Dosimetric Impact of Primary Planning Parameters in Dynamic Conformal Arc Technique for Lung SBRT

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Introduction

As one of the stereotactic body radiation therapy (SBRT) techniques, dynamic conformal arc therapy (DCAT) is commonly adopted to efficiently deliver conformal doses. However, as the DCAT uses numerous beams at individual control points, the dosimetric errors generated from each beam can be accumulated and manifested. In SBRT, therefore, due to the high fractional dose within a few fractions to moving target, the determination of the applied plan parameters can be critical and the evaluation of dosimetric impact of planning parameters would play an important role in DCAT planning process.

In this study, we systematically evaluated the dosimetric influence caused by the variable grid size and the angular increment in DCAT for lung SBRT. Dose variations with different parameters were estimated for spherical and elongated tumors on an anthropomorphic phantom. The systematic analysis of the generated dose variation would guide to determine appropriate plan parameters and to estimate the dose errors in planning process in a clinical perspective of DCAT.

Materials and Methods

A. Planning scheme

Planning simulations were performed for a humanoid phantom (RANDO phantom, The Phantom Laboratory, Salem, NY) using a Pinnacle planning system (Philips Medical Systems North America, Andover, MA).

We intended to adopt a commonly used dose-fractionation scheme of 48 Gy in 4 fractions for lung SBRT. In this study, the prescribed dose was scaled down by 10 (i.e., 480 cGy in 4 fractions) using just one coplanar arc beam with the consideration of the limited machine output.

B. Planning volumes

Three spherical planning target volumes (PTVs) [in the radii of 2 cm (S_2), 3cm (S_3),and 4cm (S_4)]and 2 ellipsoidal PTVs [an oblate (EL_{lat}) and a prolate (EL_{ap}) spheroid] were considered for this study. Dose variation by angular increment of 5°, 10°, and 20° was evaluated with placing the spinal cord in a set of 8 different locations as shown in Fig. 1.

C. Grid size and angular increment

Three grid sizes of 2 mm, 3 mm, and 4 mm were considered. as the angular increment was fixed with 5°. For each PTV and grid size, plan optimization was manually performed in a way

that 95% of the PTV volume was covered by the prescribed dose. Three angular spacing of 5°, 10°, and 20° were applied for the evaluation of angular increment effect on dose distribution, as the grid size was fixed with 4 mm assuming no significant cross effect between grid size and angular increment existed.

Results and Discussion

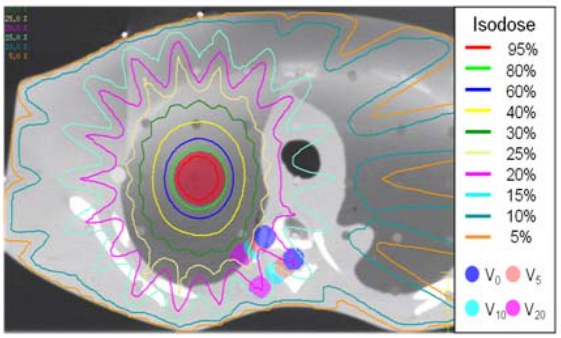

FIG 1. Dose distributions in an axial plane calculated with the angular increment of 20° for the PTV, S_3.

As shown in Table 1, if planning is performed with a coarse grid size, an overestimated MU would be obtained. Accordingly, uncertainty toward overdose would be induced by delivering more MUs than needed.

Dose undulation can be observed, especially at lower dose region (starting from 5%, 0%, and 20% for angular interval of 5°, 10°, and 20°, respectively) in Fig.1.

Table 1. MUs, maximum point dose of PTV and maximum point dose of the spinal cord with varying grid size.

	Grid size	PTV				
		S_2	S_3	S_4	EL_{lat}	EL_{ap}
Monitor unit	2 mm	1.00	1.00	1.00	1.00	1.00
	3 mm	1.02	1.02	1.02	1.02	1.03
	4 mm	1.07	1.06	1.04	1.05	1.06
Max dose of PTV (cGy)	2 mm	1.00	1.00	1.00	1.00	1.00
	3 mm	1.02	1.02	1.02	1.02	1.02
	4 mm	1.06	1.05	1.04	1.06	1.05
Max dose of spinal cord (cGy)	2 mm	1.00	1.00	1.00	1.00	1.00
	3 mm	1.02	1.02	1.02	1.01	1.02
	4 mm	1.06	1.06	1.04	1.04	1.05

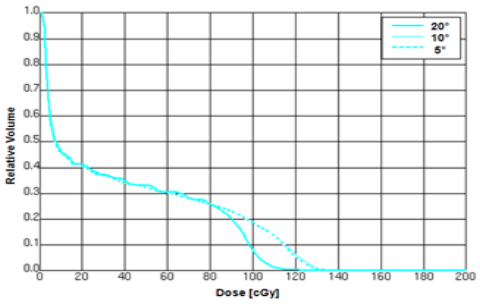

FIG 2. Dose volume histograms of simulated spinal cords at 7 cm distance according to the applied angular increment.

Note that no undulation is expected in actual beam delivery because of continuous irradiation with gantry rotation. The 20° increment caused significant variations reaching up to 10% for 5 cm distant volumes and 24% for 7 cm distant volumes, implying either over- or under-estimation of OAR dose could be easily made when angular increment was not chosen properly during DCAT planning. Especially for serial OARs such as the spinal cord, the analysis of possible dose variation due to angular increment planning parameter should be considered to avoid serious complications (Fig.2).

Conclusion

It was found that two plan parameters, grid size and angular increment, in DCAT could cause non-negligible dose uncertainty. Coarse grid size led patients to get unnecessary overdose. Coarse angular increment could make significantly inaccurate prediction of OAR dose, resulting in either over- or under- estimation depending on the location of OAR relative to the isocenter.

References

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