Inter and Intrafraction Uncertainty in Prostate Bed Image-Guided Radiotherapy

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Purpose/Objective(s): Highly precise and accurate prostate bed radiotherapy necessitates the evaluation of target motion and defining appropriate margins to account for different sources of error. The purpose of this study is to analyze inter- and intra-fraction set-up error (SE) and prostate bed motion (PBM) in patients undergoing post-prostatectomy image-guided radiotherapy (IGRT) and propose appropriate population-based three dimensional (3D) margins in both non-IGRT and IGRT scenarios.

Materials/Methods: In this prospective study, 14 patients underwent adjuvant or salvage radiotherapy to the prostate bed consisting of 66Gy in 33 fractions, under image guidance using linac-based kilovoltage conebeam computed tomography (kV CBCT). Inter- and intra-fraction uncertainty/motion was assessed by three consecutive daily kV CBCT images of the patient 1) after initial setup, 2) after correction for positional error/immediately prior to radiation therapy, and 3) immediately after radiotherapy. Scans 2 and 3 provided an estimate of intra-fraction motion. All images were retrospectively aligned to their original planning kilovoltage CT and the corresponding shifts in bony anatomy (for SE) and surgical clips (for PBM) were recorded and analyzed. The vanHerk formula was used to calculate margins for radiotherapy in image-guided and non-image guided settings.

Results: Shifts were recorded in anterior-posterior (AP), superior-inferior (SI) and lateral (L) planes and reported as mean (M), systematic variation (Σ) and random error (σ). Maximum inter-fraction prostate bed motion (PBM) was in the AP direction: M=1.86 mm, Σ=2.48mm and σ=2.98mm. Maximum intra-fraction PBM was: M=-0.38mm (SI), Σ =1.06mm (AP), σ=2.98mm (AP). With some exceptions, inter-fraction motion can be summarized as follows: SE<PBM, AP>SI>L and σ>Σ>M. Similarly, intra-fraction motion can be summarized as follows: PBM>SE, AP>SI>L and σ>Σ>M.

Conclusions: With advances in IGRT and conformal radiotherapy, assessment of intra-fraction motion of the prostate bed becomes increasingly relevant in clinical practice and has not been reported to date. The data presented here demonstrate that PBM is a predominant source of intra-fraction error in all axes of motion with implications on appropriate clinical target volume (CTV) margins. Based on variances in inter-fraction motion and an estimate of intra-fraction motion of the prostate bed using pre- and post-kV CBCT images, adequate vanHerk margins for prostate bed treatment of 3-5mm with IGRT and 4-7mm without IGRT will ensure 95% of the prescribed dose to the CTV in 90% of patients.