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Abstract

Density Override on GTV Dose Difference between Pencil Beam and Monte Carlo

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Abstract

Objectives: The study aims to investigate the effect of density override on dose difference of gross tumor volume (GTV) in individual phase of breathing cycle between pencil beam algorithm (PB) and fast Monte-Carlo simulation (MC).

Methods: 8 lung patients treated with SBRT technique were retrospectively studied. GTV was contoured on each phase of the 4D dataset as well as free-breathing and average datasets by one board-certified radiation oncologist. A 360-degree co-planar arc was utilized to plan on five density schemes. The initial 2mm-MLC aperture was manually optimized to achieve desirable dose coverage. Each plan was recalculated with the same plan parameters (MU, MLC shapes, weighting, etc.) using iPlan PB and MC algorithms on 4 individual phases of the breathing cycle without any density override: inhale 0% (In0), inhale 50% (In50), inhale 100% (In100), and exhale 50% (Ex50). Spatial resolution of 2mm and variance of 1% was used for MC simulation. D95 deficiency of GTV was used as a dosimetric endpoint of our study.

Results: Five density schemes were generated: 1) FB image sets (FB), mean intensity projection image set (AVG), FB image sets with internal target volume overridden to water density (ITV_OV), FB image sets with planning target volume overridden to water density (PTV_OV), and FB image sets with planning target volume with 2mm expansion overridden to water density (PTV2mm_OV). Treatment plans based on FB and AVG image sets resulted in comparable D95 deficiency by MC simulation in all the four phases calculated. Density override in ITV, PTV and PTV with 2mm expansion increasingly reduced the D95 deficiency. PTV2mm_OV led to the greatest reduction of D95 deficiency, which are 24.24% in In0 phage ($P< 0.05$), 21.17% in In50 phase ($P< 0.01$), 25.22% in In100 phase ($P<0.01$), and 29.72% in Ex50 phase ($P<0.01$) compared to the plans generated in FB image sets. The coefficient of determination (R2) of the single linear regression between the standard deviation of the 2mm shell structure outside the PTV and the relative reduction of D95 deficiency using PTV2mm_OV planning are 0.9817, 0.7569, 0.3778, and 0.8089 for In0, In50, In100 and Ex50 for the cases without bony structure in PTV.

Conclusions: We demonstrated that density override could reduce the D95 deficiency between pencil beam calculation and Monte-Carlo simulation. Also, without bony structure surrounding, the standard deviation of the 2mm shell structure outside PTV correlates with the relative improvement resulted from density override in treatment planning.

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