Intrafractional motion effects during stereotactic body radiation therapy of lung tumors

Akademisk avhandling
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Abstract
Patient shifts and tumor motions occurring during stereotactic body radiation therapy (SBRT) have been analyzed to determine the related effects on the delivered dose. Methods: 4-dimensional computed tomography series were retrospectively reviewed to characterize respiratory-induced lung tumor motions in 126 patients. A method using deformable image registrations (DIR) to theoretically simulate the dosimetric effect of such tumor motions was developed and evaluated in a thorax phantom. Additionally, an investigation of the accuracy of three commercial DIR algorithms has been performed. The simulation method that was developed was used on patients with different tumor sizes and motion amplitudes to assess the dosimetric effect of the respiratory-induced tumor motions. In parallel, the intrafractional tumor and patient shifts registered between the start and the end of each treatment fraction were prospectively analyzed for 25 patients using a frameless immobilization approach in combination with surface guided radiation therapy (SGRT) monitoring during treatment. The purpose was to determine the feasibility of such immobilizations for delivery of high accuracy SBRT.

Results: Respiratory-induced lung tumor motion was largest in the inferior-superior direction where 13% of the tumors moved ≥ 15 mm. The mean and maximum amplitude in this direction was 6.9 and 53.0 mm respectively. For visually acceptable DIRs, registration errors resulting in deviations ≤ 2.0% of the prescribed tumor mean dose were observed for the studied DIR algorithms for tumor motions ≤ 27 mm. The simulated impact of tumor motion on the delivered tumor mean dose for 9 patients treated with 4 different treatment plans was ≤ 2.4% from the planned value. The maximum dose deviation for tumors moving < 15 mm was 8.1% irrespective of treatment technique. For tumors moving > 15 mm there were regions within the tumor with dose deviations up to 35.2% when volumetric modulated arc therapy (VMAT) techniques were used for irradiation. This value was only up to 11.6% when using a less complex treatment technique like conformal arc. The accuracy of the frameless immobilization was comparable to traditional SBRT-immobilizations with observed patient shifts ≤ 2 mm in > 96.3% of the examined cases.

Conclusions: Frameless immobilization in combination with SGRT resulted in clinically acceptable patient shifts during irradiation. The majority of patients have respiratory-induced lung tumor motions < 15 mm. If treating tumors moving > 15 mm, the dosimetric effect should preferably be estimated prior to treatment, as local dose differences up to 35.2% have been observed. Using a less complex delivery technique like conformal arc could potentially decrease the maximal dose difference for such tumors.

Keywords: Motion effects, interplay, SBRT, SGRT, lung tumors, VMAT, CA

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