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Abstract

The Effect of Physiologic Spinal Cord Motion on Cord Dose in Spine SBRT

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Abstract

Objectives: Stereotactic body radiation therapy (SBRT) is being increasingly used to treat spine tumors. Because these tumors are in close proximity to the spinal cord, exceeding strict dose limits can cause devastating neurologic complications. Generally accepted spinal cord dose constraints have been established. However, while physiologic CSF and spinal cord motion are well known, their dosimetric effects on the spinal cord have not been evaluated.

Methods: Dynamic cardiac-gated balanced fast field echo sequences were obtained in addition to routine treatment planning imaging for VMAT-based spine SBRT in 21 patients with spine metastases. Dosimetric data and images were retrospectively analyzed in this IRB approved study. Planning CT data sets, static T2-weighted (cordstat), and each of 15 phases of the dynamic MRI images (corddyn) were coregistered. Motion on the dynamic imaging was compared to the static T2-weighted images using Dice and Jaccard coefficients, and the amount of distance the centroids of corddyn moved with respect to cordstat. was calculated. The average (averaged across the dynamic imaging) and the maximum of the maximal dose to the moving corddyn was compared with cordstat and cordstat with various planning organ at risk volume (PRV) margins. Prescription and spinal cord doses were converted to equivalent dose in 2 Gy fractions (EQD2) to account for the variable 3- or 5-fraction SBRT schedules.

Results: Dice and Jaccard coefficients of corddyn and cordstat ranged from 0.70 to 0.95 (median: 0.87) and 0.54 to 0.90 (median: 0.77), respectively. The average EQD2 dose received by corddyn exceeded that of cordstat in 14 of the 21 patients (67%) by 0.6-13.1% (median: 3.0%), corresponding to 0.1 Gy to 3.9 Gy (median: 0.8 Gy). Compared to the planning contour, corddyn spatially extended outside the 1 mm PRV margin in 9 of the 21 patients (43%). The maximum dose received by corddyn exceeded the dose the cordstat+1 mm PRV margin in 7 of those 9 patients (78%). In none of the patients did the maximum corddyn dose exceed that of the dose to cordstat+1.5 mm PRV margin. Corddyn did not extend outside the 1.5 mm PRV margin of cordstat. There was a subtle tendency for the dose ratio to increase with an increasing excursion of corddyn (r = 0.19, p=0.27), although the trend did not become apparent until the excursion of corddyn was close to 1 mm from cordstat.

Conclusions: The spinal cord shows inherent motion, resulting in measurable dosimetric effects which should be considered during SBRT dosimetry. Maximum dose received by the moving

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spinal cord exceeds that calculated using static planning images, even if 1 mm PRV margin is included. A 2 mm PRV margin surrounding the cord, always included the inherent spinal cord motion and did not underestimate the maximum spinal cord dose. We advise incorporating a 2 mm PRV margin or dynamic imaging to assess individual patients' cord motion during SBRT planning.