Lowering the Dose: mA and kVp

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Disclosure of Commercial Interest

I have a financial relationship with a commercial organization that may have a direct or indirect interest in the content as follows:

• Siemens Medical Solutions: consultant, speakers bureau
Objective

- Describe role of mA and kVp in lowering CT in an adult population
Major CT Parameters Affecting Dose

- Tube current (mA)
- Tube voltage (kV)
- Pitch
- Collimation
Effect of CT Adaptations on Dose

• 50% decrease in mA = 50% dose decrease
• 80 kVp = 30% to 50% dose decrease

• 50% increase in pitch = 50% dose decrease
• Thicker slices = dose decrease
mA and kV

• Tube milliamperage (mA)
  – rate of x-ray production

• Kilovoltage (kV)
  – number of x-rays produced
mA

Tube Current Reduction
Best Approach for mA Reduction

• Automated technology introduced in 1990s
• Superior to technique charts (no guess work)
• Exceptions: screening chest CT
• Other exception is head CT where beam attenuation comes from bone formation and this process is age dependent so mA is age dependent-use fixed tube current

Graser AJR 2006; 659
Herzog et al. AJR 2008, 1232
Mulkens Radiology 2005; 213
Automated mA Reduction

- mA is adapted to **body parts**, not patient weight, thinner parts need less radiation
- mA based on attenuation data from scout image
- Dose modulation done in x, y, z planes
Ex: shoulders to pelvis
Ref value 150 mA
Automated mA Modulation Mean Dose Reduction

- **Stone disease** 64%
  - Mulkens AJR 2007; 188: 553

- **Cardiac CT** 60%
  - Herzog, AJR 2008; 190:1232

- **Colonography** 35%
  - Graser, AJR 2006; 187:695
Lung Cancer Screening

- Fixed tube current
- mA of 20 to 40 rather than standard 150
- Low attenuation background of air-filled lungs offers a high contrast setting which can be used favorably to assess lung abnormalities
Older woman breast cancer
low dose vs. standard CT

150 mA vs. 20 mA

Similar image quality
National Lung Cancer Screening Trial

- 26,724 participants
- Scanned with 20-40 mA
- Average effective dose
  - 2 mSv for low-dose CT vs.
  - 7-8 mSv for standard chest CT
- Dose >> females than males (2.4/1.6)

Larke et al. AJR Nov 2011; 197:1165-1169
A Tale of Two Techniques

kV Modulation
Major Untapped Potential has been kV

Distribution of scans in clinical practice
Why use low kV---Rationale

- Lowers radiation dose
- Improves contrast
- Greatest benefit in contrast CT exams

Siegel MJ Radiology 2004; 233:515
Funama, et al., Radiology 2005
Nakayama, et al., Radiology 2005
Huda, et al., Med Phys 2004
Nakayama, et al. AJR 2006
Low kV-Effect on Dose: Phantom Study

- Reducing kV reduces dose

Siegel MJ: Radiology 2004; 233: 515
Low kVp: Effect on Contrast

- Reducing kV increases Iodine contrast (HU)

Siegel MJ: Radiology 2004; 233: 515
Low kVp

- Decreases dose & increases contrast
- Rationale: K-edge of iodine 32 keV
- Mean photon energy
  - 80 kVp        44 keV
  - 100 kVp       52 keV
  - 120 kVp       57 keV
  - 140 kVp       62 keV

Reducing kV increases image noise in large phantoms
kV Modulation-Key Point

• The use of lower-kV is highly dependent on patient size and diagnostic task

• Increases in contrast are seen ONLY with high atomic number substances
  – Iodine
  – NOT water, soft tissue, calcium

• Benefit greatest in children and small sized adults and contrast examinations
Approaches for kV Reduction?

- Conventionally done using technique charts
- Recently automatic selection tools have become available (2011)
- Most experience with kV reduction is in PE and cardiac CTA
Low kV Coronary CTA

- 100 patients (≤ 85 kg)
  - Dual Source 64 CT
  - Retrospective gating
  - 120 kVp / 330 mAs: 12 mSv
  - 100 kVp / 330 mAs: < 8 mSv
- 39% decrease in radiation exposure

Low kVp and High Pitch CT

- Dose < 1 mSv
- Total scan time 0.25-0.27s

Achenbach et al. Eur Heart J. 2010;31:340-6

100 kV and 0.8 mSv
Low kV Pulmonary Embolism CTA

- **Park et al.** *(Korean J Radiol 2009; 10:235)*
  - dose reduction of 24%
  - 10.1 to 7.8 mSv (120 to 100 kV)
  - Smaller patients (BMI < 25)

- **Matsuoka et al.** *(AJR 2009; 1651-1656)*
  - 40 to 50% dose reduction (120 to 100 kV)
Low kV—Pulmonary Embolism CTA

• Lower dose, better contrast
• Mean enhancement > with 100 kVp (492 vs. 345 HU)
• Sensitivity 100% for detecting PE

Szucs-Farkas AJR 2011: 197:852
Automated kV Selection Technology

- A tool which automatically adjusts kV for body size determined from topogram and the exam type
- Up to 60% dose reduction
Auto kV User Interface

- With auto kV off: choose exam type as you would routinely do, screen shows mA, kV & dose -
- Turn auto kV on: take scout CT-program selects best kV to lower dose and maintain image quality
Auto kV

- Used in conjunction with auto mA
- kV decreases AND mA increases
- But overall dose is lower than with fixed kV
Auto kV contrast abdomen, pelvis

- 15 year old boy
- REF: 120kV / 75mA, CTDIvol = 5.77 mGy
- 80 kV / 177mA  CTDIvol = 3.2 mGy
Automated kV selection based on the attenuation profile of the topogram is feasible, provides a diagnostic image quality for body CTA, and reduces overall radiation dose by 25% as compared with a standard protocol with 120 kV.
Auto kV vs. Image Quality

Investigative Radiology 2011
Summary

• Beautiful pictures do **NOT** need to come at the cost of higher radiation dose

• *Adjusting mA and kV can dial down the dose and drive up imaging quality*-ALARA