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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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 localizer 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 localizer(s) provide the initial data to inform the behavior of the AEC
- The apparent size of the patient on the localizer(s) or the measured attenuation are used to set the initial dose level for the exam
- The localizer(s) may also be used to adjust the longitudinal or angular tube current modulation
- The use of multiple localizers and the order of their acquisition may affect the behavior of the system's AEC

Effect of CT Localizer – Hitachi

- If only one localizer is acquired, the choice of the localizer (AP vs. Lateral vs. PA) does impact AEC calculations

- If two localizers are acquired, the order of the localizer (AP + LAT vs LAT + AP) does not impact AEC calculations

Effect of CT Localizer – Hitachi

- The scanning parameters (e.g. tube voltage, mA) of the localizer do not impact AEC calculations

Effect of CT Localizer – vendor recommendations – Hitachi

- For head/neck exams it is recommended to use:
  - Two localizers
  - Lateral localizer, if only one localizer is used
  - Lateral first, if two localizers are used
  - Fixed tube voltage for localizer
  - a minimum of 120 kV and 25/25 mA on an average size adult patient for AP/PA and lateral, respectively
- For chest/abdomen/pelvis exams it is recommended to use:
  - Two localizers
  - PA localizer, if only one localizer is used
  - PA first, if two localizers are used
  - Fixed tube voltage for localizer
  - a minimum of 120 kV and 25/25 mA on an average size adult patient for AP/PA and lateral, respectively

Effect of CT Localizer – Hitachi

- Mis-centering of the patient does impact AEC calculations
- If a patient appears mis-centered in the localizer, the operator can judge the centering of the patient from the console and can compensate for the mis-centering horizontally without entering the scanner room for some products but cannot compensate for the mis-centering vertically without entering the scanner room

Effect of CT Localizer – Hitachi

- Once the patient mis-centering has been corrected, it is recommended that new localizer(s) be acquired for accurate AEC calculations.

Effect of CT Localizer – Hitachi

- If the prescribed CT scan range exceeds the range of the acquired localizer, the AEC algorithm (pick the one that applies):
  - Uses the same technique for the scan range beyond the localizer as the closest z location included in the localizer

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 localizer) 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 – Hitachi

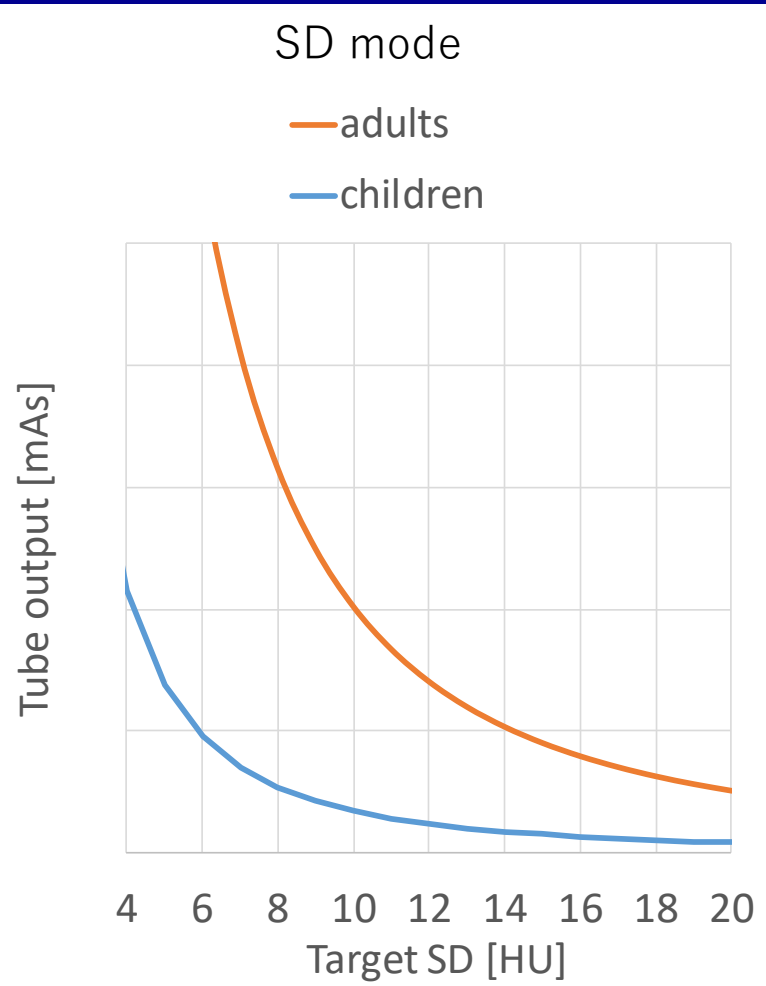
- The primary image quality reference parameter for "SD mode" of AEC for this manufacturer is called Target SD.
- The primary image quality reference parameter for "CNR mode" of AEC for this manufacturer is called Reference SD and standard body weight("std weight" in the following).
  - The "std weight" is different for adults and children. Operators can set them on "Preference Settings window". Their default values are 69kg and 22kg for adults and children respectively.

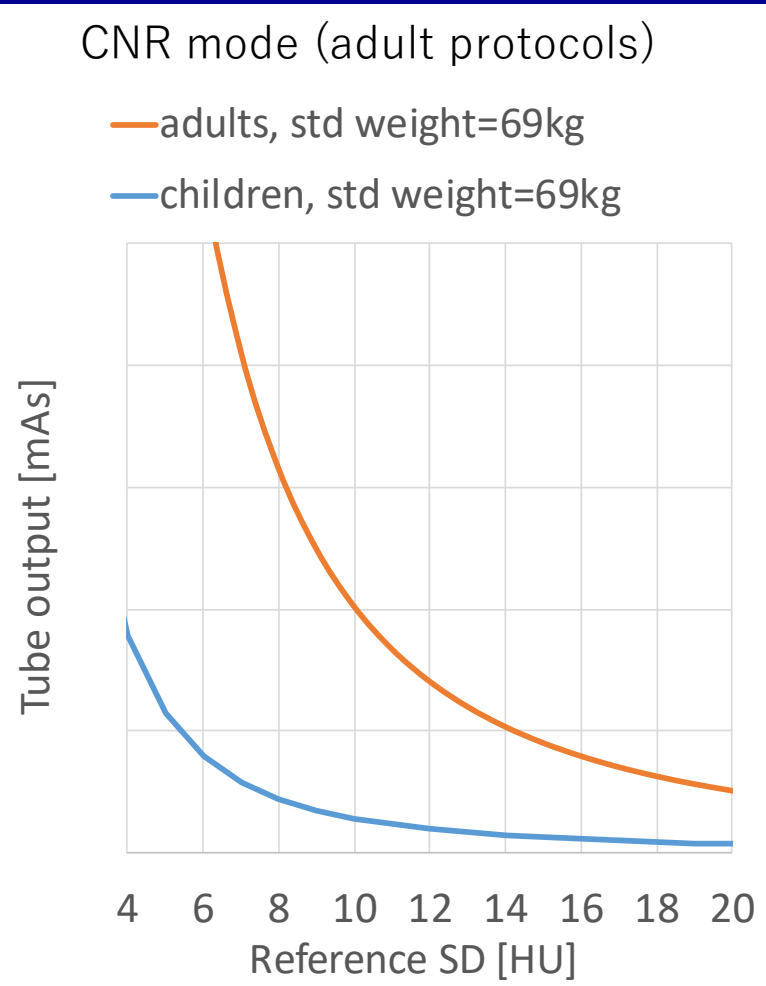
Effect of image quality reference parameter for AEC – Hitachi

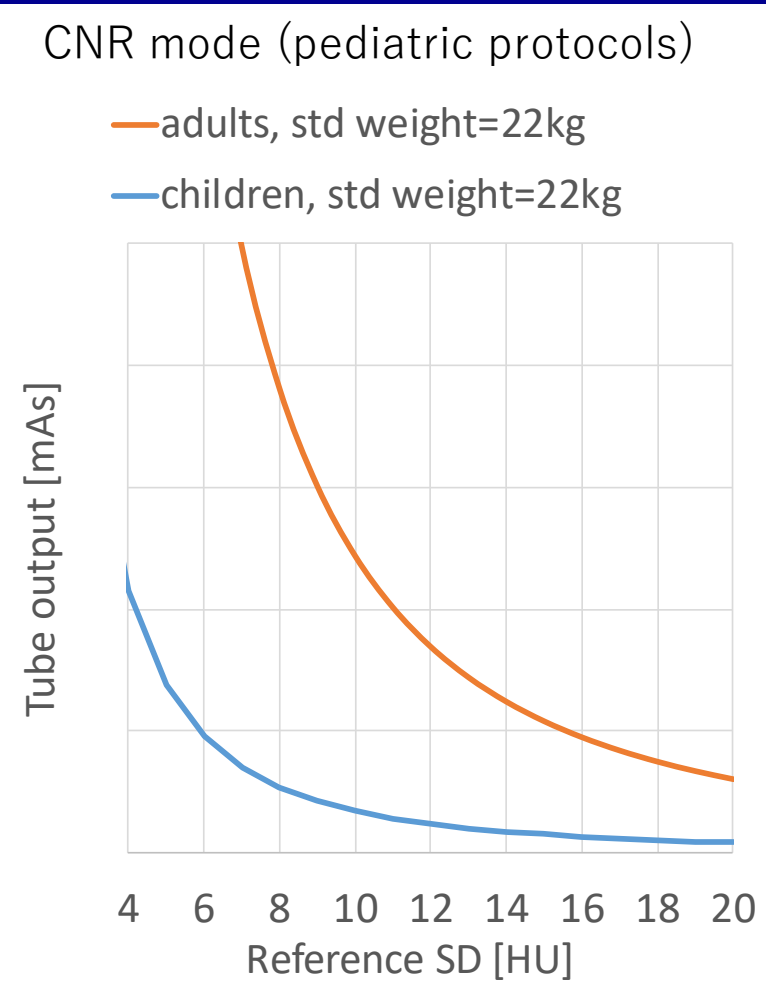
- The tube output (i.e., effective mAs) has the following relationship with the image quality reference parameter for AEC (all other factors being equal):
  - Inverse square root

- Please provide a curve or schematic showing the tube output vs image quality reference parameter profile for one or more patient attenuation values (next page).

Effect of image quality reference parameter for AEC – Hitachi





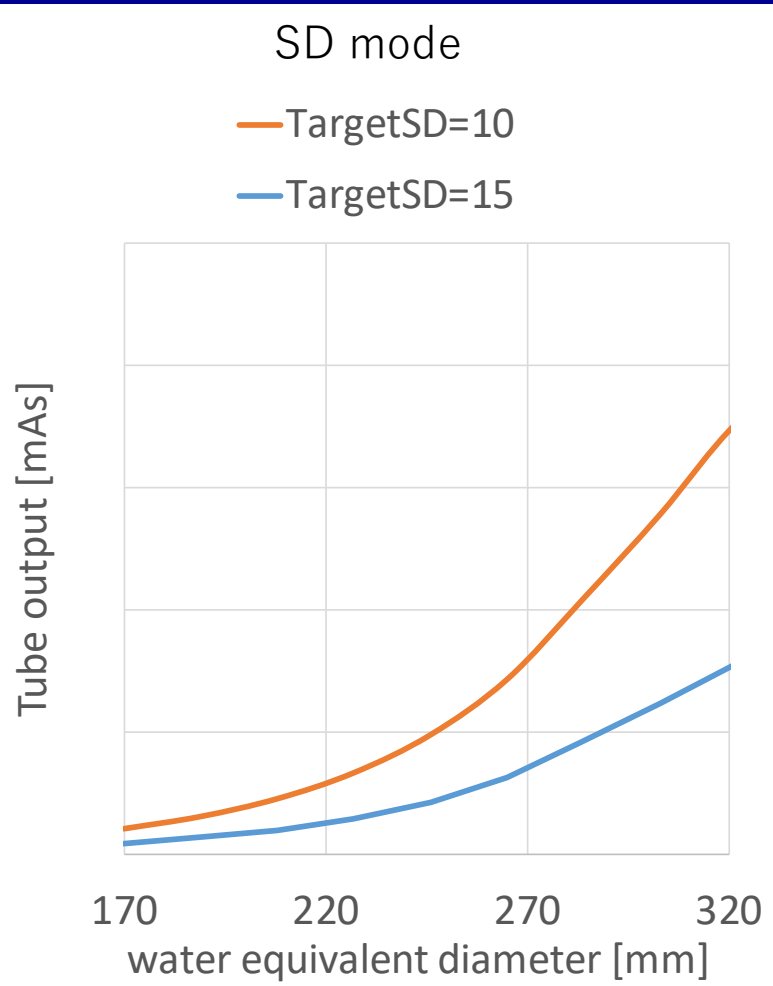


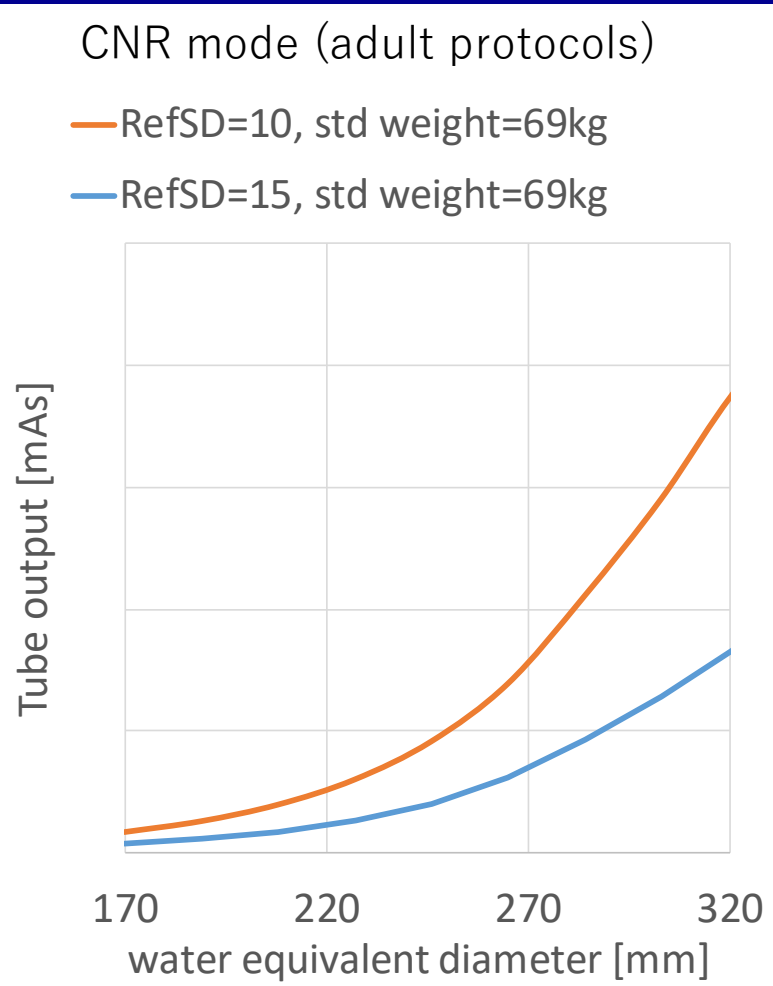
Effect of patient size – Hitachi

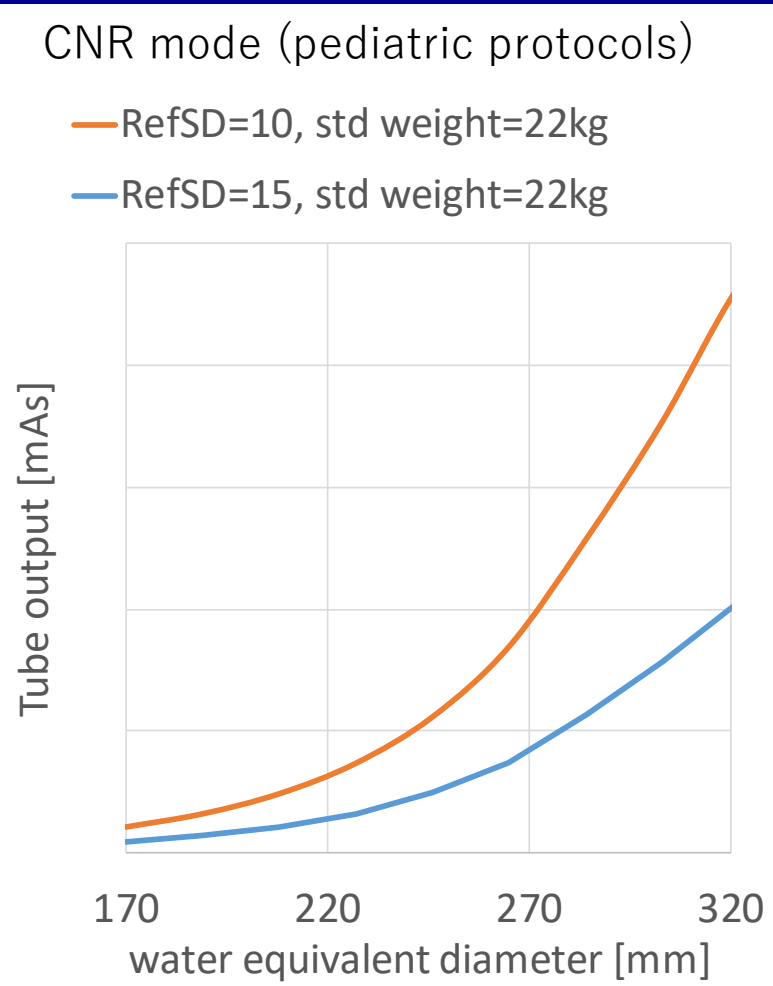
- The tube output (i.e., effective mAs) has the following relationship with the size of the patient (all other factors being equal):
  - Exponential increase, to provide constant noise across patient sizes for SD mode
  - A more than exponential increase, to provide lower image noise for larger patients,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

- Please provide a plot showing the tube output vs patient size (effective or water equivalent diameter) profile for one or more values of the image quality reference parameter for AEC (next page).

Effect of Patient Size – Hitachi







Effect of scanned anatomy – Hitachi

- The tube output (i.e., effective mAs) is independent of the organ or anatomy being scanned (all other factors being equal)

- If the organ or anatomy being scanned affects the tube output (other than intrinsic differences in attenuation), please describe which parameter in the CT protocol affects this particular behavior.

Effect of first or expected reconstruction settings – Hitachi

- The tube output (i.e., effective mAs) is affected by the first reconstruction for that protocol (all other factors being equal)
- If the first or expected reconstruction affects the tube output, please describe which parameters in the CT protocol affect this particular behavior, and how they influence the tube output.
  - image slice thickness : provides higher tube output with thinner thickness.
  - B.G.C. : provides higher tube output in the case of ON.
  - B.H.C.(for head) : provides higher tube output in the case of OFF.
  - *filter : provides higher tube output with sharper filter.
  - *image filter : provides higher tube output with sharper image filter.

*filter and image filter can be set independently for some products.

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 – Hitachi

- ECG-based tube current modulation is available
  - If only certain scanners have the feature, please specify
  - SCENARIA, SCENARIA View

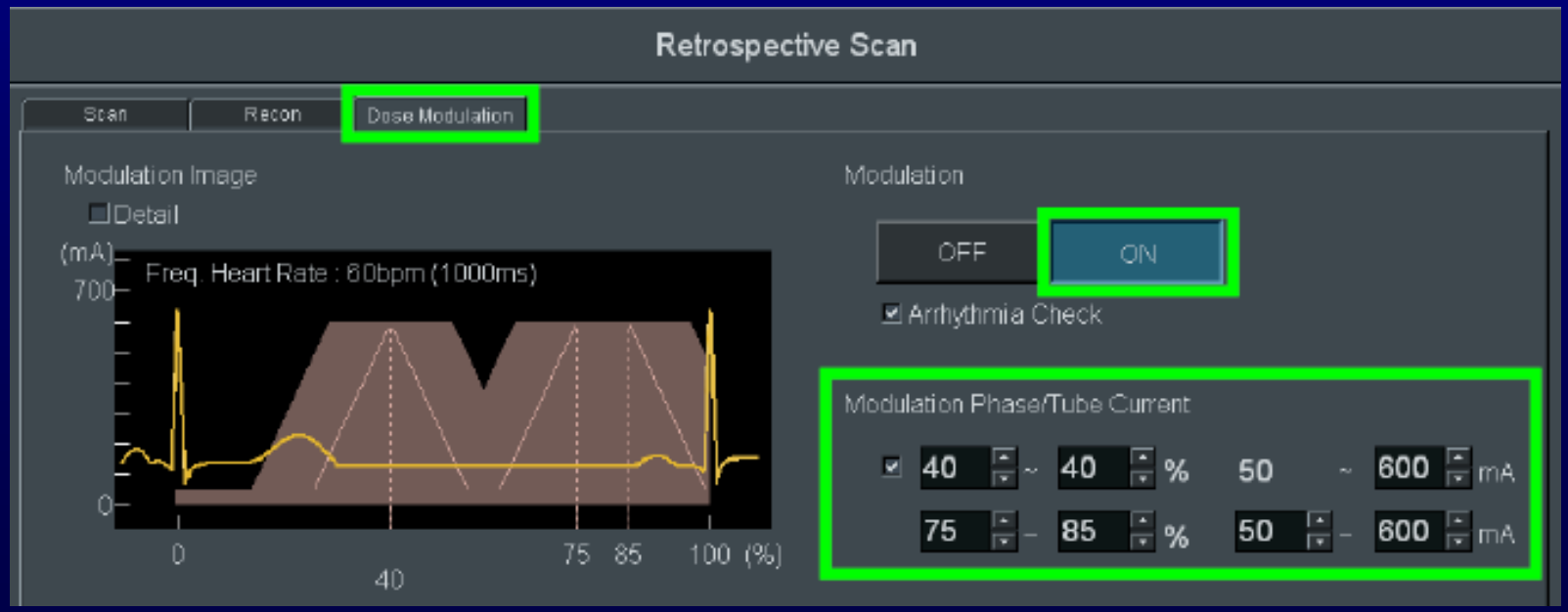
- When ECG-based tube current modulation is activated:
  - there is not simultaneous Longitudinal (z) tube current modulation
  - there is not simultaneous Angular (x-y) tube current modulation

AEC in cardiac exams – Hitachi

- In Prospective Triggering Mode with table movement,
  - there is not option for tube current modulation at selected cardiac phase range.
  - there is not Adaptive triggering to handle irregular heart beat.

AEC in cardiac exams – Hitachi

- In Retrospective Gating Mode with table movement,
  - there is option for tube current modulation at selected cardiac phase range
  - If the answer to above question is Yes, for the cardiac phase range where the user intends to reduce dose, the reduction of tube current is freely selected.



AEC in cardiac exams – Hitachi

- In cardiac acquisition without table movement (i.e. using wide beam collimation),
  - N/A

Unusual attenuation profiles – Hitachi

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

- To achieve ideal image quality/dose performance, there is not dedicated AEC parameter settings for head/neck exams.

Unusual attenuation profiles – Hitachi

- 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.

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