Purpose: To assess uncertainties of internal target volume (ITV) using CT and PET scans, target repositioning using immobilization devices and image guidance, and to evaluate differences among IMRT, VMAT, and multiple short arcs (MSA) techniques.

Methods: Over sixty patients were accrued for ITV delineation using CT simulation scans and diagnosis PET-CT scans. IMRT and MSA plans were both generated for early patients and VMAT plans were added for the last ten patients. Daily XVI was acquired prior to treatment and manually aligned with the planned ITV. On-line 3D shifts were applied to early cases and additional 3D rotations were applied to the last 15 cases after installation of Elekta HexaPOD tabletop and iGUIDE optical tracking. Daily XVI image sets for 30 cases were registered in patient plans in exact treated positions and ITVs were delineated on daily XVI images. Composite DVHs were calculated and compared with the original planning DVHs.

Results: ITV defined in PET could differ by up to 10 times for some cases. MSA plans provided higher BED to the ITV while maintaining the same V90 and different V50 to the lung and nearby structures. VMAT was the most efficient in dose delivery. Interfractional motions from 1 to 3 cm were corrected with XVI-guidance. There were 2-mm intrafractional displacements for nodule in various locations shown in repeated daily XVI. Combined ITV was >99% if 3-mm margin was used for planning target volume. Optical tracking, body-frame, and abdomen compression had marginal effects.

Conclusions: ITV should be determined from the union of ITVs from PET and CT scans. Interfractional motion was eliminated by daily XVI guidance. A 3-mm expansion of ITV was still required for planning target volume. IMRT and VMAT optimization offers rooms for improvement against MSA.