Basic Principles of CT and Dose Implications

M. Kuntzsch, Dublin (IE)

Computed Tomography or CT is the modality, which contributes to almost 20% of the collective doses even though with only 2% of all x-ray examinations it is one of the least frequent examinations. The reason for the relative high doses lies within the principles used in this technology. Fast rotational times, overlapping helical scans and the use of more and more slices being accumulated per rotation all lead to an increase in patient dose. Even with new improved dose reduction features the CT is still the modality with the highest contribution to the effective collective doses of all man made exposures to the population.

The idea of CT or a rotational scan and reconstruction of an image into a two dimensional image is quite old, however it took till 1972 when the first generation of CT systems was built by engineer Godfrey Hounsfield of EMI Laboratories.

With the 1st generation of CT scanners acquisition of a whole body would have taken several minutes. Today most places are using scanners of the 4th generation, using digital detector arrays to accumulate signals in multiple slices in a matter of seconds.

With decreased rotational times of 0.5 seconds and systems currently in development that are taking up to 256 slices simultaneously it is now a lot easier to get good clinical images within a short period of time.

With all those developments however an increase of effective dose can be seen in multi-slice CT vs. single-slice CT. The difference in doses between single slice images and a multi-slice scan of the same area can be up to 35%.

This trend has been recognised and there are new dose reduction techniques in use today that are reducing the dose to the patient to a minimum.

With dose reduction techniques the scanners radiation output is adjusted automatically depending on the thickness of the patient, keeping noise levels constant, and doses to the patient to a minimum.

As all the detectors are digital detectors the images are acquired in a digital format. The images are reconstructed using software for noise reduction and image enhancement.

At the reconstruction phase the voxel information is converted into a Hounsfield unit depending on the amount of radiation received by each of the detectors.

The (windowing) or window levels are setup to display the contrast that is required for this examination type. This optimisation is achieved by looking at different areas of the Hounsfield scale. The scale of Hounsfield units varies from -1000 to + 1000, however as the human eye is only able to discern approximately 80 different grey values so the amount of Hounsfield units displayed are reduced to maximise the visibility of the voxel values required for interpretation of the scan.

To guarantee good image quality over time at low radiation doses to patients the quality control on CT-scanners should be performed on a regular base. Quality control is looking at various parameters of the scanner such as the kV, table movements, noise assessment, CT number uniformity and linearity as well as the CTDI or Computed Tomography Dose Index. The CTDI is a commonly used dosimetry parameter which can be expressed in a variety of different ways but gives the operator an idea of changes in the scanner performance over time and a comparative value for other scanners.