Diagnostic Imaging Pathways - Suspected Acute Coronary Syndrome

Population Covered By The Guidance

This pathway provides guidance on the imaging investigation of adult patients with suspected acute coronary syndrome (ACS). This pathway does not provide guidance on the management of suspected ACS.

Date reviewed: May 2018
Date of next review: May 2021
Published: April 2019

Quick User Guide

Move the mouse cursor over the PINK text boxes inside the flow chart to bring up a pop up box with salient points. Clicking on the PINK text box will bring up the full text. The relative radiation level (RRL) of each imaging investigation is displayed in the pop up box.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>RRL</th>
<th>EFFECTIVE DOSE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Minimal</td>
<td>&lt; 1 millisieverts</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1-5 mSv</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>5-10 mSv</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>&gt;10 mSv</td>
</tr>
</tbody>
</table>

Pathway Diagram
**Diagnostic Imaging Pathways - Suspected Acute Coronary Syndrome**

**Suspected ACS Pathway**

- History, exam, ECG, serial troponins, resuscitation as necessary
- Consider CXR

**STEMI**
- Urgent cardiology referral

**NSTEMI Unstable Angina**
- High risk: Urgent cardiology referral warranted

**High Sensitivity Troponin Negative Chest Pain without ECG Changes**
- Clinical reassessment, consider use of validated risk stratification tool, consider cardiology referral

**Intermediate or Low Risk**
- Timing of further investigations based on clinical judgement

**Very Low Risk**
- Timing of further investigations based on clinical judgement

**Stress ECG**
- Negative: Consider other causes of chest pain
- If stress ECG not tolerated, unavailable, or result is positive or equivocal: Stress Echo

**Prior confirmed CAD**
- Functional Imaging

**No prior confirmed CAD**
- CTCA
- Positive

**Non-Flow Limiting Lesion**
- <50% stenosis with consideration of embolic infarcts or other causes of chest pain
- Consider other causes of chest pain

**Flow Limiting Lesion**
- >50% stenosis
- Functional Imaging if not already done
- Cardiology referral if not already done, consider if intervention indicated

**Invasive Coronary Angiography**

---

**Image Gallery**

*Note: These images open in a new page*
Normal CT Coronary Angiogram

Image 1a, 1b, and 1c (CT Coronary Angiogram): Angiogram demonstrating a patent left main, left anterior descending, left circumflex and right coronary arteries.

Coronary Artery Disease

Image 2a, 2b, and 2c (Acute Resting Thallium and Stress MIBI): A small basolateral abnormality is present likely representing a previous infarction. A moderate-severe area of Dipyridamole-induced reversibility in the anterior and lateral wall also suggests significant proximal coronary artery disease.

Teaching Points

- Acute coronary syndromes include ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI) and unstable angina
- The initial diagnosis of myocardial infarction (MI) is based on clinical assessment, repeat troponin assays and ECG changes. There are a number of different validated HS-troponin protocols to rule out MI
- A small proportion of patients with troponin negative chest pain may have ischaemic heart disease, which can be evaluated with imaging. This may be done in the outpatient setting shortly after discharge for chest pain presentations to the emergency department, such as through a rapid access chest pain clinic. The timing of investigation should be based on clinical judgement
- Investigations can be divided into tests that assess coronary anatomy (CTCA and invasive coronary angiogram) or functional tests that demonstrate ischaemia (stress ECG, stress echo, MPS)
- Non-invasive imaging techniques avoid the risks of a catheter angiogram in patients who would otherwise not require invasive treatment
CTCA is recommended as the first line non-invasive test to evaluate suspected ACS
Patients with prior confirmed coronary artery disease should have functional imaging instead of CTCA. This includes patients with a history of ischaemic heart disease, or evidence of coronary artery disease on any previous CT, including non-gated studies
The overall choice of non-invasive imaging technique depends on various factors, particularly local expertise & availability of services

Acute Coronary Syndrome (ACS)

In Australia, ischaemic heart disease and acute coronary syndrome (ACS) account for over 19 000 deaths and 156 000 hospitalisations per year.

In the emergency setting, acute chest pain represents around 5-10% of all presentations, yet only 15-25% of patients have a final diagnosis of ACS.

The current gold standard of excluding acute myocardial infarction (AMI) is serial ECGs and repeat troponins
- High-sensitivity troponin assays are now widely available and can rule out an AMI earlier than standard troponins
- Algorithms for repeat high-sensitivity troponins at 1, 2 and 3 hours from presentation have been validated with negative predictive values over 99% to rule out AMI.

As current assays quickly and accurately rule out AMI in the Emergency Department setting, imaging may not initially be required for diagnosis.

Chest Radiography

Plain chest films (CXR) should be considered where a non-cardiac cause of chest pain is suspected.
They can be useful in diagnosing non-cardiac causes of chest pain.
CXR may demonstrate complications of myocardial infarction, such as pulmonary oedema, or secondary diagnoses, such as pneumonia.
12-19% of patients presenting with chest pain have abnormal findings on CXR, however findings are not always clinically significant. A retrospective study found that CXR potentially changed the management of only 3.8% of patients.
Although CXR has a low yield in patients presenting with chest pain, it is easily accessible in the acute setting.
A chest radiograph should not delay urgent reperfusion therapy where indicated.

CT Coronary Angiography

CT coronary angiography (CTCA) is an established technique that uses contrast to enhance the coronary arteries.
CTCA is comparable to invasive cardiac angiogram for assessing coronary artery anatomy, but avoids the risks of an invasive procedure.
A normal CTCA has a high negative predictive value for coronary artery disease, between 97 and 99%.
Multiple studies have validated the accuracy of CTCA to detect coronary artery stenosis. Meta-analysis found CTCA to have a sensitivity of 96% and specificity of 79% for detecting 50% stenosis.
Currently no statistical difference in mortality or major cardiac events has been demonstrated between patients randomised to CTCA compared with standard treatment, functional testing or stress ECG over an approximately 2 year follow-up period.

Limitations:
- Some protocols require the patient to have an optimal target heart rate around 65bpm, and IV beta-blockers may be administered to achieve this. The patient may also need to hold their breath for around 10 seconds.
- Contraindications for CTCA include renal failure, contrast allergy, severe arrhythmia and haemodynamic insufficiency. Coronary arteries cannot be fully evaluated in some patients due to calcifications. With modern techniques and scanners, the radiation dose of a CTCA is around 2-5mSv.
- If anatomical disease is demonstrated, further stress testing to confirm functional ischaemia is still recommended. Severe stenosis may warrant proceeding to catheter angiography with a view to treatment.

Functional Imaging

- Functional imaging is performed when subjecting the heart to either exercise or pharmacological stress to assess the presence of stress-related ischaemia.
- Stress echo, MPS and cardiac MR have comparable accuracy so choice of functional test should be based on local and patient factors, taking into consideration availability and radiation exposure.
- Read about:
  - Stress Echo
  - Myocardial Perfusion Scintigraphy
  - Cardiac Magnetic Resonance Imaging

Stress Echocardiogram

- Stress echocardiogram (stress echo) is a functional test that can demonstrate cardiac ischaemia.
- The testing method normally occurs as follows. A baseline resting reading is taken. The patient's heart is stressed through exercise (e.g. treadmill, supine bike) or pharmacologically for patients who are unable to exercise (e.g. dobutamine, dipyridamole or adenosine). A second reading is taken while the patient is at peak stress. The two readings are then interpreted together.
- Stress echocardiography (stress echo) is considered positive if there is abnormal ventricular wall motion or thickness in response to stress.
- Contrast echocardiography using microbubbles to show myocardial capillaries can also assess perfusion which improves the diagnostic accuracy of stress echo.
- In meta-analysis, the sensitivity of stress echo was 76-84% to detect 50% stenosis, with a specificity of 79-86%. The specificity is higher (88-90%) for detecting stenosis over 70%.
- A normal stress echo has a good prognosis: normal results are associated with an annual risk of 0.4-0.9% for cardiac mortality or acute myocardial infarction.
- Unlike MPS, there is no radiation dose from stress echo.
- Limitations:
  - As with other forms of ultrasound imaging, the quality and hence overall diagnostic accuracy of echocardiography is limited by the experience of the sonographer and the interpreting physician.
  - There is risk associated with inducing stress, with death in 1 in 10 000 and ventricular arrhythmia or MI in 1 in 5 000.

---

Footnotes:
12 Functional testing
13 Stress ECG
5 Radiation dose for CTCA
9 Read about:
15-17 Contrast echocardiography sensitivity
5 The specificity is higher (88-90%) for detecting stenosis over 70%.
18 Annual risk of 0.4-0.9% for cardiac mortality or acute myocardial infarction.
Dipyridamole and adenosine are relatively contraindicated in severe asthma or profound obstructive pulmonary disease 5,19

- Stress echo, MPS and cardiac MR have comparable accuracy so choice of functional test should be based on local and patient factors, taking into consideration availability and radiation exposure 9
- If the study is suboptimal and unable to answer the clinical question, for example the acoustic window is restricted due to body habitus, cardiac MR could be considered 4

Myocardial Perfusion Scintigraphy

- Myocardial perfusion scintigraphy (MPS) using single photon emission computed tomography (SPECT) is a widely available and well validated method of functional cardiac imaging 20
- A radioactive tracer (such as technetium-99m or thallium-201) is injected, followed by imaging of the myocardial uptake via SPECT. This is usually done twice; once with the patient at rest and later with the patient under stress, either during exercise or after administration of a vasodilator (such as dipyridamole or adenosine). The images at rest and under stress are assessed together. Areas of myocardium that show reversible defects (i.e. tracer uptake at rest, but not under stress) represent myocardial ischaemia. Areas that show irreversible defects (no tracer uptake at rest or under stress) represent infarcted myocardium
- Meta-analysis found MPS to have a sensitivity of 78% and specificity of 81% to detect 50% stenosis. MPS combined with CTCA has a sensitivity of 94% and specificity of 95% 5
- A normal MPS has a good prognosis: a meta-analysis of 31 studies showed that the rate of death or myocardial infarction was 0.85% per year, which is comparable to event rates in populations without coronary artery disease 21
- Limitations:
  - The main disadvantage of MPS is the high radiation dose. Generally, the radiation dose from MPS using technetium-99 is around 7mSv 22 but can be >20mSv with thallium-201 23
    - dose also depends on the protocol used
  - MPS is time consuming, taking three to four hours. 5 Some protocols comparing rest and stress images require the tracers to leave the heart which may take up to a week, requiring two visits and delaying results 24
  - A false negative result may occur when there is widespread ischaemia throughout the whole myocardium, such as in triple vessel disease. 25 This is because the interpretation of the study relies on comparison of ischaemic areas to normal areas
  - There is a 1 in 10 000 risk of death associated with stress induction 5

Cardiac Magnetic Resonance Imaging

- Cardiac magnetic resonance imaging (cardiac MR) is becoming increasingly used to assess stable coronary artery disease
- It has the benefit of assessing both coronary artery anatomy and functional ischaemia. Vasodilator techniques use adenosine or regadenoson with gadolinium contrast to assess perfusion defects. 24 Stress cardiac MR can be performed with dobutamine to demonstrate wall motion abnormalities indicating ischaemia 26
- Cardiac MR is also accepted as the non-invasive gold standard for assessing cardiac structure and function. 24 Other cardiac conditions that may cause chest pain can be demonstrated on cardiac MR, including Takotsubo cardiomyopathy and myocarditis 4
Cardiac MR has a sensitivity and specificity of 86% for detecting 50% stenosis compared to invasive coronary angiogram. There is no associated radiation dose and the safety is comparable to stress echo. Limitations:
- Availability is one of the main limitations. Access to cardiac MR and reporting expertise is limited.
- Long procedure (approximately 1hr) during which patients must be able to lie still. Scan may not be tolerated due to claustrophobia.
- Incompatible metal implants and foreign bodies are contraindicated in MRI.
- Renal failure is a relative contraindication to gadolinium contrast.
- There is risk of death and cardiac events associated with inducing stress.

Stress echo, MPS and cardiac MR have comparable accuracy so choice of functional test should be based on local and patient factors, taking into consideration availability and radiation exposure.

**Stress ECG**

- Stress electrocardiography (stress ECG) is a widely available and affordable test that can demonstrate reproducible symptoms of cardiac ischaemia.
- Exercise can be performed on a treadmill or exercise bicycle, with exercise increased incrementally until the patient reaches a target heart rate (normally 85% of maximum heart rate) or the patient can no longer continue. A stress ECG test is considered positive if the stress elicits ST segment elevation or depression of 0.10 mV.
- Treadmill score correlate well with prognosis. A low risk score has a good prognosis with an associated mortality rate of 0.25% per year compared to 5% per year for a high risk score. The negative predictive value has been found to be over 99%.
- The reported sensitivity is 66-94% with specificity 75-95% with higher sensitivity in specificity in low risk populations (prevalence of NSTEMI or unstable angina <10%).
- The sensitivity and specificity of stress ECG is lower than functional studies, however there are no randomised trials to suggest that this has an adverse effect on patient outcomes.
- Limitations:
  - The main limitation with stress ECG is patients with pre-existing ECG changes. These changes (such as left bundle branch block, baseline ST depression, digoxin therapy or pacemakers) make interpretation difficult.
  - Patients who are unable to exercise for other reasons, such as musculoskeletal problems, are also not suitable for stress ECG.
  - Testing may be inconclusive if the patient is unable to achieve the target heart rate in the absence of symptoms of ischaemia.

Invasive coronary angiography is considered to be the gold standard for diagnosing coronary artery disease. Intervention such as balloon angioplasty or stenting may be simultaneously undertaken if disease is found.

**Limitations:**
ICA is expensive and depends on operator expertise
- There are risks associated with performing an invasive procedure. Serious risks include stroke, myocardial infarction and death. The rate of non-fatal complications is 74 per 1000.  
- The side-effects make ICA less acceptable to patients
- Procedures may take approximately 1.5 hours
- There is also a significant associated radiation exposure of 4-6mSv
- There are risks associated with contrast administration and renal failure is a relative contraindication

ICA is rarely indicated for diagnosis only; non-invasive imaging techniques are recommended to identify patients who can be managed conservatively and can avoid the risks of an invasive procedure

---

**References**

References are graded from Level I to V according to the Oxford Centre for Evidence-Based Medicine, Levels of Evidence. Download the document

1. Cardiovascular health compendium. AIHW; 2017. View the reference


Information for Consumers

<table>
<thead>
<tr>
<th>Information from this website</th>
<th>Information from the Royal Australian and New Zealand College of Radiologists’ website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent to Procedure or Treatment</td>
<td>Angiography</td>
</tr>
<tr>
<td>Radiation Risks of X-rays and Scans</td>
<td>Computed Tomography (CT)</td>
</tr>
<tr>
<td>Angiography (Angiogram)</td>
<td>Iodine-Containing Contrast Medium</td>
</tr>
<tr>
<td>Computed Tomography (CT)</td>
<td>Plain Radiography/X-rays</td>
</tr>
<tr>
<td>Computed Tomography (CT) Angiography</td>
<td>Radiation Risk of Medical Imaging During Pregnancy</td>
</tr>
<tr>
<td>Chest Radiograph (X-ray)</td>
<td>Radiation Risk of Medical Imaging for Pregnancy</td>
</tr>
</tbody>
</table>
### Adults and Children

<table>
<thead>
<tr>
<th>Diagnostic Imaging Pathways - Suspected Acute Coronary Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Coronary Angiography (CTCA)</td>
</tr>
<tr>
<td>MRI Heart - Stress Perfusion</td>
</tr>
<tr>
<td>Nuclear Medicine Cardiac Stress Test</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
</tr>
</tbody>
</table>

### Copyright

© Copyright 2015, Department of Health Western Australia. All Rights Reserved. This web site and its content has been prepared by The Department of Health, Western Australia. The information contained on this web site is protected by copyright.

### Legal Notice

Please remember that this leaflet is intended as general information only. It is not definitive and The Department of Health, Western Australia can not accept any legal liability arising from its use. The information is kept as up to date and accurate as possible, but please be warned that it is always subject to change.

### File Formats

Some documents for download on this website are in a Portable Document Format (PDF). To read these files you might need to download Adobe Acrobat Reader.

### Legal Matters