Diagnostic Imaging Pathways - Suspected Stable Angina

Population Covered By The Guidance

This pathway provides guidance on the imaging investigation of adult patients with suspected stable angina.

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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.

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<th>RRL</th>
<th>EFFECTIVE DOSE RANGE</th>
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<td></td>
<td>None</td>
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<tr>
<td></td>
<td>Minimal</td>
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<td>Low</td>
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<td>Medium</td>
<td>5-10 mSv</td>
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<td></td>
<td>High</td>
<td>&gt;10 mSv</td>
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Pathway Diagram
SUSPECTED STABLE ANGINA

History, physical examination, ECG

If ACS suspected, go to the Suspected ACS Pathway

Diamond-Forrester model
Criteria for anginal pain:
- Constricting discomfort in the front of the chest, or in the neck, shoulders, jaw, or arms
- Precipitated by physical exertion
- Relieved by rest or GTN within about 5 minutes

1 criterion or less and no ST-T changes or Q waves

Consider other causes of chest pain

No previous CABG

No CAD, or 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

CTCA

Confirmation of lesion with functional imaging

Intervention indicated

Invasive Coronary Angiography

2 criteria or more, or 1 criterion or less with ST-T changes or Q waves on ECG

Prior confirmed CAD

Typical anginal pain – treat as stable angina

No CAD, or non-flow limiting lesion <50% stenosis with consideration of embolic infarcts or other causes of chest pain

Consider other causes of chest pain

CTCA to confirm patency of grafts

No prior confirmed CAD

Uncertain whether pain is due to myocardial ischaemia

Functional imaging, or stress ECG if suitable

Previous CABG

CAD = Coronary artery disease

About Functional Imaging

Stress Echo
MPS
Cardiac MR

Image Gallery
Teaching Points

- The updated Diamond-Forrester model (Genders model) has been shown to have a good level of discrimination between patients with and without stable angina, based on a large contemporary multicentre cohort study.
- Patients with atypical or typical angina should be offered diagnostic testing.
- The presence of ST-T changes or Q waves on resting ECG warrants further testing even in people with non-anginal pain.
- Patients with non-anginal pain should not be routinely investigated for coronary artery disease (CAD) regardless of pre-test probability, unless there are indications to suggest the chest pain may in fact be of cardiac origin.
- CTCA is recommended as the first line non-invasive test to evaluate suspected stable chest pain with no prior history of CAD.
- CTCA is also the first line investigation to confirm the patency of coronary bypass grafts.
- Patients with patients with CAD should be investigated further using functional imaging instead of CTCA of coronary artery disease on any previous CT, including non-gated studies.
- If anatomical disease is demonstrated, further stress testing to confirm functional ischaemia is still recommended.
- Functional imaging can be used as a second-line test if CTCA show CAD of unknown significance.
- 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.
- Invasive catheter angiography is a third-line investigation when results of non-invasive testing are inconclusive.
- The overall choice of non-invasive imaging technique depends on various factors, particularly local expertise & availability of services.

Diamond-Forrester Model (Genders Model)

- Anginal pain is:
  - Constricting discomfort in the front of the chest, or in the neck, shoulders, jaw, or arms
  - Precipitated by physical exertion

Presence of one or more of the features is defined as non-anginal pain.
Presence of two features is defined as atypical angina.
Presence of all three features is defined as typical angina.
- The presence of ST-T changes or Q waves on resting ECG warrants further testing even in people with non-anginal pain.
- Patients with atypical or typical angina should be offered diagnostic testing.
- Patients with non-anginal pain should not be routinely investigated for CAD regardless of pre-test probability, unless there are indications to suggest the chest pain may in fact be of cardiac origin.
- The updated Diamond-Forrester model (Genders model) has been shown to have a good level of discrimination between patients with and without stable angina, based on a large contemporary multicentre cohort study. It is the most well-validated prediction model compared to other models such as the Framingham Risk Score and the Duke Clinical Score.
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 be able 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 directly to catheter angiography with a view to treatment.
- Functional imaging may be offered if CTCA shows CAD of uncertain significance or is non-diagnostic.

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 echocardiography. In meta-analysis, the sensitivity of stress echocardiography 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.
- Dipyridamole and adenosine are relatively contraindicated in severe asthma or profound obstructive pulmonary disease.
- 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.
- 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.

### 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. 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%.

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.

### Limitations:
- The main disadvantage of MPS is the high radiation dose. Generally, the radiation dose is moderate with the use of technetium-99m (7-10 mSv) but can be 20 mSv or more with thallium-201.
- MPS protocols requiring rest and stress images require the tracers to leave the heart which may take up to a week, requiring two visits and delaying results.
- A false negative result may occur when there is widespread ischaemia throughout the whole myocardium giving a normal appearance on comparison of ischaemic areas to normal areas.
- There is a 1 in 10 000 risk of death associated with stress induction.
- 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.
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. Stress cardiac MR can be performed with dobutamine to demonstrate wall motion abnormalities indicating ischaemia. 19
- Cardiac MR is also accepted as the non-invasive gold standard for assessing cardiac structure and function. 21 Other cardiac conditions that may cause chest pain can be demonstrated on cardiac MR, including Takotsubo cardiomyopathy and myocarditis. 14
- Cardiac MR has a sensitivity and specificity of 86% for detecting 50% stenosis compared to invasive coronary angiogram. 2
- There is no associated radiation dose and the safety is comparable to stress echo. 14
- Limitations 2, 13
  - 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. 3

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. 22 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. 23 The negative predictive value has been found to be over 99%. 24
- 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%). 25-29
- 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. 14, 30
- 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.
The presence of anatomical disease cannot be confirmed, so stress ECG is only recommended for patients who have had coronary artery disease previously confirmed with invasive or non-invasive studies.

Invasive Coronary Angiography

- Invasive coronary angiography (ICA) 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 10,000. 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.

6. CT coronary angiography in patients with suspected angina due to coronary heart disease.


27. Bennett P, Dyer P. Exercise stress test utility in patients with chest pain presumed to be of cardiac origin. Acute medicine. 2013. (Level III evidence);12(3):146-50. View the reference


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