Dose Broadening Due to Target Position Variability During Fractionated Breath-held Radiation Therapy

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I. Introduction

Recent advances in Stereotactic Radiosurgery/Conformal Radiotherapy have made it possible to deliver surgically precise radiation therapy to small lesions while preserving the surrounding tissue. However, because of physiological motion, the relationship between the leftward shift of the tumor DVH curve and the magnitude of the position variability is monotonic but non-linear. The volume of surrounding tissue receiving 50% dose and that receiving 80% dose dropped as the position standard deviation increased.

II. Methods

The effect of the magnitude of the position variability on the changes in the observed dose was studied using standard deviations in tumor position that ranged from 1 to 4 mm. For a human subject, tumor position variability data was gathered from pretreatment MRI datasets (results presented previously [1]) and also applied in the analysis. Using representative tumor position variability values and corresponding margin definitions, a comparison was made between the volumes of lung tissue that would be expected to receive harmful doses of radiation using end-expiration breath holding versus end-inspiration breath-holding during treatment planning and radiation delivery.

III. Results

A. Target Position Variability and Dose Broadening

The result of the convolution of the dose matrix by the position variability matrix is an eroded version of the original tumor is, at present, geared toward slowing the progression of disease rather than obtaining a cure.

B. Broadening Versus Number of Fractions

The volume of lung tissue receiving 50% dose and that receiving 80% dose dropped as the position standard deviation increased.

IV. Conclusions

Preliminary Clinical Results:

These results demonstrate that the entire tumor volume was irradiated to >47 Gy – well above the tumoricidal threshold. This finding was substantiated by the clinical results: there was evidence of tumor shrinkage during treatment and all but one of the lesions had disappeared completely by the end of the ten-day therapy. At the 6 and 12-month follow-ups, all 3 lesions had been eradicated with no indication of disease recurrence at the treatment sites.

End-Expiration Breath-Holds Better than Deep-Inspiration BH

Using end-expiration breath holds (EEBH) to compensate for respiratory-derived lung motion results in a more favorable lung mass exposure in the high dose region compared with using a deep end-inspiration breath-holding (DBBH) approach for these targets, even after considering the decrease in lung tissue density due to the increased volume of air in the lungs for DBBHs, based on the results of [3-4] and our analysis. This is primarily a result of the larger variability in diaphragm position over repeated breath holds at end-inspiration compared with end-expiration, even when lung volume feedback via a spirometer is used in the end-inspiration method and not in the EEBH method.

Take Home Message

This information suggests that curative treatment of lung and liver lesions is possible when simple end-expiration breath-hold is used to compensate for respiratory-derived motion.

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