Choosing CT Scan Parameters
Cardiac CT, Perfusion CT

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Introduction
• Cardiac CT and Perfusion CT are deemed high dose CT procedures
• However, from past few years, radiation doses have trended downward
• Choosing appropriate type of scan parameters are contributing towards this downward trend

Categories of CT procedures (78.7 million in 2015)

HCAP: ~76% of all CT procedures
Scan Parameters impacting Dose and Image Quality in CT

Primary Factors
- Tube Current (mA)
- Tube Voltage (kV)
- Scan Time
- Pitch
- Scan Acquisition Type

Secondary Factors
- Scan Field of View (SFOV)
- Display Field of View (DFOV)
- Beam Collimation
- Reconstructed Slice Width
- Reconstruction Interval
- Reconstruction Algorithms

Other Factors
- Patient Size
- Patient Motion
- Geometry and Detector Efficiency
- Training and experience

Cardiac CT

Prominent scan types
- Calcium Scoring Studies
- CT Angiography Studies
- Cardiac CT prior to EP Ablation procedures
**Tube Current**

(vary with clinical indications)

- Calcium Score Image
  Range: 25 to 200 mA
- CTA Image
  Range: 200 to 800 mA

**Retrospective ECG Gating**

- Temporal Resolution
- Radiation dose higher than prospective triggering
- Continuous recording of spiral scan and ECG
- ECG moving couch-top
- Time / Pos.

**Prospective ECG Triggering**

- Temporal resolution
- Radiation dose minimized
- Limited data set
- Conventional Axial "Partial Scan" (Step and Shoot)
- ECG
CTA Dose: Prospective vs Retrospective

Helical mode: 11.2 mSv
Sequential mode: 3.6 mSv

PROTECTION I study, AJR, 2010

Motivation for advancement in CT technology

Goal
- To image entire heart in single CT gantry rotation
  - Achieved by wide-detector CT systems
- To image entire heart in a single heart beat
  - Achieved with high-pitch scan using dual source CT

Scan coverage - 320 vs 64 slice MDCT

Toshiba
Aquilion 64 - 320 slice MDCT - 320 mm beam width
Aquilion One - 320 slice MDCT - 160 mm beam width

MDCT Physics: The Basics..., Lippincott, 2009
**Dual Source CT**

Definition – FLASH
2nd detector set still smaller than 1st but larger than Definition
SFOV: 1st detector ~ 50 cm, 2nd detector ~ 34 cm

* Siemens

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**Single Source vs Dual Source CT**

64 Slice MDCT ~190 ms
DSCT ~ 90 ms

180° Data Acquisition 90° Data Acquisition per tube

Temporal resolution: 1/3rd to 1/4th of gantry rotation time

* Siemens

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**High Pitch Cardiac CT Scan with DSCT**

- Interleaved spiral path from dual source is used in image reconstruction
- High-pitch (>3) scans enables data acquisition within single heartbeat
- High demand on patient selection (< 60 bpm desired)

* Achenbach S, JCCT, 3:117-121, 2009
CTA Dose: Conventional vs High Pitch

Conventional: 4.7 ± 4.8 mSv
High pitch (DSCT): 2.0 ± 2.4 mSv

PROTECTION IV study, JCC, 2015

CT Dose Modulation

Spatial Dose Modulation

Temporal Dose Modulation

Temporal Dose Modulation for coronary CT Angiography

- Constant tube current through entire R-R cycle can be modulated
- Tube current is lowered outside diastolic region enabling dose reduction during cardiac CT
Cardiac CT: Take Home Points

- Calcium scoring studies are done mostly with fixed techniques – low tube current - lower radiation dose
- Cardiac CT Angiography studies are increasingly prospective triggered acquisition
- Also, temporal dose modulation, lower tube voltage along with iterative reconstruction techniques all are aiding in lowering dose in CT Angiography studies

Perfusion CT

What is CT Perfusion?

- CT Perfusion is an imaging procedure that allows functional evaluation of tissue vascularity
- Perfusion CT is based on temporal changes in tissue attenuation after intravenous administration of iodinated contrast material
- Post intravenous injection of iodine contrast material, tissue enhancement is evaluated based on its distribution in intravascular or extravascular compartment
How is CT Perfusion done?

- After injecting iodine contrast materials, series of CT scans are done over same region.
- Repeated acquisitions of volume of interest during first pass of contrast material is obtained – can last approximately 1 or 2 min.
- Followed by CT acquisition of delayed phases – can last from 2 to 10 minutes.

Brain Perfusion CT Acquisitions

- White – Mask
- Red – early arterial phase, Yellow – peak arterial phase
- Blue – late arterial phase, Green – venous phase


CT Perfusion Dose Data

Techniques to watch out.
Effective Dose: Brain Perfusion CT

- 4 mSv for perfusion CT of brain
- 23 to 26 mSv for perfusion CT body protocols


CT Perfusion in Oncology

- Conventional CT before Therapy
- Hepatic Perfusion before Therapy
- Hepatic Perfusion 4 hours after Therapy

AJR: 200, 2013

Radiation Injuries from CT Perfusion Studies

NY Times, Aug 2nd, 2010
Radiation Injuries in CT – Rare but possible!

CT Perfusion: Take Home Points

- Watch out for skin dose exceeding threshold to cause deterministic effects due to repeat scans
- Using lower tube voltage 100 kV or 80 kV during contiguous acquisition are critical to reduce skin injuries
- CTDIvol displayed at end of CT exam can be used as conservative predictor of peak skin dose for most CT perfusion studies

Iterative Reconstruction

- Objective is to enable user to acquire CT data at low dose and improve image quality with iterative process
- Most iterative reconstruction algorithms due to manufacturer proprieties act as ‘BLACK BOX’
Effect of Iterative Reconstruction

CT at full dose (22 mGy)

CT at half dose (11 mGy)

Degraded
CT images

Low

Moderate

High

RadioGraphics, 34, 849-862, 2014

Iterative Reconstruction Techniques: SAFIRE 1 to 5

1

2

3

4

5

Increasing from 1 to 5 results in progressively less noise, but a more opaque appearance

Iterative Reconstruction:

Degradation of CT low contrast at reduced dose

- Dose reductions of 25%–50%
  - Degraded low-contrast spatial resolution compared with FBP even with use of IR
  - Ability to visualize low-contrast rods in ACR CT accreditation phantom can be lost
- Use of IR techniques at decreased radiation dose levels may degrade diagnostic performance

RadioGraphics, 34, 849-862, 2014
CTA Dose: Impact of IR

Reduced mA + IR: 2.2 (1.6 – 3.3) mSv
Standard mA + FBP: 3.1 (2.0 – 4.5) mSv

PROTECTION V study, JACC, 2015

Tube Voltage Modulation

- Lower tube voltage improves image contrast and reduce dose
- As tube voltage decreases, tube current may have to be increased to maintain image noise

Radiology 2012; 264(2): 567-580

Influence of Tube Voltage on CTA Dose

Effective Dose Estimation
A - 100 kV: 8.4 ± 3.6 mSv
B - 120 kV: 12.2 ± 4.4 mSv

PROTECTION II study, JACC, 2010
Conclusions

• Cardiac CT imaging has been the driving force behind many technical advances in MDCT
• Understanding and choosing appropriate scan parameters is key to deliver optimal dose in cardiac CT or perfusion CT