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Instrumentation & Data Analysis: Image Generation SPECT Reconstruction and Compensation

Fine-structure modeling of the psrf of a parallel-hole collimator yields improved recovery of activity within focal volumes

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Objectives: For a Siemens Symbia SPECT/CT as an example, the center-to-center distance (CTOCD) for the holes of the medium-energy (4.1mm), ultra-high-energy (5.9mm), and high-energy (6.0mm) parallel-hole collimator is greater than the camera's intrinsic resolution (3.9mm). With 512x512 sampling, the central part of the point source response function (psrf) of an appropriate radionuclide is composed of multiple peaks on a hexagonal grid. We will model this fine structure to improve the activity recovery for small objects to potentially obtain more accurate tumor dosimetry even without partial-volume correction. **Methods:** We measured the I-131 psrf at five depths ranging from 2.0 to 24.5cm using a Marconi camera and its high-energy collimator (CTOCD =5.5mm). The psrf at each depth was modeled via a least-squares fit that returned the amplitude and width of a rotationally-symmetric two-sided exponential (for septal penetration) and the location of the central peak, the size of the hexagon, and the amplitudes and width of all peaks. The dependence of each parameter on depth was found by further least-squares fitting and used to create a "fine-structure" model. The model was down-sampled to obtain 128x128 projection images to save reconstruction time. Projection data for a large cylinder containing either two or four spheres with sizes ranging from 200cc to 4.2cc was simulated analytically using the model with attenuation but no scatter. The data was reconstructed using 3D OS-EM with attenuation correction and either the fine-structure model or a low-frequency one (a single depth-dependent angularly-symmetric Gaussian plus two-sided exponential). **Results:** For the two-sphere phantom, the counts recovered using the fine-structure model were 95% of the true value in the 200cc sphere and 87% in the 11cc sphere but only 84% and 75% respectively using the low-frequency model. For the four-sphere phantom, the activity recovery coefficients (RCs) were 0.89 and 0.72 for the 11cc and 4.2cc spheres. These improve upon average experimental RC values using

low-frequency models of 0.69 and 0.44. Further improvement can be expected with finer sampling of the projection space. **Conclusions:** Activity is better recovered with a fine-structure model of the psrf for a high-energy SPECT collimator.