Effects of Inconsistent Bladder and Rectal Preparation on Seminal Vesicle Target Coverage When Treating Intermediate Risk Prostate Patients With Proton Therapy

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Purpose

The objective of this study was to evaluate if the inconsistences in the bladder and rectal preparation affect the placement of the seminal vesicles (SV) due to their proximity of nearby organs at risk (OAR). Variation in SV positioning could result in compromised target coverage when treating intermediate risk (IR) prostate patients. By replicating the treatment process on a prior computed tomography (CT) data set with varying rectal/bladder positions, we can determine if institutional process changes are needed to ensure SV coverage under these circumstances.

Background

A total of 10 IR prostate patients were included in this study. All patients had three gold fiducials placed in the prostate prior to CT simulation. Patients were educated about proper nutrition and hydration needed for treatment. At the time of the initial simulation, patients were instructed to drink 32 oz of water followed by a "Eval-CT" scan. Based off visual inspection, if the bladder fill was inadequate or the rectum contained large amounts of stool/gas, then the CT simulation was rescheduled for a later date. After emphasizing the importance of preparation, the patient would return for a new CT scan. If the preparation was adequate, then the new CT would be used for treatment planning. If there are no changes between CT scans the attending physician would provide input on how to proceed.

Institutional PTV margins for IR prostate patients:

- CTV = Prostate and SV
- PTV = CTV + 4mm Except 3mm Posterior Only
- PTV_Eval = PTV + 5mm Left / Right Only

Institutional Setup Tolerances for IR prostate patients:

- Fiducials Within 1 mm
- Translational Shifts Allowed
- 1.0 cm Maximum bony discrepancy
- Pitch / Roll / Yaw to be Within 1 Degree of Bony Anatomy

When on-treatment setup tolerances cannot be achieved, a verification CT is performed to identify possible anatomical changes, fiducial migration, as well as the evaluation of target coverage.

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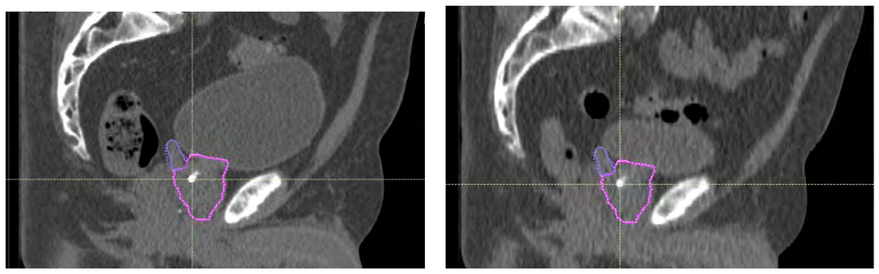
Methods

A retrospective randomized selection of ten patients were chosen for this study. All of whom had inadequate bladder/rectal preparation at the time of CT simulation and were rescheduled for an additional treatment planning CT. A comparison between the two scans with and without proper bladder/rectal preparation were evaluated for SV target coverage robustness.

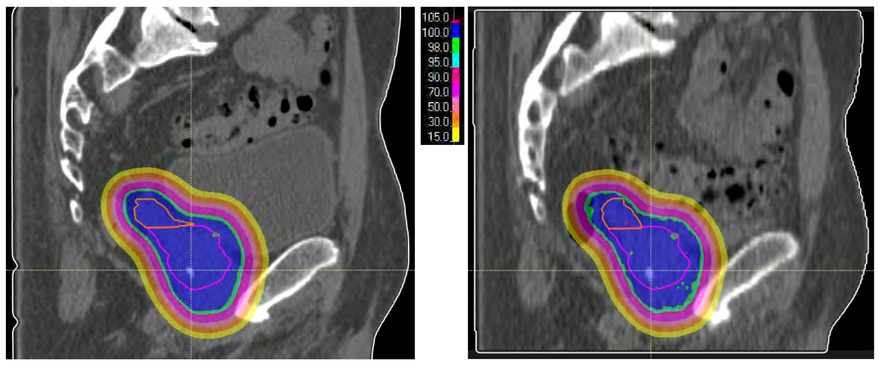
1. A rigid fusion was performed between the Eval-CT and treatment planning CT scans. Shifts were applied that kept the alignment of the two image sets within institutional setup tolerances. The prostate and SV target volumes were copied/edited from the planning CT to the Eval-CT with the assistance of a MRI fusion for further evaluation.

Figure 1: Fusion performed and targets transferred / edited



2. The clinical treatment plan was recalculated on the Eval-CT scan to determine if the SV coverage was compromised from the differing bladder/rectum position based on the improved preparation.

Figure 2: Quality assurance plan calculated onto Eval-CT scan



3. Patients with fusions that could not be aligned within institutional setup tolerances were excluded from this study. These setup discrepancies would trigger the need for a verification CT to further investigate any changes, possibly resulting in a potential adaptive plan.

Figure 3: Fiducials and/or bony not within tolerances showing SV displacement

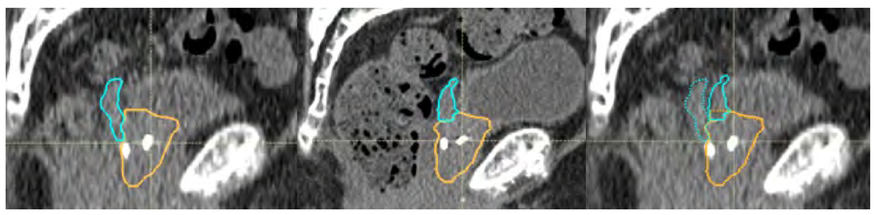
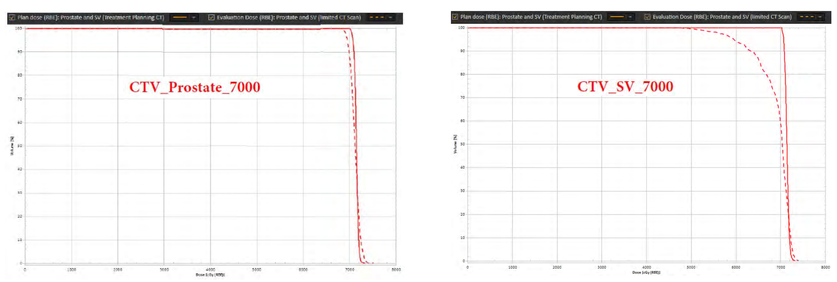


Figure 4: Example of a patient with setup tolerances outside of institutional standards triggering a verification CT

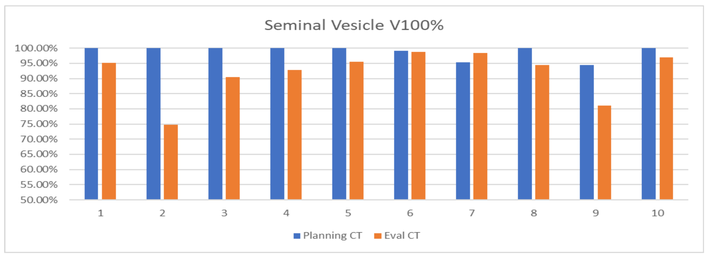


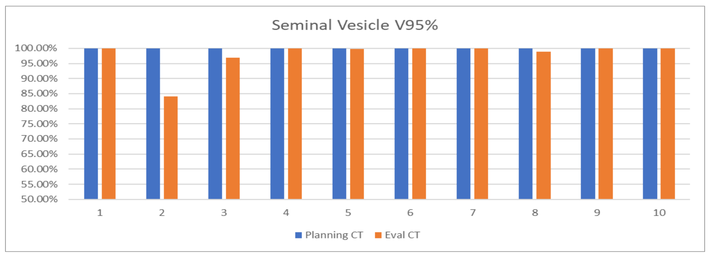
Results

The differences in the bladder and rectum position had a larger impact on the V100% then the V95% to the SV target coverage.

Patient # 2 had the largest V100% and V95% difference between the planning and Eval-CT. After evaluation, this appeared to be due to the large amount of stool in the rectum, displacing the SV's.

Figure 5: SV coverage V100% and V95%: Eval-CT Vs. treatment planning CT





	Average	Min	Max	Range
Planning CT - V100%	98.88%	94.36%	100.00%	5.64%
Planning CT - V95%	100.00%	100.00%	100.00%	0.00%
Eval CT - V100%	91.82%	74.71%	98.69%	23.98%
Eval CT - V95%	97.99%	84.13%	100.00%	15.87%

Discussion

Proton therapy Pencil Beam Scanning (PBS) utilizes the Bragg Peak of a proton's depth dose distribution which allows for a sharp distal dose fall off. This physical characteristic of proton therapy allows for two lateral fields to deliver a homogeneous dose distribution when treating prostate cancer. Small setup discrepancies can result in target coverage loss due to this sharp falloff of the proton beam.

Inconsistent preparation prior to CT simulation and during treatment has the potential to displace the SV position, resulting in a loss of target coverage. Having institutional guidelines in place for verification scans could prevent the SV target volume from potentially being under covered.

Conclusion

The results of our study provided evidence that patient's preparation is important to maintain a robust plan. When setup tolerances can't be achieved a triggered verification scan has shown anatomical changes that affected SV positioning in relation to fiducials and/or bony anatomy. These changes may result in the SV target coverage loss, triggering an adaptive plan.

The implementation of treatment setup guidelines and achieving a reproduceable setup could identify/eliminate potential anatomical changes that could result in target coverage loss. Maintaining a consistent bladder fill and rectal stool/gas mitigation has the potential to diminish the variance of displacement to the SV target volume, potentially providing a more robust treatment plan. Due to the anatomical positioning of the SV volume in relation to the rectum and bladder a unique PTV for the SV target could be considered to ensure SV target coverage.