Pushing the limits of cardiac CT

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Introduction

- Rapid technological advances and new clinical applications in cardiovascular imaging technology, coupled with increasing therapeutic options for cardiovascular disease, have led to explosive growth in cardiovascular imaging.

- Armamentarium of non-invasive diagnostic tools has expanded:
  - (3D) echocardiography;
  - CT for coronary angiography, cardiac structure and morphology, and calcium scoring;
  - CMR for myocardial structure, function, and viability;
  - molecular radionuclide imaging.

- New opportunities for physicians to utilize non-invasive techniques to gain important information about the condition of their patients.
1998 : 4slice MDCT
Non-Calcified Plaque in LAD
4-Slice MDCT

AO
RVOT

LA
LV
Dual source flash mode (Siemens)

2 X-ray tubes in 90° (SOMATOM Definition Flash 2 x 128)
high pitch (3 - 3.2) spiral mode, interleaving spiral

table feed 43 cm/sec, scan length ≈ 15 cm: very short exposure-time (≈ 0.3 sec)
→ single beat prospective acquisition of entire heart in diastolic phase
→ low radiation dose

HR < 65 bpm & regular, non-obese
acquisition between ± 55-85% of RR
Tailoring the acquisition

Siemens SOMATOM Definition Flash (UZ Leuven)

< 65 bpm, not obese → flash

> 65 bpm, < 80 bpm → step-and-shoot

< 65 bpm & obese

> 80 bpm → spiral

any heartrate & very obese
CT: Radiation dose issues

= mainly based on reduction of exposure time

• Scan mode
F 75y
spiral
140 kV - 233 mAs
DLP 1404 mGy.cm
ED 24 mSv

M 52y
step-and-shoot
100 kV - 241 mAs
DLP 257 mGy.cm
ED 4.5 mSv

F 32y
flash
100 kV - 260 mAs
DLP 52 mGy.cm
ED 0.9 mSv
Radiation dose optimisation

Patient characteristics…
50% moderate
## Image analysis - stenosis

### Table 2  Diagnostic performance and predictive value of 64-slice CTCA for the detection of \( \geq 50\% \) stenosis on quantitative coronary angiography

<table>
<thead>
<tr>
<th></th>
<th>Prevalence of disease, %</th>
<th>n</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>k</th>
<th>Sensitivity, % (95% CI)</th>
<th>Specificity, % (95% CI)</th>
<th>PPV, % (95% CI)</th>
<th>NPV, % (95% CI)</th>
<th>+LR</th>
<th>-LR</th>
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<tbody>
<tr>
<td>All patients</td>
<td>86</td>
<td>104</td>
<td>88</td>
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<td>0.84</td>
<td>100 (86 to 100)</td>
<td>75 (47 to 92)</td>
<td>86 (89 to 99)</td>
<td>100 (70 to 100)</td>
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<td>100 (93 to 100)</td>
<td>73 (39 to 93)</td>
<td>95 (95 to 99)</td>
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<td>80 (30 to 90)</td>
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<td>96 (94 to 98)</td>
<td>78 (73 to 83)</td>
<td>71 (64 to 77)</td>
<td>99 (86 to 100)</td>
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<td>96 (85 to 99)</td>
<td>72 (50 to 83)</td>
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<td>286</td>
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<td>80 (61 to 92)</td>
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<td>87 (72 to 92)</td>
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<td>51 (38 to 83)</td>
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<td>11.85</td>
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</tr>
</tbody>
</table>

*Meijboom et al. Heart 2007*
Patient 3 y

FLASH Cardio

80 kV (2x)
22 mAs/rotation

CTDIvol 0.19 mGy
DLP 0.7 mGy cm
Effective dose 0.05 mSv
What does CT offer?

• Morphology: high spatial resolution
• Tissue characterization
  – Calcium scoring
  – Density analysis
• Cardiac function:
  – Systolic function
• Myocardial perfusion imaging (CTP)
• Valvular assessment
  • Artificial valves
  • TAVR
  • Assist devices
• Coronary artery imaging
• Great vessels
Cardiac function - CT

- Used to be only feasible with spiral acquisition (radiation dose!)
- Any cardiac phase is contained in an ECG-gated helical MDCT dataset: images from different phases can be produced retrospectively
- Functional analysis not possible with single heart beat mode


N = 181, Cardiac Function; CT vd MR

EF : 53±14% for MRI vs. 53%±15% for CT.
EDV : 74±23 ml at MRI vs. 71±19 ml at CT
MM : 63±20 g at MRI and 56±18 g at CT
Cardiac function

Global function

Regional function
Valvular Assessment CT

- No means of quantifying valvular regurgitations
- Can be considered in selected clinical scenarios
  - TAVR – aortic Valve replacement
  - Mechanical valve dysfunction
  - Assessment of external devices
TAVI

• Prior to valve repair

  o anatomy LVOT & aortic root
  o plaque burden
  o distance aortic annulus - coronary ostia
  o diameter aortic annulus
  o predicting optimal angiographic projection for deployment
• Prosthetic valves
Cardiac anatomy

- Coronary venous anatomy for CRT: left ventricular pacing lead implantation in coronary sinus

Assist device

- HeartMate II (Thoratec) LVAD (up to 10l/min)
Assist device

- Synergy (CircuLite) LVAD (partial support - 3l/min)

4D FLASH acquisition: 10 frames
Coronaries vs Perfusion

CT

Adenosine stress MRI
Myocardial Infarction

CT

MRI

Edema

Perfusion

Microvascular Status

Dual Energy CT at rest

Vliegenthart AJR 2012; 199:S54–S63
Conclusion

- CT has matured into clinically important non-invasive imaging techniques
- More advantages than shortcomings if compared to recent past.
- Following appropriateness criteria, the best choice of protocol can be made
- Use of Siemens Dual Source CT has expanded both in applications and patient selection
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