Cardiac CT
Optimal Use of Evolving Scanner Technologies

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Disclosures

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  – Partners Imaging

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Contrast not FDA approved for coronary CTA or MRA

Radiation Dose in Cardiac CT depends on

• Patient selection
  – Appropriate indications

• Patient preparation
  – Betablockers, breast displacement, positioning

• Acquisition mode selection

• Tube potential selection

• Tube current selection/modulation
Tube Potential Selection

100 kV → 53% dose reduction (preserved image quality, thin patients)

Recommendation

A tube potential of 100 kV could be considered for patients weighing ≤90 kg or with a BMI ≤ 30 kg/m²; a tube potential of 120 kV is usually indicated for patients weighing >90 kg and with a BMI > 30 kg/m². Higher tube potential may be indicated for severely obese patients.

SCCT guidelines on radiation dose and dose-optimization strategies in cardiovascular CT.

BMI ≠ Chest Size

8% larger chest; same BMI:

A
Female, BMI 31, Chest Area 817 cm²

B
Male, BMI 31, Chest Area 887 cm²

Automatic tube Potential Selection

Mode: Prospective (axial-sequential)
5’5”, 192 lbs: BMI 34.5

**Default:**
- kV: 120
- mAs: 292
- Predicted DLP: 148

**APS on:**
- kV: 100
- mAs: 253
- DLP: 110

- Dose: 1.5 mSv
- LM CNR: 17.6
- Excellent IQ*

*Ferencik et al. Image quality parameters. EJR. 2006

Brian Oboshnaja, MGH

Some of the “BMI” can move!

Paul T. Eur Radiol. 2007
Cardiac CT – Unique Technical Aspects

**Data reconstruction**
- Halve scan algorithm
- Multi segment algorithm

**Cardiac Synchronization**
- Prospective triggering
- Retrospective gating

Without ECG gating

With ECG gating & Halfscan Reconstruction

Image Courtesy Stephan Achenbach, MD
With ECG gating & Halfscan Reconstruction

Half Scan Reconstruction

Multi Segment Reconstruction
4 x 45° projections
Acquisition Algorithms

- **Prospective Triggering**
  - Axial, stop and shoot
  - ‘Padding’, ‘Adaptive’, etc.
- **Retrospective Gating**
  - Helical, Tube Modulation
- **Prospectively Triggered Helical Acquisition**
  - High Pitch mode, requires DSCT

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**Retrospective Gating**

- Higher radiation dose!
- Allows multiple time points in R-R interval
- Allows ECG editing

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**Retrospective gated MDCT**

- SYSTOLE
- DIASTOLE
Multiple cardiac phases in one spatial location → cine images

4D CT Ventriculogram

Dyskinesia in LAD Territory → acute MI

Regular Irregularity

Bigemini – Only PVCs Reconstructed

Retrospective Gating w Tube-modulation

mA modulated according to EKG
mA output reduction by 80% in systole
How much radiation can we save?

- 50 bpm: Dose reduction 50%
- 80 bpm: Dose reduction 20%

When not to use tube modulation:

- PVCs

When not to use tube modulation - PVCs
Retrospective Gating w Tube-modulation

Widening or narrowing of max. plateau
Narrow $\rightarrow$ less dose, more risk of motion artefact
Retrospective Gating w Tube-modulation

Lowering of systolic tube output
Systolic reconstructions very noisy
May not get sufficient functional data

Retrospective Gating w Tube-modulation

Tube Current reduction in systole by ~96%

Lowering of systolic tube output
Systolic reconstructions very noisy
May not get sufficient functional data

Prospective Triggering – Axial Sequential

Minimal dose
High risk for motion artifact
Prospective Triggering – Axial Sequential

Symmetric "padding"
Higher dose
Reduced risk for motion artifact

"Smart" algorithm senses premature beats and skips acquisitions
Reduces risk for motion artifact

Symmetric "padding"
Higher dose
Reduced risk for motion artifact
Prospective Triggering – Axial Sequential

User defined “padding”
- Higher dose
- Reduced risk for motion artifact

Prospective Triggering – Axial Sequential

Variable tube output Triggering

User defined “padding” at full dose
- PLUS user defined low dose acquisition
- May allow function
- Reduced risk for motion artifact

Prospective Triggering – Axial Sequential

User defined plateau at full dose
- & user defined low dose acquisition
- May allow function
- Reduced risk for motion artifact
**Prospective Triggering – Axial Sequential**

- Pitch > 3 on Dual Source CT system
- Second tube offset by 90° ("fills gap"), therefore image reconstruction is possible

**High Pitch Mode**

- Pitch > 3 on Dual Source CT system
- Table moves continuously (and very fast)

**Prospective Triggered Helical Acquisition**

- Minimal dose
- Excellent temporal resolution
- Risk for motion artifact
Available Today:
- **ASIR** Adaptive Statistical Iterative Reconstruction (GE)
- **IRIS** Iterative Reconstruction in Image Space (Siemens)
- **iDose** (Philips)
- **AIDR** Adaptive iterative dose reduction (Toshiba)

Work in progress:
- **MBIR** Model Based Iterative Reconstruction (GE)
- **MBAI** Model Based Algebraic Iteration (© HH Pien, Mass General)
- **SAFIRE** Sinogram affirmed iterative reconstruction (Siemens)

Types of iterative reconstructions

- **FBP**
- **ASIR -30**
- **MBIR**
- **IRIS**
- **50 mAs**
- **iDose**
- **AIDR**
- **SAFIRE**

Courtesy S Singh, M Kalra, CT-DOSE Program, MGH
MBAI image reconstruction resulted in lower image noise and sharper edges.

Courtesy H. Pien, S. Singh, M. Kalra, LMIC, MGH

Reduced Angle Tomography

Ground truth

CW (200 500)

FBP 10% angular scan

IRT 10% angular scan

Siemens DSCT, 1160 rotation angles

116 rotation angles

116 rotation angles

Temporal Resolution (Half-scan Technique)

Cardiac CT
Changes in Radiation Doses past 10 Years

- Cardiac CT
- Chest CT
- SPECT
- Cath
- Thallium s/r


0 5 10 15 20 25 30 35 40

mgY

MGH Radiation Dose for ALL PATIENTS (all indications, BMI, includes ca-scoring, perfusion DE)

2005: 12.4 mSv
2011: 3.6 mSv

Lowest dose: 0.3 mSv

61yof, BMI 31 → Effective Dose 1.3 mSv

Thank you!

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