Dosimetric comparison of biologically-guided radiotherapy and X-ray-guided stereotactic ablative radiotherapy for oligometastatic prostate cancer

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Purpose

Stereotactic ablative radiotherapy (SABR) of oligometastatic (OM) prostate cancer can improve clinical outcomes [1], but tracking small soft-tissue lesions during treatment is challenging with current techniques. PSMA-PET/CT currently provides unparalleled sensitivity and specificity to metastatic prostate cancer [2], with an example in Fig. 1a).

A linear accelerator capable of biologically-guided radiotherapy (BgRT) is being developed to make use of PET emissions for tumor tracking during treatment, shown in Fig. 1b).

The purpose of this study is to produce 18F-DCFPyL PSMA-PET-based BgRT plans in a cohort of OM prostate cancer patients using a novel plan optimizer, and compare resultant plans to clinical SABR plans.

Methods

15 OM prostate cancer patients imaged with 18F-DCFPyL PSMA-PET/CT and treated with SABR as part of our phase II randomized trial of SABR for hormone-sensitive OM prostate cancer [3] were re-planned using a research treatment planning system (TPS) designed for the BgRT tumor tracking approach outlined in Fig. 2.

Figure 2 Schematic of the proposed BgRT tumor tracking technique. The system reconstructs a partial PET image with every 180° of gantry rotation (500 ms). The BFZ mask is applied to prevent treatment outside the target, the PET signal is converted to fluence, and the beam is delivered with an average of 400 ms latency.

A biological firing zone (BFZ) structure was added to each CT to prevent the treatment of non-specific PET uptake outside of the target, as shown in Fig. 3. The re-planning workflow is shown in Fig. 4.

Figure 3 BgRT uses PET emissions to track internal tumor motion, eliminating the need for an internal target volume (ITV). BgRT requires a biological firing zone (BFZ), which acts as a mask to prevent the treatment of non-specific uptake outside of the target. In this study, the clinical ITV was also used for BgRT planning and the BFZ was produced by expanding the clinical ITV by 4 mm isotropically.

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