Cureus

Open Access
Abstract
Published 02/11/2022

Dosimetric Impact of Interfraction Prostate and Seminal Vesicle Volume Changes and Rotation: A Post-Hoc Analysis of a Phase III Randomized Trial of MRI-Guided versus CT-Guided Stereotactic Body Radiotherapy

T. Martin Ma [1], Minsong Cao [2], Jack Neylon [1], Maria Casado [1], Sahil Sharma [1], Michael L. Steinberg [3], James Lamb [3], Amar U. Kishan [4]

1. Radiation Oncology, University of California Los Angeles, Los Angeles, USA 2. Department of Radiation Oncology, University of California Los Angeles, Los Angeles, USA 3. Department of Radiation Oncology, University of California, Los Angeles, Los Angeles, USA 4. Department of Radiation Oncology, University of California, Los Angeles, Los Angelas, USA

Corresponding author: T. Martin Ma, tma@mednet.ucla.edu

Categories: Medical Physics, Radiation Oncology
Keywords: dosimetry, mri-guided sbrt, prostate cancer

How to cite this abstract
Ma T, Cao M, Neylon J, et al. (February 11, 2022) Dosimetric Impact of Interfraction Prostate and Seminal Vesicle Volume Changes and Rotation: A Post-Hoc Analysis of a Phase III Randomized Trial of MRI-Guided versus CT-Guided Stereotactic Body Radiotherapy. Cureus 14(2): a744

Abstract

Objective: Highly precise targeting and delivery are integral to the safe and effective delivery of stereotactic body radiotherapy (SBRT) for prostate cancer, and aggressive planning margin reduction can potentially minimize treatment-related toxicity. However, it remains unclear whether interfraction volumetric changes and rotations in the prostate and proximal seminal vesicles (SVs) might have an amplified dosimetric impact when tight margins are used. The purpose of this study was to interrogate high-quality on-board MRI images from patients treated with MRI-guided SBRT on a phase III randomized trial to better understand the dosimetric consequences of these interfraction volume changes and rotational shifts.

Methods: Twenty consecutive patients treated with MRI-guided prostate SBRT enrolled on the MRI arm of a phase III randomized trial (NCT04384770) between 2/2021 and 7/2021 were included. The clinical target volume (CTV) consisted of the prostate and proximal 1 cm of SV. A 2 mm isotropic margin was added to generate a planning target volume (PTV). 40 Gy in 5 fractions was prescribed such that 95% of the PTV received 100% of the dose, and MRI-guided SBRT was delivered using an MRI Linac. The prostate and proximal SVs were contoured on a 0.35 T simulation MRI and five on-board pre-treatment MRIs for all patients. Target volume, maximal dimension of the prostate in left-right, anterior-posterior and superior-inferior directions, angles of the two lobes of the proximal SV on axial view (angle α) and the angle of the proximal SV in relation to the vertical axis (angle θ) on the sagittal view were measured. DICE co-efficient of the targets at each fraction relative to the simulation scan as well as target dosimetry (V100%, V95%, mean dose and D95% to CTV) were calculated without taking into account of intrafraction gating. Paired t-test was used to determine the significance of the volume change.

Results: All patients experienced an isotropic increase in prostate volume during SBRT (p=0.0016), with increases of 0.1%, 9.0%, 12.1%, 15.1%, and 14.2% for fractions 1-5, respectively, with respect to the simulation MRI, with a median maximal volume increase of 16.3% (interquartile range [IQR] 9.9-20.7%). The extent of prostate swelling was not associated with baseline prostate volume. Patients started on neoadjuvant androgen deprivation therapy (ADT) before SBRT had significantly reduced prostate swelling both at its maximum and after 4 fractions of SBRT (p=0.023 and p=0.0042 respectively). There was also significant increase in proximal SV volume at the start of the 5th fraction, with median % of volume increase of 22.7% (IQR 9.4—37.8%), though this was not associated with ADT use (p=0.28). There was minimal interfraction rotation of prostate in the axial and coronal plane (IQR -0.04—0.74°and -0.01—0.16°, respectively), while the rotation in the sagittal plane exhibits the largest magnitude (IQR -2.25—2.95°, range -10—13.4°). Median rotation was 0° in all three planes. Compared to the simulation MRI, there were considerable changes in proximal SV angle α (median 17.6°, IQR 12.7—24.3°) and angle θ (median 17.6°, IQR 12.7—24.3°) throughout the treatment course. The median DICE co-efficient of prostate CTV contour at fraction 1-5 setup scans compared to simulation scan was 0.93, 0.90, 0.89, 0.89 and 0.89, respectively, and 0.63, 0.53, 0.60, 0.57 and 0.57, respectively for proximal SV. Median V100%, V95%, D95% and mean dose of the prostate CTV was 96.1%, 98.9%, 39.9Gy and 41.4Gy, respectively. Median V100%, V95%, D95% and mean dose of the proximal SV CTV was 83.9%, 91.3%, 37.0Gy and 40.8Gy, respectively.

Conclusion: There was consistent increase in both prostate and proximal SV volume during SBRT, with the most dramatic volumetric changes of the prostate seen after the first and second fractions; the magnitude of prostate swelling was lower in patients who had already started ADT. Interfraction rotation of prostate was minimal while robust rotation of the proximal SV was seen. Despite the volumetric changes, prostate dosimetry was favorable even with a 2 mm margin. While proximal SV dosimetry was reasonably preserved,

it exhibited more sensitivity to these changes. Overall, online adaptive therapy may be indicated in some instances to account for prostatic swelling, and in particular, may be useful in patients exhibiting large angle rotational shifts of the proximal SVs.