

Geant4 Monte Carlo simulations for size specific organ dose estimates in CT based on patient silhouette and voxelized phantoms

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Background: Patient dose in Computed Tomography (CT) is currently evaluated for reference persons digital phantoms, these presenting the average patient silhouette. We present a Geant4 Monte Carlo code for organ dose estimates in CT calculated before the CT scan, using reference voxelized phantoms adapted to the shape of the specific patient optically scanned for derivation of the 3D silhouette.

Material and Methods: A Monte Carlo code based on Geant4 toolkit and the physics list Option4 was developed to simulate a specific CT scanner. The beam characteristics (intensity profile and HVL) were modelled based on measurements on a clinical Astelion Toshiba CT scanner. The code was validated vs CTDI measurements and dose measurements in phantoms conducted via GafChromic films, as well as on literature data. The patient models were taken from the database in ref. [1]. The shape of the phantom was defined using an Artec Eva 3D optical scanner that allows the production of a 3D model of the external shape of the patient body. Then, a rigid transformation was performed to adapt the shape of the digital patient phantoms to the measured shape.

Preliminary results: In the validation tests, discrepancies between measured and simulated CTDI were contained within $\pm 2\%$, for tube voltages between 80 kV and 135 kV. Differences between computed organ dose and dose estimated by means of the NCICT code [1] were within 12% for male phantoms, except for the dose to the pituitary gland at 80 kV, whose discrepancy reaches 24%. Table 1 reports discrepancies between dose estimated by means of female standard phantoms and customized phantoms. Differences can reach values as high as 36% evaluated for the brain tissue at 100 kV. In a case study for a male phantom, differences are within 14%.

Voltage	Percent difference between dose for standard and customized phantom (female) (%)			
	Brain	Eyeballs	Lens	Pit. gland
80 kV	+17.9	+8.9	+4.7	+20.4
100 kV	+36.3	+30.8	28.2	38.0
120 kV	22.2	17.6	14.9	23.3
135 kV	-15.1	-10.2	-17.3	-21.9

Table 1: Percent difference between dose calculated for standard and customized female phantom.

[1] C. Lee *et al.*, J Radiol Prot (2015). Vol: 35, 891.