Differential imaging: what for which patient?

Jeroen J Bax
Dept of Cardiology
Leiden Univ Medical Center
The Netherlands
Davos, feb 2013

Research grants: Medtronic, Biotronik, Boston Scientific, St Jude, BMS imaging, GE Healthcare, Edwards Lifescience
Coronary Atherosclerosis

"Coronary Narrowing"

Transient Ischemia
Angina - Infarction

"Severity"

"Vulnerable Plaque"

Myocardial Infarction
Sudden Death

"Vulnerability"
Ischemia – Severity
How to evaluate non-invasively?
Diagnosis of ischemia - the ischemic cascade

- Systolic wall motion imaging
- Perfusion imaging
- Hypoperfusion
- Diastolic dysfunction
- Systolic dysfunction
- ECG changes
- Angina

Time from onset of ischemia

Schinkel et al. EHJ 2003
Ischemia as an expression of a flow-limiting stenosis

- Assessment of
  - perfusion abnormalities (stress-inducible)

- Assessment of
  - systolic wall motion abnormalities (stress-inducible)
Nuclear perfusion imaging, SPECT

Polar map to quantify extent and severity of ischemia
Nuclear perfusion imaging with ECG gating

- Permits assessment of LVEF, LV volumes and regional function
- At rest and stress
Resolution of SPECT vs PET

Beanlands et al. JNC 2010
Diagnostic accuracy
SPECT vs PET

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Sensitivity (sens)</th>
<th>Specificity (spec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underwood et al. EJNM 2004</td>
<td>87%</td>
<td>73%</td>
</tr>
<tr>
<td>Beanlands et al. JNC 2010</td>
<td>90%</td>
<td>89%</td>
</tr>
</tbody>
</table>
Stress echo to assess flow-limiting stenosis: wall motion

rest

10 mcg

40

rest
Stress echo to detect CAD
hall mark: WMA

percentage

100
80
60
40

sens 80
spec 84

28 studies
2246 pts

Geleijnse et al. JACC 1997
Addition on intravenous contrast to improve border opacification
Quantification using strain or strain rate imaging
Stress MRI to assess flow-limiting stenosis: wall motion
MRI – perfusion imaging
Stress MRI to assess flow-limiting stenosis: perfusion vs wall motion

<table>
<thead>
<tr>
<th>percentage</th>
<th>sens</th>
<th>spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>88</td>
<td></td>
</tr>
</tbody>
</table>

15 studies, 355 pts

12 studies, 704 pts
Comparison of imaging techniques for assessment of ischemia

- all modern techniques
- can assess perfusion
- and systolic function

- perfusion may be more sensitive
- to assess ischemia
- than systolic function
Plaque – Vulnerability?  
How to evaluate non-invasively?
MRI – angiography (1.5T)

Leiden, NL
Aarhus, DK
Munich, GER
Boston, USA

Berlin, GER
Leeds, UK
Kurashiki, JP
St. Louis, USA

NEJM 2002
MRI to detect CAD

Percentage

77% sens
87% spec
88% sens
72% spec

23 studies
761 pts

Multi-center trial 2010
7 hosp, 138 pts

Schuijf et al. AHJ 2006
Kato et al. JACC 2010
MRI - angiography

Stronger magnets: 3T coronary imaging

Yang et al. JACC 2009
curved MPR

RCA

LAD

LCX
Patient-based detection (n=1286)

- Sensitivity: 99%
- Specificity: 89%
- PPV: 93%
- NPV: 100%

- ≥ 50% stenosis
- versus CAG
- Not assessable: 4% (0-14%)

Mowatt et al. *Heart* 2008
Technical developments

• Dual-source CT: higher temporal resolution
• Prospective gating: lower radiation
• 256- and 320-slice CT
Accuracy dual-source CT

24 studies, 801 pts
gold standard ≥ 50% stenosis on angiography

Sens: 98%
Spec: 87%
PPV: 88%
NPV: 96%

Achenbach et al. EHJ 2010
320-CT

Coverage of the heart in 1 rotation

16 cm
Meta-analysis 64-slice CT

Patient-based detection (n=1286)

- Sensitivity: 99%
- Specificity: 89%
- PPV: 93%
- NPV: 100%

Rule out CAD

Mowatt et al Heart 2008
Patient example

Man 47 years old

Outpatient clinics:

Dyspnea or atypical chest pain at exercise

Risk factors for CAD:

*Dyslipidemia
Non-invasive angiography - MSCT

LAD: normal, intramural course mid

LCx: normal
320-CT – rule out CAD

57 yr old woman, 2x TIA
Analysis cardiac source of embolism
320-CT – rule out CAD

Smoking 39 pack years

Severe dyslipidemia (chol 7.8 mmol/L)

MSCT angiography to exclude (?) CAD

LAD

LCx

RCA

No significant stenosis
MSCT coronary angiography for actual rule out of CAD

N=340

No CAD: 40%
Non-obstructive CAD: 34%
Obstructive CAD: 21%
Uninterpretable: 5%

Henneman et al. EHJ 2008
Prognosis MSCT
13,966 pts, mean F-up 22.5 months

Mortality

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>normal CT</td>
</tr>
<tr>
<td>1.99</td>
<td>Non-obstr CAD</td>
</tr>
<tr>
<td>2.90</td>
<td>Non-high risk CAD</td>
</tr>
<tr>
<td>4.95</td>
<td>High risk CAD</td>
</tr>
</tbody>
</table>

Chow et al. Circ 2011
If there is atherosclerosis, then which of these lesions is vulnerable?
EXAMPLE

- Male, 45 years, no cardiac history
- Presented at ED with acute chest pain

Risk factors for CAD:

- Hypertension and positive family history

LAB and ECG:

- ECG: no ST elevation, no Q waves
- Troponin borderline elevated

ACS?
MSCT calcium

CALCIUM = 0

No significant CAD?
MSCT coronary angiography

<50% stenosis LAD (non-calcified)
MSCT coronary angiography

>>70% stenosis
RCA
(non-calcified)

Henneman et al. JACC 2008
Fusion between anatomic and functional imaging: PET/SPECT-CT
Fusion of anatomic and functional imaging (PET-CT) - carotid arteries

Unstable (recent TIA)

Stable

Rudd et al. Circ 2002
Coregistered FDG-PET and CTA images demonstrating increased FDG uptake in LAD plaques stented for ACS
Assessing vulnerable plaque:

- What are the characteristics?
- Which imaging technology?
- When to assess?
- Do we need to assess periodically?
- Will it improve outcome?
- What are the therapeutic consequences?