Population Covered By The Guidance

This pathway provides guidance on the imaging investigation of adult patients with suspected acute coronary syndrome.

Date reviewed: January 2012

Date of next review: 2017/2018

Published: January 2012

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
1a 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.

1b

1c
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

- Noninvasive imaging is increasingly being used in the acute assessment of suspected acute coronary syndrome
- CTCA & TRO can help rule out important causes of chest pain & have been shown to reduce hospital admissions & lengths of stay. CT techniques can be done quickly & relatively cheaply
- MPS & stress testing (ECG and echo) remain important imaging techniques in the assessment of acute coronary syndrome
- The overall choice of non-invasive imaging technique depends on various factors, particularly local expertise & availability of services

Acute Coronary Syndrome (ACS)

- Ischaemic heart disease and acute coronary syndrome (ACS) are major causes of morbidity and mortality throughout the western world. In Australia, they account for over 22000 deaths and 162000 hospitalisations per year.\(^1\)
- In the emergency setting, acute chest pain represents around 5-10% of all presentations to Australian Emergency Departments, yet only 15-25% of patients have a final diagnosis of ACS. Only a small proportion are serious and require urgent re-perfusion therapy.\(^2\)
- Despite better diagnostic tests and improved ACS detection rates, 2% of patients with acute myocardial infarction (AMI) are still missed and discharged inappropriately.\(^3,4\)
- The current gold standard of excluding AMI is serial ECGs and repeat troponin. However, this requires the patient to wait in ED, adding time and cost to the health system
- Modern CT imaging may be useful as an early negative predictor as ACS, as well as providing diagnostic information regarding other life-threatening causes of acute chest pain
Computed Tomopgraphy Coronary Angiogram (CTCA) / Triple Rule Out (TRO)

- Traditionally, computed tomography's main role in the ACS pathway was for diagnosis or exclusion of important differential diagnoses such as pulmonary embolism or aortic dissection.
- Newer CT technologies (such as 64 slice multidetector CT (MDCT), dual source CT (DSCT) and ECG gating) have allowed CT to have the spatial and temporal resolution to image a heart within a single breath hold. This means that CT can now be used to diagnose or exclude ACS.
- In the ED setting, two CT protocols have been evaluated for their utility in the exclusion of ACS.

Computed Tomopgraphy Coronary Angiogram (CTCA)

- CTCA is an established technique that uses contrast to enhance the coronary arteries. Even with modern 64-slice MDCT, most 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 also needs to be able to take an adequate breath hold for around 10 seconds. The contraindications for CTCA are renal failure, contrast allergy, severe arrhythmia and haemodynamic insufficiency. With modern techniques and scanners, the radiation dose of a CTCA is around 3-6mSv.
- The efficacy of CTCA has been validated in many single-centre trials examining its use in the ED setting for exclusion of ACS in low & intermediate risk patients.
- The combined data from these trials show that CTCA has a very high sensitivity (77-100%, avg 92%), high specificity (74-96%, avg 89%), moderate PPV (25-95%, avg 41%), and very high NPV (89-100%, avg 99%). CTCA has sufficient NPV to further exclude ACS in the low & intermediate risk groups. Follow up in these groups varied between 30d, 6m and 1yr, but in general, the number of major adverse cardiac events was nil or very low in the patients discharged with normal CTCA.

Triple Rule Out (TRO)

- TRO is a recently introduced extended CTCA protocol aimed at ruling out the major life-threatening causes of acute chest pain (ie. ACS, PE & acute aortic syndrome) in a single scan. TRO has a larger field of view (includes the entire chest) and scanning range (from aortic arch to adrenal glands) compared to CTCA. The acquisition time is slightly longer, requiring patients to breath hold for up to 15 seconds. It has the same contraindications as for CTCA. TRO is ideally suited for investigating patients with acute chest pain that is likely of non-cardiac origin. This is an emerging technique, and so far there is no standardised protocol, particularly with regard to contrast injection.
- There have only been a handful of studies examining its utility. They generally demonstrate that TRO has a very high NPV of 99-100%. In one trial of 201 patients, TRO provided a non-coronary diagnosis in 11% of patients and provided a clinically important non-coronary diagnosis that did not explain the patient's symptoms in 14% of patients. Follow up after 30 days showed that in patients with no or mild disease, there were no adverse outcomes. 76% of patients did not require further testing.
- The radiation exposure for TRO was previously around 18mSv (generally about 50% higher than CTCA) for 64 slice MDCT. Various techniques such as tube current modulation, z-axis reduction and use of iterative reconstruction software have been demonstrated to reduce radiation exposure without reducing image quality. The radiation dose for TRO is now around 6mSv.
- Larger multicenter trials are required to determine an appropriate protocol and further elucidate the role of TRO in the investigation of acute chest pain. TRO may be used in low risk patients, where
there is clinical suspicion of PE or aortic syndrome

Chest Radiography

- Plain chest films are a useful routine initial investigation for patients with suspected ACS. They can rule out conditions that masquerade as acute MI (such as pneumothorax, rib fractures and malignancies) or provide secondary indications of an MI (such as acute pulmonary oedema without cardiac enlargement).
- Other life-threatening conditions such as pulmonary embolism and aortic aneurysm may be diagnosed from a chest radiograph, though with a much lower sensitivity than CT. 9
- A chest radiograph should not delay reperfusion therapy where indicated.

Myocardial Perfusion Scintigraphy (MPS)

- MPS using single photon emission computed tomography (SPECT) are a common and well validated method of functional cardiac imaging. 25 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.
- A large metaanalysis found that nuclear stress imaging using adenosine provided the best sensitivity and specificity (90%, 81% respectively) compared to exercise stress imaging and the use of other vasodilators. 26
- In patients with suspected ACS who are at intermediate risk, MPS is indicated in early follow-up testing. In various trials, patients who have normal MPS, have very good outcomes with annual mortality rates <1%. 27,28 In patients with ischaemia on MPS, the extent of inducible ischaemia is strongly correlated to overall prognosis and can guide further therapy (i.e. medical management or revascularisation).
- The radiation dose from MPS varies depending on the isotope and protocols used. Generally, the radiation dose from MPS using technetium-99 is around 10mSv but can be >20mSv with thallium-201. 29

TIMI Risk Criteria

- The TIMI (Thrombolyis in Myocardial Infarction) score was derived from a large international, randomised, double-blind trial (TIMI trial). 5
- This trial was initially designed to investigate the safety and efficacy of enoxaparin vs unfractionated heparin in the setting of acute myocardial infarction. Using baseline characteristics from one arm of the study, the investigators performed univariate and multivariate analyses to assess the statistical significance of each characteristic. Once these were elucidated, the risk score was developed. They then validated this score on the other arm of the trial, as well as on the both arms of another similar large trial (ESSENCE trial).
- It has since been validated among many other patient cohorts around the world, although no Australian validation studies exist yet. 6,7,8
- TIMI scores are useful for prognostication, and also for separating patients in to risk categories.
However, it is important to remember that they are an adjunct to and not a replacement for good clinical judgement.

The TIMI Risk Score

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥ 65yo</td>
<td>Y=1</td>
</tr>
<tr>
<td>≥ 3 risk factors for CAD</td>
<td>Y=1</td>
</tr>
<tr>
<td>Risk factors being:</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>Htn (BP &gt;140/90, or on antihypertensives)</td>
<td></td>
</tr>
<tr>
<td>Low HDL &lt;40mg/dL</td>
<td></td>
</tr>
<tr>
<td>Family history of premature CAD</td>
<td></td>
</tr>
<tr>
<td>Known CAD (stenosis ≥ 50%)</td>
<td>Y=1</td>
</tr>
<tr>
<td>ASA (aspirin) use in past 7d</td>
<td>Y=1</td>
</tr>
<tr>
<td>Severe angina (≥ 2 episodes w/in 24 hrs)</td>
<td>Y=1</td>
</tr>
<tr>
<td>ST changes ≥ 0.5mm</td>
<td>Y=1</td>
</tr>
<tr>
<td>Positive cardiac markers (e.g. troponin rise)</td>
<td>Y=1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Prognosis (% risk at 14d of all-cause mortality or significant cardiac event)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low 0-1</td>
<td>4.7%</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Intermediate 3</td>
<td>13.2%</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>High 5</td>
<td>26.2%</td>
</tr>
<tr>
<td></td>
<td>6-7</td>
</tr>
</tbody>
</table>

Stress Echocardiogram & Stress Echocardiography

- These are both commonly used screening tests for CAD
- 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 (e.g. dipyridamole, adenosine). A second reading is taken while the patient is at peak stress. The two readings are then interpreted together.
- A stress ECG test is considered positive if the stress elicits ST segment elevation or depression of ≥0.10 mV. The sensitivity of exercise treadmill testing to detect CAD is 70% and specificity 75%. The NPV is generally very high (89-100%) 30.
- 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.
- Stress echocardiography (stress echo) is considered positive if there is abnormal ventricular wall...
motion or thickness in response to stress. In a large metaanalysis, stress echo was shown to be slightly less sensitive (80% vs 90%) but more specific (87% vs 81%) than MPS. In one head to head trial comparing all three modalities in patients without known CAD, pharmacological stress echo had similar sensitivity (~60%) when compared to exercise stress ECG, but was much more specific (96%) and had better overall diagnostic accuracy. However, overall, MPS was still the most sensitive and accurate.

- As with other forms of ultrasound imaging, the quality and hence overall diagnostic accuracy of echocardiography is limited by the experience of the ultrasonographer and the interpreting physician.
- In terms of overall accuracy, MPS > stress echo > stress ECG, and generally pharmacologic stress > exercise stress.

### 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. **Coronary heart disease.** [Internet] AIHW; c2011 [cited 2015 Jan 12]. [View the reference](#).
MDCT provide a comprehensive evaluation? AJR Am J Roentgenol. 2005;185:533-40. (Level III evidence)


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>Contrast Medium (Gadolinium versus Iodine)</td>
</tr>
<tr>
<td>Computed Tomography (CT)</td>
<td>Gadolinium Contrast Medium</td>
</tr>
<tr>
<td>Computed Tomography (CT) Angiography</td>
<td>Iodine-Containing Contrast Medium</td>
</tr>
<tr>
<td>Chest Radiograph (X-ray)</td>
<td>Plain Radiography/X-rays</td>
</tr>
<tr>
<td>Radiation Risk of Medical Imaging During Pregnancy</td>
<td></td>
</tr>
<tr>
<td>Radiation Risk of Medical Imaging for Adults and Children</td>
<td></td>
</tr>
<tr>
<td>CT Coronary Angiography (CTCA)</td>
<td>MRI Heart - Stress Perfusion</td>
</tr>
<tr>
<td>Nuclear Medicine Cardiac Stress Test</td>
<td>Nuclear Medicine</td>
</tr>
</tbody>
</table>