

PURPOSE: We simulated effects of full (no repositioning) and reduced (using fiducial markers and on-line repositioning following EPI) uncertainties on dose distributions in PTV, prostate, and organs at risk – bladder and rectum; and evaluated limits for dose escalation if on-line repositioning is implemented and tight PTV margins are applied.

METHODS AND MATERIALS: Three patients' anatomies, with large (68cc), medium (55cc) and small (40cc) prostate volumes were used. PTV margins of 2, 4, 6, 9 and 12mm were tested for a conventional 70Gy/35fr, and dose escalated schedules of 74Gy/37fr and 78Gy/39fr. Setup and organ motion uncertainties were modeled in a stochastic manner to generate a dose population histogram. The outcome of each treatment was then scored based on dose distributions in organs. These have been summarized as equivalent uniform doses (EUD) calculated on survival basis for prostate and effective doses from reduced dose-volume histograms for bladder and rectum. We deemed dose escalation acceptable as long as the currently observed complication rate was not exceeded. To verify validity of obtained margin prescription, 20 patients were studied with the above simulation methods with acceptable margins only.

RESULTS: With reduced positioning uncertainties using fiducials, the dose can be escalated to 78 Gy with a reduced PTV margin of 4mm without compromising tumor control probability. Even if large PTV margins (12mm) were applied and dose was escalated to 78Gy, bladder doses did not exceed tolerance levels. The rectal complication probability is comparable to the currently observed rates or even less if rectal bleeding is proven to show strong volume dependence (parallel model) even treating to 78Gy with 4mm margin. The additional 20 patients studied provided similar results.

CONCLUSION: Reduced positioning uncertainties using fiducial markers allow us to reduce PTV margin to 4mm and escalate dose to 78Gy with similar or lower rectal toxicity rates.