Analysis of dose deposition in lung lesions: a modified PTV for a robust optimization

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Introduction

SBRT in lung cancer delivers high doses to a small and dense GTV moving into a lower density tissue. IMRT and VMAT techniques usually generate a high modulated photon fluence inside a 3D shell (PTV-GTV) due to its low electron density (ED). This situation gives the paradox that 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 was designed to evaluate this phenomenon and to suggest a more robust dose optimization.

Materials and Methods

A TPS Monaco 5.11 (Elekta, SWE) with a MC algorithm was used to simulate a SBRT treatment in a dummy patient (55 Gy in 5 fractions). Two Electron Density maps were defined for the PTV: the original one (EDo) and a "forced" one (EDf), in which the ED of the PTV was overwritten to the mean ED of the GTV (Fig.1).

PTV_{EDo} PTV_{EDf} *Fig. 1*
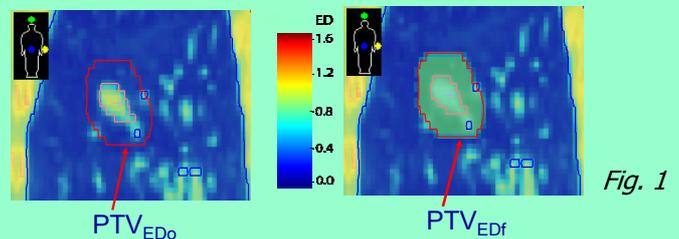
Results 1

In a first step, the photon fluence was optimized for the original PTV_{EDo} and then used to calculate the dose on the "forced" PTV_{EDf}, in order to evaluate the dose discrepancy when considering the motion of the GTV. Dosimetric comparisons between the original and recalculated dose distribution were made (Fig.2).

Dose profiles, calculated on EDo and EDf, differ up to 6.6%, 3.4% and 3.8% on longitudinal, sagittal and transversal axes along the center of PTV. Dose increments of 1.8% for D98%, 2.5% for Dmean and 5% for D2% were obtained for PTV-GTV (Fig.3).

Fig. 2   Dose distribution difference   Longitudinal dose profile

EDf-EDo   *Fig. 3*
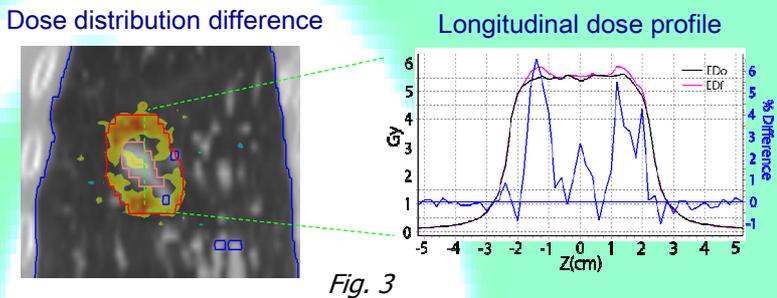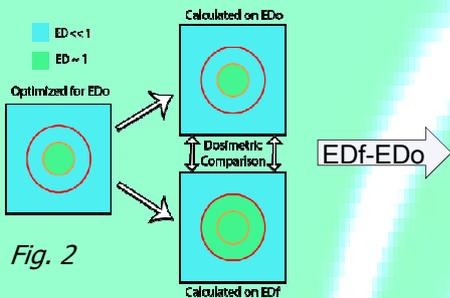
Results 2

In a second step the photon fluence was optimized on PTV_{EDf} and then it was used for the dose calculation on PTV_{EDo}, in order to evaluate the dose variation on the lower ED region of the PTV and inside the GTV (Fig.4).

Dosimetric comparisons between the original and recalculated dose distribution were made. The maximum difference between dose profiles was -3% for all three axes along the plan isocenter. A reductions of -1.5% for D98%, -1.4% for Dmean and -1.2% for D2% were achieved for PTV-GTV. Non-significant variations (< 0.1 Gy) were observed for the GTV in both steps (Fig.5).

Fig. 4   Dose distribution difference   Longitudinal dose profile

EDo-EDf   *Fig. 5*
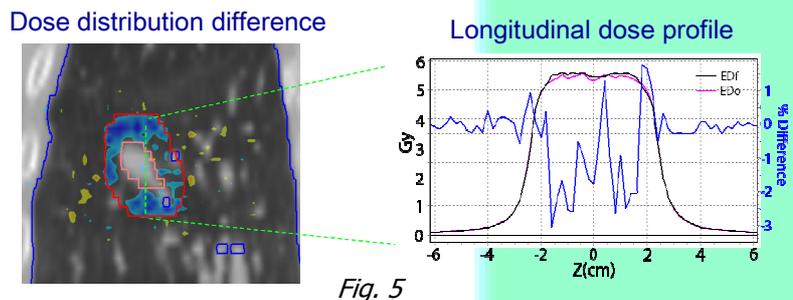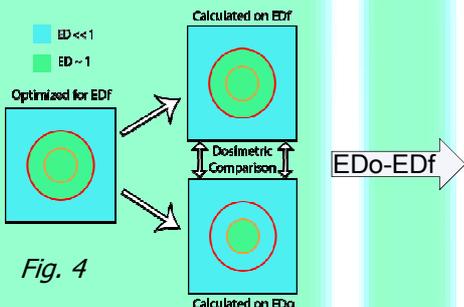
Conclusions

If the GTV is static, it should receive a constant dose, but Step I shows that the dose delivered to the GTV, when the GTV reaches a position inside the PTV, where the photon fluence is optimized for low electron densities, is higher than what estimated on the original EDo map. The GTV is thus irradiated in a more homogeneous way in Step II in which the fluence is optimized everywhere inside the PTV for the GTV mean ED. We propose that, in lung small lesions, the PTV should be modified in terms of electron density considering the GTV mobility. Optimizing the photon fluence for the forced electron density map appears an effective way to evaluate a more realistic dose delivered to the GTV.

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