medical Conditions Table] and adults aged 65 years and older. The extended interval may reduce the risk of myocarditis and pericarditis and may improve vaccine effectiveness. Providers should consider the potential risk of myocarditis and pericarditis when selecting a COVID-19 vaccine brand and dose interval, taking into account an individual's age, preferences and any precautions to specific vaccine brands.
- The recommended vaccine for a booster dose in people aged 16 to 17 years is the Pfizer vaccine, since the Moderna vaccine is only licensed as a third dose for 18+ years.
Background

What is myocarditis and pericarditis?

Myocarditis refers to inflammation of the heart muscle, and pericarditis refers to inflammation of the thin sac that surrounds the heart. These conditions can occur separately or together (myopericarditis). Myocarditis and pericarditis are also commonly seen in the general population from a variety of causes, and not all cases that occur after vaccination are necessarily caused by the vaccine. The estimated incidence of myocarditis was 22 per 100,000 people, or approximately 1.5 million cases in the 2013 world population. Overall, myocarditis occurs more commonly in males than in females. The estimated ‘background rate’ of myocarditis or pericarditis for females aged 18-34 years is 16 per 100,000 person years (95% prediction interval 8-32), and for males aged 18-34 years is 37 per 100,000 person years (16 – 88).

Myocarditis and/or pericarditis have been reported as rare side effects after COVID-19 vaccines particularly in young males aged 16-40 years. Cases have also rarely been reported in children.

What is the risk of myocarditis and pericarditis after COVID-19?

COVID-19 is estimated to cause myocarditis at a rate of 30 excess cases per million (95% CI:29,31). Post COVID-19 condition (“long COVID”) is also associated with several cardiovascular complications.

What is the risk after COVID-19 - vaccination, and who is at greatest risk?

Reported rates of myocarditis after COVID-19 vaccination vary by country, vaccine type, age, gender, and interval between vaccine doses. The majority of cases of myocarditis/pericarditis reported after COVID-19 vaccines have occurred in males under 40, and the majority have occurred within 1-5 days (median 2 days) following the second dose. It is also more common after the second dose of Moderna compared to second doses of Pfizer and AstraZeneca (see section below on Is the risk higher for Moderna compared to Pfizer?).

mRNA vaccines

From a UK study, after dose two, Pfizer vaccine has been estimated to cause myocarditis at a rate of 12 excess cases per million for males under 40 years (the highest risk group). For Moderna vaccine the estimated rate is 101 excess cases per million for males under 40 years. Those at highest risk have been observed to be adolescent males and this is consistent across studies from UK, Israel, USA, Australia and Europe. Error! Reference source not found. Reference source not found. Provides the most recent rates per million of myocarditis by age and sex adapted from the Therapeutic Goods Administration (TGA) in Australia where the rates appear highest in males aged 12-17 years.
Table 1: Rates of myocarditis per million doses by age cohort and sex following dose two of Comirnaty (Pfizer) and Spikevax (Moderna) adapted from the rates reported by the Therapeutic Goods Administration (TGA) in Australia\textsuperscript{13}

<table>
<thead>
<tr>
<th>Age Cohort</th>
<th>Pfizer</th>
<th>Moderna</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose 2</td>
<td>Dose 2</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>5-11*</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>12-17</td>
<td>107</td>
<td>24</td>
</tr>
<tr>
<td>18-29</td>
<td>67</td>
<td>20</td>
</tr>
<tr>
<td>30-39</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>40-49</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>50-59</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>60-69</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>≥70</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>All ages</td>
<td>37</td>
<td>12</td>
</tr>
</tbody>
</table>

\*Up to 27 February 2022 approximately 1.2 million doses had been administered to children aged 5-11 years, and no cases of myocarditis had been reported, noting that majority of these would have been first doses.


Non-mRNA vaccines

Can AstraZeneca cause myocarditis or pericarditis?

It was previously reported that there was no apparent increased risk of myocarditis or pericarditis associated with AstraZeneca vaccine, however new data from the UK indicates an increased risk.

A UK study in December 2021 found an increased risk across sex and doses, and the risk was highest in men aged under 40 years 8-14 days after dose 2 (estimated excess of 14 cases per million doses (95% CI 8-17)).\textsuperscript{5} UK Yellow Card reports also indicate a risk, with rates per million being reported in young adults (18-29 years) as 10 per million doses after dose one and 16 per million after dose two.\textsuperscript{10} However, the risk after AstraZeneca remains smaller than that for mRNA vaccines.
Can Nuvaxovid (Novavax) cause myocarditis or pericarditis?

The risk of myocarditis/pericarditis after Novavax is not yet known. Cases were reported in a clinical trial, however this trial was underpowered to assess the risk of rare adverse events and a causal association with the vaccine was not confirmed.14

Further data is needed from real-world use of Novavax. ATAGI will continue to monitor data as it emerges and update advice accordingly. Providers may wish to consider extending the interval for the primary schedule to 8 weeks between dose one and two for Novavax given the potential to reduce the risk of myocarditis and pericarditis observed with mRNA vaccines (see section below; Does a longer interval between COVID-19 vaccine doses reduce the risk of myocarditis?)

What is the risk of myocarditis and pericarditis in children aged 5-11?

Early data suggests that the risk of myocarditis in children aged 5-11 is significantly lower compared to adolescents and young adults.

Data from the Vaccine Adverse Events Reporting System (VAERS) safety system in the USA showed that for males aged 5-11 years who received a second dose, the rate within 7 days following Pfizer was observed to be 4.3 per million doses, and for females of the same age, who also received a second dose, the rate was 2.0 per million doses.15 In Australia, the TGA weekly safety report for 03 March 2022 reported that up until 27 February 2022 approximately 1.2 million doses had been administered to children aged 5-11, and they had received 14 reports of suspected myocarditis and/or pericarditis following dose 1 of the vaccine. However, following review it was reported that two children possibly met the criteria for pericarditis13

What is the risk of myocarditis after a third dose?

Preliminary data from Israel, UK and USA suggest the risk of myocarditis or pericarditis following a third dose appears lower than for dose two. As a means of comparison, table 2 provides a summary of the rates for males aged under 40 years, after each dose of Pfizer, Moderna and AstraZeneca, noting that the sources of information differ in how they define cases and how they obtain rates, i.e. some are passive vaccine safety surveillance systems.

Early data from Israel’s active surveillance reported that for Pfizer and Moderna vaccines males aged 16-29 the rate after dose three was 30 per million (11 cases in 368,903 doses) compared to 114 per million doses after dose two (82 cases in 714,070 doses).12

Data from the UK Yellow Card passive surveillance reports from 23 February 2022 reported the rates for males and females aged 18-29 after a third dose of Moderna was 21 per million compared to 70 per million after dose two. This report also estimated a third dose rate of 15 per million for Pfizer compared to 27 per million for dose two.10

Early data from the USA reported the rates of myocarditis were lower after a third dose than a second. In males aged 18-24 rates following a third dose of Pfizer and Moderna were 4.1 per million and 8.7 per million respectively.11,16

For adolescents aged 12-15 there is not sufficient data from Israel, but early data from the USA suggests that for 12-17 year olds the rate for dose three is 11 per million doses compared to 71 per million and 106 per million for dose two for 12-15 and 16-17 year olds respectively.11,17

There are no data on the risk following subsequent (i.e., beyond third) doses.
### Table 2: Summary of rates of myocarditis per million doses for each dose of COVID-19 vaccination in males of high-risk age cohorts

<table>
<thead>
<tr>
<th>Country</th>
<th>Age Cohort</th>
<th>Dose 1</th>
<th>Dose 2</th>
<th>Dose 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pfizer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia¹³</td>
<td>12-17</td>
<td>Not available</td>
<td>107</td>
<td>Not available</td>
</tr>
<tr>
<td>Australia¹³</td>
<td>18-29</td>
<td>Not available</td>
<td>67</td>
<td>Not available</td>
</tr>
<tr>
<td>Canada¹⁸</td>
<td>18-29</td>
<td>10</td>
<td>25</td>
<td>Not available</td>
</tr>
<tr>
<td>Canada¹⁹</td>
<td>18-24</td>
<td>26</td>
<td>59</td>
<td>Not available</td>
</tr>
<tr>
<td>Denmark²⁰</td>
<td>12-39</td>
<td>Not available</td>
<td>18</td>
<td>Not available</td>
</tr>
<tr>
<td>France²¹</td>
<td>18-24</td>
<td>7</td>
<td>43</td>
<td>Not available</td>
</tr>
<tr>
<td>Germany²²</td>
<td>18-24</td>
<td>Not available</td>
<td>47</td>
<td>Not available</td>
</tr>
<tr>
<td>Israel¹²</td>
<td>16-29</td>
<td>1</td>
<td>114</td>
<td>30</td>
</tr>
<tr>
<td>UK¹⁰</td>
<td>Under 18</td>
<td>14</td>
<td>11</td>
<td>Not available</td>
</tr>
<tr>
<td>UK¹⁰</td>
<td>18-29</td>
<td>24</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>USA¹¹,¹⁷</td>
<td>12-17</td>
<td>7</td>
<td>71 – 106*</td>
<td>11</td>
</tr>
<tr>
<td>USA¹¹,¹⁶</td>
<td>18-24</td>
<td>4</td>
<td>52</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Moderna</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia¹³</td>
<td>12-17</td>
<td>Not available</td>
<td>159</td>
<td>Not available</td>
</tr>
<tr>
<td>Australia¹³</td>
<td>18-29</td>
<td>Not available</td>
<td>142</td>
<td>Not available</td>
</tr>
<tr>
<td>Canada¹⁸</td>
<td>18-29</td>
<td>24</td>
<td>140</td>
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<tr>
<td>Canada¹⁹</td>
<td>18-24</td>
<td>29</td>
<td>300</td>
<td>Not available</td>
</tr>
<tr>
<td>Denmark²⁰</td>
<td>12-39</td>
<td>Not available</td>
<td>94</td>
<td>Not available</td>
</tr>
<tr>
<td>France²³</td>
<td>18-29</td>
<td>30</td>
<td>139</td>
<td>Not available</td>
</tr>
<tr>
<td>Germany²²</td>
<td>18-24</td>
<td>Not available</td>
<td>117</td>
<td>Not available</td>
</tr>
<tr>
<td>UK¹⁰</td>
<td>18-29</td>
<td>57</td>
<td>70</td>
<td>21</td>
</tr>
<tr>
<td>USA¹¹,¹⁶</td>
<td>18-24</td>
<td>10</td>
<td>56</td>
<td>8.7</td>
</tr>
<tr>
<td><strong>AstraZeneca</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK¹⁰</td>
<td>18-29</td>
<td>10</td>
<td>16</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

*Third dose data for 12-17 year olds were not separated by age cohorts 12-15 and 16-17 as was previously done for dose 2, therefore dose 2 values have been combined (12-15 years = 71 per million doses and 16-17 = 106 per million doses)

*Data is for males and females in this age group

**Is the risk higher with Moderna compared to Pfizer?**

Data from multiple countries surveillance systems and studies have observed a trend of a higher risk of myocarditis after Moderna compared to Pfizer. Table 2 presents rates following each dose for Pfizer, Moderna and AstraZeneca. The rates following dose two for Pfizer range from 11 per million for males aged under 18 in the UK to 114 per million for males aged 16-29 in Israel. There are many factors that influence these rates such as case definitions and if the data is from an active or passive surveillance system.
In a head-to-head analysis of Vaccine Safety Datalink data from the USA, the rate differential was only statistically significant when observed for either dose for all ages and sex, noting that Moderna is not yet registered in the US for children and adolescents under 18 years of age. For people aged 18-39 years, in the 0-7 days following vaccination an estimated eight excess cases per million doses of Moderna were observed compared to Pfizer (aRR 1.61 95% CI: 1.02-2.54 p = 0.041). A Canadian study also found a higher risk associated with Moderna when compared to Pfizer. They found that the vaccine attributable risk (the risk when background cases are removed) in males aged 18-28 years was 3.06 (95% CI: 1.4-6.69, p = 0.007) times higher for Moderna compared to Pfizer. Another Canadian study also found the rate of myocarditis in males aged 18-24 to be 5.1 (95% CI: 1.9-15.5) times higher for Moderna compared to Pfizer (300 vs 59 per million respectively).

There is no evidence that clinical severity in the myocarditis and pericarditis cases differs when comparing the Moderna and Pfizer associated cases.

Moderna is a safe and more immunogenic vaccine, therefore ATAGI supports individual and provider risk-benefit decisions around vaccine preference.

**Does a longer interval between COVID-19 vaccine doses reduce the risk of myocarditis?**

The USA, Canada and WHO have a preferential recommendation for an 8-week interval between doses in a 2-dose primary series for all COVID-19 mRNA vaccinations for all ages.

These recommendations have been based on an observed higher vaccine effectiveness and the potential for reduced risk of myocarditis and/or pericarditis with a longer inter-dose interval. Studies from the UK and Canada found a higher vaccine effectiveness associated with a longer interval between dose one and two. A Canadian study during the Delta period found the vaccine effectiveness for Pfizer and Moderna against infection was around 10 percentage points higher for an interval of 7-8 weeks compared to an interval of 3-4 weeks (89% vs 79%). Protection against hospitalisation was also higher with a longer interval with a vaccine effectiveness of 98% for the longer interval compared to 87% for the shorter interval. A UK study during the Alpha and Delta periods observed the vaccine effectiveness was also up to around 10 percentage points higher for an 8-9 week interval compared to a 3-4 week interval.

A preprint study from Canada found that for both Pfizer and Moderna, a higher rate of myocarditis and/or pericarditis was observed in people ≥12 years of age when the interval between dose one and dose two was ≤30 days. When compared to an interval of ≥30 days after dose one, were ~3 times more likely to develop myocarditis and/or pericarditis (353 vs 103.2 per million). This risk was also greater when receiving Pfizer followed by Moderna at a ≤30 day interval.

**Advice for people with a history of cardiac conditions**

COVID-19 vaccines are recommended to prevent COVID-19 in people with a history of chronic cardiovascular conditions, including coronary artery disease, myocardial infarction, stable heart failure, arrhythmias, rheumatic heart disease (RHD), Kawasaki Disease, congenital heart disease, cardiomyopathy, or cardiac transplant, and in people with implantable cardiac devices. No specific precautions are recommended for people in these groups. There are no current data suggesting that their risk of developing myocarditis or pericarditis after vaccination is any higher than for the general population.

People with a history of any of the following conditions **can receive** COVID-19 vaccines, but should consult a GP, immunisation specialist service or cardiologist about the best timing of vaccination and whether any additional precautions are recommended:

- Current or recent (i.e., within past 3 months) myocarditis or pericarditis due to causes other than vaccination (see Future Does Recommendations)
- Acute rheumatic fever or acute rheumatic heart disease (i.e., with evidence of active inflammation)
- Acute decompensated heart failure

These patients should be counselled about the symptoms to look out for after vaccination, and some may be advised by their cardiologist to schedule a routine visit with their general practitioner a few days after vaccination to screen for any concerning symptoms or signs.

Advice for vaccine recipients regarding clinical features of myocarditis or pericarditis following COVID-19 vaccination

During the consent process, all people who receive a COVID-19 vaccine should be advised of the very rare risk of myocarditis and/or pericarditis after vaccination and be advised of the symptoms in Table 3, and what to do if they develop.

Symptoms typically start within a few days after vaccination (median 2 days). People who experience any of these symptoms after receiving a COVID-19 vaccine should seek prompt medical attention. People who feel well and do not have any of these symptoms after vaccination can continue with their usual physical activity and do not routinely need to avoid physical exertion.

People who have underlying heart dysfunction should seek medical attention for new onset or worsening of pre-existing symptoms following vaccination.

Table 3: Symptoms and signs of myocarditis or pericarditis

<table>
<thead>
<tr>
<th></th>
<th>Myocarditis</th>
<th>Pericarditis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symptoms</strong></td>
<td>Chest pain, pressure or discomfort, Palpitations, Shortness of breath, Non-specific symptoms e.g. fatigue</td>
<td>Chest pain which may be sharp, worse when lying down, and alleviated when sitting up and leaning forward, Pain on deep inspiration</td>
</tr>
<tr>
<td><strong>Signs</strong></td>
<td>May have normal examination, Tachycardia, Severe myocarditis: signs of cardiac dysfunction e.g. third heart sound, oedema</td>
<td>Pericardial rub on auscultation</td>
</tr>
</tbody>
</table>
Assessment of possible myocarditis or pericarditis in a primary care setting

Initial investigations can be performed in the primary care setting, based on clinical judgement, if:

- the patient is not acutely unwell, and has mild symptoms
- the referring practice can **obtain and review all the results** of initial investigations within **12 hours**. If required, contact your local pathology service before sending the patient for blood tests to ensure this.

**Patients with significant clinical suspicion of myocarditis and/or pericarditis should immediately be referred to ED if any of the following apply:**

- they are acutely unwell as assessed by the clinician (any age)
- they have suspicious and/or concerning chest pain and are aged ≥ 30 years
- they have abnormal ECG findings (refer to **Table 4**: Initial diagnostic evaluation of myocarditis and pericarditis below)
- initial investigations cannot be performed and reviewed within **12 hours**

Refer to **Table** below for the initial investigations recommended for the evaluation of myocarditis or pericarditis.

**Table 4**: Initial diagnostic evaluation of myocarditis and pericarditis

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>12-lead ECG</strong></td>
<td>ST or T-wave abnormalities*, Q waves</td>
</tr>
<tr>
<td></td>
<td>Premature atrial complexes</td>
</tr>
<tr>
<td></td>
<td>Premature ventricular complexes</td>
</tr>
<tr>
<td></td>
<td>Can be normal</td>
</tr>
<tr>
<td></td>
<td>Widespread ST elevation (typically concave up)</td>
</tr>
<tr>
<td></td>
<td>PR depression</td>
</tr>
<tr>
<td></td>
<td>Small QRS (reflecting pericardial effusion)</td>
</tr>
<tr>
<td></td>
<td>Can be normal or atypical</td>
</tr>
<tr>
<td><strong>Troponin</strong></td>
<td>Commonly raised, however absence of elevation* does not exclude myocarditis</td>
</tr>
<tr>
<td></td>
<td>May be increased (suggestive of myopericarditis)</td>
</tr>
<tr>
<td><strong>Inflammatory markers: CRP, ESR</strong></td>
<td>Commonly raised (although nonspecific)</td>
</tr>
<tr>
<td></td>
<td>Commonly raised (although nonspecific)</td>
</tr>
<tr>
<td><strong>Chest X-ray (PA)</strong></td>
<td>Heart size can be normal or enlarged (in children this is defined as cardiothoracic ratio &gt;0.5)</td>
</tr>
<tr>
<td></td>
<td>Typically normal</td>
</tr>
<tr>
<td></td>
<td>Rarely, large pericardial effusion can lead to cardiomegaly</td>
</tr>
</tbody>
</table>

*N.B. T wave inversion in anterior leads can be normal in people aged ≤ 16 years

* If ongoing clinical concern, could consider repeating troponin in 12 hours

**Referral & Management**

Patients with confirmed myocarditis or pericarditis may require referral to a cardiologist for advice regarding management (depending on the patient’s location a telehealth consult may be appropriate with a cardiologist and/or medical retrieval team). All children and adolescents with a confirmed diagnosis should be referred.
Further investigations may be required, including:
- Investigations to exclude other causes e.g., viral illness
- Echocardiogram
- Coronary angiography or CT coronary angiogram for selected patients who may present with features indistinguishable from acute coronary syndrome
- Cardiac MRI
- Endomyocardial biopsy is rarely indicated (as determined by cardiologist)

Treatment of myocarditis and pericarditis is determined on a case-by-case basis and often supportive treatment is all that is required.  

Patients with confirmed myocarditis should be admitted to hospital for cardiac monitoring (ideally continuous ECG monitoring), until the cardiac biomarker levels have peaked and symptoms have resolved.

**Follow up in the community**
- People for whom management in the community is advised should be reviewed by their general practitioner every 1-2 days.
- Advise patients with a confirmed diagnosis of myocarditis or pericarditis to avoid high-intensity exercise or competitive sports until resolution of symptoms and ECG changes, and normalisation of cardiac function.
- After a diagnosis of myocarditis and/or pericarditis, cardiology follow-up will be required for at least 12 months. A repeat ECG and echocardiogram are likely to be required.

**Follow up of patients with normal investigations**
- Patients with minor symptoms, normal ECG, and no elevation in troponin and/or inflammatory markers can be monitored in the community with GP review every 1-2 days.
- Investigations should be repeated if symptoms are persistent.
- Advise patients to avoid high-intensity exercise or competitive sports until symptoms have resolved.
- Clinical judgement should be used as to the need for specialist consultation. Refer to ED or discuss with a cardiologist if there are any abnormalities on repeat investigations, or if any concerning symptoms (even if investigations are normal).
Assessment of possible myocarditis or pericarditis in an emergency department setting

Chest pain is a common emergency department presentation in adults and has a broad differential. Adults who present with chest pain following a COVID-19 vaccine should be investigated for other causes of chest pain (such as acute coronary syndrome) as indicated, based on their history and examination findings.

Chest pain is less common in children and adolescents. **Figure 1** outlines the recommended investigations in children and adolescents with possible vaccine-induced myocarditis/pericarditis, developed by the Paediatric Research in Emergency Departments International Collaborative, ACEM, ATAGI, New Zealand Immunisation Advisory Centre and Cardiac Society of Australia and New Zealand and is available at: https://www.predict.org.au/mrna-chest-pain-guideline.

**Figure 1**: Australian and New Zealand guideline for assessment of possible vaccine-induced pericarditis/myocarditis in children and adolescents presenting to the ED23

- **1 or more cardiac symptoms**
  - Acute chest pain / pressure palpitations, diaphoresis
  - Dyspnoea (after exercise, at rest or lying down)
  - Syncope, cardiac arrest

- **Send COVID / viral swab if meets criteria**

- **Consider Pericarditis and/or myocarditis**

- **2 or more non-specific symptoms WITHOUT an alternative cause after clinical assessment**
  - Fatigue, abdominal pain
  - Dizziness, oedema
  - Cough

- **Physical examination**
  - Pericardial friction rub
  - Pulmonary paradoxic
  - Distant heart sounds

- **ECG**
  - Pericarditis
    - Diffuse concave-upward ST-segment elevation
    - ST-segment depression in aVR
    - PR-depression throughout the leads (best shown in leads II & V3) without reciprocal ST-segment changes (depressions)

- **Troponin**
  - Myocarditis
    - Paroxysmal or sustained atrial or ventricular arrhythmias
    - AV nodal conduction delays or intraventricular conduction defects
    - Continuous monitor with frequent atrial or ventricular ectopy

  - **Non-specific ECG changes only? Add CRP (and ESR if available)**
    - Elevated troponin
    - Evidence of pericardial effusion
      - CXR - enlarged cardiac shadow
      - Ultrasound / echo - definite effusion
Future dose recommendations

Recommendations regarding future COVID-19 vaccine doses will depend on the specific diagnosis (i.e., myocarditis or pericarditis), level of certainty of the diagnosis, and the patient’s age. Options include deferring any further COVID-19 vaccine until further information is available, choosing an alternate vaccine formulation, or proceeding with further doses using the same COVID-19 vaccine type.

**Myocarditis**

As the more serious adverse event following immunisation (AEFI), myocarditis should be discussed with a specialist immunisation service (SIS) and/or cardiologist prior to administering a subsequent COVID-19 vaccine dose.

**Pericarditis**

Figure 2 outlines the approach to revaccination in people with pericarditis attributed to a COVID-19 vaccine. Referral to a specialist immunisation service (SIS) or cardiologist is not always required.

People who have had a clinical diagnosis of pericarditis following a COVID-19 vaccine but who have normal investigations (i.e., ECG, echocardiogram, troponin and chest X-ray) can receive further doses after full recovery. Patients should be symptom free for at least 6 weeks. The need and choice of further doses is informed by investigation findings, age and sex.
Figure 2: Approach to revaccination in people with pericarditis attributed to an mRNA COVID-19 vaccine

*SIS = specialist immunisation service; # Brighton case definitions are summarised in Appendix 1
^ AZ & NVX not licensed for <18yo; * Risk appears lower following AZ and risk is not yet known for NVX

Source: Adapted from Pericarditis (AESI) & COVID-19 mRNA Vaccine Decision Guide (SAEFVIC)13
Severity, outcomes, and long-term prognosis and long-term follow up

It is important to consider pericarditis and myocarditis separately when reviewing clinical outcomes. Most myocarditis cases linked to COVID-19 vaccination have required hospitalisation, with the majority of cases having a relatively mild and self-limiting course. 7,10,32

An enhanced surveillance report from the US CDC presented preliminary data up to January 2022 on functional status and clinical outcomes of 850 patients aged 12-29 with probable myocarditis after mRNA COVID-19 vaccination.33 Cardiologists and healthcare providers were surveyed about patients who were at least 90 days from when they were first diagnosed with myocarditis, and they indicated 81% of patients had fully or probably recovered. The surveyed clinicians also reported that 93% of patients had normal cardiac function on echocardiogram.

There are yet to be studies on severity and outcomes of cases of myocarditis after other COVID-19 vaccines, but it is likely to be the same as for mRNA vaccines. There is also on-going monitoring and extension of follow up to include children aged 5-11.

Pericarditis cases are often managed in primary and/or ambulatory care and also have a short, self-limiting course.

Patients with myocarditis and/or pericarditis after an mRNA COVID-19 vaccine whose symptoms resolve quickly, who do not have any arrhythmia associated with the acute myocarditis, and who have not had prolonged impairment of ventricular systolic function should be followed up for at least 12 months. There will usually be some restriction of exercise (particularly strenuous exercise or competitive sport) if they have confirmed myocarditis.

For any patient who is found to have a persisting abnormality, e.g. heart block or ventricular tachycardia, persisting ventricular dysfunction, or persisting abnormalities on a cardiac MRI (where applicable), follow-up should be extended in consultation with their treating specialist.

Reporting adverse events

Suspected cases of myocarditis or pericarditis following a COVID-19 vaccine should be reported to your jurisdiction vaccine safety service, with details available at the Therapeutic Goods Administration website.

More information

- CSANZ: www.csanz.edu.au/
- Australian Product Information on Pfizer and Moderna COVID-19 vaccines, available on the TGA website.
- Brighton Collaboration case definitions of myocarditis and pericarditis are available at https://brightoncollaboration.us/myocarditis-case-definition-update/.
- CDC case definitions: https://www.fda.gov/media/150054/download
References

Appendix 1: Brighton Collaboration Case Definitions for Pericarditis

**PERICARDITIS: Algorithm for Brighton Case Definition Levels of Certainty**

- Histopathologic examination of pericardial tissue (autopsy or surgical biopsy) showed pericardial inflammation

- No inflammation seen or tissue not examined or results unknown

Meets at least 2 of the 3 following criteria:
- □ Evidence of abnormal fluid collection or pericardial inflammation by imaging (Echocardiogram, MR, cMR or CT)
- □ ECG shows all 3 abnormalities as listed in BOX 1 below, that are new and/or normalises on recovery
- □ ≥1 physical exam finding of pericardial fluid:
  - pericardial friction rub
  - pulsus paradoxus
  - distant heart sounds (infants/children)

No

Symptoms at presentation meets (a) or (b) below:
- □ (a) ≥ 1 of the following: acute chest pain or pressure, palpitations, dyspnea after exercise, at rest or lying down, diaphoresis, sudden death
- □ (b) If infant/young child ≥2 of: irritability, vomiting, poor feeding or sweating

**AND for all ages**

At least 1 of the 3 following criteria met:
- □ ≥1 ECG change as listed in Box 1, that is new and/or normalises on recovery
- □ Imaging (Echo, MR, cMR or CT) shows abnormal pericardial fluid collection and/or inflammation
- □ Physical exam finding(s) of pericardial fluid: pericardial friction rub and/or pulsus paradoxus

No

Symptoms at presentation meets (c) or (d) below:
- □ (c) at least 1 non-specific symptom listed in BOX 2 below **AND** ≥1 of the following:
  - new onset cardiac chest pain or pressure
  - palpitations
  - dyspnea after exercise, at rest or lying down
- □ (d) infant/young child ≥2 of: irritability, vomiting, poor feeding, back pain, tachypnea, lethargy

**AND for all ages:**
- □ chest radiograph shows enlarged heart
- □ non-specific ECG abnormalities that are new and/or normalise on recovery

No

**Level 1 Pericarditis (Definitive Case)**

Was there a clear alternative explanation to explain the illness?

Yes

**Level 2 Pericarditis (Probable case)**

Was there a clear alternative explanation to explain the illness?

Yes

**Level 3 Pericarditis (Possible Case)**

Was there a clear alternative explanation to explain the illness?

No

**Level 5: NOT a case of Pericarditis**

**NOTE** - Classify as Level 4 “reported case of pericarditis that fails to meet level 1, 2 or 3 of the case definition” if insufficient evidence to meet level 1, 2 or 3 because test(s) not done or results unknown or history/physical exam features not documented

**BOX 1. Electrocardiogram abnormalities:**
- Diffuse concave-upward ST-segment elevation
- ST-segment depression in avR
- PR-depression throughout the leads (best shown in leads II & V3) without reciprocal ST-segment changes (depressions)

**BOX 2. Non-specific symptoms:**
- Cough
- Weakness
- Shoulder+/or upper back pain
- Edema
- Fatigue
- Low grade intermittent fever (≥38.0°C)
- Cyanosis
- Altered mental status
- GI (nausea+/or vomiting+/or diarrhea)

Source: Adapted from https://brightoncollaboration.us