Diagnosis of Coronary Artery Disease: Computed Tomography

Young Jin Kim
Department of Radiology
Yonsei University Health System
Noninvasive Diagnosis of CAD

- Detection of hemodynamic consequences ("ischemia")
  - Nuclear imaging, stress Echo or MRI
- Detection of atherosclerosis
  - CAC scoring
  - CCTA
Value of CAC scoring

- CAC \approx \text{total atherosclerotic plaque burden}
- Not site-specific
- Independent incremental information in addition to traditional risk factors for prediction of all-cause mortality

- Most useful for prognostification rather than detection of CAD
Value of CAC scoring

From a registry of 25,253 patients
C-index; CAC 0.757, age 0.771, gender <0.586, FHx 0.440, smoking 0.573, DM 0.577, ethnicity 0.518, hyperlipidemia 0.484, HTN 0.562

*Budoff et al. 2007 JACC*
Computed Tomography
Value of Cardiac MDCT

- Assessment of coronary artery stenosis
- Plaque imaging
  - Plaque composition
  - Total plaque burden
- Additional information
  - It’s just not coronaries!
  - Cardiac/Extracardiac
Value of Cardiac MDCT

- Assessment of coronary artery stenosis
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### Pooled Sensitivity and Specificity and Overall Diagnostic Performance of Multidetector CT Angiography according to Type of Analysis and CT Scanner

<table>
<thead>
<tr>
<th>Analysis and CT Scanner Type</th>
<th>No. of Studies</th>
<th>Combined Data*</th>
<th>Sensitivity†</th>
<th>Specificity†</th>
<th>D Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Per-segment analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Four detector</td>
<td>18</td>
<td>8209</td>
<td>0.84 (0.81, 0.88)</td>
<td>0.93 (0.91, 0.95)</td>
<td>4.47 (4.00, 4.94)</td>
</tr>
<tr>
<td>16 detector</td>
<td>25</td>
<td>17 340</td>
<td>0.83 (0.76, 0.90)</td>
<td>0.96 (0.95, 0.97)</td>
<td>5.00 (4.26, 5.74)</td>
</tr>
<tr>
<td>64 detector</td>
<td>6</td>
<td>5030</td>
<td>0.93 (0.88, 0.97)</td>
<td>0.96 (0.96, 0.97)</td>
<td>5.78 (4.96, 6.60)</td>
</tr>
<tr>
<td><strong>Per-vessel analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Four detector</td>
<td>3</td>
<td>491</td>
<td>0.87 (0.78, 0.96)</td>
<td>0.87 (0.73, 1.00)</td>
<td>3.97 (2.09, 5.85)</td>
</tr>
<tr>
<td>16 detector</td>
<td>6</td>
<td>1601</td>
<td>0.93 (0.89, 0.97)</td>
<td>0.92 (0.89, 0.96)</td>
<td>4.88 (3.93, 5.84)</td>
</tr>
<tr>
<td>64 detector</td>
<td>2</td>
<td>597</td>
<td>0.95 (0.91, 0.99)</td>
<td>0.93 (0.90, 0.95)</td>
<td>5.51 (4.54, 6.48)</td>
</tr>
<tr>
<td><strong>Per-patient analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Four detector</td>
<td>7</td>
<td>357</td>
<td>0.91 (0.87, 0.95)</td>
<td>0.83 (0.68, 0.99)</td>
<td>3.41 (2.46, 4.37)</td>
</tr>
<tr>
<td>16 detector</td>
<td>11</td>
<td>704</td>
<td>0.97 (0.94, 0.99)</td>
<td>0.81 (0.72, 0.90)</td>
<td>4.06 (3.00, 5.12)</td>
</tr>
<tr>
<td>64 detector</td>
<td>6</td>
<td>363</td>
<td>0.99 (0.97, 1.00)</td>
<td>0.93 (0.89, 0.98)</td>
<td>5.00 (3.89, 6.11)</td>
</tr>
</tbody>
</table>

* Data are the combined number of segments, vessels, or patients from the studies included in the per-segment, per-vessel, or per-patient analysis, respectively.

† Data are proportions. Numbers in parentheses are 95% confidence intervals (CIs). \(D = \log\) of diagnostic odds ratio.

Current status of MDCT in assessing CAD

- ↑ detector number
  - ↓ ↓ nonassessable segments
  - ↑ diagnostic performance
- Excellent sensitivity and NPV in patient-based analysis! (MPI- lower specificity)
- Temporal resolution 83ms/ Spatial resolution 0.4mm/ Beta blocker/ Arrhythmia

- Limitation of study population
Coronary CTA for ER patients with chest pain

- 2.1% of AMI, 2.3% of unstable angina mistakenly discharged

- Rubinshtein et al (Circulation 2007;115:1762-8)
  - 58 ED patients /c chest pain of uncertain origin
  - Dx of ACS; sens 100%, spec 92%, PPV 87%, NPV 100%
  - During f/u(15mo)- no MACE in 35 pts discharged from ED after initial triage
  - CT provides early direct PCI
Real Culprit lesion?

Cardiac SPECT/CT Fusion

Gaemperli et al. JNM 2007;48:696-703
Value of Cardiac MDCT

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• Plaque imaging
  – Plaque composition
  – Total plaque burden
• Additional information
  – It’s just not coronaries!
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Plaque characterization using CT

<table>
<thead>
<tr>
<th></th>
<th>Hypoechoic plaque</th>
<th>Hyperechoic plaque</th>
<th>Calcified plaque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leber et al.</td>
<td>49±22</td>
<td>91±22</td>
<td>391±156</td>
</tr>
<tr>
<td>Schroeder et al.</td>
<td>14±26</td>
<td>91±21</td>
<td>419±194</td>
</tr>
<tr>
<td>Rasouli et al. (EBT)</td>
<td>30±33</td>
<td>105</td>
<td>395±230</td>
</tr>
</tbody>
</table>
Plaque Characterization & Volume Quantification
Accuracy of Plaque Volume Quantification

- MDCT substantially underestimates plaque volume per segment as compared with IVUS.

- Technical restrictions prevent an exact separation of lumen, plaque, and vessel wall.-- Edge definition of the outer vessel boundary

Leber et al. J Am Coll Cardiol 2006;47:672–7
F/49
Atypical chest pain
CAC-0, hypercholesterolemia
Prevalence of Noncalcified Plaque by 64-CT in Patients with an Intermediate Risk for Significant CAD

Hausleiter et al. JACC 2006;48:312–8

★ Patients with noncalcified plaques
- higher TChol, LDL, and CRP/ more DM
Prevalence of CAD and plaque morphology in Asx DM patients
Scholete et al. Heart 2007
Regression of Coronary Atherosclerotic Plaque as Shown by CT Arteriography during atorvastatin therapy

Potential of plaque CT

- Early detection of CAD
- Prognostic information/risk stratification
- Therapeutic monitoring
- Pathogenesis of atherosclerosis
Value of Cardiac MDCT

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“It’s not just coronaries!”
M/62: squeezing chest pain

F/54: chest discomfort

“It’s not just coronaries!”

M/34: chest discomfort

F/54: chest discomfort
“It’s not just coronaries!”
“It’s not just coronaries!”
Extracardiac Findings at Cardiac CT

• Noncardiac findings *(2007 JTI)*
  – 25~61% of cases
  – Major findings: 5~10%
• Haller et al *(2006 AJR)*
  – 41 extracardiac findings of 166 pts
  – 2 lung ca, 3 pneumonia, 1 PE
• Patel et al *(2005 AJR)*
  – 60 extracardiac findings of 98 pts
  – 16 nodules(>4mm, 2 lung ca), 12 LNE, 3 mediastinal mass, 1 PE, 7 liver lesions
As a first-line imaging

- Accuracy
- Radiation dose
- Iodine contrast
- Cost effectiveness
Radiation dose

- ECG based dose modulation
  - Minidose: low dose plateau- 4% of max. dose
- Adaptive pitch
- ECG gating
  - Retrospectively gated helical mode
  - Prospectively gated axial mode
MDCT with Prospective Gating

Prospectively gated axial acquisition

Retrospectively gated helical acquisition

X-ray exposure time
## Radiation dose

### Protocols with uncompromised image Quality

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Dose</th>
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<tbody>
<tr>
<td>Cardiac Helical CT</td>
<td>20-25 mSv*</td>
</tr>
<tr>
<td>Cardiac Helical CT with ECG modulation</td>
<td>6-15 mSv*</td>
</tr>
<tr>
<td>Cardiac Axial CT with prospective ECG gating</td>
<td>3-6 mSv*</td>
</tr>
<tr>
<td>Calcium Scoring</td>
<td>~0.6 mSv</td>
</tr>
</tbody>
</table>

### Dose References

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest radiographs – 2 views</td>
<td>0.08 mSv</td>
</tr>
<tr>
<td>Mammogram</td>
<td>0.13 mSv</td>
</tr>
<tr>
<td>Natural Background (Annual)</td>
<td>3 mSv</td>
</tr>
<tr>
<td>Diagnostic Cath</td>
<td>1-10 mSv</td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
</tr>
<tr>
<td>Tc-99m MIBI (rest only)</td>
<td>4 – 5 mSv</td>
</tr>
<tr>
<td>Tc-99m MIBI (rest+stress)</td>
<td>9 – 13 mSv</td>
</tr>
<tr>
<td>TI-201 (rest+stress)</td>
<td>~34 mSv</td>
</tr>
</tbody>
</table>
Summary; CT in CAD

- Intermediate likelihood of CAD or aSx high-risk patients - 1st line noninvasive imaging
- Value of CT as plaque imaging
- Valuable additional information
- Atherosclerosis vs Ischemia
  - Therapeutic modality
  - Risk factor modification