CT Protocol Optimization over the Range of CT Scanner Types: Recommendations & Misconceptions

Evolution to Helical/ Spiral CT Scanners

Evolution to Multislice Scanners 2, 4, 8, 16, 64, … ?
Evolution to Multislice Scanners

2, 4, 8, 16, 64, ... ?

Definition of Pitch for Single-slice Helical / Spiral Scanning

\[
\text{Pitch} = \frac{\text{Table travel per 360° tube rotation}}{\text{Nominal Slice Thickness}}
\]

Definition of Pitch for Multi-slice Helical / Spiral Scanning

\[
\text{Pitch} = \frac{\text{Table travel per 360° tube rotation}}{\text{Total collimation width of all simultaneously collected slices}}
\]

CT Protocols

Series 3 - Abdomen/ Pelvis

Medium Adult

From Recon 1: Sa & Co Referential Ave., 0.9 mm thick & 2.3 mm interval

<table>
<thead>
<tr>
<th>Scanner</th>
<th>GE LS Xtra</th>
<th>GE LS 16</th>
<th>GE LS 16 Pro</th>
<th>GE LS VCT 64</th>
<th>GE LS 8</th>
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<tbody>
<tr>
<td>Scan Type</td>
<td>Helical</td>
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<td>Rotation Time (sec)</td>
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<tr>
<td>Detector Coverage (mm)</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
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<tr>
<td>Beam Collimation (mm)</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>8</td>
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<tr>
<td>Detector Rows</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>64</td>
<td>8</td>
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<tr>
<td>Pitch</td>
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<td>0.516</td>
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<tr>
<td>Speed (mm/rot)</td>
<td>18.75</td>
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<tr>
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<td>16 x 1.25</td>
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<td>16 x 1.25</td>
<td>64 x 0.625</td>
<td>8 x 1.25</td>
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<td>Slice Thickness (mm)</td>
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<tr>
<td>Smart mA/ Auto mA Range</td>
<td>150-600</td>
<td>120-440</td>
<td>120-660</td>
<td>60-660</td>
<td>180-440</td>
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<td>24</td>
<td>24</td>
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<tr>
<td>(Manual mA)</td>
<td>570</td>
<td>440</td>
<td>460</td>
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### CT Protocols

<table>
<thead>
<tr>
<th>Recon 1:</th>
<th>CT 1</th>
<th>CT 2</th>
<th>CT 3</th>
<th>CT 4 &amp;</th>
<th>East &amp; RP CT</th>
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<td>Plus</td>
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<td>Recon Option</td>
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<table>
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<tr>
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<td>WW/ WL</td>
<td>325/15</td>
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<td>Recon Option</td>
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<td>Slice Thickness (mm)</td>
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</tr>
<tr>
<td>Interval (mm)</td>
<td>3.0</td>
</tr>
</tbody>
</table>

### Dose in Computed Tomography

### RADIATION UNITS

**Absorbed Dose**
- Units: \( \text{gray (Gy)} \) or \( \text{rad (r)} \)

**Equivalent Dose**
- Units: \( \text{sievert (Sv)} \) or \( \text{rem} \)

**Effective Dose**
- Units: \( \text{sievert (Sv)} \) or \( \text{rem} \)

### Effective Dose

The concept of effective dose takes into account the risk to the person exposed to radiation that is **not uniform** over the entire body.

Different organs have different sensitivities to radiation.

This is expressed by the tissue **weighting factor**: \( w_T \)
CT Dose

- **CTDI**
  - CTDI_{100} measured at the center of the phantom is called CTDI_{100} (center)
  - CTDI_{100} measured near the surface of the phantom is called CTDI_{100} (surface) or CTDI_{100} (peripheral)

CT Dose

- **CTDI**
  - CTDI_{w} is a weighted value of CTDI_{100} that attempts to give the average dose throughout the volume of the phantom (again, for contiguous axial slices or for helical scanning at a pitch of 1). It is defined as:
    \[
    CTDI_w = \frac{1}{3} CTDI_{100} \text{ (center)} + \frac{2}{3} CTDI_{100} \text{ (surface)}
    \]

CT Dose

- **CTDI**
  - If you then take into account the effect of pitch on dose for a helical/spiral scan then you have another version of CTDI:
    \[
    CTDI_{vol} = CTDI_w / \text{Pitch}
    \]
  - This is an approximation of the dose averaged over the volume of the phantom.

CT Dose

- **DLP**
  - A final dosimetry measure is the Dose Length Product (DLP) which is defined as:
    \[
    \text{DLP} = CTDI_{vol} \times \text{Scan Length}
    \]
  - and has units of mGy • cm
  - CTDI_{vol} and DLP are the radiation units provided by the CT Scanner.
CT Dose

- **DLP**
  - Estimates of a patient’s effective dose (E) can be derived from the values of DLP for an examination. Use the following equation containing a coefficient $E_{DLP}$ appropriate to the examination:

$$E = E_{DLP} \times DLP$$

---

CT Dose

- **DLP**
  - Values of $E_{DLP}$ for Adult scans:

<table>
<thead>
<tr>
<th>Region of Body</th>
<th>$E_{DLP}$ (mSv / mGy•cm)</th>
<th>Phantom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.0023</td>
<td>0.0021</td>
</tr>
<tr>
<td>Head &amp; Neck</td>
<td>0.0031</td>
<td>0.0031</td>
</tr>
<tr>
<td>Neck</td>
<td>0.0054</td>
<td>0.0059</td>
</tr>
<tr>
<td>Chest</td>
<td>0.017</td>
<td>0.014</td>
</tr>
<tr>
<td>Abdomen</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>Pelvis</td>
<td>0.019</td>
<td>0.015</td>
</tr>
</tbody>
</table>

\[ \text{Two different sources} \]

---

CT Dose

- Converting DLP to Effective Dose for Adults
  
  Quick method of getting the effective dose in mSv from the DLP in mGy•cm:
  
  - Take the DLP and divide it by 100
    - For the Body, then **multiply by 1.5**
    - For the Head, then **divide by 4**
Image Quality in Computed Tomography

Image Quality and Dose:

- Dose
- Image Sharpness
- Image Noise
- Low Contrast Detectability
- Artifacts

Image Reconstruction Filters, Algorithms, or Kernels

Below are the measured MTF functions for the reconstruction algorithms available on a GE scanner. The algorithms that do not have a “hump” in the MTF are: soft, standard, detail, bone, and edge in order of increasing sharpness. A hump in the MTF indicates a form of edge enhancement of the image; these are evident in the lung reconstruction and the bone plus reconstruction.

Image Reconstruction Filters, Algorithms, or Kernels (Siemens)

Kernel names have 4 positions. Example: B10f.
- Pos.1: kernel type (B=body, C=child head, H=head, U=ultra high resolution, S=special kernel, T=topo.)
- Pos. 2: resolution (1,...,9. Higher number = higher resolution)
- Pos. 3: version (0,...,9)
- Pos. 4: scan mode (f=fast (no FFS, no UHR comb), s=standard (with FFS, no UHR comb), h=highres (with FFS, no UHR comb), u=ultrahighres (with FFS, with UHR comb))

The use of FFS is not coded to the kernel name.

- B10f, B18f, B19f, B20f, B25f, B29f, B30f, B31f, B35f, B36f, B39f, B40f, B41f, B45f, B46f, B47f, B50f, B60f, B65f, B70f, B75f, B80f.
- B08s, B10s, B18s, B19s, B20s, B25s, B29s, B30s, B31s, B35s, B39s, B40s, B41s, B45s, B46s, B47s, B50s, B60s, B65s, B70s, B75h, B80s.
- B30m/B40m (m=f,s) are standard kernels, B20m/B10m are more smooth.
- Br1m (r=3,4) have about the same visual sharpness as Br0m, but a finer noise structure (better image impression, improved LC).
- B35m is designed for Ca-scoring and quantitative analysis, B30m is a sharper version of B35m.
- B30m/B40m are more softening.
- B37m/B47m/B49m/B50m/B60m/B70m/B80m (m=f,h,s) are lungHR kernels, B49m has the same visual sharpness as B40m, but a finer noise structure (better image impression, improved LC).
- H10f, H19f, H20f, H21f, H22f, H23f, H29f, H30f, H31f, H32f, H37f, H39f, H40f, H41f, H42f, H45f, H47f.
- H10s, H19s, H20s, H21s, H22s, H23s, H29s, H30s, H31s, H32s, H37s, H39s, H40s, H41s, H42s, H45s, H47s.
- H50f, H60f, H10h, H19h, H20h, H21h, H22h, H23h, H29h, H30h, H31h, H32h, H37h, H39h, H40h, H41h, H42h, H45h, H47h.
- H50s, H60s, H10s, H19s, H20s, H21s, H22s, H23s, H29s, H30s, H31s, H32s, H37s, H39s, H40s, H41s, H42s, H45s, H47s.
- H70h, H80h (Open only).
- H50m (m=f,s) is the standard kernel, H30m, H20m or H10m lead to softer images.
- Hr1m (r=2,3,4) have about the same visual sharpness as Hr0m, but a finer noise structure (better image impression, improved LC).
- Hr40m (m=f,s) are the PET/SPECT versions of Hr0m.
- H70h gives highest resolution without comb.
- H80h gives the hires specification for Sensation Open.
Image Sharpness:
Images of a resolution pattern made with different Image Reconstruction Algorithms

Image Noise:
Images of a uniform water pattern imaged using mAs values incrementing by a factor of 2, from 50 mAs to 1600 mAs.

Low Contrast Detectability:
Images of a low contrast detectability pattern imaged using mAs values incrementing by a factor of 2, from 50 mAs to 1600 mAs.

Artifacts from Data Acquisition Problems
- Ring Artifacts
Artifacts from Data Acquisition Problems

- Ring Artifacts

Ring Artifacts Detected with a Large Uniformity Phantom

- Images of 48 cm uniform phantom starting at 40 mA and incrementing by 20 mA up to the maximum mA at 120 kV

Beam Hardening & Partial Volume Artifacts

Beam Hardening Artifacts

“Small body” reconstruction without iterative correction
“Head” reconstruction with iterative correction
Motion Artifacts

No Motion

With Motion

Artifact due to the patient extending outside the Scan Field of View; ALSO “Stringy” noise artifact

Effect of CT Protocols on Image Quality and Dose
Axial Scan Techniques Affecting Image Quality & Dose

- kV
- mAs – mA & scan time
- Slice thickness

Helical Scan Techniques Affecting Image Quality & Dose

- kV
- mAs – mA & scan time
- Slice thickness
- Pitch

Helical Scan Techniques Affecting Image Quality & Dose

Definition of Pitch for Multislice Helical / Spiral Scanning:

\[
\text{Pitch}_{\text{coll}} = \frac{\text{Table travel per 360}^\circ \text{ tube rotation}}{\text{Total collimation width of all simultaneously collected slices}}
\]

Helical Scan Techniques Affecting Image Quality & Dose

- Some scanners when using helical or spiral CT use the concept of “effective mAs"

  Effective mAs = mAs / pitch

- To make things even more confusing, some scanners (Philips) call the effective mAs in helical scanning simply the “mAs”
Manual vs. Automatic Exposure

One big defect of CT Scanners before 2001

- They did not contain any type of “phototimer” or automatic exposure control (AEC) to assure a proper patient dose.
- Therefore, manual technique charts were needed for different patient sizes.
- Usually this was not done so that techniques more suited for larger patients were used on all patients resulting in unneeded radiation exposure.

Automatic Exposure Control in CT Scanners

- Most modern CT scanners have some type of automatic exposure control (AEC) that changes the mA during the scan.
- There are two basic types of AEC that can be used separately or together:
  - The scanner varies the mA at different axial positions of the patient.
  - The scanner varies the mA as the tube rotates around the patient.
- It is usually optimal to use both types together if the scanner allows it.

Caution: The methods used by different manufacturers to perform AEC in CT are very different and may achieve very different clinical results.
Automatic Exposure Control in CT Scanners

- Some scanners (GE, Toshiba) try to keep the image noise constant as patient size increases: the automatic exposure control is adjusted by selecting the amount of noise that you wish in the image. This is done by selecting a “Noise Index” or “SD” (standard deviation).
- Typical values of Noise Index are 2.5 to 3.5 for a standard adult head scan and 12 to 20 for the body.
- The scanner attempts to keep the image noise constant by adjusting the mA within set limits.

GE:

- With GE scanners you must select whether you will be using manual techniques “Manual mA” or AEC techniques “Auto mA”. One uses an actual mA setting, the other uses a Noise Index setting. Having one set correctly in a protocol does nothing to insure the other is properly set.

Other scanners (Siemens, Philips) allow you to select the “mAs” or the “Effective mAs” that you would use for an average size patient. For Siemens scanners this selection is called the “Quality reference mAs”.

- Then the scanner automatically increases or decreases the effective mAs for larger or smaller patients. This is done by varying the mA.

Effective mAs = (mA x rotation time) / pitch

Siemens:

- With Siemens scanners you select the “eff. mAs” whether you will be using manual techniques OR AEC techniques. In manual mode this is the actual eff. mAs used and in AEC mode it is the eff. mAs that you would desire for an “average” size patient. There is not the use of 2 different parameters for manual & AEC mode.
Automatic Exposure Control in CT Scanners

- Scanners that try to keep the image noise constant have the problem that they can quickly reach the maximum mA “ceiling” before getting to very large patients.
- Scanners that use a reference mAs setting will generally allow the mA to increase only modestly with increased patient size, allowing the image noise to increase substantially for large patients.
- What is needed is a new hybrid approach.

A Siemens Problem:
- After performing the topo scan, Siemens scanners warn you if the available effective mAs is lower than the effective mAs requested by the automatic exposure control system, which will result in unacceptable image quality.
- However the scanner does not let you increase the kV from 120 to 140 which could solve the problem!
- This means a “work-around” is required: temporarily reduce the Quality Ref mAs to a very low value. You can then raise the kV to 140. Then increase the Quality Ref mAs to at least ½ of its original value, if possible.

A GE (and Toshiba) Problem:
- Since the GE scanner requires two separate parameters for determining the mA in manual and AEC mode, one must understand the application and use of the “Noise Index” parameter when using AEC.
- When switching from manual to AEC mode or from AEC to manual mode one must be sure that the exposure parameter of “manual mA” or “Noise Index” is properly adjusted. When one of these modes is the manufacturer’s “default” mode one cannot assume that correct settings will result when switching modes.

Manual vs. Automatic Exposure
- Increasing the kV will have different effects when using manual exposure mode and different types of automatic exposure modes.
Manual vs. Automatic Exposure

- In a manual mode increasing the kV will always increase the patient dose, if all other scan parameters are kept constant.
- With GE and Toshiba scanners, increasing the kV in AEC mode will decrease the patient dose, if all other scan parameters are kept constant.
- With Siemens and Philips scanners, increasing the kV in AEC mode will increase the patient dose, if all other scan parameters are kept constant.

Optimizing CT Protocols:

Misconceptions

Scanning at 140 kV will reduce patient dose for any type of CT scan: head, body, adult or pediatric.

For head scans, 140 kV should be used through the posterior fossa region to reduce image artifacts from bone.

Recommendations for Scan and Imaging Parameters
Recommendations:

- The theoretical optimal kV for any CT imaging is the kV that will give the highest ratio of contrast to noise at a given patient dose.

- For all Head CT scans and all Head or Body Pediatric scans this “theoretical optimal” would be 80 kV.

- For Adult Body CT scans this “theoretical optimal” will range from 80 kV up to 140 kV.

- Modern CT scanners now have higher x-ray power & much more efficient use of this power through multi-slice design. They also have improved beam hardening/ bone correction algorithms. These features allow you to use lower kV settings.

Optimal kV Technique Setting for Axial or Helical Scanning

**kV – Head CT**

- Use 80 kV for Peds Head 0 - 3y w / wo contrast
- Use 80 kV for Peds Head 3 - 6y w contrast
- Use 100 kV for Peds Head 3 - 6y wo contrast
- Use 100 kV for Adult Head w contrast
- Use 120 kV for Adult Head w/o contrast

**kV – Body CT**

- Use 80 kV for Peds Body up to 80 lb
- Use 100 kV for Peds Body from 80 to 125 lb
**Optimal Technique Setting for Axial or Helical Scanning**

<table>
<thead>
<tr>
<th>kV – Body CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use <strong>100 kV</strong> for Small Adults below 125 lb</td>
</tr>
<tr>
<td>Use <strong>120 kV</strong> for Medium Size Adults.</td>
</tr>
<tr>
<td>Use <strong>140 kV</strong> for Large Adults for whom the sum of lateral and AP dimensions is greater than 75 cm.</td>
</tr>
<tr>
<td><strong>140 kV</strong> for Large Adults reduces image noise and provides better image quality without large exposure increases.</td>
</tr>
</tbody>
</table>

**kV**

**Recommendations:**

- For scanning the neck or upper thorax, the amount of lateral attenuation through the shoulders is a serious problem.
- It will cause some degree of horizontal streaking artifact through the shoulder, which is actually a noise effect.

**kV and Pitch - Pediatric**

**Misconceptions:**

- Using **140 kV** for children will generally raise the dose for equal image quality and is **not recommended**.
- Using a pitch greater than 1.0 for children is often strongly recommended to reduce radiation dose. **This is totally misguided.**
**Pitch**

**Misconceptions**

- Scanning at higher pitch should be used as a strategy to reduce patient dose and is the best way to reduce scan time and motion artifact and blur.

  **WRONG!!!**

**Pitch**

**Misconceptions:**

- A pitch of less than one over-irradiates the patient due to scanning overlap.
- Thus one should avoid using a pitch less than one, particularly in pediatric scans.

  **WRONG!!!**

**Pitch**

**Recommendations:**

- Changing the pitch from 1.0 to 0.5 increases the patient dose by a factor of 2 but also decreases image noise.
- The effects on dose and noise are the same as increasing the mA or the rotation time by a factor of 2, but with the added advantage of decreasing helical artifacts.

**Pitch**

**Recommendations:**

- The effect of increased dose at lower pitch is easily countered by reducing the rotation time or mA in manual mode.
- There is NO increase in dose when decreasing pitch in AEC mode since the AEC mode in all scanners will keep the dose constant.
Pitch Recommendations:
- Lowering the pitch and decreasing the exposure time by the same factor will keep the patient dose and exam time constant, but provide better image quality — you get something for nothing!

Pitch
- **Example:**
  - Change a 1.0 sec rotation time and a pitch of 1.1 to a 0.5 sec rotation time and a pitch of 0.55

Pitch
- **Recommendations:**
  - For head scanning ALWAYS use a pitch of less than 1.0 to minimize helical artifact.
  - Best results are usually with a pitch just above 0.5: 1.

Pitch
- **Recommendations:**
  - For body scanning use a pitch of less than 1.0 whenever possible to minimize helical artifact and allow more radiation for the adequate imaging of larger patients.
  - When decreasing pitch in body scans, you need to be aware of breath hold limitations and contrast considerations.
**Pitch**

**Recommendations:**
- Many people believe that increasing pitch is a proper dose reduction strategy – It is NOT!

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**Pitch**

**Recommendations:**
- Instead of increasing pitch, the proper dose reduction strategy is:
  1. Reduce the rotation time (will reduce dose in manual mode and is the first step in AEC mode).
  2. Reduce the effective mAs (in manual or AEC mode), reduce the mA (in manual mode, or increase the noise index (in AEC mode).
  3. Only then increase pitch if required to reduce total exam time.

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**Axial vs. Helical Scanning**

**Misconceptions:**
- Heads should always be scanned using the axial rather than the helical mode or you will get a lower quality image.
Axial vs. Helical Scanning

Recommendations:

- Helical scanning will almost always allow an exam with equal or better image quality than an axial scan if you have a CT scanner with 16 or more slices and select proper scan techniques.

- Axial scanning is still useful if required for positioning of the patient to avoid artifacts, since tilting the gantry is not allowed with helical scanning.

Advantages of Helical scanning:

- Shorter total scan time with less chance for patient motion during the scan.

- The ability to reconstruct slices at intervals less than the slice thickness. 
  
  **VERY IMPORTANT!**

Axial vs. Helical Scanning and slice reconstruction interval

Recommendations:

- With axial scanning, the slice reconstruction incrementation is normally equal to the slice thickness.

Axial vs. Helical Scanning and slice reconstruction interval

Recommendations:

- With helical scanning, the slice reconstruction incrementation can be set at any value. The best z-resolution is obtained by reconstructing at intervals \( \frac{1}{2} \) of the actual slice thickness – this particularly helps with multiplanar reformatting.

- This is a significant advantage of helical scanning that is often not utilized.
Detector Configuration

Misconceptions:
- The acquisition slice width (acquisition detector configuration) can always be equal to the reconstructed slice thickness.

Detector Configuration

Recommendations:
- Streaking artifacts off of bone and air are due to both beam hardening and partial volume artifacts.
- Thus it is important to use scan techniques to reduce partial volume artifacts.

Detector Configuration

Recommendations:
- To minimize partial volume artifacts in head scans always use the smallest detector width in acquiring the scan data, regardless of the image slice thickness.
- You may be restricted in some body scans since using the smallest detector width can also reduce the total beam width and increase the exam time.

Detector Configuration

Recommendations:
- For head scans this means using 16 x 0.5 mm, 16 x 0.6 mm, or 16 x 0.625 mm for a 16 slice scanner and using 32, 40, or 64 x 0.5, 0.6, or 0.625 mm for 32 to 64 slice scanners.
- Do not use 2.5 mm or 5 mm acquisition for example.
Detector Configuration
Recommendations:

- With a GE 16 slice scanner you can use a 16 x 0.625 acquisition for the best quality in the head, but this only gives you a 10 mm beam width.
- In the body you may need to go to a 16 x 1.25 acquisition which provides a 20 mm beam width and allows you to scan at twice the speed.

- However the 16 slice GE scanner also allows you to use it in an 8 slice mode: 8 x 1.25 mm or 8 x 2.5 mm - which should NEVER BE USED.
- Likewise the GE 8 slice scanner can also be used in a 4 slice mode - which again should NEVER BE USED.
With a manual technique of 120 kV, 600 mA, 0.5 sec, 0.75 pitch, what is the **effective mAs** used in this scan?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600 mAs</td>
</tr>
<tr>
<td>2</td>
<td>300 mAs</td>
</tr>
<tr>
<td>3</td>
<td>450 mAs</td>
</tr>
<tr>
<td>4</td>
<td>400 mAs</td>
</tr>
<tr>
<td>5</td>
<td>225 mAs</td>
</tr>
</tbody>
</table>

**Answer:** 4. 400 mAs

Effective mAs = 600mA * 0.5s / 0.75 = 400


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Which of the following changes in technique will decrease the image noise by a factor of 2?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Increase the slice thickness by a factor of 4</td>
</tr>
<tr>
<td>2</td>
<td>Increase the slice thickness by a factor of 2</td>
</tr>
<tr>
<td>3</td>
<td>Decrease the slice thickness by a factor of 2</td>
</tr>
<tr>
<td>4</td>
<td>Decrease the mAs by a factor of 2</td>
</tr>
<tr>
<td>5</td>
<td>Decrease the kV by 20 kV</td>
</tr>
</tbody>
</table>

**Answer:** 1. Increase the slice thickness by a factor of 4

For an AEC control that uses a quality reference (or target) effective mAs (mAsQR), if you change the kV from 120 to 80 and keep the mAsQR constant, how will the dose change?

0%  1. Increase by about a factor of 1.5
0%  2. Increase by about a factor of 3
0%  3. Remain approximately the same
0%  4. Decrease by about a factor of 1.5
0%  5. Decrease by about a factor of 3

Answer:  5. Decrease by about a factor of 3
Ref: Siemens Somatom Sensation Datasheet & Siemens Somatom Sensation Application Guide

For an AEC control that uses a Noise Index (NI) – or Standard Deviation (SD), if you change the kV from 120 to 80 and keep the NI or SD constant, how will the dose change?

0%  1. Increase by about a factor of 1.5
0%  2. Increase by about a factor of 3
0%  3. Remain approximately the same
0%  4. Decrease by about a factor of 1.5
0%  5. Decrease by about a factor of 3

Answer:  2. Increase by about a factor of 3
Starting with a manual technique of 120 kV, 400 mA, 1.0 sec, 0.75 pitch, which is the best way to reduce the dose by a factor of 2?

- 0% 1. 120 kV, 200 mA, 1.0 sec, 0.75 pitch
- 0% 2. 120 kV, 400 mA, 1.0 sec, 1.5 pitch
- 0% 3. 120 kV, 400 mA, 0.5 sec, 0.75 pitch
- 0% 4. 140 kV, 400 mA, 1.0 sec, 0.75 pitch
- 0% 5. 140 kV, 400 mA, 1.0 sec, 1.5 pitch

Answer: 3. 120 kV, 400 mA, 0.5 sec, 0.75 pitch

Which of the following axial slice thickness and slice incrementation combinations should be used to obtain soft tissue isotropic resolution and optimal image reformatting in a non-axial plane?

- 0% 1. 2.0 mm x 1.0 mm
- 0% 2. 1.2 mm x 1.2 mm
- 0% 3. 1.2 mm x 0.6 mm
- 0% 4. 0.6 mm x 0.6 mm
- 0% 5. 0.6 mm x 0.3 mm

Answer: 3. 1.2 mm x 0.6 mm