Myocardial perfusion assessed through CT coronary angiography: a comparison with positron emission tomography

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ESC Congress 2010
Stockholmsmässan - Stockholm, Sweden
August 29th 2010
BACKGROUND

• CT coronary angiography (CTCA) allows acquisition of high resolution images of the heart and coronary vessels, but may also be used to examine myocardial perfusion.

• Previous studies have compared CTCA with single photon emission computed tomography, but with the latter technique only relative differences in perfusion may be assessed.
  

• Positron emission tomography (PET) provides absolute values of myocardial blood flow (MBF).
The aim of the study was to compare CTCA with PET in the evaluation of myocardial perfusion in a population with suspected or previously documented coronary artery disease.
METHODS - Study population

• Patients at low-intermediate risk symptomatic for angina or asymptomatic but with multiple coronary risk factors and/or equivocal exercise electrocardiography

• Exclusion criteria:
  ✓ severe respiratory disease
  ✓ overt hyperthyroidism, untreated subclinical hyperthyroidism
  ✓ atrial fibrillation
  ✓ unstable angina or acute myocardial infarction
  ✓ severe chronic heart failure
  ✓ atrio-ventricular conduction disturbances other than first-degree atrio-ventricular block
  ✓ chronic kidney disease with serum creatinine > 2 mg/dl
METHODS - Imaging protocols

**CTCA**

• GE Light-Speed 64 VCT scanner
• Patients in normal sinus rhythm (max 5 mg metoprolol iv if needed)
• Iv nitroglycerin (max 1 mg) to induce maximal epicardial vasodilation
• **110 ml** of contrast medium (Iomeprol 400), injected at **8 ml/sec**

**PET**

• GE Discovery CT/PET machine
• Measurement of absolute MBF by N\(^{13}\)-ammonia, both at rest and during pharmacological stress with intravenous dipyridamole (0.56 mg/kg administered in 4 minutes)
• Construction of 17-segment MBF polar maps (rest and stress)
METHODS - Offline analysis of CTCA images

1) Long-axis reformatting and selection of ventricular VOI

2) Extraction of the left ventricular cavity

3) Segmentation of the left ventricular myocardium

4) Calibration of myocardial contrast enhancement (MCE)

5) Generation of 17-segment bull’s eye maps
METHODS - Extraction of the left ventricular cavity

- Volume thresholding
- Select the largest 3D blob
- Trace the left ventricular endocardial boundary
**Normalized Opacification Index**

\[
\alpha(x, y, z) = \frac{\mu(x, y, z) - \mu_{tissue}(x, y, z)}{\mu_{cm_{\text{ref}}}}
\]

\(\mu(x, y, z)\) corresponds to the post-contrast myocardial opacification

\(\mu_{tissue}(x, y, z)\) is measured from a slice acquired before contrast injection

\(\mu_{cm_{\text{ref}}}\) is measured at the aortic root

All values of \(\mu\) are expressed in Hounsfield Units
# RESULTS - Baseline characteristics (25 patients)

<table>
<thead>
<tr>
<th>Baseline characteristics</th>
<th>Value</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>61±13</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>72</td>
</tr>
<tr>
<td>History of myocardial infarction (%)</td>
<td>8</td>
</tr>
<tr>
<td>History of coronary revascularization (%)</td>
<td>21</td>
</tr>
<tr>
<td>Left ventricular ejection fraction (%)</td>
<td>53±9.7</td>
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</tbody>
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## CORONARY RISK FACTORS

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Value</th>
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<tbody>
<tr>
<td>Family history of coronary artery disease (%)</td>
<td>35</td>
</tr>
<tr>
<td>Past or current smoker (%)</td>
<td>65</td>
</tr>
<tr>
<td>Obesity (%)</td>
<td>26</td>
</tr>
<tr>
<td>Arterial hypertension (%)</td>
<td>65</td>
</tr>
<tr>
<td>Hypercholesterolemia (%)</td>
<td>42</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>35</td>
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## INSTRUMENTAL DATA

<table>
<thead>
<tr>
<th>Instrumental Data</th>
<th>Value</th>
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<tbody>
<tr>
<td>Coronary artery disease at CTCA (%)</td>
<td>40</td>
</tr>
<tr>
<td>MCE at CTCA</td>
<td>0.14±0.08</td>
</tr>
<tr>
<td>Basal MBF at PET (ml/min/g)</td>
<td>0.55±0.19</td>
</tr>
<tr>
<td>Dipyridamole MBF at PET (ml/min/g)</td>
<td>1.16±0.49</td>
</tr>
</tbody>
</table>
RESULTS - Case 1

- 58-year-old male patient symptomatic for exertional angina
RESULTS - Case 1

- Normal coronary arteries, reduced left ventricular systolic function, diffuse hypokinesia → **dilated cardiomyopathy**
RESULTS - Case 2

- 73-year-old male patient symptomatic for angina at rest
RESULTS - Case 2

- Normal global left ventricular systolic function with akinesia of the basal inferior segment
RESULTS - Case 2

- Occlusion of mid RCA, occlusion of proximal LCX, subcritical stenoses of LMCA and LAD → remote inferior MI with residual ischaemia

CTCA
PET basal
PET dipyridamole
RESULTS - Case 2

CTCA fusion images (anatomy and perfusion)
RESULTS - Case 2

Short axis 3D reconstructions at the base, midlevel and apex of the left ventricle
RESULTS - CTCA MCE vs. PET MBF

* Analyses performed using Spearman’s rank correlation, under the weak assumption of monotonic dependence, on a segment-per-segment basis.
LIMITATIONS

- Limited number of patients

- Heterogenous population (dilated cardiomyopathy, prior myocardial infarction, etc) with relatively low values of MBF

- 64-slice CT scanner (radiation exposure, image quality)

- CTCA MCE and PET MBF are not synonymous!

- Correlations with coronary anatomy? (work in progress...)
CLINICAL IMPLICATIONS

Coronary anatomy

Left ventricular function (global and regional)

Myocardial perfusion

Myocardial infarction

Reversible ischaemia

Microcirculatory disease
Thank you for the kind attention!
NITRATES vs CONTRAST MEDIUM

Basal
Post ic contrast
Post ic nitrates
Post iv adenosine