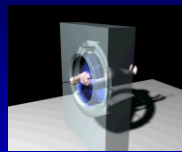
CT Protocol Optimization over the Range of CT Scanner Types:
Recommendations & Misconceptions



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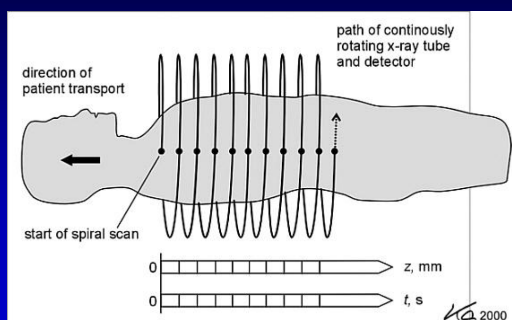
University of Wisconsin – School of Medicine & Public Health

TOPICS:

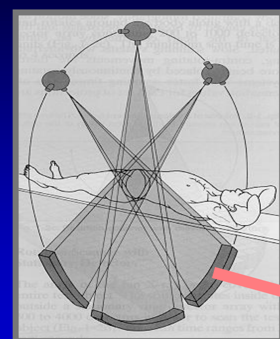
- Computed Tomography Quick Overview
- CT Dosimetry
- CT Image Quality
- Optimization of CT Scan Techniques for Dose & Image Quality

Evolution to Helical/ Spiral CT Scanners

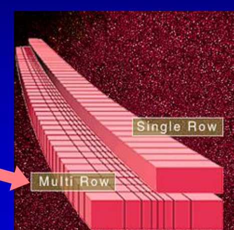
Single Slice Helical/ Spiral CT



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



Data Acquisition



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 Reformat: Ave., 5.0 mm thick & 2.5 mm interval		
	CT 1	**CT 2**	**CT 3**	**CT 4 &**	**East & RP CT**
Scanner	GE LS Xtra	GE LS 16	GE LS 16 Pro	GE LS VCT 64	GE LS 8
Scan Type	Helical	Helical	Helical	Helical	Helical
Rotation Time (sec)	0.5	0.5	0.5	0.5	0.5
Detector Coverage (mm) Beam Collimation (mm)	20	20	20	40	10
Detector Rows	16	16	16	64	8
Pitch	0.938	0.938	0.938	0.516	1.35
Speed (mm/rot)	18.75	18.75	18.75	20.64	13.5
Detector Configuration	16 x 1.25	16 x 1.25	16 x 1.25	64 x 0.625	8 x 1.25
Slice Thickness (mm)	1.25	1.25	1.25	1.25	1.25
Interval (mm)	0.625	0.625	0.625	0.625	0.625
Scan FOV	Large	Large	Large	Large Body	Large
kV	120	120	120	120	120
Smart mA/ Auto mA Range	150-660	120-440	120-660	60-660	180-440
Noise Index	24	24	24	24	24
(Manual mA)	570	440	460	240	440
Recon 1:					
DFOV	36	36	36	36	36
Recon Type	Standard	Standard	Standard	Standard	Standard
WW/ WL	325/15	325/15	325/15	325/15	325/15
Recon Option	Plus	Plus	Plus	Plus	Plus
Recon Option				IQ Enhance	
Recon 2:					
DFOV	36	36	36	36	36
Recon Type	Standard	Standard	Standard	Standard	Standard
WW/ WL	325/15	325/15	325/15	325/15	325/15
Recon Option	Plus	Plus	Plus	Plus	Plus
Slice Thickness (mm)	5.0	5.0	5.0	5.0	5.0
Interval (mm)	3.0	3.0	3.0	3.0	3.0

CT Protocols

Series 3 - Abdomen/ Pelvis --Medium Adult--			From Recon 1: Sa & Co Reformat: Ave., 5.0 mm thick & 2.5 mm interval		
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Scan FOV	Large	Large	Large	Large Body	Large
kV	120	120	120	120	120
Smart mA/ Auto mA Range	150-660	120-440	120-660	60-660	180-440
Noise Index	24	24	24	24	24
(Manual mA)	570	440	460	240	440

CT Protocols

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Recon Option				IQ Enhance	
Recon 2:					
DFOV	36	36	36	36	36
Recon Type	Standard	Standard	Standard	Standard	Standard
WW/ WL	325/15	325/15	325/15	325/15	325/15
Recon Option	Plus	Plus	Plus	Plus	Plus
Slice Thickness (mm)	5.0	5.0	5.0	5.0	5.0
Interval (mm)	3.0	3.0	3.0	3.0	3.0

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Dose in Computed Tomography

RADIATION UNITS

		New SI Units		Old Conventional Units
Absorbed Dose	*Units:*	**gray (Gy)**	or	**rad (r)**
Equivalent Dose	*Units:*	**sievert (Sv)**	or	**rem**
Effective Dose	*Units:*	**sievert (Sv)**	or	**rem**

RADIATION UNITS

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:

$$CTDI_w = 1/3\ CTDI_{100}\ (center) + 2/3\ CTDI_{100}\ (surface)$$

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:

$$CTDI_{vol} = CTDI_w\ /\ Pitch$$

  - 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:

$$DLP = CTDI_{vol} \times Scan\ Length$$

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:

Region of Body	E_{DLP} (mSv / mGy•cm)		Phantom
Head	0.0023	0.0021	16 cm
Head & Neck		0.0031	16 cm
Neck	0.0054	0.0059	32 cm
Chest	0.017	0.014	32 cm
Abdomen	0.015	0.015	32 cm
Pelvis	0.019	0.015	32 cm

⇑ 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:

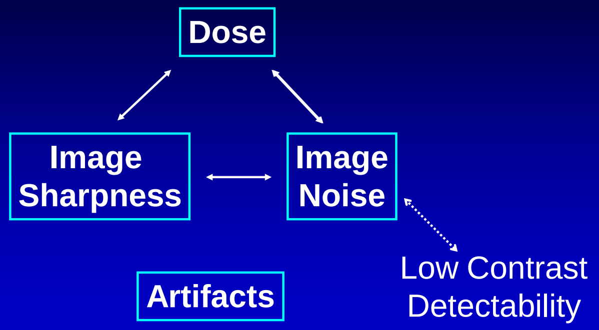


Image Reconstruction Filters, Algorithms, or Kernels

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.

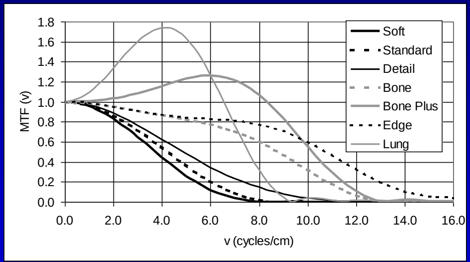


Image Reconstruction Filters, Algorithms, or Kernels (Siemens)

- Kernel names have 4 positions. Example: B31s.
- 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 j-FFS , no UHR comb), s=standard (with j-FFS , no UHR comb), h=highres (with j-FFS, no UHR comb), u=ultrahighres (with j-FFS, with UHR comb))
- The use of z-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).
B25m correspond to kernels B30m with ASA.
B35m is designed for Ca-scoring and quantitative analysis,
B36f is a sharper version of B35f,
B45m has intermediate resolution.
B46m is for investigations of patency of stents and for quantitative investigations.
B47m have resolution between B46m and B50m.
B50m, B60m, B70m are sharper kernels (for cervical spine, shoulder, extremities, thorax).
B65m is a special lungHR-kernel for quantitative evaluations.
B80m is a special lungHR-kernel (corresponding to HCE with B40m); not as sharp as B70m.
B18m are the kernels B10m with stronger de-ringing.
Br9m (r=1,2,3) are the PET/SPECT versions of Br0m.
B75m (m=f,h) are lungHR kernels with less overshooting at edges.

H10f, H19f, H20f, H21f, H22f, H23f, H29f, H30f, H31f, H32f, H37f, H39f, H40f, H41f, H42f, H45f, H47f, H48f, H50f, H60f,

H10s, H19s, H20s, H21s, H22s, H23s, H29s, H30s, H31s, H32s, H37s, H39s, H40s, H41s, H42s, H45s, H47s, H48s, H50s, H60s,

H70h, H80h (Open only).

H40m (m=f, s) is the standard kernel,
H30m, H20m or H10m lead to softer images.
Hr1m (r=2,3,4) yield the same visual sharpness as Hr0m, but have a finer noise structure (better image impression, improved LC). Therefore Hr1m are used in standard protocols.
Hr2m are the kernels Hr0m without PFO.
H23m serves for Neuro PBV.
H37m, H47m, H48m are alternative kernels with different noise impression.
H45m serve for intermediate resolution,
H50m, H60m are sharper kernels.
Hr9m (r=1,2,3) 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

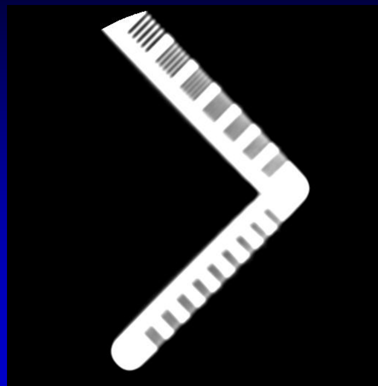
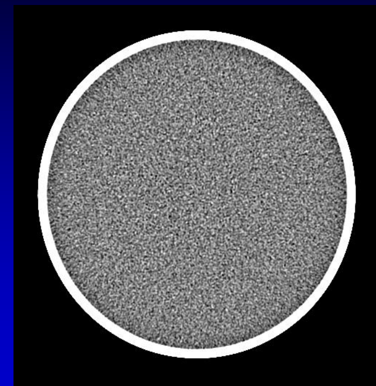


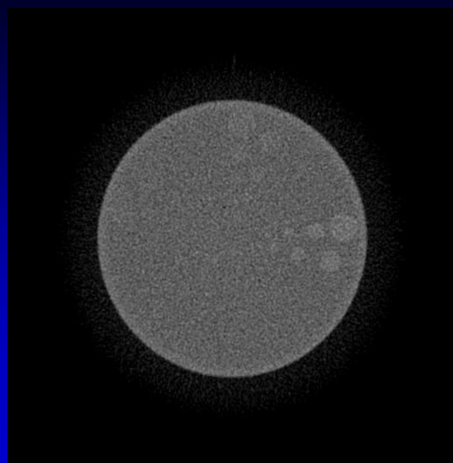
Image Noise:

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



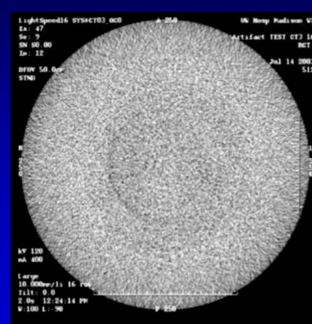
Low Contrast Detectability:

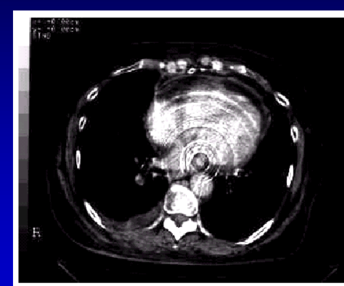
Images of a low contrast detectability pattern imaged using mAs values incrementing by a factor of 2, from 50 mAs to 1600 mAs.



Artifacts from Data Acquisition Problems

- Ring Artifacts





Artifacts from Data Acquisition Problems

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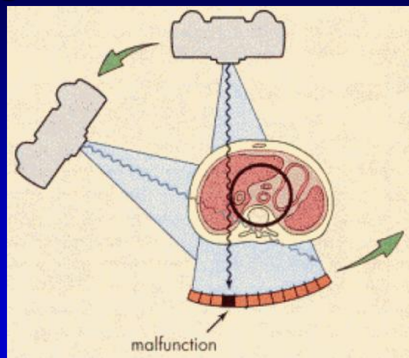
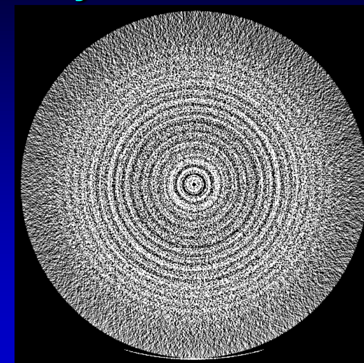
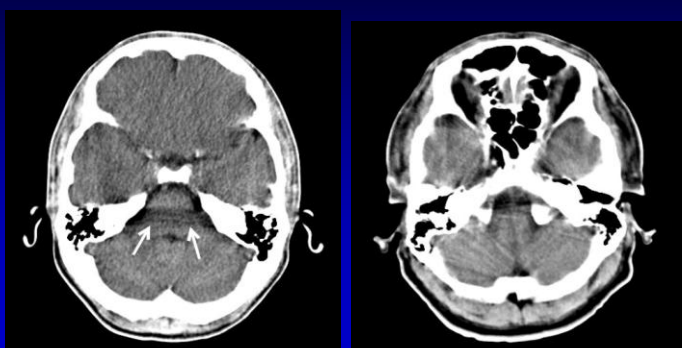


Ring Artifacts Detected with a Large Uniformity Phantom

- 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



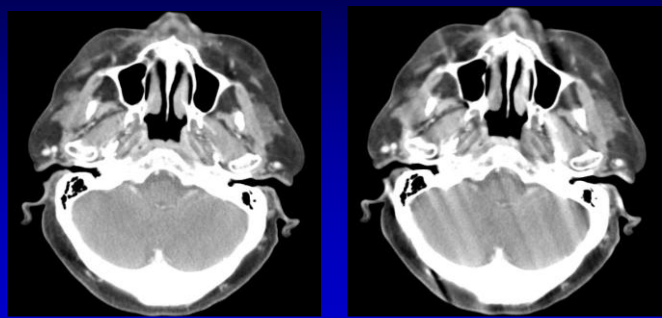
Beam Hardening Artifacts

"Small body" reconstruction without iterative correction

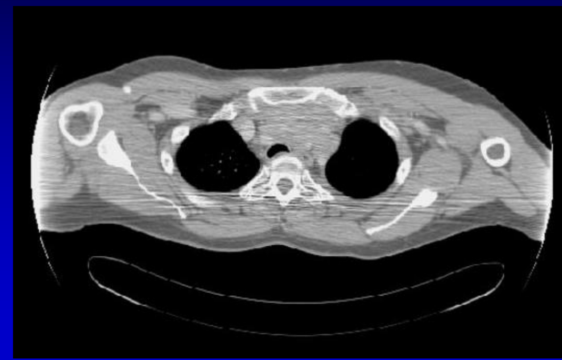
"Head" reconstruction **with** iterative correction

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:

$$Pitch_{coll} = \frac{\text{Table travel per 360° tube rotation}}{\text{Total collimation width of all simultaneously collected slices}}$$

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

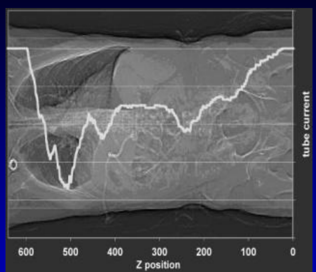
One big defect of CT Scanners before 2001

- 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.

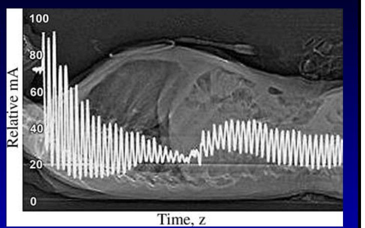
Automatic Exposure Control in CT Scanners

- 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.

Automatic Exposure Control in CT Scanners



The scanner varies the mA at different axial positions of the patient.



The scanner varies the mA at different axial positions of the patient and also varies the mA as the tube rotates around the patient.

Automatic Exposure Control in CT Scanners

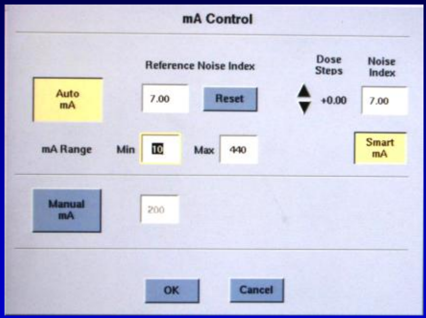
- Caution: The methods used by different manufacturers to perform AEC in CT are very different and may achieve very different clinical results.

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.

Automatic Exposure Control in CT Scanners

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.

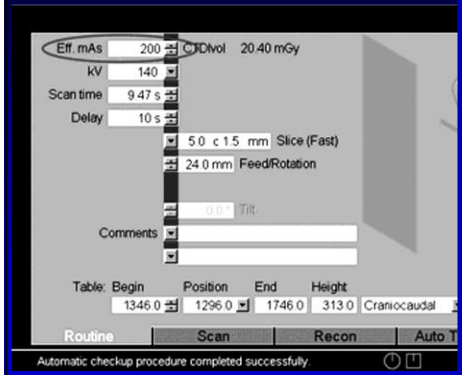
Automatic Exposure Control in CT Scanners

- 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

Automatic Exposure Control in CT Scanners

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.

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Automatic Exposure Control in CT Scanners

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.

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Automatic Exposure Control in CT Scanners

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.

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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

and

Recommendations

for

Scan and Imaging Parameters

kV

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.

kV

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.

kV

Recommendations:

- 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

Optimal kV Technique Setting for Axial or Helical Scanning

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

kV – Body CT

- Use 100 kV for Small Adults below 125 lb
- Use 120 kV for Medium Size Adults.
- Use 140 kV for Large Adults for whom the sum of lateral and AP dimensions is greater than 75 cm.
  - 140 kV for Large Adults reduces image noise and provides better image quality without large exposure increases.

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

Recommendations:

- Here the solution is to *increase* the kV from 120 kV to 140 kV to reduce the amount of lateral attenuation through the shoulders as much as possible and thus reduce this “noise” streaking artifact.

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

Recommendations:

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!

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.

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.**

Axial vs. Helical Scanning and slice reconstruction interval

Recommendations:

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 ½ 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 <u>acquiring</u> 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.**
- **<u>Do not</u> 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.

Detector Configuration

Recommendations:

- 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.

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With a manual technique of 120 kV, 600 mA, 0.5 sec, 0.75 pitch, what is the **effective mAs** used in this scan ?

0% 1. 600 mAs
0% 2. 300 mAs
0% 3. 450 mAs
0% 4. 400 mAs
0% 5. 225 mAs

10

With a manual technique of 120 kV, 600 mA, 0.5 sec, 0.75 pitch, what is the **effective mAs** used in this scan ?

0% 1. 600 mAs
0% 2. 300 mAs
0% 3. 450 mAs
0% 4. 400 mAs
0% 5. 225 mAs

Answer: 4. 400 mAs

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

Ref: M Mahesh, *MDCT Physics – The Basics* (2009)

10

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

0% 1. Increase the slice thickness by a factor of 4
0% 2. Increase the slice thickness by a factor of 2
0% 3. Decrease the slice thickness by a factor of 2
0% 4. Decrease the mA by a factor of 2
0% 5. Decrease the kV by 20 kV

10

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

0% 1. Increase the slice thickness by a factor of 4
0% 2. Increase the slice thickness by a factor of 2
0% 3. Decrease the slice thickness by a factor of 2
0% 4. Decrease the mA by a factor of 2
0% 5. Decrease the kV by 20 kV

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

Ref: M. McNitt-Gray, "AAPM/RSNA Physics Tutorial for Residents: Topics in CT: Radiation Dose in CT," RadioGraphics 2002; 22:1541–1553 .

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For an AEC control that uses a quality reference (or target) effective mAs (mAs_{QR}), if you change the kV from 120 to 80 and keep the mAs_{QR} 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

10

For an AEC control that uses a quality reference (or target) effective mAs (mAs_{QR}), if you change the kV from 120 to 80 and keep the mAs_{QR} 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

10

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

10

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

Ref: H. Brisse, "Automated exposure control in multichannel CT with tube current modulation to achieve a constant level of noise." Med. Phys. 34 (7), July 2009.

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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

10

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

Ref: J Hsieh, *Computed Tomography – Principles, Design, Artifacts, and Recent Advances* (2009)

10

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

10

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

Ref: W. Kalender, *Computed Tomography – Fundamentals, System, Technology, Image Quality, Applications* (2011)

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