Estimation of Effective Atomic Number using Dual-Energy Imaging of CT Simulator for Radiation Therapy

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Background: This study aimed to estimate effective atomic number (EAN) based on dual-energy imaging (DEI) algorithm using images obtained from conventional computed tomography (CT) simulator for radiation therapy. The estimated EAN can be used for more accurate dose calculation.

Materials and Methods: The electron density phantom (Model 062M, CIRS, Norfolk, VA) was scanned at 80 kVp and 140 kVp tube potentials. The CT simulator (Brilliance CT Big Bore, Philips Medical Systems, Cleveland, OH) was used for scanning. Using the known mass composition, reference EANs of the phantom was calculated. EAN of each CT pixel was estimated with three physics-based methods and compared with the reference. Unknown parameters in first and second methods was obtained with CT images and the reference EANs. The MATLAB optimization toolbox was used to fit parameters. For the third method, image-based material decomposition was conducted. 80 keV and 140 keV virtual monoenergetic images are synthesized and used for EAN estimation. The monoenergetic attenuation coefficient ratio of elements was calculated with NIST data and then atomic numbers in typical body range vs monoenergetic attenuation ratios were fitted by polynomial function. Estimated EANs of phantom materials were measured using region of interests covering 80 % of each plug.

Results: In plug ROIs, estimated EAN by the second method was more precise than the first and third methods. Largest errors are seen with the material simulating lung during inhalation. The relative differences between estimated values by the first and third methods and their reference values are ranged from -3.2% to 5.7% for soft tissue and bone inserts and up to -11.3% for lung inserts, respectively. EANs estimated by the second method varied within 4.7% for all inserts. Estimated EAN was comparable to the ones obtained with dedicated dual-energy scanner.

Conclusions: EAN was estimated using DEI with CT simulator images from sequential dual scans. Three different methods were used for estimation and the results from each method were compared. The estimated EAN can be used to derive the electron density and the stopping power for improving dose calculation.

Reference

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