AAPM Computed Tomography Automatic Exposure Control Education Slides

Many of the terms used in these slides can be found in the CT Terminology Lexicon

http://www.aapm.org/pubs/CTProtocols/documents/CTTerminologyLexicon.pdf

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Vendor Specific Slide Details

- The presence of a vendor name in the title of the slide indicates that the slide is vendor specific slide

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Motivation

- These slides are provided to aid in understanding the factors that affect performance of Automatic Exposure Control, specifically image quality and radiation dose, in CT studies

Outline

- Effect of CT scan projection radiograph on AEC

- Image quality reference parameter for AEC

- Effect of patient size on AEC

- Effect of scanned anatomy

- Effect of first or expected reconstruction settings

- Advanced AEC features

Effect of CT Localizer

- The CT scan projection radiograph(s) provide the initial data to inform the behavior of the AEC

- The apparent size of the patient on the scan projection radiograph(s) or the measured attenuation are used to set the initial dose level for the exam

- The scan projection radiograph(s) may also be used to adjust the longitudinal or angular tube current modulation

- The use of multiple scan projection radiographs and the order of their acquisition may affect the behavior of the system's AEC

Effect of CT Localizer - Canon

- If only one scan projection radiograph is acquired, the choice of the scan projection radiograph (AP vs. LAT vs. PA) does impact AEC calculations

  - If only one scan projection radiograph is acquired, patient thickness in the other direction will be estimated from that scan projection radiograph.

  - If only the LAT scan projection radiograph is acquired, photon starvation through the shoulders may impact the result.

- If two scan projection radiographs are acquired, the order of the scan projection radiograph (AP + LAT vs LAT + AP) does impact AEC calculations

Effect of CT Localizer- Canon

- The scanning parameters (e.g. tube voltage, mA) of the scan projection radiograph do impact AEC calculations
  - At excessively low values of mA, AEC calculations can be compromised. Tube voltage does not affect calculations, unless mA is excessively low.
  - Representative protocols (Aquilion GENESIS, 320 row)
    - Routine Brain (Volume)

Scanogram - Lateral Scanogram Below base of skull to vertex									
Scan mode	Start time (s)	Wait time (s)	kV	mA	Range (mm)	Direction	Display filter	Scano angle	CE
Scanogram(Lat)	0.00	0.00	120	50	240.0	OUT	Standard (FL04)	90	OFF

Scanogram - AP Scanogram									
Scan mode	Start time (s)	Wait time (s)	kV	mA	Range (mm)	Direction	Display filter	Scano angle	CE
Scanogram(AP)	0.00	0.00	120	50	240.0	IN	Standard (FL04)	0	OFF

    - Adult chest, non-contrast

Scanogram - AP Scanogram Above shoulders to below liver									
Scan mode	Start time (s)	Wait time (s)	kV	mA	Range (mm)	Direction	Display filter	Scano angle	CE
Scanogram(AP)	0.00	0.00	120	50	500.0	OUT	Standard (FL04)	0	OFF

Scanogram - Lateral Scanogram									
Scan mode	Start time (s)	Wait time (s)	kV	mA	Range (mm)	Direction	Display filter	Scano angle	CE
Scanogram(Lat)	0.00	0.00	120	100	500.0	IN	Standard (FL04)	90	OFF

Effect of CT Localizer – vendor recommendations: Canon

- For head exams, systems do not generally use AEC. For neck exams,
  - Two scan projection radiographs,
  - Lateral first
  - Fixed tube voltage for scan projection radiograph

- For chest/abdomen/pelvis exams it is recommended to use:
  - Two scan projection radiographs,
  - AP first
  - Fixed tube voltage for scan projection radiograph

Effect of CT Localizer - Canon

- Mis-centering of the patient does not impact AEC calculations

  – *Software will correct mis-centering.*

- If a patient appears mis-centered in the scan projection radiograph, the operator can judge the centering of the patient from the console and can compensate for the mis-centering without entering the scanner room

  – Most of Canon scanners with newer software versions offer a standard feature called ^{SURE}Position that permits patient centering from the console.

- Once the patient mis-centering has been corrected, it is not recommended that a new scan projection radiograph be acquired for accurate AEC calculations

Effect of CT Localizer - Canon

- If the prescribed CT scan range exceeds the range of the acquired scan projection radiograph, the AEC algorithm:

  - Uses the same technique for the scan range beyond the scan projection radiograph as the closest z location included in the scan projection radiograph

Image quality reference parameter for AEC

- The image quality reference parameter for AEC is generally a measure of image quality in the reconstructed images

- The image quality reference parameter for AEC has a unique relationship with both tube output and patient size

- Specifically, the Image quality reference parameter is used together with the patient attenuation profile (as estimated by the CT scan projection radiograph) to determine the tube output for a particular exam

- The operation of the AEC may be independent of the reconstruction parameters, or related to them

Image quality reference parameter(s) for AEC - Canon

- The primary image quality reference parameter for AEC for this manufacturer is a standard deviation based <u>metric.</u>

- AEC calculation does not use a reference patient size.

Effect of image quality reference parameter for AEC - Canon

- The tube output (i.e., effective mAs) has the following relationship with the image quality reference parameter for AEC (all other factors being equal):
  - In general, as tube output goes down, standard deviation goes up.

Effect of patient size - Canon

- The tube output (i.e., effective mAs) has the following relationship with the size of the patient (all other factors being equal):
  - A less than exponential increase, to provide higher image noise for larger patients, and lower image noise for smaller patients

Effect of scanned anatomy - Canon

- The tube output (i.e., effective mAs) is independent of the organ or anatomy being scanned (all other factors being equal)
  - The behavior of the tube current modulation does not vary with the anatomical site being scanned. Rather, the target image quality level varies.

Effect of first or expected reconstruction settings - Canon

- The tube output (i.e., effective mAs) is not affected by the first/expected reconstruction for that protocol (all other factors being equal)

- The tube output is determined by global AEC settings (rather than protocol specific parameters) that specify a reconstruction algorithm and kernel, as well as slice thickness, for tube output determination.

Advanced AEC Features Outline

- AEC in cardiac exams

- Unusual attenuation profiles
  - Head/Neck exams (strategy to handle abrupt change of attenuation profile)
  - Extremity exams
  - Neonates and very small children
  - Metal/Foreign objects within Scan FOV
  - Obese patients

- Automatic tube voltage selection

- Organ based tube current modulation

AEC in cardiac exams - Canon

- ECG-based tube current modulation is available

- When ECG-based tube current modulation is activated:
  - there is simultaneous Longitudinal (z) tube current modulation
  - there is simultaneous Angular (x-y) tube current modulation

AEC in cardiac exams - Canon

- In Prospective Triggering Mode with table movement,
  - there is option for tube current modulation at selected cardiac phase range.
    - System will calculate the mA using ^{Sure}Exposure setting
  - there is Adaptive triggering to handle irregular heart beat.

  Prospective scanning has Arrhythmia Rejection Control:
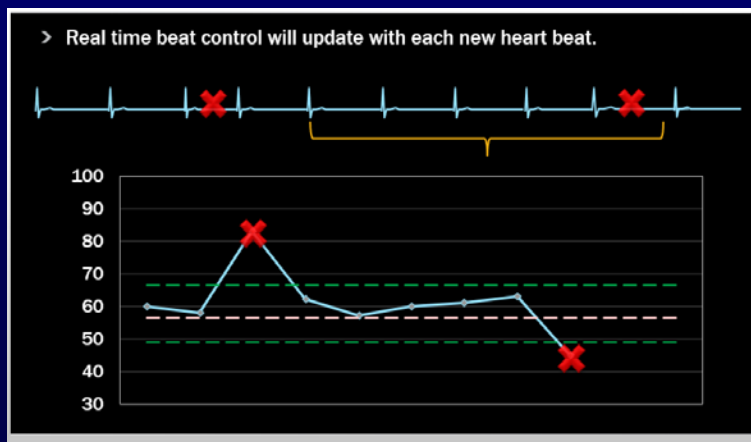
AEC in cardiac exams - Canon

- In Retrospective Gating Mode with table movement,
  - there <u>is</u> an option for tube current modulation at selected cardiac phase range
  - For the cardiac phase range where the user intends to reduce dose, the reduction of tube current is selectable by user
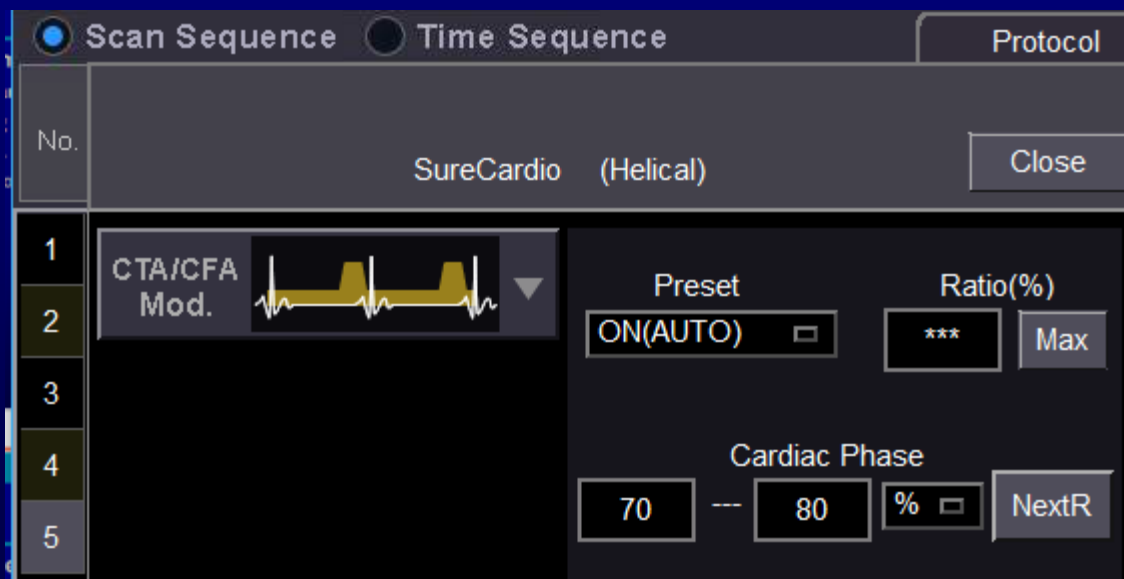
AEC in cardiac exams - Canon

- In cardiac acquisition without table movement (i.e. using wide beam collimation),
  - within one heart beat (R-R interval), there is ECG based tube current modulation at selected phase range
  - at multiple heart beats (R-R interval), there is ECG based tube current modulation at selected phase range
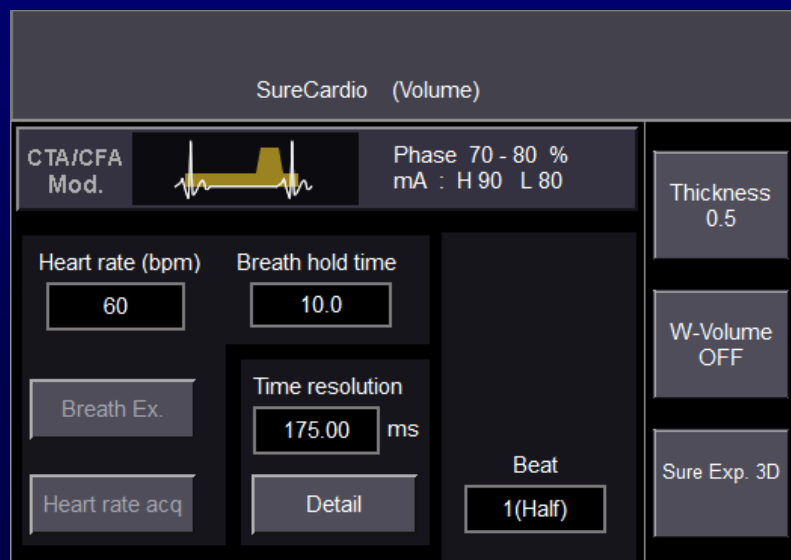
Unusual attenuation profiles - Canon

- For head/neck exams, there is no specific recommended direction to scan the patient for best AEC dose modulation

- To achieve ideal image quality/dose performance, there is dedicated AEC parameter settings for head/neck exams.
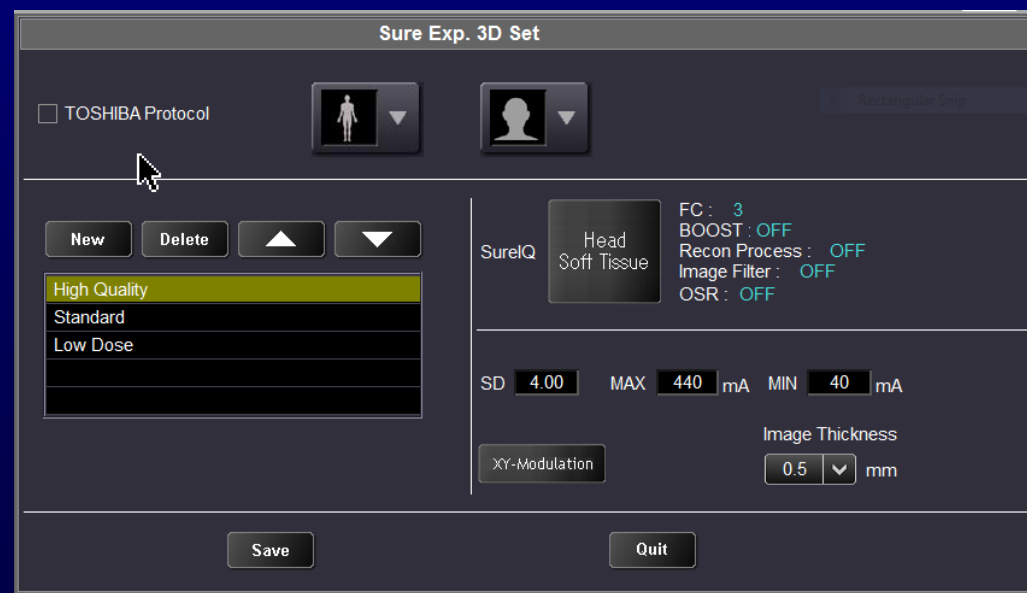
Unusual attenuation profiles - Canon

- The following are clinical scenarios where achieving desired image quality/dose performance can be challenging with the use of AEC. If applicable to your system, please provide comments/cautions accordingly:

  – Scanning neonates and very small children

  – There are Metal/Foreign objects within scan FOV

  – Extremity exams:

    • Lower extremity

    • Upper extremity with arm(s) raised up above the shoulder

    • Upper extremity with arms(s) kept down aside the torso

No specific recommendation

Unusual attenuation profiles - Canon

- For scans where the tube power limitations are reached using AEC, automatic adjustment of the scanning parameters is not available

  - Canon systems alert the technologist, but do not automatically change the parameters

Automatic Tube voltage selection - Canon

- Automatic tube voltage selection based on the CT localizer scan(s) is available
  - All systems

- Automatic tube voltage selection algorithm is dependent on whether contrast media is used for the exam

Automatic Tube voltage selection - Canon

- Please list the parameters that specifically control the automatic tube voltage selection for this manufacturer. If applicable, please provide screenshot(s) of user interface.

  – Auto kV parameters are by kV level for Adult and Peds, with and without contrast for regions: Head, neck, body and cardiac

Automatic Tube voltage selection - Canon

- The tube voltage is automatically selected based on the patient attenuation profile and exam type using the following principle
  - Lowest tube voltage that can be selected without reaching a maximum tube output

Automatic Tube voltage selection - Canon

- The user <u>is</u> allowed to disable specific tube voltages for each exam using automatic tube voltage selection

- Canon recommends use of Auto kV for CT Angiography and contrast studies, as a lower kV selection can increase the appearance of iodinated contrast agents. The user is able to override the system to select an alternate kV if necessary

Organ based tube current modulation - Canon

- Organ-based tube current modulation is available
  - Organ Effective Modulation is available on all systems

- The change in tube output (i.e. effective mAs) for projections over the organ of interest is up to -60% (*positive for increase, negative for decrease*)

- There <u>is not</u> compensation in tube output for projections outside the "organ of interest" range.

Organ based tube current modulation - Canon

- If organ-based modulation is activated for a CT scan, the total tube output (mAs) is lower than without organ-based modulation with other scanning conditions kept the same.

- When organ-based modulation is enabled, there is not restriction on other scanning techniques (i.e. rotation time, pitch).

- Organ-based modulation is available for the following exam types:
  - Head, body, cardiac

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