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Dose deposition in small lung lesions: Modifying the PTV for a more robust optimization

In lung cancer, SBRT is used to deliver high doses to a small dense GTV moving into a low-density tissue (margin generating the PTV). If IMRT or VMAT are used to treat such inhomogeneous PTV, a homogeneous dose distribution is achieved generating high photon fluence inside a 3D shell (PTV-GTV). Paradoxically the dose distribution is apparently uniform, but the GTV, which moves into the PTV, will receive a dose that depends on its position. This work studies this phenomenon. Monaco v5.11 (Elekta, SWE) with MC algorithm was used to simulate a SBRT treatment. In a first part, the photon fluence was optimized for the original PTV electron density (EDo) and then used to recalculate the dose on a modified PTV electron density (EDf) in which the mean value of the GTV electron density was forced as the relative electron density of the PTV. In a second part the photon fluence was optimized for PTV EDf and then used for the dose calculation on PTV EDo. In part one, dose increments of 1.6% for D98%, 2.5% for Dmean and 5% for D2% were obtained for PTV-GTV, dose profiles calculated on EDo and EDf, differ up to 6.6% on longitudinal axis along the plan isocenter. A maximum dose difference of 9% of the prescribed dose was obtained between the 3D dose distributions. This means, when the GTV reaches a position inside the PTV, where the photon fluence is optimized for low electron densities, it will receive higher doses than what estimated on the original EDo map. In the second part a reduction of -1.5% for D98%, Dmean and D2% were achieved for PTV-GTV and the maximum difference between dose profiles was -3% for longitudinal axis. The maximum difference between the 3D dose distributions was 6% of the prescribed dose. The GTV is thus irradiated in a more homogeneous way in part two in which the fluence is optimized for its mean electron density everywhere in the PTV. We propose that, in lung small lesions, the PTV must be modified in terms of electron density considering the GTV mobility.

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