Evaluation of Intra-Fractional Patient Movement during Image-Guided Stereotactic Body Radiation Therapy of Spine and Lung Patients

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Introduction

In radiotherapy (RT) planning, the clinical target volume (CTV) contains the macroscopic and microscopic tumor volumes.
Although the volume of normal tissue within the treatment fields must be limited to avoid toxicity, additional margins are added to the CTV, resulting in the planning target volume (PTV) . This CTV-to-PTV margin accounts for any uncertainties during treatment such as organ shape and motion, changes of target shape and patient setup errors.
The knowledge of these setup errors is essential in RT planning, because these errors directly influence the target definition process by contributing to the CTV-to-PTV margin. In this poster, we report on our clinical experience with the Elekta Synergy S linear accelerator. The linear accelerator offers the possibility of three-dimensional (3D) volume imaging of the patient in the treatment position using a kilovoltage cone-beam CT (CB-CT) scanner. Translational and rotational setup errors were recorded. to quantify the intra-fractional geometric stability during image-guided stereotactic body radiation therapy (SBRT) of spinal and lung lesions.

Materials & Methods

14 lung and 14 spinal cases were considered. For the spine treatments, a prescription dose of 15 Gy was given in a single-fraction regimen. For the lung treatments, a prescription dose of 48 Gy was given in 4 fractions. Patients were immobilized with a custom-fit blue bag vacuum mold (Medical Intelligence, Inc.). Additional plastic sheets (BodyFix, Medical Intelligence, Inc.) which wrapped around the patients were used for the lung treatment to reduce respiratory motion. An initial volumetric cone-beam CT (ini-CBCT) scan was performed to determine positioning displacement. A HexaPOD™ robotic couch was utilized to correct for any translational displacement. Another CBCT scan was performed immediately following the correction to verify the target position accuracy (veri-CBCT) and the treatment was delivered. Two additional CBCT scans were performed, one at the middle of treatment (mid-CBCT) and one at the end of treatment (end-CBCT)to verify the patient setup. The CBCT data at various stages of treatments were analyzed to quantify intra-fraction motion.

Results

For the 14 spinal cases, the mean overall intra-fractional displacement was 1.3±0.5 mm (from veri-CBCT to end-CBCT). The mean overall time for these patients was 22±8 min (from ini-CBCT to end-CBCT). For the 14 lung cases, a similar mean overall displacement of 1.6±0.4 mm was obtained. However, mean total time (per fraction) was 43±7 min, about twice that of the spinal cases. Figure 1 shows the vector displacements for the 14 spine cases and the average vector displacements (over the 4 fractions) for the 14 lung cases. Average rotational displacements which were not corrected for were 1.3° , 1.1°, and 0.8° for the spine cases in the pitch, roll, and yaw directions, respectively. Similar rotational displacements were observed for the lung cases. The maximum rotational displacement observed was 2.8°

Conclusion

SBRT treatment is especially susceptible to patient motion due to the relatively long setup and treatment times. Effective immobilization technique should be used, ideally combined with patient monitoring during treatment. For the 28 SBRT cases studied with a total of 70 treatment fractions, the maximum translational and rotational displacements were 3.0 mm and 2.8°, respectively. Such rotational errors were independent of the translational errors, in that small translational errors did not correlate with small rotational errors.

Figure 1: Vector Displacement