

Monte Carlo Simulation of Thyroid Phantom Imaging Using Geant4-GATE

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Abstract : Introduction: Monte Carlo simulations of preclinical imaging systems allow opportunity to enable new research that could range from designing hardware up to discovery of new imaging application. The simulation system which could accurately model an imaging modality provides a platform for imaging developments that might be inconvenient in physical experiment systems due to the expense, unnecessary radiation exposures and technological difficulties. The aim of present study is to validate the Monte Carlo simulation of thyroid phantom imaging using Geant4-GATE for Siemen's e-cam single head gamma camera. Upon the validation of the gamma camera simulation model by comparing physical characteristic such as energy resolution, spatial resolution, sensitivity, and dead time, the GATE simulation of thyroid phantom imaging is carried out. Methods: A thyroid phantom is defined geometrically which comprises of 2 lobes with 80mm in diameter, 1 hot spot, and 3 cold spots. This geometry accurately resembling the actual dimensions of thyroid phantom. A planar image of 500k counts with 128x128 matrix size was acquired using simulation model and in actual experimental setup. Upon image acquisition, quantitative image analysis was performed by investigating the total number of counts in image, the contrast of the image, radioactivity distributions on image and the dimension of hot spot. Algorithm for each quantification is described in detail. The difference in estimated and actual values for both simulation and experimental setup is analyzed for radioactivity distribution and dimension of hot spot. Results: The results show that the difference between contrast level of simulation image and experimental image is within 2%. The difference in the total count between simulation and actual study is 0.4%. The results of activity estimation show that the relative difference between estimated and actual activity for experimental and simulation is 4.62% and 3.03% respectively. The deviation in estimated diameter of hot spot for both simulation and experimental study are similar which is 0.5 pixel. In conclusion, the comparisons show good agreement between the simulation and experimental data.

Keywords : gamma camera, Geant4 application of tomographic emission (GATE), Monte Carlo, thyroid imaging

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