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Development and Validation of Methods for Quantitative In Vivo SPECT of Pb-212

Pb-212 (T1/2 = 10.6h) has gained considerable interest in targeted alpha-therapy (TAT) since it serves as an in vivo generator for Bi-212 (T1/2 = 61 m), producing both α- and β-particles. Accurate dosimetry requires estimates of organ activity at multiple time points. Imaging Pb-212 is challenging because of the relatively low administered activities, complicated decay scheme in including multiple daughters, and wide range of energies emitted. The objective of this study is to develop and validate a Pb-212 quantitative SPECT (QSPECT) imaging method that includes compensations for all physical image degrading effects.

Experimental projection data were obtained using a NEMA IEC Body Phantom with one off-center hot sphere (3.7cm diameter) imaged by a Siemens Symbia system. A medium energy collimator was used with energy windows of 67-91 keV and 220-257 keV. The energy windows were selected by optimizing a signal-to-noise ratio that considered geometrically collimated photons as signal and all other photons as adding only noise. Measured, simulated, and model-based projector generated projections were compared quantitatively. Simulated anthropomorphic-phantom data were also generated using the SIMIND Monte Carlo code. We investigated the qualitative image quality and precision of activity estimates at 1, 24, and 48 hours post-administration of a 2.1 mCi injected activity.

Good agreement was achieved between measured phantom projection, simulation, and mode-based projector. For the simulated patient data, we studied the convergence properties of the iterative reconstruction by looking at the reconstructed counts in the organs as a function of iteration. These tended to converge at about five iterations. The coefficients of variation (COVs), a measure of precision, for organs other than the marrow at five iterations ranged from 1.0-2.6% at 1 hr, 2.2 to 9.4% at 24 hours, and 7.5-23% at 48 hours. The COVs for a marrow compartment were substantially higher, ranging from 16% at 1 hour to 43% at 48 hours.

The results indicate that quantitative imaging pf Pb-212 is feasible. The improved quantitative accuracy from QSPECT methods has the potential for providing more accurate patient specific dosimetry in TAT.

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