Differential imaging: which imaging when?

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4 major imaging techniques:

- Echocardiography
- Magnetic resonance imaging
- Multi-slice CT
- Nuclear imaging (PET and SPECT)

- Can provide all anatomical and functional information, but use should be clinically driven
Based on the clinical presentation:

Ask yourself questions:

What information do I need to
- diagnose
- treat
this patient
Diagnosis is important

But the imaging results need to have impact on choice of therapy
Man 41 years old

Outpatient clinics:

No symptoms

Risk factors for CAD:
* Brother SCD age 43
Asymptomatic individual, low risk for atherosclerosis

The question is:

Risk stratification – early detection
Blood: biomarkers

Early detection of CVD

Large arteries:
Global: atherosclerosis

Coronary arteries:
Focal: lesion characteristics
Cardiovascular event-free survival, according to CRP and LDL
Blood: biomarkers

Early detection of CVD

Large arteries:
Global: atherosclerosis

Coronary arteries:
Focal: lesion characteristics
Carotid Intima Media Thickness (CIMT)

Tissue between luminal edge of the artery and the boundary between media and adventitia

I = Intima
M = Media
A = Adventitia
Assessment of CIMT

Semi-automatic B-mode ultrasound measurements

Left and right common carotid artery, directly proximal to the bifurcation

Mean CIMT measurements at four angles

Calculation of the average of 8 mean CIMT per patient
Cumulative event free rate (stroke or MI) according to IMT quintiles

Blood:
- Biomarkers

Coronary arteries:
- Focal: lesion characteristics

Large arteries:
- Global: atherosclerosis

Early detection of CVD

Coronary arteries:
- Focal: lesion characteristics
Calcium Scoring (EBCT/MSCT)

No calcification

Moderate calcification

Extensive calcification

Coronary calcifications provide a marker for atherosclerotic disease burden
Calcium score vs risk stratification

- All-cause mortality
- 25,253 asymptomatic individuals

Budoff et al. JACC 2007
Man 54 years old

We have screened some years ago: nothing; now the symptoms change and developed 1 RF

Outpatient clinics:

Dyspnea or atypical chest pain at exercise

Risk factors for CAD:

*Dyslipidemia
Non-invasive assessment of CAD: Which Patients?

Pre-test (Clinical) Probability of CAD (%)

Post-test Probability of CAD (%)

45 y/o M, asymptomatic, no risk factors
45 y/o M, asymptomatic, multiple risk factors
45 y/o M, typical angina

(-) test
(+ ) test

Patterson et al. JACC 1989
Non-invasive assessment of CAD: Which Patients?

- Pre-test (Clinical) Probability of CAD (%)
- Post-test Probability of CAD (%)

- 45 y/o M, asymptomatic, no risk factors
  - (+) athero
  - (-) athero

- 45 y/o M, asymptomatic, multiple risk factors
  - (+) isch
  - (-) isch

- 45 y/o M, typical angina
  - (+) isch

Patterson et al. JACC 1989
The question is:

Atherosclerosis? (medical therapy needed and follow-up or discharge?)

We order a non-invasive anatomical test to detect/exclude atherosclerosis
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
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
Non-invasive angiography - MSCT

LAD: normal
LCx: normal
Prognosis MSCT
13,966 pts, mean F-up 22.5 months

Mortality

- Normal CT: 0.65%
- Non-obstr CAD: 1.99%
- Non-high risk CAD: 2.90%
- High risk CAD: 4.95%

Chow et al. Circ 2011
Man 61 years old

Earlier on no atherosclerosis, but RFs have increased, symptoms have changed

Outpatient clinics:

chest pain at rest, sometimes stress

Risk factors for CAD:
* Hypercholesterolemia
* Hypertension
* Smoking
Non-invasive assessment of CAD: Which Patients?

Pre-test (Clinical) Probability of CAD (%)

Post-test Probability of CAD (%)

- 45 y/o M, asymptomatic, no risk factors
  - (+) athero
  - (-) isch
  - (-) athero

- 45 y/o M, asymptomatic, multiple risk factors
  - (+) isch

- 45 y/o M, typical angina
  - (+) isch

Patterson et al. JACC 1989
Symptomatic patient, intermed – high pre-test likelihood

The patient has high likelihood to have atherosclerosis

The question is: does he have ischemia? (is intervention needed?)

We order a non-invasive ischemia test
Nuclear perfusion imaging, SPECT

**POLAR MAP TO QUANTIFY EXTENT AND SEVERITY OF ISCHEMIA**

<table>
<thead>
<tr>
<th></th>
<th>STRESS</th>
<th>REST</th>
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Stress echo to assess flow-limiting stenosis: wall motion

Stress echo images at different stages:
- Rest
- 10 mcg
- 40
- Rest
Addition on intravenous contrast to improve border opacification
Stress MRI to assess flow-limiting stenosis: wall motion
MRI – perfusion imaging
Man 61 years old

Outpatient clinics:

He has developed CAD, we treated based on ischemia

Now the patient developed PAF
AF ablation: success and failure

Oral H et al. NEJM 2006; Khan et al. NEJM 2008
Prediction of successful RFCA

Assessment of substrate for AF

- LA enlargement
- LA fibrosis
  - Direct assessment
  - Indirect assessment
    - Mechanical consequence
    - Electrical conduction heterogeneities
Left atrial dimensions

Linear dimensions
- AP diameter

LA volume
- Modified Simpson’s rule
Real-time 3D echocardiography
Left atrial fibrosis imaging - MRI

Taclas et al. Heart Rhythm 2010
• N = 333 AF patients
• LA fibrosis before RFCA: DE-MRI
LA fibrosis vs. RFCA outcome

AF recurrence (%)

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<tr>
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<th>Utah I</th>
<th>Utah II</th>
<th>Utah III</th>
<th>Utah IV</th>
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<td>0</td>
<td>18</td>
<td>38</td>
<td>100</td>
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<tr>
<td>Non-lone AF</td>
<td>0</td>
<td>29</td>
<td>37</td>
<td>95</td>
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</table>

Lone AF Non-lone AF
Left atrial electro-mechanical properties

- PA-TDI as predictor of new onset AF in heart failure patients

**TDI**

↓

Total atrial conduction time (PA-TDI)

↓

Time interval from the onset of the P-wave to the A’-wave peak
N = 495
79% male
21% previous paroxysmal AF

Number of patients at risk:

<table>
<thead>
<tr>
<th>Follow-up months</th>
<th>PA-TDI duration &lt;139 ms</th>
<th>PA-TDI duration ≥139 ms</th>
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<tr>
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<tr>
<td>30</td>
<td>38</td>
<td>43</td>
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</tbody>
</table>

Chi-square = 21.79, p < 0.001

PA-TDI
HR: 1.01 (1.01-1.02)
P<0.001
Patient 1  No AF

Patient 2  New onset AF
Different patient: extensive CAD

Male, 72 yrs

- 2001: Infero-postero-lateral infarct – PCI
- 2004: CABG: LIMA-graft LAD, venous graft MO-LCX and RDP/RCA
- 2004: LV dilated, EF 28%

Co-morbidities

- Diabetes II
Man 72 years old

CAD has been treated

History of MI, EF is reduced

Outpatient clinics:

Does he need an ICD?
Does he need an ICD?

• Patients with:
  previous infarction
  LVEF <30-35%

• Benefit from ICD:

• MADIT II: improved survival
ICD shocks in primary prevention

N=720 pts, MADIT II
Follow-up 21 months

Shocks:

Moss et al. Circ 2004
What is the pathophysiological substrate for SCD in CAD?

Courtesy W Stevenson
MRI to assess arrhythmogenic substrate:

- Late-gadolinium enhancement: scar area and peri-infarct zone
Value of border zone to predict VTs

HR (95%CI): 1.47 (1.04 to 2.08)  
P = 0.003
Conclusions

• Virtually all anatomical and functional information can be obtained by (a combination) of the available imaging techniques

• The choice of techniques should be guided by the information needed (the questions we need answers to)

• The imaging results must affect treatment