CT Myocardial Perfusion: Is there Added Value to Coronary CT?

U. Joseph Schoepf, MD, FAHA, FSCBT-MR, FSCCT
Professor of Radiology, Medicine, and Pediatrics
Director of Cardiovascular Imaging
Consultant for / research support from

Bayer
Bracco
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Medrad
Siemens
Integrative CHD Imaging with CT

- Primary morphological vs. functional evaluation of CAD (i.e. SPECT vs. ICA, CTA)?
- Early attempts at CT imaging
  - Limited by experimental nature
  - Limited by dedicated acquisition protocols
- Hybrid Imaging (e.g. SPECT and CT)
- Dual-energy CT for myocardial perfusion defects
- Delayed enhancement dual-energy CT
- Adenosine stress dual-energy CT
- Quantitative, time-resolved perfusion assessment
EBCT: Porcine Model of Myocardial Perfusion

Perfusion CT: Animal Models

Integrative Imaging: DECT
DECT for Myocardial Ischemia

74-yo woman with chest pain and abnormal SPECT

2x64x0.6mm, 80kV/140kV 0.33 s rotation time
Morphology and Function: DECT

74-yo woman with chest pain and abnormal SPECT
Tight proximal stenosis D1

B. Ruzsics et al., Circulation 2008
Morphology and Function: DECT

74-yo woman with chest pain and abnormal SPECT

B. Ruzsics et al., Circulation 2008
DECT Postprocessing

F. Schwarz et al., Eur J Radiol 2008
DECT Can Detect Subtle Pathology

Vliegenthart et al., AJR in press
<table>
<thead>
<tr>
<th>Time</th>
<th>Procedure Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1 month</td>
<td>Abnormal SPECT rest and/or stress</td>
</tr>
<tr>
<td></td>
<td><strong>Adenosine Stress DECT</strong></td>
</tr>
<tr>
<td>0</td>
<td>Rest DECT</td>
</tr>
<tr>
<td>1 week</td>
<td>Rest ceMRI (perfusion)</td>
</tr>
</tbody>
</table>

Adenosine protocol: 140 µg/min/kg

**B. Ruzsics et al., AHA 2008**
Adenosine Stress DECT

Reversible Ischemia
Adenosine Stress cMRI

Reversible Ischemia
Reversible Ischemia
Reversible Ischemia
Quantitative DECT Perfusion

Rest

Stress
ECG-triggered sequential shuttle mode, coverage 8 cm

Dynamic Time Resolved Perfusion
Dynamic Time Resolved Perfusion

140 µg/min/kg Adenosine Stress

G. Bastarrika et al., J Cardiovasc Comput Tomography 2010
Absolute MBF Quantification

MBF: 124ml/100 ml/min

MBF: 60ml/100 ml/min
50yo man w/ chest pain
Dynamic Time Resolved Perfusion
Monitoring Therapeutic Effects

95% RCA stenosis

Stress

Rest

Blood flow in defect: 65 cc/100 cc/min

Blood flow in healthy myocardium: 112 cc/100 cc/min

Rotation time: 0.28 s
Temporal resolution: 75 ms
Tube voltage: 100 kV
Prospectively triggered scans for 30 s

Ho et al., Journal of Cardiovascular Computed Tomography, Vol 5, No 2, March/April 2011
Monitoring Therapeutic Effects

Blood flow in former defect:
118 cc/ 100 cc/ min

Blood flow in healthy myocardium:
112 cc/ 100 cc/ min

Rotation time: 0.28 s
Temporal resolution: 75 ms
Tube voltage: 100 kV
Prospectively triggered scans for 30 s

Ho et al., Journal of Cardiovascular Computed Tomography, Vol 5, No 2, March/April 2011
Solving Clinical Dilemmas...

- **No stenosis**: Rule-out
- **Intermediate stenosis**: Rule-in (Dynamic Volumetric Stress MPI or DECT Stress/Rest MPI)
  - Discharge
- **High grade stenosis**: Rule-out
  - Cathlab
Solving Clinical Dilemmas...

F. Bamberg et al., Radiology 2011
## Discriminator

<table>
<thead>
<tr>
<th></th>
<th>DECT</th>
<th>Dynamic Perfusion</th>
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</thead>
<tbody>
<tr>
<td>Radiation dose</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Volume coverage</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Ease of acquisition</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Ease of post-processing</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Structural information</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Perfusion information</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Viability information</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Quantification</td>
<td>++</td>
<td>+++</td>
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</table>
Myocardial Perfusion CT vs. CT-FFR

Pulsatile flow velocity reconstructed from CCTA

WSS

Courtesy Charles A. Taylor, Ph.D, HeartFlow Inc.
Investigational device. Not available for commercial use
Dynamic CT imaging:
time-resolved, first-pass perfusion

CT perfusion:
semi-quantitative analysis

SPECT:
stress perfusion imaging
Promising developments for CT imaging of myocardial perfusion and delayed enhancement

CT not the primary method for evaluation of myocardial perfusion

CTA is mainly aimed at imaging the coronaries

CT a possibly attractive modality for integrative imaging of anatomy and perfusion

Further refinements in technique (e.g. area detector CT, dual-energy CT)