Low kV Imaging: Indication, Application and Innovation

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Disclosures

• MGH has research agreement
  – GE Health Care
  – Siemens Medical Systems
Which of the following is **NOT** true Regarding CT Dose?

A. There is a linear relationship between tube current (mA) and dose

B. Tube potential (kVp) has a quadratic relationship with dose \((dose \propto kVp^2)\)

C. Thinner slices increases image noise and dose

D. Patient with a larger body size require substantially higher dose for a diagnostic image quality

E. Arterial phase acquisition delivers more radiation than venous phase
Factors that Influence Dose

- Tube potential
- Exposure time
- Tube Current
- Beam Quality
- Collimation
- Patient Size & anatomy

\[ \text{dose} \propto kVp^2 \]

\[ \text{dose} \propto mAS \]
Benefits of low-kV selection

- Increased iodine contrast
  - CTA studies

Stiller et al, Eur J Radiol. 2011
Perisinakis et al, Br J Radiol. 2011
Utsunomiya et al, Eur Radiol. 2010
Marin et al, Radiology. 2010
Hunsaker AR. AJR. 2010
Godoy MC. Eur J Radiol. 2010
Feuchtner GM. Eur J Radiol. 2010
CTA: Visualization of renal artery branches

Effect of kV: Hypervascular Lesions

Hepatic Arterial Phase: Multiple Adenomas
Benefits / Challenges of low-kV selection

- Reduction in radiation dose

- Small and medium size patients

"Appropriateness of using lower-kV is highly dependent on patient size and CT indication"

References:
- Siegel MJ Radiology 2004
- Nakayama, et al. AJR 2006
- McCollough C, ISMDCT 2012
MDCT protocols into 3-4 groups

Low-Contrast
I+ phase CECT (portal/nephro)

Hi-Contrast
CTA/CTU/CTC Arterial phase

Screening
Stone/CTC Post Procedure

Low mA options
kVp+/- (fixed)

Low kVp options
mA optimized

Low kVp
Low mA

MGH
Strategies for kV selection

- Body weight

- Body mass index (BMI)
  - <25, 25-30, >30

- Abdominal width
  - < 30 cm = 80*/100#
  - 30-45 cm = 100*/120#
  - 45-50 cm = 120*/120#
  - >50 cm = 140*/140#

*=CTA, #=CECT
kVp Selection Based on Body Weight & Indication: CTA

kVp 80-100
mA/mAs = 550/280

- 200-300 lbs: 120 kVp
- >150-200 lbs: 100 kVp
- < 150 lbs: 80 kVp

- > 300 lbs = 140 kVp
- 162 lbs-80 kVp
- CT dose – 2.2 mSv
CT Cholangiography

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>kV</th>
<th>mA</th>
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</thead>
<tbody>
<tr>
<td>&lt;200</td>
<td>80</td>
<td>350</td>
</tr>
<tr>
<td>&gt;200</td>
<td>100</td>
<td>350</td>
</tr>
</tbody>
</table>

20 mL Cholografin (50%) mixed in 80mL saline and drip infused over 30-40 before scanning

Benadryl

Yeh B et al. Radiology 2005
# Diagnostic Arterial Phase CT

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Siemens 64</th>
<th>GE 64</th>
<th>Phillips 64</th>
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<tr>
<td></td>
<td>kV</td>
<td>Ref mA</td>
<td>Pitch</td>
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<tr>
<td>&lt;200 lbs</td>
<td>100</td>
<td>200</td>
<td>1.3</td>
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<tr>
<td>201-300 lbs</td>
<td>120</td>
<td>220</td>
<td>1.3</td>
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<tr>
<td>&gt; 300 lbs</td>
<td>120</td>
<td>250</td>
<td>1.3</td>
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100 kV selection for <200 lbs patients
Low kVp Imaging

33 yr old, 67 kg woman, kV 100/120, DLP=538
## Stone Protocol: Initial and FU CT

<table>
<thead>
<tr>
<th>Weight</th>
<th>Siemens Flash (initial/follow up)</th>
<th>GE HD (initial/follow up)</th>
<th>Phillips</th>
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<tbody>
<tr>
<td></td>
<td>kV</td>
<td>Ref mA</td>
<td>kV</td>
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<tr>
<td>&lt; 200 lbs</td>
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<td>100/40</td>
<td>120/100</td>
</tr>
<tr>
<td>&gt; 300 lbs</td>
<td>120/80</td>
<td>100/40</td>
<td>120/100</td>
</tr>
</tbody>
</table>

**FU:** 80 kV < 200 lbs & 100 kV > 200 lbs
## Post-Interevention

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<th>GE</th>
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</thead>
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<td></td>
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<td>Ref mA</td>
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<td>40</td>
</tr>
<tr>
<td>&gt; 300 lbs</td>
<td>100</td>
<td>40</td>
</tr>
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</table>
Automated kV selection (CARE kV-Siemens)

- Automatically recommends the optimal kV setting
  - individual patient
  - specific exam
- Information from topogram
  - user-chosen contrast-to-noise ratio
At 100kV, the CT dose is 2.8 mSv at 138lbs.
At 120kV, the CT dose is 7.3 mSv at 138lbs.
At 100kV, the CT dose is 7.1 mSv at 205lbs.
At 120kV, the CT dose is 11.7 mSv at 205lbs.
kV selection - CARE kV

kV selected (compared to a weight-based protocol)

- 100 kV: 62
- 120 kV: 4
- 140 kV: 20

- Higher: 6
- Equal: 31
- Lower: 49
Automated kV selection

- Automatic kV selection is feasible
  - Simple workflow – technologists
- > 50% of the patients → kV selected lower than the weight-based protocol
- Provides Diagnostic image quality with a lower dose
- When iterative technique is combined with CARE kV there is further drop in the radiation dose
Summary

- **kV optimization in CT**
  - dual benefit of higher iodine attenuation and low dose

- **Several approaches available**
  - kV selection based on body size and indication
    - Small and average size patients can be scanned using <120 kV
  - High contrast studies allow low kV application without image quality limitations
  - In larger patients 120/140 kV
  - Automated kV selection is promising

- **Applications**
  - improved detection and characterization
  - Evaluation of vascular structures.
  - Reduce iodinated contrast material dose