Studying inter- and intrafraction motion mitigation with sequential 4DCTs of NSCLC patients*

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Introduction

The physical and biological properties of scanned carbon ion beam therapy potentially permit more conformal irradiation than photons. Range sensitivity and interplay renders treatment of moving tumors complex. Optimized treatment planning parameters, ITV-PTV margins and multiple field (using SFUD) were investigated to compensate for tumor motion and interfractional patient variability.

Material & methods

For 4 NSCLC lung tumor patients from the University of Texas MD Anderson Cancer Center (MDACC) [1], a total of 30 weekly 4DCT datasets were available. Reference phases of each subsequent CT were registered rigidly to mimic patient setup. Motion phases of each 4DCT were registered non-rigidly [2]. Single and multiple field gating plans were simulated using the GSI treatment planning system TRiP4D [3], including 4D-dose simulations. A range-considering ITV [4] was computed on the 4DCT of the first week for each field. Using one single field first, the impact of variations in focus size and length of the gating window (GW) was analyzed. Three beam foci (6, 10 and 15 mm full width at half maximum) and three GW (11.9, 30 and 50% of the amplitude) were studied. Using one single field again, the influence of range (3mm water-equivalent + 3%) and isotropic (3mm) ITV-PTV margins were investigated. Combination of both margins was also analyzed. Finally multiple fields (2 and 3 fields) simulations with and without ITV-PTV margins were performed. For each case, results were evaluated using the obtained V95 (dose coverage) and CN [5] (conformity number, see equation 1).

$$CN = \frac{V_{CTV,95\%}}{V_{CTV}} \times \frac{V_{CTV,95\%}}{V_{95\%}} \quad (1)$$

Results & discussion

Table 1 shows that, using one field, the best V95 was obtained with the largest focus and the shortest GW. Combined with this best configuration, ITV-PTV margins permitted to increase V95 up to almost 98%, but a decreasing CN showed that more dose was delivered to the healthy tissue. Using multiple fields with ITV margins improved CN significantly but V95 only slightly compared to single field simulations. Finally, multiple fields combined with ITV-PTV margins yielded the best results in terms of V95, but CN, even though higher than for single field calculations, decreased compared to multiple fields calculations with ITV margins only.

Conclusion

It was shown here that using adapted parameters can improve dose delivery. However, the still unsatisfactory results can be further improved by using margins. Moreover, treatment with more fields is also a solution to increase target coverage and decrease regions of high dose in normal tissue. Using margins in addition allows to recover for positioning uncertainties.

Number of fields	Margins	Focus	GW	V95 (range)	CN (range)
1	ITV	6	50	**69.9** (42.8 to 94.5)	**0.39** (0.14 to 62)
		15	11.9	**88** (67.5 to 99.7)	**0.45** (0.17 to 0.66)
	ITV + isotopic 3mm	15	11.9	**93.7** (76.8 to 100)	**0.37** (0.18 to 0.52)
	ITV + range 3%+3mm	15	11.9	**95.9** (80.7 to 100)	**0.37** (0.2 to 0.53)
	ITV + isotropic 3mm + range 3%+3mm	15	11.9	**97.7** (81.8 to 100)	**0.32** (0.19 to 0.45)
2	ITV	15	11.9	**92.7** (75.8 to 100)	**0.51** (0.26 to 0.63)
	ITV + isotropic 3mm + range 3%+3mm	15	11.9	**99.1** (85.3 to 100)	**0.34** (0.22 to 0.46)
3	ITV	15	11.9	**92.9** (72.6 to 99.9)	**0.56** (0.31 to 0.58)
	ITV + isotropic 3mm + range 3%+3mm	15	11.9	**99.2** (83.7 to 100)	**0.37** (0.27 to 0.48)

Table 1: Impact of focus, gating window (GW), ITV-PTV margins and multiple fields on dose coverage (V95) and conformirty number (CN).

References

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