
Volume 11 - Issue 2, 2011 - Cover Story: A Primer on Radiation Protection: Patient & Personnel Safety in Focus

Does Reduction in Computed Tomography (CT)

Professionals in the radiology department have to ensure that every examination is justified, optimised and tailored to the clinical question. Radiation dose optimisation is very important in CT examinations and factors affecting patients' radiation doses have been reviewed (please see "learning resources"). Various technical approaches have been introduced to reduce radiation dose and improve dose utilisation. Automatic exposure control (AEC) with tube current modulation (TCM) is an important technical feature that helps reduce the radiation dose required for diagnosis. AEC adjusts exposure to the patient's size, shape and composition. Properly used, AEC can typically decrease doses by 15 - 40 percent, compared with protocols with fixed milliamperere (mA) levels. However, a potential drawback of AEC is the increased complexity.

The AEC system has three main functions:

1. Providing a means for defining the desired image quality/dose level (i.e. an input value);
2. Acquiring information about patient size, shape and composition;
3. Modulating the tube current based on the input value and acquired patient information.

With AEC, the traditional mA-selection has been replaced by an input value which is, unfortunately, manufacturer specific and refers to either mAs (reference effective mAs) or image quality (noise index, reference image or standard deviation).

AEC uses size and attenuation information from a scout image (and/or from a previous rotation) to adjust the tube current while scanning. Most often it is adjusted according to a patient's size at each:

- i) Acquisition angle;
- ii) Table position; or
- iii) Both.

The tube current can also be adjusted to patient size in general or varied with cardiac phase, using ECG, independent of patient size and the angular position of the tube. New scanners are generally equipped with a combination of angular and z-axis TCM but, in older scanners, TCM is often only available in one direction (angular or z-axis).

Efficient AEC Use is Not Intuitive

AEC was introduced in CT scanners to decrease patient dose while maintaining appropriate image quality. However, knowing how to use AEC correctly and efficiently is essential for optimal effect. Efficient use of AEC requires knowing the TCM type available in the scanner and thorough understanding of all user-selectable parameters as well as the AEC input values.

The input value indicates the radiation exposure for an average sized patient; for a smaller patient, it will be less; for a larger patient, more. It is important to know how the radiation dose is affected by changing the input value. A convenient linear relationship exists between mAs (and reference effective mAs) and patient dose; increasing the mAs will cause a proportionally equal dose increase, but it is more complex for the image noise based input values, as the image noise is inversely proportional to the square of the tube current.

Optimise Protocols

In general, AEC systems promptly do what they are supposed to, and mA is adjusted accurately (within the predefined range) to patient size and shape. The input value is, however, user selectable and needs to be chosen wisely to acquire the expected dose reduction. AEC does not in any way change the need for appropriate selection of other parameters, e.g. beam energy, slice thickness and noise reduction filters. It is important to realise that altering parameters that affect image quality (e.g. kV, pitch and recon image thickness) may affect the mA as decided by the AEC, especially in scanners with image noise based AEC input values, because AEC aims at maintaining image quality. There is a considerable difference from one scanner to another. For example, reducing slice thickness (at constant AEC input value) leads to higher mA in one scanner but increased noise in another scanner. The same applies to changing the reconstruction algorithm for the first reconstruction.

The TCM modulates the tube current within a given range (e.g. 10 - 500mA), but patient diameter can vary greatly. In addition, the subject contrast increases with body size and, if size correction is not built-in to the AEC system, the AEC input value should be altered with regards to size. It is still of the utmost importance to create special paediatric protocols.

Implementation and Potential Pitfalls

AEC is probably best implemented under the supervision of an application specialist who is familiar with the exact scanner type. It is normal to encounter some problems but given the fact that the AEC is a mature technique now, most of the problems will probably be related to work procedures. Frustration may arise when noisy images appear but it is important to find the reason for the error, correct it and head towards the goal of utilising the benefits of AEC. Systematic errors may have gone unnoticed but result in TCM errors when AEC is used. CT design, in general, assumes that the patient is positioned in the centre of rotation; for an offcentred patient, size calculations on which the TCM is based

will be incorrect. Note that a new scout image is needed to correct the TCM after correcting the position.

The indirect effects of other scan and reconstruction parameters on the exposure first came with the introduction of AEC and need to be realised to avoid unintentional dose increase. For example, if parameters are changed to decrease the dose, AEC may alter the mA to compensate. The fact that AEC differs between scanners may increase the risk of errors.

Possible reasons for sub-quality images when using AEC:

- Incorrect positioning or patient's position changed after scout acquisition;
- Low subject contrast in small patients;
- Narrow mA range or high image quality demands;
- High image quality demands may result in the mA being constantly at the maximum and the proposed constant image quality from one patient to another will not be achieved;
- Composition different from what the AEC assumes (e.g. relatively dense body areas, such as knees or large metal implants);
- Protocols are not standardised;
- Beam energy and tube angle when scout is acquired may affect the TCM;
- Sharp boundaries or incomplete coverage of the scout;
- TCM adjacent to sharp boundaries may be incorrect, and/or,
- The scout has to cover the entire area scanned (including extra-rotations).

All the potential pitfalls are best avoided by well educated professionals. Modern equipment with excellent technical solutions will not ensure CT examination optimisation on its own. Sufficient training is essential.

Recommendations

- Study the AEC in your scanner/s
- Study how image noise and patient's dose are related
- Use AEC for all examinations of the trunk
- Create protocols for average, paediatric and obese patients
- Standardise procedures and look systematically for reasons for errors
- Observe the mA for individual patients and learn when adjustments are needed
- Read and react to scanner generated messages

This summary is based on the article Optimal Use of AEC in CT: A Literature Review by Jónína Guðjónsdóttir, Borgny Ween and Dag Rune Olsen from ASRT Radiologic Technology, March/April 2010, Vol. 81 (4) pp.309-317.

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