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Instrumentation & Data Analysis: Image Generation

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Influence of septal penetration and scatter on ^{123}I SPECT detector response modeling

Jonathan Moody[1], Yuni Dewaraja[2], Jeffrey Fessler[2] and Edward Ficaro[1]

[1] INVIA, LLC, Ann Arbor, MI [2] University of Michigan, Ann Arbor, MI

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Objectives: Septal penetration of high energy (HE) photons is a well-known problem for LEHR collimation of cardiac ^{123}I SPECT, which can be addressed by modeling detector response in the reconstruction. This work evaluated the relative contributions of septal penetration (SP) and scatter correction (SC) to 3D-OSEM reconstruction using 3 different detector response models.

Methods: Projections of an ^{123}I point source in air were acquired at various detector distances (Siemens Symbia SPECT/CT, LEHR collimator). The data were fit to 3 analytic functions [gauss (G), gauss+exp (SP1), and gauss+exp+exp(exp) (SP2)] to model the geometric and penetration components of a depth-dependent PSF, which was then included in a 3D-OSEM reconstruction program. Three ^{123}I phantom datasets were acquired: point source in a cold water cylinder, and torso phantom with heart/lung/liver inserts and 2 sets of activity ratios (H:Lu:Liv:BG): 20:5:10:1 (P1), 15:8:10:1 (P2). All datasets included a 20% photopeak and 6% windows adjacent to the main peak for triple energy window SC. Each dataset was reconstructed 6 ways: with/without SC and using the 3 PSF models. The images were assessed by maximizing the contrast-to-noise ratio(CNR) between the heart wall/ventricle with respect to OSEM iteration.

Results: The SP1 model gave adequate fits within a radius of ~12cm of the PSF center, while SP2 provided better fits out to a radius of 31cm. The CNR results are summarized below. The point source FWHM and FWTM was unchanged when SP1 or SP2 was included in the reconstruction.

Conclusions: In these phantom studies, including septal penetration with the geometric component of an ^{123}I detector response model contributed the same percent improvement to cardiac CNR (25-35%) as SC. A model that included the central ~40% of the penetration tails was as effective as a model that included the entire tails. A smaller PSF model may reduce reconstruction time while providing adequate compensation for detector response.

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