Secondary Care Cardiac Investigations: A guide to the GP

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Investigating Chest Pain

• A very common symptom.... With many causes

• Incidence of angina\textsuperscript{1}:
  - 55-64 years – 8% in men, 3% in women
  - 65-74 years – 14% in men, 8% in women

• So which tests and when?
• What is the role of history taking and assessing cardiac risk?

\textsuperscript{1}: Health Survey for England (2006)
Presentation with stable chest pain
Diagnose stable angina based on one of the following:
- clinical assessment alone or
- clinical assessment plus diagnostic testing (that is, anatomical testing for obstructive coronary artery disease [CAD] and/or functional testing for myocardial ischaemia)

If people have features of typical angina based on clinical assessment and their estimated likelihood of CAD is greater than 90% further diagnostic investigation is unnecessary. Manage as angina.
Assessing Likelihood of CAD

Table 1 Percentage of people estimated to have coronary artery disease according to typicality of symptoms, age, sex and risk factors

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Non-anginal chest pain</th>
<th>Atypical angina</th>
<th>Typical angina</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men Lo</td>
<td>Hi</td>
<td>Women Lo</td>
</tr>
<tr>
<td>35</td>
<td>3</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>9</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>55</td>
<td>23</td>
<td>59</td>
<td>4</td>
</tr>
<tr>
<td>65</td>
<td>49</td>
<td>69</td>
<td>9</td>
</tr>
</tbody>
</table>

For men older than 70 with atypical or typical symptoms, assume an estimate > 90%.
For women older than 70, assume an estimate of 61–90% EXCEPT women at high risk AND with typical symptoms where a risk of > 90% should be assumed.

Values are per cent of people at each mid-decade age with significant coronary artery disease (CAD).
Hi = High risk = diabetes, smoking and hyperlipidaemia (total cholesterol > 6.47 mmol/litre).
Lo = Low risk = none of these three.
The shaded area represents people with symptoms of non-anginal chest pain, who would not be investigated for stable angina routinely.

**Note:** These results are likely to overestimate CAD in primary care populations. If there are resting ECG ST-T changes or Q waves, the likelihood of CAD is higher in each cell of the table.
Anatomical versus Functional Assessment

- NICE guidance advises investigation is dependent on likelihood of CAD

- “If people have features of typical angina based on clinical assessment and their estimated likelihood of CAD is greater than 90%, further diagnostic investigation is unnecessary. Manage as angina.”

- Angiography? Depends on management strategy
“Offer people optimal drug treatment for the initial management of stable angina. Optimal drug treatment consists of one or two anti-anginal drugs as necessary plus drugs for secondary prevention of cardiovascular disease.”

“Discuss the following with people whose symptoms are satisfactorily controlled with optimal medical treatment:
- their prognosis without further investigation
- the likelihood of having left main stem disease or proximal three-vessel disease
- the availability of CABG to improve the prognosis in a subgroup of people with left main stem or proximal three-vessel disease”
Moderate Likelihood of CAD

• “If the estimated likelihood of CAD is 61–90%, offer invasive coronary angiography as the first-line diagnostic investigation if appropriate”
Intermediate Likelihood

• “If the estimated likelihood of CAD is 30–60%, offer **functional** imaging as the first-line diagnostic investigation”
Intermediate-Low Likelihood

• “If the estimated likelihood of CAD is 10–29%, offer CT calcium scoring as the first-line diagnostic investigation”

• “Do not use exercise ECG to diagnose or exclude stable angina for people without known CAD”
Investigation of Chest Pain

**RISK**

- **> 90%**
  - Manage as Angina +/- ANGIOGRAPHY

- **61 - 90%**
  - ANGIOGRAPHY

- **30 - 60%**
  - FUNCTIONAL TEST (MPS or DSE)

- **10 - 29%**
  - CT CALCIUM/CTCA

- **< 10%**
  - NON CARDIAC
Anatomical vs Functional

• Anatomical:
  - CT Calcium Scoring
  - CT Coronary Angiography
  - MRI Coronary Angiography
  - Invasive Coronary Angiography
  - (Intravascular Ultrasound - IVUS)
  - (Optical Coherence Tomography – OCT)

• Functional:
  - (ETT)
  - Stress Echocardiography
  - Nuclear Perfusion Scintigraphy
  - Stress MR perfusion
  - (Pressure wire studies – FFR)
  - (?IVUS)
CT Calcium Scoring

Score
0 – consider alternative diagnosis
1-400 – offer CTCA
>400 – follow 61-90% risk pathway

Meta-analysis of 25000 patients with no coronary calcium (2010)²
- The absence of coronary calcium is associated with a very low risk of coronary events – 0.56% over mean FU 51 months
- Negative predictive value 99%, Sensitivity 98%

Diagnostic and prognostic value of absence of coronary artery calcification.
CT Coronary Angiography

- The studies and meta-analyses of MDCT to detect CAD have generally shown high negative predictive values (NPVs), suggesting that MDCT is excellent in excluding significant CAD.

- Only about half of the stenoses classified as significant by MDCT are associated with ischaemia.

CTCA

On the inappropriateness of noninvasive multidetector computed tomography coronary angiography to trigger coronary revascularization: a comparison with invasive angiography.


- Good concordance between CTCA and coronary angiography
- CTCA performed poorly at predicting functionally important CAD – sensitivity 79%, specificity 68%. In this study CTCA alone would have resulted in ‘inappropriate’ revascularisation in 22%
CTCA

• An excellent reassurance
• May visualise plaque burden well before plaque burden encroaches – would this be missed with invasive angiography
• Radiation issue?
  - Risk of cancer: 20 yo female 1:219 (14mSv)
  - 60 yo female 1:715 (14mSv)
  - 60 yo male 1:1911 (9 mSv)
• Currently there are no data to suggest MR Coronary angiography should be used to detect or assess CAD
• This may change - ? A hybrid functional approach

Invasive Coronary Angiography

• The ‘Gold Standard’ anatomical test
• Clear place for assessment of patients with moderate risk of CAD and chest pain.
• Can easily identify ‘prognostic’ CAD
• Additional therapeutic component (percutaneous coronary intervention)
• Not without risk ....... 1:1000 risk of complication
Table 7  Indications of different imaging tests for the diagnosis of obstructive coronary artery disease and for the assessment of prognosis in subjects without known coronary artery disease

<table>
<thead>
<tr>
<th>Asymptomatic (screening)</th>
<th>Symptomatic</th>
<th>Prognostic value of positive result</th>
<th>Prognostic value of negative result</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest likelihood of obstructive disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

### Anatomical test

<table>
<thead>
<tr>
<th>Invasive angiography</th>
<th>III A</th>
<th>III A</th>
<th>IIb A</th>
<th>IA</th>
<th>IA</th>
<th>IA</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDCT angiography</td>
<td>III B&lt;sup&gt;c&lt;/sup&gt;</td>
<td>IIb B</td>
<td>IIA B</td>
<td>III B</td>
<td>IIb B</td>
<td>IIA B</td>
<td>17–20</td>
</tr>
<tr>
<td>MRI angiography</td>
<td>III B</td>
<td>III B</td>
<td>III B</td>
<td>III C</td>
<td>III C</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

### Functional test

<table>
<thead>
<tr>
<th>Stress echo</th>
<th>III A</th>
<th>III A</th>
<th>IA</th>
<th>III A&lt;sup&gt;d&lt;/sup&gt;</th>
<th>IA</th>
<th>IA</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear imaging</td>
<td>III A</td>
<td>III A</td>
<td>IA</td>
<td>III A&lt;sup&gt;d&lt;/sup&gt;</td>
<td>IA</td>
<td>IA</td>
<td>12</td>
</tr>
<tr>
<td>Stress MRI</td>
<td>III B</td>
<td>III C</td>
<td>IIa B</td>
<td>III B&lt;sup&gt;d&lt;/sup&gt;</td>
<td>IIa B</td>
<td>IIa B</td>
<td>12, 23–25</td>
</tr>
<tr>
<td>PET perfusion</td>
<td>III B</td>
<td>III C</td>
<td>IIa B</td>
<td>III B&lt;sup&gt;d&lt;/sup&gt;</td>
<td>IIa B</td>
<td>IIa B</td>
<td>26</td>
</tr>
</tbody>
</table>

<sup>a</sup>For the prognostic assessment of known coronary stenosis, functional imaging is similarly indicated.

<sup>b</sup>The pretest likelihood of disease is calculated based on symptoms, sex, and risk factors.

<sup>c</sup>This refers to MDCT angiography, not calcium scoring.

<sup>d</sup>In patients with obstructive CAD documented by angiography, functional testing may be useful in guiding the revascularization strategy based on the extent, severity, and localization of ischaemia.

CAD = coronary artery disease; MDCT = multidetector computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.
A good functional assessment?

• Not really

• Even experienced interventional cardiologists cannot predict accurately the significance of most intermediate stenoses on the basis of visual assessment or quantitative coronary angiography

• The hybrid approach

IVUS and OCT

• Additional anatomical modalities
• Indirect functional assessment (IVUS)
• An adjunct to invasive coronary angiography

• IntraVascular Ultrasound – Minimal Luminal Area (MLA) used to suggest ‘functionally important’ stenoses – e.g. <4mm² for main epicardial vessels
IVUS
OCT

- Optical Coherence Tomography
- Very little functional validation
Anatomical vs Functional

• Anatomical:
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Functional Assessment

• ETT – not recommended – but still useful?

• Stress Echocardiography
Stress ECHO

• 1935: Observation that coronary occlusion resulted in instantaneous abnormality of wall motion\(^5\)

• Stressors include exercise, dypiridamole and dobutamine.

• Relatively inexpensive.

• Does not involve ionising radiation.

• Good safety profile. Rate of death approx. 1:5000\(^6\)

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\(^6\): Source: Stress echocardiography expert consensus statement. European Journal of Echocardiography. 2008. 9; 415-437
DSE Performance

• A negative test equates to a 1 year cardiac event rate of 0.4-0.9% (equivalent to MPS)\(^7\)

• Sensitivity approx 84%

• Specificity approx 86%\(^8\)

• ETT: sensitivity 68%, specificity 77%


Reporting

• Baseline, low dose, high dose and recovery images are compared in each view

• A normal response is demonstrated by progressive improvement in wall motion from baseline through to the high dose images

• Ischaemia is indicated by a ‘biphasic’ response in a given territory (i.e. an initial improvement, followed by reduction in contractile function at high dose)

• Myocardial viability is indicated by any improvement in contractility either at low or high dose.

• Reporter variability. Learning curve
Nuclear Perfusion Scintigraphy

• E.g. Thalium or Myoview
• Exercise more practical or Adenosine (+ newer agents)
• Prognostic value. A normal technetium-99 sestamibi SPECT study results is associated with an annual mortality rate of 0.2%\(^9\)
• Sensitivity 85-90%, Specificity 70-75%
• Like Stress Echo can localise ischaemia
• But radiation – 8mSv

MPS
Stress CMR/PET

• Evolving
• CMR stress useful if other information required e.g. evidence of infarction, structural information
• Sensitivity of 79-89%\textsuperscript{10}
• Specificity of 71-83%
FFR

- Fractional Flow Reserve – Invasive coronary pressure measurements at time of angiography
Fractional Flow Reserve (FFR)

During maximal hyperemia

$$FFR = \frac{Q_{S}^{N}}{Q_{max}} = \frac{P_d}{P_a}$$

FFR = the ratio of maximal myocardial flow in the stenotic territory to maximal myocardial flow in that same territory if the stenosis were absent
FFR for decision-making in the cath lab

Based on the teaching file of Paul G. Yock MD, Stanford University.

Note: The specificity of this cut-off value is 100% and the sensitivity is 88%.

References:
Direction of Travel

• Imaging that does not involve ionising radiation – stress ECHO increasing (greater contrast use), CMR (as techniques improve)

• Combined approaches – anatomical and functional e.g. angiography + pressure wire.......... or CTCA and non-invasive FFR

• History remains key!
A what about the humble ECG?

• Vital role in risk stratification

• Can be diagnostic and may prevent further unnecessary investigation......
Any Questions?