Evidence-based Nuclear Cardiology: Imaging of CAD

The ESC document
Clinical value, cost-effectiveness, and safety of myocardial perfusion scintigraphy: a position statement
Diagnosis of obstructive CAD in pts. with intermediate pre-test probability:

- Sensitivity = 87%
- Specificity = 73% (referral bias)
- Specificity using Normalcy Rate = 91%

Evidence: Class I, Level B  
Issuing body: ESC, ACC/AHA

Additional comments:

- Gated SPECT
- Attenuation correction
- Scatter correction
  
  ...increase the accuracy of MPS
MPS as primary diagnostic test:

- Women with diabetes
- Anticipated poor exercise performance
- Inability to exercise
- Abnormal resting ECG

MPS as secondary diagnostic test:

- Women (alternative)
- Non-diagnostic ECG
- Unexpected ECG results
- Intermediate Duke Treadmill Score
## Recommendations for MPS in patients with suspected or known CAD according to current clinical guidelines

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<td>Diagnosis of CAD in pts. w. intermediate pre-test likelihood:</td>
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<td>Unable to exercise</td>
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<td>Identification of target coronary lesions</td>
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<td>Assessment hemodynamic significance of known coronary lesions</td>
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<td>Evaluation post PCI/CABG</td>
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<td><strong>Acute chest pain</strong></td>
<td>Detection resting ischemia</td>
<td>ESC ACC/AHA</td>
<td>IIb</td>
<td>IIa</td>
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<td>Detection resting ischemia in low/intermediate risk pts. after UA/NSTEMI</td>
<td>ESC ACC/AHA</td>
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<td>B</td>
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<td>Detection ischemia in pts. w. uncertain diagnosis</td>
<td>ESC ACC/AHA</td>
<td>I</td>
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<td>Assessment of infarct size and myocardium at risk after STEMI</td>
<td>ESC ACC/AHA</td>
<td>I</td>
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<td>Risk stratification before elective non-cardiac surgery</td>
<td>ACC/AHA</td>
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<td>Heart failure</td>
<td>Detection of ischemia and viability assessment</td>
<td>ACC/AHA</td>
<td>IIa</td>
<td>B</td>
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<td>ESC study group report</td>
<td></td>
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<tr>
<td></td>
<td>Diagnosis of CAD</td>
<td>ACC/AHA</td>
<td>IIb</td>
<td>C</td>
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</table>
Normal MPS in pts. with interm./high likelihood of CAD predicts very low event rate (≤1%/yr), yielding NPV≥99%.

Even in pts. with risk factors, low event rate extend for ≥2 yrs.

Abnormal MPS in pts. with interm./high likelihood of CAD increases annualized event rate x7, with risk 3-7% according to severity of defects.

LVEF post-stress or EDV ≥70 ml indicate adverse outcome even if perfusion is normal or near-normal.

Gated SPECT provides additional prognostic info over clinical, ECG and CA data, for the general population, following ACS, and after revasc.

Markers of LV dysfunction are more predictive of death, markers of ischemia are more predictive of non-fatal cardiac events (angina, IM).
Myocardial perfusion scintigraphy after acute coronary syndromes

- Resting MPS to exclude ACS in pts. with chest pain and non-diag. ECG.
  Evidence: Class II a-b, Level B  
  Issuing body: ESC, ACC/AHA

- Risk stratification in pts. with otherwise low/interm. risk after UA/NSTEMI
  Evidence: Class I, Level B  
  Issuing body: ESC, ACC/AHA

- Selectively in pts. unable to exercise, inconclusive stress ECG, women.
  Evidence: Class I, Level A  
  Issuing body: ESC, ACC/AHA

- Assessment of infarct size and myoc. at risk after uncomplicated STEMI:
  • STEMI with thrombolytic therapy, before CA.
  • STEMI with preserved LV function, uninterpretable ECG.
  Evidence: Class I, Level B  
  Issuing body: ESC, ACC/AHA
Risk stratification before elective non-cardiac surgery:

- Intermediate clinical predictors of cardiac risk + poor ex. tolerance
- Intermediate clinical predictors + high surgical risk
- High surgical risk + poor ex. tolerance regardless of clinical predictors

Evidence: Class I, Level C
Issuing body: ACC/AHA

Additional comments:

- Information derived from MPS should also be used for subsequent cardiac management of patients after surgery.
Assessment of viability in the initial evaluation of pts. with heart failure, known CAD, and no angina.

Evidence: Class IIa, Level B

Issuing body: ACC/AHA

Diagnosis of CAD in pts. with symptomatic LV dysfunction.

Evidence: Class IIb, Level C

Issuing body: ACC/AHA

Additional comments:

- Dysfunctional, viable myocardium associated with poor prognosis.
- This can be reversed with appropriate intervention (revascularization).
- European guidelines for chronic heart failure do not address the issue but ESC has made recommendations.
In pts. with stable angina and intermediate pre-test prob. of CAD, MPS is more cost-effective than sECG and CA.

MPS-led management results in 23-41% cost savings compared with direct CA.

Normal sECG does not prevent additional diagnostic testing.

Normal MPS is a strong deterrent of additional investigations.

In pts. with known CAD, MPS leads to significant savings by limiting costly procedures to those with high-risk scans.

Greatest cost-effectiveness in women, resulting in reduction of normal CA and increase in the detection of multivessel disease.
MPS has a high NP accuracy for ruling out ACS and future cardiac events in pts. with chest pain, non-diagnostic ECG and negative enzymes.

MPS can reduce costs by avoiding unnecessary admissions without compromising patient outcome.

MPS-guided chest pain work-up decreases the rate of hospitalization.

MPS influence triage decisions and lower the threshold for early discharge of pts. with low-risk scans.

MPS may be particularly cost-effective in special subgroups like diabetics.
Effective doses of different diagnostic procedures:

- 1-day MPS ($^{99m}$Tc, 1600-2000 MBq, 43-54 mCi) = 12-20 mSv.
- 2-day MPS ($^{99m}$Tc, 1200-1800 MBq, 32-48 mCi) = 4.5-9 mSv.
- Stress-redist. ($^{201}$Tl, 74-111 MBq, 2-3 mCi) = 12.9-19.5 mSv.
- Stress-redist.-reinj. ($^{201}$Tl, + 37 MBq, 1 mCi) = + 6.5 mSv.
- Catheterization coronary angiography = 2-6 mSv.
- Multi-slice CT angiography = 6-15 mSv.

Comments:

- Additional lifetime risk of fatal cancer: 0.04% / Sv in young/middle aged.
- In elderly pts. risk is balanced by delay in event vs. life expectancy.
<table>
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<tr>
<th>Diagnostic modality</th>
<th>Typical effective radiation dose (mSv)</th>
<th>Equivalent number of chest X-rays</th>
<th>Approximate equivalent period of natural background radiation</th>
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<tr>
<td>Chest (single PA film)</td>
<td>0.02</td>
<td>1</td>
<td>3 days</td>
</tr>
<tr>
<td>Echocardiography</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electron-beam CT</td>
<td>1.5–2</td>
<td>75–100</td>
<td>7–9 months</td>
</tr>
<tr>
<td>Multi-slice CT</td>
<td></td>
<td></td>
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<tr>
<td>Calcium score</td>
<td>1.5–2.7</td>
<td>75–135</td>
<td>7–14 months</td>
</tr>
<tr>
<td>CTCA (16 slices)</td>
<td>6.5–10.7</td>
<td>325–535</td>
<td>2.7–4.4 years</td>
</tr>
<tr>
<td>CTCA s/p CABG (16 slices)</td>
<td>12.9</td>
<td>645</td>
<td>5.3 years</td>
</tr>
<tr>
<td><strong>CTCA (64 slices)</strong></td>
<td><strong>10.5</strong></td>
<td><strong>400</strong></td>
<td><strong>3 years</strong></td>
</tr>
<tr>
<td>Magnetic resonance imaging</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Catheterisation laboratory</td>
<td></td>
<td></td>
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<tr>
<td><strong>Diagnostic coronary study (Coronary angiography and ventriculography)</strong></td>
<td><strong>2.1–7</strong></td>
<td><strong>105–350</strong></td>
<td><strong>0.9–2.9 years</strong></td>
</tr>
<tr>
<td>Angiography s/p CABG</td>
<td>6.3</td>
<td>315</td>
<td>2.6 years</td>
</tr>
<tr>
<td>Aortography</td>
<td>4</td>
<td>200</td>
<td>1.6 years</td>
</tr>
<tr>
<td>Coronary angioplasty</td>
<td>7.5–57</td>
<td>375–2,850</td>
<td>3–23 years</td>
</tr>
<tr>
<td>Carotid stenting</td>
<td>10</td>
<td>500</td>
<td>4.1 years</td>
</tr>
<tr>
<td>Nuclear cardiology</td>
<td></td>
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<tr>
<td>$^{201}$Thallium-CI (2 mCi)</td>
<td>17</td>
<td>850</td>
<td>7 years</td>
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<tr>
<td>$^{99m}$Technetium tetrofosmin (30 mCi)</td>
<td>8.5</td>
<td>425</td>
<td>3.5 years</td>
</tr>
<tr>
<td>$^{99m}$Technetium sestamibi (30 mCi)</td>
<td>8.9</td>
<td>445</td>
<td>3.7 years</td>
</tr>
</tbody>
</table>
Complication rates of stress tests (death, IM, sustained VT):

- Dynamic exercise = 1.2 / 10,000.
- Dypiridamole = 3.5 / 10,000.
- Dobutamine = 29.8 / 10,000.

Comments:

- For dypiridamole, complication rate is low even shortly after an uncomplicated MI (<3 days).
MPS has proven a safe and highly cost-effective strategy for the early detection of obstructive CAD in symptomatic individuals.

It is powerful to stratify patients according to their risk of cardiac death or nonfatal MI.

It assists clinical decision-making with regard to medical treatment or intervention.

MPS is successfully integrated in several guidelines for clinical practice in cardiology.
Rate of utilization of MPS in 2003 (studies/1000)

Growth of MPS utilization between 1998-2002

MPS vs. stress Echocardiography

Head-to-head comparison – 23 studies – 1,421 pts. in total.
MPS vs. stress Echocardiography

**Sensitivity**
- Dipi: 87%
- Dobu: 88%
- Exer: 85%

**Specificity**
- Dipi: 90%
- Dobu: 91%
- Exer: 88%

**Accuracy**
- Dipi: 83%
- Dobu: 73%
- Exer: 81%

Head-to-head comparison – 23 studies – 1,421 pts. in total.
General situation and trends of MPS

- The technique is growing in all countries, at different pace.
- Still underutilized as compared to the USA.
- SPECT is the rule, planar imaging almost disappearing.
- Pharmacologic stress is increasing.
- Attenuation correction rarely applied.
- Gated SPECT increasing but still less than desired.
Thank you