

Using Daily Image-Guidance CBCT Scans to Determine the Impact on Delivered Dose From Variations in Bladder and Rectal Filling During IMRT for High-Risk Prostate Cancer

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INTRODUCTION

A typical high-risk prostate cancer patient receiving radiation therapy will be treated for 43 fractions delivered over approximately nine weeks when treated daily. During this time, patients may exhibit large daily variations in bladder and rectal volumes compared to the original planning CT simulation. Such fluctuations in the volumes of organs-at-risk (OARs) can cause a change in coverage of the prostate and seminal vesicles (SV) and pelvic lymph nodes (PLN) clinical target volumes (CTVs).

AIM

To evaluate the impact on delivered dose to CTVs in patients with high-risk prostate cancer from daily variations in bladder and rectal filling as determined from image-guidance cone-beam computed tomography (CBCT) scans.

METHOD

- Deformable image registration matched CTVs and OARs from daily CBCT to planning CT
- Contour based deformable dose accumulation compared planned vs. delivered dose for each fraction
- Daily trend in bladder and rectal volumes obtained to observe reproducibility from planning CT
- CTVs prostate, SV, and PLN minimum dose coverages (V100%) recorded for each daily fraction

RESULTS

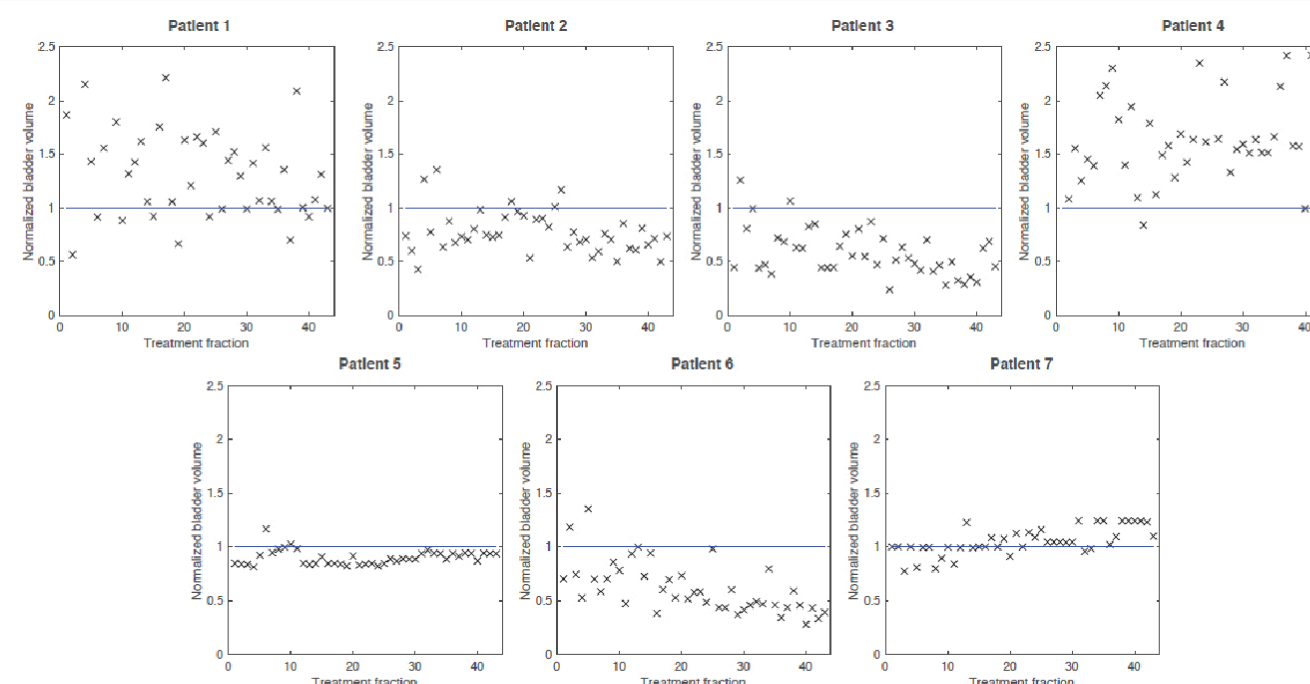


Figure 1: Daily trend of bladder volume normalized to the original planning CT volume. Cases of patients who reproduced well (5 and 7) exhibit small daily bladder volume variation. Other cases presented either constant overfilling (1 and 4) or underfilling (2, 3, and 6) of the bladder

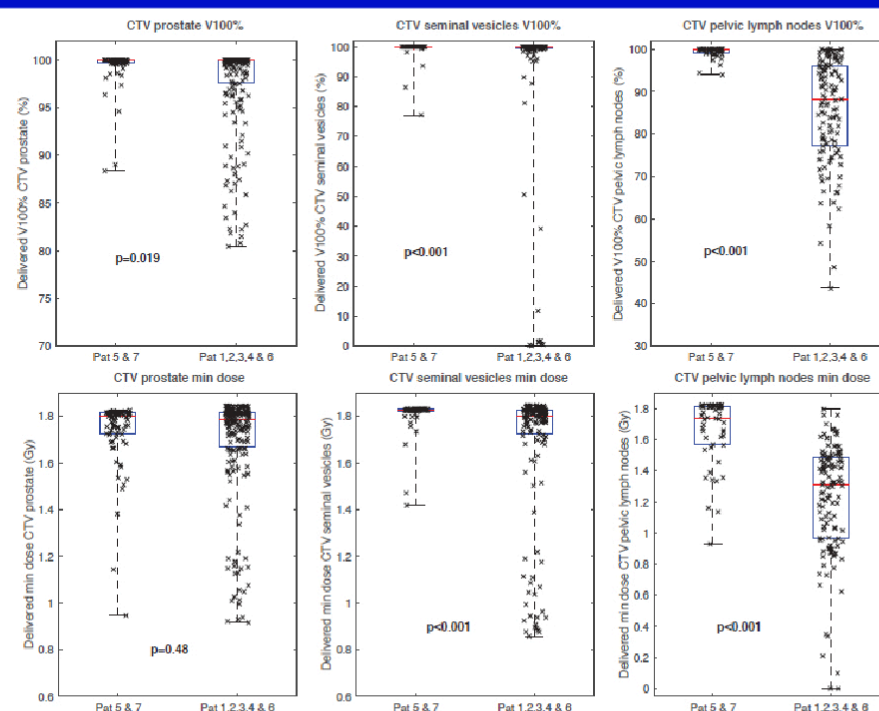


Figure 2: Comparative plots of daily recorded minimum dose (V100%) to CTVs prostate, SV, and PLN for patients with consistent reproducibility (5 and 7 on left) against patients with poor reproducibility (1, 2, 3, 4, and 6 on right).

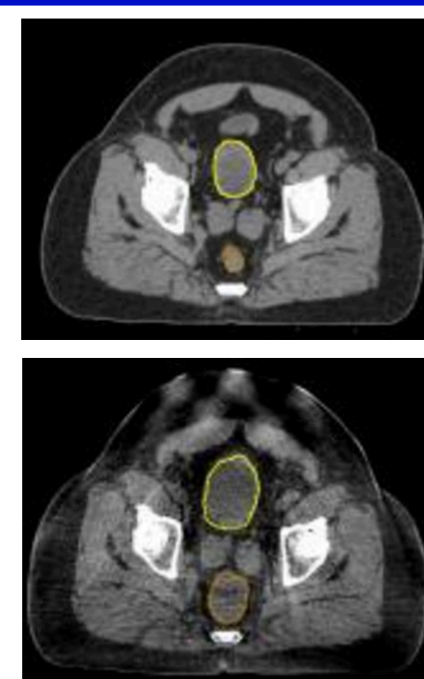


Figure 3: Axial slice of planning CT (top) and daily CBCT (bottom) conveys daily variation of OAR contours bladder (yellow) and rectum (orange).

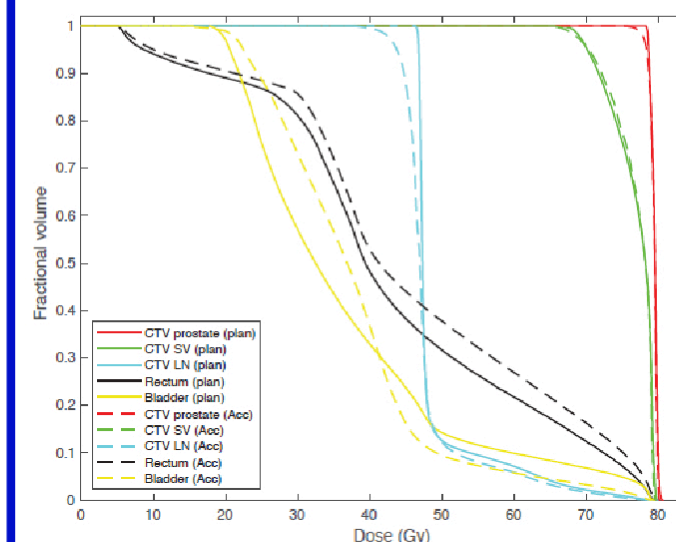


Figure 4a: Dose volume histogram (DVH) comparison of composite planned (solid lines) vs accumulated (dashed lines) conveys changes in CTV coverage for patient with good daily bladder and rectal filling reproducibility.

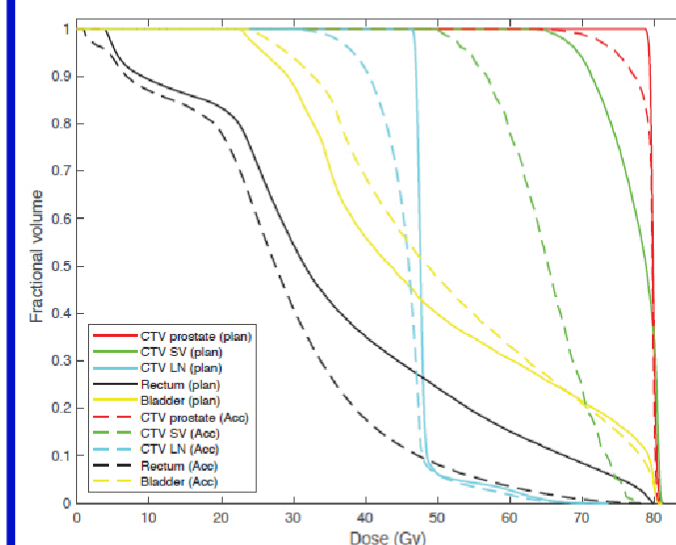


Figure 4b: DVH comparison of composite planned (solid lines) vs accumulated (dashed lines) conveys changes in CTV coverage for patient with poor daily bladder and rectal filling reproducibility.

RESULTS (CONTD)

Seven patients completing their course of treatment of 1.8 Gy per fraction for 43 fractions were included, totaling 301 fractions analyzed. Five of seven patients had considerable variation in both bladder and rectal filling with mean volumes normalized to the planning CT of 1.06 (SD: 0.28) for rectum and 1.01 (SD: 0.57) for bladder, respectively compared to 0.95 (SD: 0.16) and 0.98 (SD: 0.13) for the patients with little variation in structure filling. This led to significantly reduced V100% coverage of the prostate, SV, and PLN CTVs ($p < 0.02$ for all) and lower minimum dose coverage for the SV and PLN CTVs ($p < 0.001$) when analyzing all treatment fractions. These effects did somewhat average out over the course of treatment with average V100% for the prostate CTV of 98.2% (range between patients: 89.7-100%).

CONCLUSIONS

Daily variations in bladder and rectal filling significantly impacts target coverage for particular treatment fractions and patients with consistent filling have significantly less underdosing of target CTVs. Care should be taken to manage rectal and bladder filling especially as hypofractionated treatment regimens are becoming more common.

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