CT or PET/CT for coronary artery disease

Rotterdam 2012

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Disclosure: Juhani Knuuti, M.D.

Juhani Knuuti, M.D. has financial interests to disclose. Potential conflicts of interest have been resolved.

Research Support / Grants: None
Stock/Equity (any amount): None
Consulting: Lantheus
Employment: None
Speakers Bureau / Honoraria: Philips

Research contracts (institutional): Orion Pharma, Turku Imanet Ltd, GE Healthcare, GSK, Merck, Bayer-Schering, Novartis, Lundbeck, Roche; Lantheus
Imaging and CAD
Current main trends

- From ischemic cascade to CAD cascade
- From diagnosis of CAD to guidance of therapy
- Novel imaging applications
  - Quantification
  - Imaging of vulnerable plaque
Paradigm shift 1: From ischemic to CAD cascade

Preclinical atherosclerosis
Non-obstructive CAD
hypoperfusion
metabolic alterations
diastolic dysfunction
systolic dysfunction
ECG-Changes
angina

Myocardial perfusion

Signs of ischaemia
Multislice CT vs. Myocardial Perfusion
Regional comparison in 140 patients

MDCT findings in patients with normal SPECT perfusion imaging result

CT angiography

Curved MPR reconstructions of the major coronary vessels

CT Acquisition:
- Premedication: Metoprolol 10 mg i.v. HR 46/min
- Acquisition: Prospective step-and-shoot protocol, mA 650, 120 kV
- Contrast: Iomeron 400mg/ml 68 ml
- Radiation dose 7.4 mSV

Case: LP
PET perfusion imaging during stress

Displayed as fused volume rendered images scaled to absolute scale 0-3.5 ml/g/min
Normal perfusion: above 2.5 ml/g/min: yellow or red

PET Acquisition:
- Injected Dose: 1100 MBq O-15-water
- Stress: Adenosine 140 µg/min/kg for 6.5 min
- Acquisition time: dynamic 4.5 min
- Radiation dose 0.9 mSV

Case: LP
Invasive angiography + FFR

FFR = Fractional flow reserve – invasive measurement of the stenosis functional gradient during adenosine infusion

Case:LP
Prognostic Value of Myocardial Perfusion SPECT

$n = 12\,000\,pts$

 annual cardiac event rate %

- normal
- abnormal

$P < 0.001$

Iskander S et al. JACC 1998;32:57
Additional prognostic value of CT and perfusion imaging

Log Rank P-value < 0.005

None or mild CAD (MSCT <50%) and MPI normal (SSS <4)
None or mild CAD (MSCT <50%) and MPI abnormal (SSS ≥4)
Significant CAD (MSCT ≥50%) and MPI normal (SSS <4)
Significant CAD (MSCT ≥50%) and MPI abnormal (SSS ≥4)

N=541

Patients at risk 439 423 386 354 299 243

Imaging and CAD
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Paradigm shift 2:
From diagnosis to guidance of therapy

Anatomy
(Obstructive CAD)

Flow-Limiting
(Perfusion, FFR)

Optimal Medical Treatment

Complete Functional Revascularization and optimal medical treatment

Noninvasive function: Perfusion, WMA
Hachamovitch Circulation 2003;107:2900
COURAGE NEJM 2007;356:1503
COURAGE Circulation 2008;117:1283

Invasive function: FFR
DEFER JACC 2007;49:2105
FAME NEJM 2009;360:213
FAME JACC 2010;56:177

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Turku PET Centre
Functional consequences of stenoses

Turku PET Centre, Finland
Invasive Anatomy vs. Functional Consequences

N = 2334

Wijns, de Bruyne, Vanhoenacker, JNC 2007;93:856-61
Fractional Flow Reserve versus Angiography for Guiding Percutaneous Coronary Intervention
CT angiography

Curved MPR reconstructions of the major coronary vessels

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Case:LP
Multivessel disease: What is the culprit lesion?
Multivessel disease: What is the culprit lesion?

Case: stenoses in all major vessels; RCA is culprit
Microvascular disease
Absolute perfusion decreased but no epicardial disease
Hybrid noninvasive (PET/CT) vs. Hybrid invasive (ICA + FFR)

<table>
<thead>
<tr>
<th></th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Accuracy (%)</th>
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<tbody>
<tr>
<td>MDCT</td>
<td>76</td>
<td>94</td>
<td>91</td>
</tr>
<tr>
<td>PET</td>
<td>77</td>
<td>98</td>
<td>93</td>
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<tr>
<td>MDCT-PET hybrid</td>
<td>96</td>
<td>99</td>
<td>98</td>
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Vessel analysis in patients with intermediate likelihood of CAD, N=107

Kajander et al, Circulation 2010
Challenges and solutions of perfusion imaging

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<thead>
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# Challenges and solutions of ischemia imaging

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Impact of hybrid imaging on downstream resource utilization

Revascularisations

- 86% (p<0.001)
- 100%
- 80%
- 60%
- 45%

CAD yield Per CATH

- 96%

REVASC Per CATH

- 86%

Source: NEJM 2010 USA N=400'000

GER N=840'000

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### Challenges and solutions of CAD/ishchemia imaging

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Quantification of myocardial perfusion

Which patients will benefit?

- Balanced 3 vessel or multivessel disease
- Culprit lesion vs. non-culprit lesion in multi vessel disease
- Early changes in coronary dysfunction
Absolute flow vs Relative flow

Kajander et al Circ Cardiovasc Imaging. 2011
Absolute flow is as good as flow reserve!

Joutsiniemi et al (Circ Imaging)
Imaging and CAD
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MDCT Characterization of Coronary Plaques

- LAD
- Left main
- LCX
Plaque characterization using CT vs. Myocardial Perfusion SPECT


N=541
MDCT Characterization of Coronary Plaques - Prognosis

Large low attenuation plaque area
Positive remodeling
Spotty calcification

15 ACS in 1059 patients

Motoyama J Am Coll Cardiol 2009
Dual gated $^{18}$F-FDG PET/CT of coronary arteries in ACS patients

Myocardial FDG uptake suppressed by low carbohydrate, high fat diet

Lankinen et al ICNC 2011
Dual gated $^{18}$F-FDG PET/CT of coronary arteries in ACS patients

- 39 year old man
- Risk factors of CAD:
  - Smoking
  - Family history +
- 5 days of UAP
- ECG: lateral T-inversion
- TNT +
- LCX subtotal occlusion stented

Lankinen EHJ 2011 (abstract)
Turku PET Centre, Finland
Dual gated $^{18}$F-FDG PET/CT of coronary arteries in ACS patients

- 20 ACS (non-STEMI or UAP) patients
- Dual-gated $^{18}$F FDG PET/CT (3d after onset of symptoms)
- High-fat diet intervention to suppress myocardial uptake (Williams AJR 2008)

- Visual coronary FDG uptake in 80% of patients (3 prior to intervention)
- TBR 3.2±1.3 (range 1.8-5.4)

Lankinen EHJ 2011 (abstract)

Turku PET Centre, Finland
Concerns on sequential / hybrid imaging for CAD

• Complicated for patients (sequential)
• Logistic challenges (hybrid)
• Higher work load
• Non-standardized image analysis
• Radiation burden
• Lacking evidence and indications
• Costs and cost-effectiveness
Since upper limit of lifetime risk of any imaging test was 23 per 10 000 only 2.3% of the events need to be prevented to completely cancel the risk of imaging.