1068 In Vivo Verification of Dose Delivery to Prostate Cancer by Utilizing PET/CT Images Taken after Proton Therapy

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Purpose/Objective(s): *In vivo* determination of target coverage and organ sparing by utilizing offline PET and CT images taken directly after proton therapy for prostate cancer.
Materials/Methods: Positron emitters activated in low-perfusion bone and fat after proton therapy reportedly can verify proton beam path. Relatively long-lived ^{11}C are produced by nuclear interactions between proton beam and tissue nuclei, mainly ^{12}C. Consequently, tissues rich in carbon, such as fat, are dominantly detected on offline PET images. Immediately after one-field 2 CGE proton treatment, patients walked to the PET/CT scanner and their position was replicated using the same immobilization device as for treatment. 36 scans were performed for 8 prostate cancer patients. PET image acquisition lasted 30 minutes after CT. The duration between the start of proton irradiation and the start of PET acquisition was 16.6 ± 4.2 minutes. The activated retropubic, ischioanal and perivesical fat boundaries served as surrogates for the treatment target, rectal wall, and bladder wall positions, respectively. For each patient, the proton beam path visualized on CT was aligned with positron activation in the subcutaneous fat and pelvic bones visualized on PET. Doses were recalculated accordingly for each PET/CT study. Recalculated volumes of 95% and 50% of 78 Gy prescription dose (i.e., V_{74} and V_{39}) were compared to the initial planned volumes for prostate, rectal wall, and bladder wall.
Results: The PET-determined proton beam path varied from the planned gantry and couch angles with a standard deviation of 1.7° and 1.3°, respectively. This difference is attributable to target position variation and set-up accuracy. The PET-determined treatment isocenter was 0.2 ± 0.4 cm posterior to, and 0.5 ± 0.4 cm superior to, the posttreatment CT isocenter, revealing that gradual bladder filling moves the prostate in an inferior-anterior direction. Using the ischioanal and perivesical fat as surrogates for the in-vivo position of rectal and bladder walls, the recalculated V_{74} were found to be 9.5% (9 ± 8.1 cc) and 14.6% (27.9 ± 14.7 cc), respectively, for all 36 cases. This is a variation of 8% to 284% of the planned volumes for rectal wall and 74% to 132% for bladder wall. Correspondingly, the V_{39} of rectal and bladder walls were 24.5% (23.3 ± 13.1 cc) and 28.4% (54.4 ± 20.4 cc) overall, respectively, reflecting a variation of 65% to 147% of the planned volumes for rectal wall and 49% to 183% for bladder wall.
Conclusions: The activation of pelvic fat provides a surrogate for the position of prostate, bladder wall, and rectal wall during proton treatment. Similiarly, proton beam path may be reproduced by the activated pelvic bone and subcutaneous fat. When applied together, this novel methodololgy provides the framework for *in vivo* dose verification.

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