Ask EuroSafe Imaging
Tips & Tricks

CT Working Group

Automatic Exposure Control (Automatic Tube Current Modulation)

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Background

Automatic exposure control (AEC) is an important tool to reduce patient dose, reduce the load on the X-ray tube, reduce starvation artefacts and help the operator to achieve good image quality throughout the examination regardless of patient attenuation[1].

The technique has evolved since the '90s[2] and varies between different vendors[3].

There are many aspects that the operator should be aware of as there are many parameters and behaviors that can affect the final dose to the patient or the final image quality.

This presentation will highlight some of these differences and pitfalls but cannot replace a close collaboration with the vendors regarding updated recommendations and upgrades on user-specific AEC.

Longitudinal modulation

Fixed mA results in unnecessary dose and uneven image quality throughout the scan.

Longitudinal tube current modulation works along the z-axis and lowers the mA in less dense and massive areas whilst increasing the mA where it is needed (shoulders and hips).

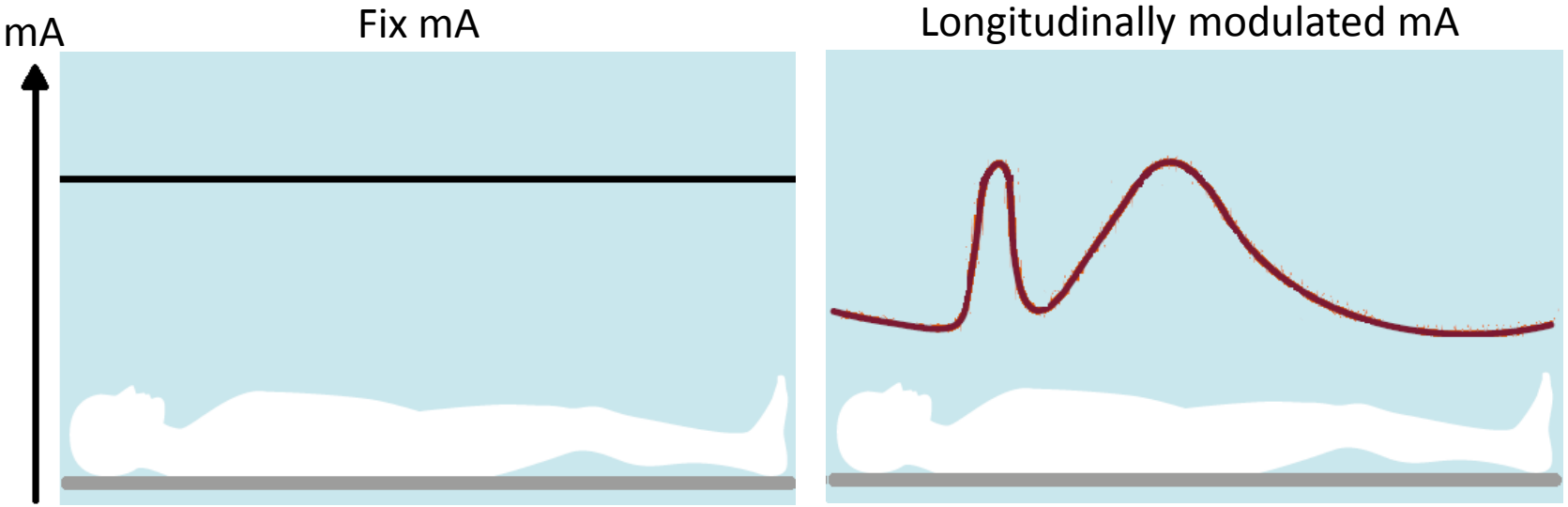


Image courtesy of Siemens

Angular modulation

The human body varies in size and density not only from head to toe, but also within the human cross-section. The shoulders being especially known to cause starvation artefacts (streaks between the shoulders that distort the anatomy in-between).

Angularly modulated mA in combination with longitudinal modulation

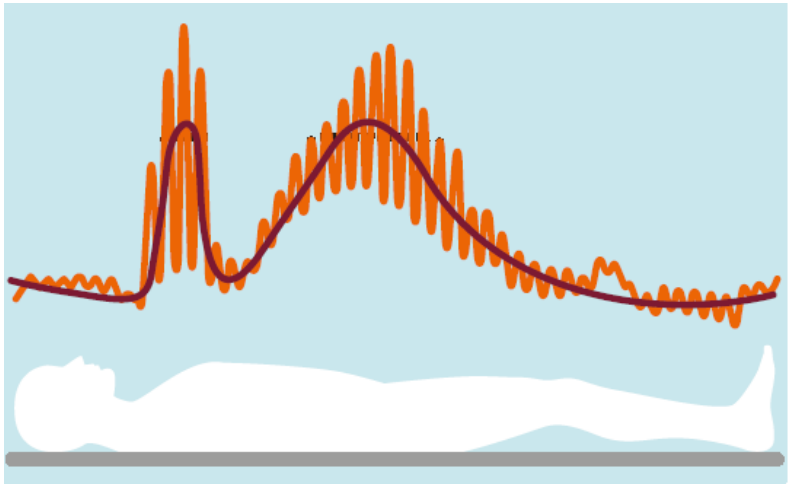


Image courtesy of Siemens

Angular tube current modulation changes the mA during the rotation (xy-axis). For the shoulders, the tube current increases laterally but decreases in the PA/AP projections.

Short summary of techniques[2]

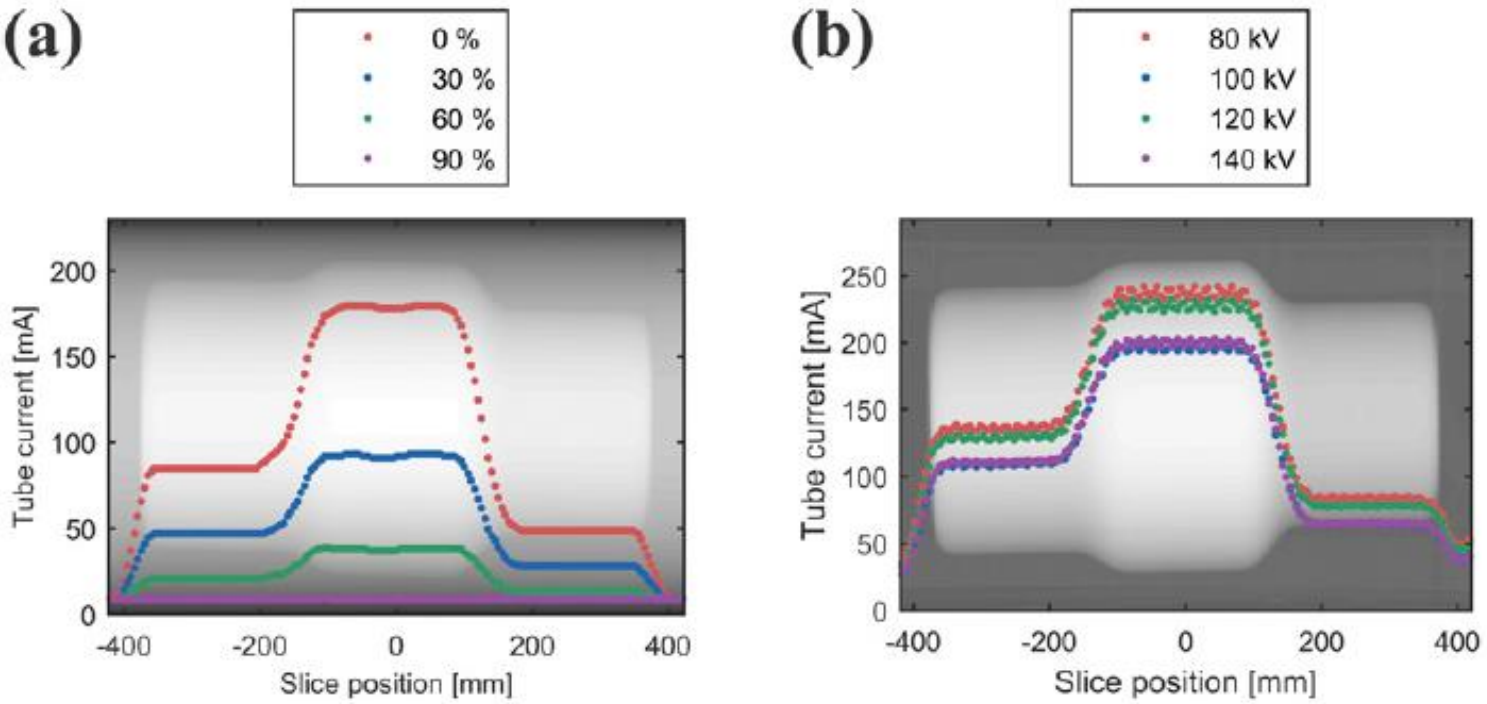
Table 1. Specification of the automatic tube current modulation systems of the CT scanners investigated in the study

	GE Revolution CT	Philips Brilliance iCT 256	Siemens SOMATOM® Force	Toshiba Aquilion One™
Name	SmartmA	DoseRight	CareDose4D	SureExposure 3D
Number of SPRs used	1	1	1 (2[a])	1 or 2, as specified
IQ reference parameter	NI	DRI	Quality ref.mAs	SD
Minimum/maximum tube current adjustable	Yes	Yes[b]	No	Yes
Online feedback	No	No	Yes	No
Aims at same noise level for all patients	Yes	No	No	Yes
Aims at constant noise throughout each scan	Yes	Yes	No	Yes

DRI, dose right index; IQ reference parameter, image quality reference parameter; NI, noise index; Quality ref.mAs, quality reference tube current-time product; SD, standard deviation; SPR, scanned projection radiograph.
[a]Combines SPRs if multiple available.
[b]Adjustable when creating the protocol only.

Highlights of different behavior[2]

Figure 5. A selection of results of particular interest from each of the investigated scanners: (a) variation of tube current in scans with different selected percentages of iterative reconstruction (ASiR-V) that is blended into the reconstructed images on the GE Revolution CT. (b) Variation of tube current throughout the scan depending on the tube voltage used for scanned projection radiograph (SPR) acquisition on the Philips Brilliance iCT. All scans were performed with 120 kV and only the tube voltage during the SPR was varied. (c) Effect of scan direction on automatic tube current modulation on the Siemens SOMATOM® Force (Siemens Healthcare, Forscheim, Germany). (d) Variation of tube current depending on the image filter used for the SPR on the Toshiba Aquilion One™ (Toshiba Medical Systems, Otawara, Japan). All other scan settings were set equal to those of the reference scan, as shown in Table 2.



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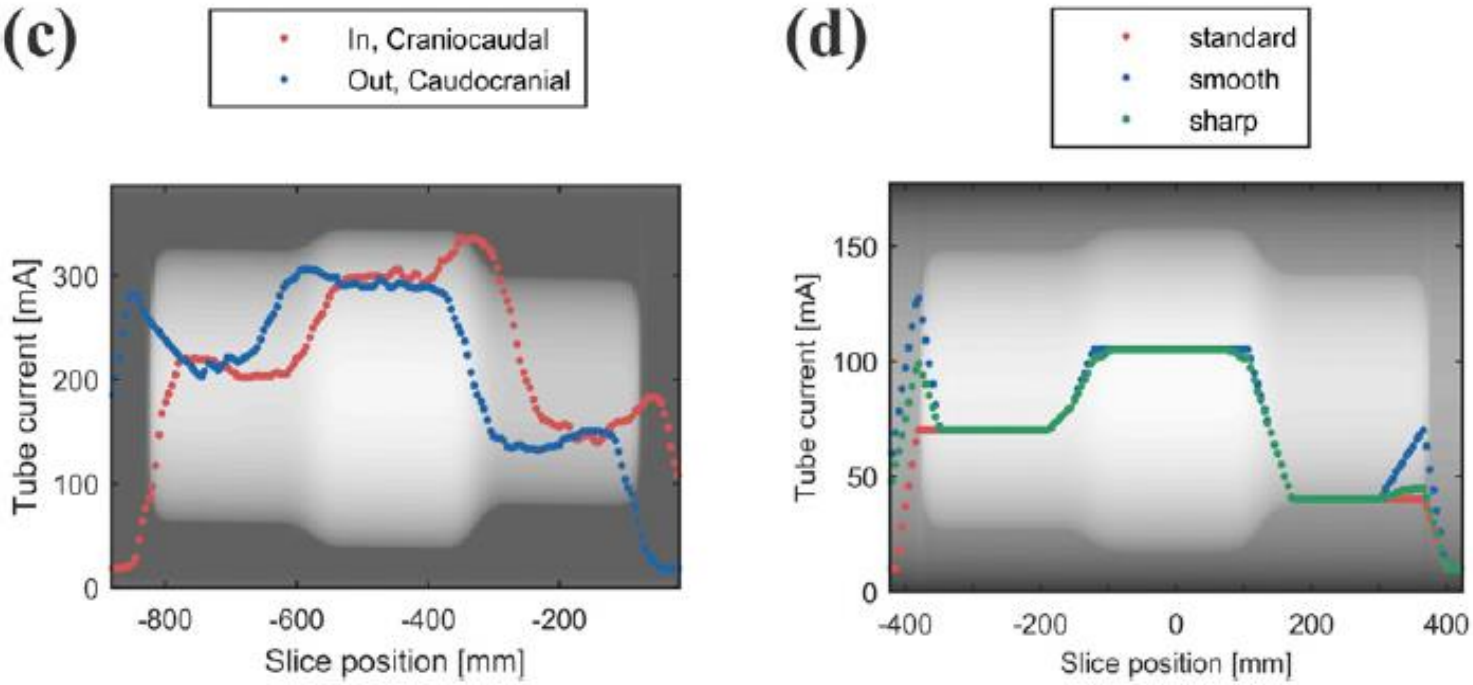

General tips and pitfalls

- The arms should have identical position between the SPR and the scan in order to receive the correctly adjusted mA[1], preferably keeping the arms lifted (if possible) for a chest examination in order to keep the dose as low as possible.
- PA projection during the SPR could result in higher dose to the patient than an AP projection due to an enlargement of the table which the AEC does not adjust for[2].
- The AEC does not work optimally if the area of interest is not fully covered by the SPR. Scanning beyond the SPR is based on different vendor solutions and may not be satisfactory.
- Keep the patient in the same position between the SPR and the scan. If the patient has been moved or repositioned, take a new SPR.
- The AEC could work differently for paediatric patients, ask your vendor for specific recommendations.

General tips and pitfalls

- Organ shields such as bismuth shielding should only be applied after the SPR in order to not increase the mA due to increased attenuation. Organ dose modulation instead of shields, is to be prefer if available.
- Positioning of the patient within the isocenter prior to the SPR is crucial. The estimate of the attenuation and size of the patient will be incorrect otherwise. Some vendors have introduced a vertical position correction, however, positioning the patient correctly from the beginning is always optimal.
- The final dose to the patient can be affected by parameters such as the pitch, the reconstruction algorithm, slice thickness or choice of tube location during the SPR. Keep an eye on the CTDI and DLP values when changing parameters!
- The reference level of image quality or noise often refers to the first reconstructed slice thickness, do not keep thin slices first in line for reconstruction if they are not the desired final product.

References

1. Söderberg M. Overview, practical tips and potential pitfalls pf using automatic exposure control in DT; Siemens CARE Dose 4D. Rad Prot Dos (2016); Vol 169; No 1-4; pp 84
2. Merzan et al. Evaluating the impact of scan settings on automatic tube current modulation in CT using a novel phantom. Br J Radiol (2017); 90