

Radiation dose from computed tomography has been an important issue for medical physicists for some time. This issue has increased in significance in the past several years due to advances in multidetector CT, which have resulted in increased utilization in areas such as pediatric CT, cardiac CT and even screening applications. Some of the key issues currently facing the medical physics community are assessing dose to patients from these various exams. One of the key building blocks to these assessments is the estimation of organ dose.

The purpose of this presentation is to describe an approach to estimating organ doses to patients using Monte Carlo-based simulation methods. In this approach, both the scanner and patient are modeled in some detail and a CT exam may be simulated.

The detailed model of the CT scanner is created by including information such as the source spectra and filtration, its geometry, beam collimation and the path that the source travels around the patient (such as the path during a helical CT exam). The development, testing and validation of these models will be discussed.

Patient models generally fall into two categories. The first consists of geometric descriptions of organs (based on cones, cylinders, etc.) such as the MIRD phantom. The second consists of voxelized descriptions of patient anatomy that are created based on actual patient scans. In these, radiosensitive organs are identified in the image data to create a voxelized model of the patient geometry. For both types of models, there are challenges to create models representing patients of different sizes, ages and genders.

Once both the scanner and patient are modeled, then different scan protocols can be simulated using a Monte Carlo based software package (such as MCNP or EGS). This involves selecting a scanner model, a patient model and then selecting a set of technical parameters, such as one would do for an actual scan – including body region being examined, etc. The Monte Carlo software then simulates the specified scan and tallies absorbed dose in each voxel or geometric unit of the patient model, which then allows the calculation of effective organ dose or the distribution of dose within an organ.

In this presentation, the results of this approach in several applications will be described, including: (a) dose to the fetus in pregnant women of early, middle and late gestational ages, (b) comparing dose to glandular breast tissue from thoracic CT scans both with and without tubercurrent modulation.

Educational Objectives:

1. Understand the Monte Carlo simulation based approach to estimating radiation dose to radiosensitive organs from CT scans.
2. Understand the current limitations of the Monte Carlo based approach
3. Describe the results of some current applications of this approach to estimating fetal dose as well as breast dose reduction from tubercurrent modulation.