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Monitor Unit Optimization in Stereotactic Body Radiotherapy Planning for Lung Tumor: A Phantom Study

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Purpose: Promising results have been obtained in studies using stereotactic body radiotherapy (SBRT) for non-small cell lung cancer. In SBRT, an extremely high radiation dose is delivered to the tumor in 3-5 fractions, which results in excessive monitor units (MUs). The high number of MUs means prolonged beam-on time, and could increase the uncertainties in the immobilization of the patient during treatment. The MU optimization tool has been integrated in the Varian Eclipse treatment planning system (TPS) to control the MU number during treatment planning. This study aims to investigate performance of the MU optimization tool for lung SBRT planning. Materials and Methods: The CIRS X-sight tracking lung phantom (model 18023) with a moving insert containing a spherical tumor with a diameter of 2.5 cm was used. Four-dimensional computed tomography (4DCT) dataset of phantom was acquired while the phantom was moving. The average intensity projection (AIP) image data set was reconstructed from 10-phase 4DCT data using the Eclipse v15.6 treatment planning system (TPS). Gross target volumes (GTVs) were contoured on the 10 phases of 4DCT images. Internal target volume (ITV) was generated by merging GTVs contoured in the 10 phases. A 5 mm margin was added to the ITV to create planning target volume (PTV). The lung, heart, and spinal cord were delineated as critical organs on AIP images. The volumetric modulated arc therapy (VMAT)-SBRT treatment plans were made using partial arcs on AIP images. A SBRT plan, saved as base plan, was generated with 6 MV photon beams from a Varian Trilogy linac equipped with a Millennium 120-leaf MLC without using the MU optimization tool. The maximum dose rate was set to 600 MU/min. The prescription dose to PTV was 54 Gy in three fractions. The MU number of this plan was defined as the reference MUref. The plan was then re-optimized using the MU optimization tool. Twenty plans were created by varying the maximum MU (Max MU) and strength (S) parameters. The Max MU parameter was set to be 90%, 80%, 70%, 60%, and 50% of MUref and S was defined to be 50, 60, 80, and 100. The best combination in terms of Max MU and S parameters was determined to be the one providing the ratio of reduction in MU and deterioration in homogeneity index (HI) closest to 1. The plan created using the best combination was evaluated with respect to the base plan in terms of PTV coverage and critical organ doses (lung V5, V10, V20, Dmean, heart Dmax and spinal cord Dmax). Results: Max MU=70% of MUref and S=80 was the best combination for MU optimization tool parameters. This combination resulted in 17.78% reduction in MU number. The deterioration in HI of PTV was found to be 22.68%. The discrepancies between MU-optimized plan and base plan regarding PTV coverage and critical organ doses were found less than 3%. Conclusion: The MU optimization tool could enable a 17.78% reduction in the MU number without compromising the PTV coverage and critical organs sparing in lung SBRT. Further investigation will be conducted using patient data.

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