Title: Monte Carlo Dosimetry For CT Brain Perfusion Studies Utilizing Volumetric Acquisitions.

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Introduction: Brain perfusion studies are commonly used for the assessment of stroke patients. These studies typically include several CT scans acquired either helically or volumetrically. While protocols may vary from institution to institution, this protocol is considered high dose at UF Health Shands Hospital as the entire study results in approximately 2000 mAs of time-integrated tube current; consequently, patient dose is of interest. This study aims to generate a model of the volumetric and helical CT x-ray source and apply this model to computational human phantoms using Monte Carlo radiation transport simulations to compute organ doses for brain perfusion studies.

Methods: To develop a model of the CT scanner several measurements are needed for each combination of tube voltage, filtration, and collimation. First, a CR cassette is exposed while the x-ray source was stationary and set at the lowest mAs setting along with a copper plate filtering the beam. This data allows the construction of a probability distribution of the photon's velocity vector from the source to isocenter. The filtration allows high contrast allowing measurement of the beam penumbra. Second, half value layer measurements are taken for each peak tube voltage setting and are used to determine the energy distribution of the photons emitted from the scanner. Third, the dose to an ion chamber is measured at isocenter and normalized per unit mAs thus allowing translation of Monte Carlo results to absolute patient exposure values. To compute organ doses the new ICRP mesh-type reference computational phantoms (MRCPs) were used with the inclusion of an updated brain model containing 42 substructures. The phantoms, with this addition allow doses to be computed to brain substructures, eye lenses, and skin. To simulate these studies a custom source generation algorithm is used implementing inverse transform sampling from the measured distributions to generate photons mimicking the CT study within PHITS (a Monte Carlo radiation transport code). They are subsequently transported through the MRCPs where doses to all organs are computed in units of dose per mAs.

Conclusion: This work presents a methodology to take clinical measurements of the CT scanner and develop an array of probability distributions needed to accurately model the studies in a Monte Carlo simulation. Additionally, an algorithm was created to sample these distributions and simulate both helical and volumetric the CT scans in PHITS allowing the creation of a library of scalable organ dose coefficients for CT perfusion studies.