Purpose: The TomoTherapy Hi Art system uses daily megavoltage cone beam computed tomography (MVCT) to help ensure accurate patient positioning for lung stereotactic body radiotherapy (SBRT). In this study we evaluate the accuracy and precision associated with registering daily TomoTherapy MVCT’s to kilovoltage CT (kVCT) images acquired at simulation for lung SBRT.

Methods: Volumetric images were retrospectively analyzed in MIMVista for 10 patients who received lung SBRT at our institution. The MVCT’s were used to define gross tumor volume (GTV). Internal target volumes (ITV) were defined on kVCT from 10 phase-binned 4DCT. The MVCT’s were fused to the kVCT’s by a mutual-information technique and cross-checked for accuracy. Registration was evaluated by 1) displacement of the GTV centroids from the ITV centroids and 2) measuring the extent of the GTV outside of the ITV. This analysis was also carried out on a novel 4D lung phantom with 3 non-coplanar lesions moving at 18 breaths per minute with +/-5mm displacement. One reference kVCT and 10 MVCT’s were acquired, and fusion was achieved using 3 fixed radio-opaque markers.

Results: The average extent of the patient GTV’s outside of the ITV’s was 3.5 +/- 1.1 mm, with a maximum extent of 8.3 mm. The average centroid variation was 3.3 +/- 1.3 mm, with a maximum variation of 8.0 mm. The average extent of the phantom GTV’s outside of the ITV’s was 1.9 +/- 0.5 mm, with a maximum extent of 4.4 mm. The average centroid variation was 2.4 +/- 0.6 mm, with a maximum variation of 3.1 mm.

Conclusions: The phantom set-up showed an uncertainty of 2-3 mm for the TomoTherapy MVCT registration process. The patient data showed an uncertainty of 3-4 mm. This suggests that a margin of at least 3-4 mm around the ITV is required for TomoTherapy lung SBRT cases.