Purpose/Objective(s): Multiple imaging techniques are available for imaging bone marrow and guiding radiation therapy planning. This study aimed to compare FDG-PET and FLT-PET for the purpose of identifying active pelvic bone marrow (BM), to quantify variation in the location of active BM, and determine which technique is likely to be better for bone marrow-sparing radiation planning.

Materials/Methods: We sampled 41 patients from three prospective clinical trials, of which 25 underwent pretreatment FDG-PET/CT only, 7 underwent pretreatment FDG-PET/CT only, and 9 underwent both. Following registration of each PET/CT with the planning CT, an active BM subvolume was defined as the subset of the pelvic BM with standardized uptake values (SUV) above a designated threshold. Three SUV thresholds were chosen for each PET image such that they defined an active BM subvolume comprising 40%, 50%, and 60% of the total pelvic BM volume. We used the Dice similarity coefficient to quantify the percent overlap of active BM volumes of equal size. Differences in the spatial distribution of active BM were assessed using a region-growing algorithm.

Results: For patients with both FDG-PET and FLT-PET scans, the mean Dice coefficients for the 40%, 50%, and 60% subvolume thresholds were 0.683 (95% confidence interval (CI), 0.654-0.712), 0.732 (95% CI, 0.711-0.753), and 0.781 (95% CI, 0.767-0.795), respectively. For the 34 patients with FDG-PET scans, comparing individual active BM subvolumes to the mean image, Dice coefficients varied from a minimum of 0.598 at the 40% threshold to a maximum of 0.889 at the 60% threshold. The corresponding Dice coefficients for 16 patients with FLT-PET scans ranged from 0.739 at the 40% threshold to 0.912 at the 60% threshold. At each threshold, active BM subvolumes identified using FLT-PET required significantly more iterations to converge on region-growing analysis compared to FDG-PET, indicating that proliferating BM is more highly clustered than metabolically active BM.

Conclusion: We found significant agreement between FDG-PET and FLT-PET in identifying active BM; however, FLT-PET was associated with significantly less individual variation and is likely to be superior to FDG-PET for BM-sparing radiation therapy.


1086 Development and Validation of an Average Anatomy Model for Adaptive Radiation Therapy of Locally Advanced Lung Cancer Patients

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Purpose/Objective(s): Radiation therapy for lung cancer patients is subject to several geometrical uncertainties, such as baseline shifts and differential motion. Adaptive radiation therapy aims to mitigate such uncertainties by adjusting the treatment plan. A repeat CT (rCT) scan is customarily used for adapting the treatment plan but is only a new snapshot of the patient anatomy, which might not be a proper representative for treatment delivery. In order to further reduce geometric uncertainties an average anatomy model (AAM) is proposed, which benefits from the information derived from repeat imaging.

Materials/Methods: We used the first 5 fractions, or the last 5 fractions prior to acquisition of the rCT (where available) and registered each daily Cone beam CT (CBCT) deformably to the planning CT (pCT). B-Spline deformable registration (DR), which was previously validated for CBCT to CT DR of lung scans, was used in this step. The average of the 5 deformation vector fields (DVF) was then applied to the pCT to generate an AAM. To correct for the smaller field of view (FOV) of CBCT compared to pCT, the rigid component of the DVF was extracted and assigned to the voxels, which lie outside the FOV in pCT. Smooth transition between inside and outside FOV was handled by tapering the edges of DVF smoothly towards the outside. The AAM was generated for 15 patients who had a gold fiducial marker implanted in a mediastinal lymph node.

The average and standard deviation (SD) of displacement of the marker on CBCTs relative to the pCT, as well as average and SD of marker displacement relative to AAM was measured. Repeat CT scans were also available for 6 patients, for which the marker displacements were measured relative to rCT. Likewise, the displacements of the tumor relative to pCT, AAM and rCT (where available) were measured in the same fashion.

Results: The average marker displacement relative to pCT was -0.25 ± 2.30, -1.43 ± 3.31 and 0.94 ± 1.39 mm and dropped to -0.06 ± 1.10, -0.68 ± 1.35 and 0.20 ± 0.58 mm for AAM in LR, CC and AP directions, respectively. The position variability of tumor relative to pCT reduced in the same order when measured relative to AAM. Note that the reduction in SDs shows a decrease in the systematic errors. The results for the patients with rCT revealed that rCT fails to reduce the geometric uncertainties, while AAM achieves lower uncertainties. These results confirm the reduction of systematic errors of up to ~4 mm and statistically significant reduction in the vector length of the displacement (P < 0.05) when using the proposed model.

Conclusion: While rCT is demonstrated to be incapable of reducing systematic errors, AAM mitigates these errors occurring during treatment. This model can be used as an efficient and more accurate alternative for rCT in adaptive radiation therapy of lung cancer patients, which simultaneously reduces the workload and might facilitate multiple-intervention scheme to improve the treatment accuracy.

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1087 Sub-mm Accuracy Results Measured From the First Prospective Clinical Trial of a Novel Real-Time IGRT System, Kilovoltage Intrafraction Monitoring (KIM)

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Purpose/Objective(s): Kilovoltage intrafraction monitoring (KIM) is a novel real-time IGRT system; KIM uses the gantry-mounted kilovoltage imaging system during the therapy delivery to measure the positions of radio-opaque markers in each image, and then compute and display, in real-time, the 3D position of the center of the markers relative to the treatment isocenter. The positions are then used to determine the guidance decision: continue the treatment or gate the treatment and shift the patient. The first prospective clinical trial of KIM was performed with prostate cancer patients being treated with VMAT. We reported the accuracy and precision measurements from this trial.

Materials/Methods: Kilovoltage intrafraction monitoring was used as the real-time IGRT system for the 126 fractions from the four prostate cancer patients enrolled on the study to date. For each treatment fraction the KIM real-time measurements of the prostate implanted marker positions were compared to retrospectively measured kV-MV triangulated marker positions. The kV-MV triangulated positions were considered to be the ground truth. The mean and standard deviation of the measured position differences between KIM and kV-MV triangulation in the left-right (LR), superior-inferior (SI) and anterior-posterior (AP) directions were recorded and analyzed.

Results: A variety of prostate motion magnitudes and types were observed with KIM. Gating events, exceeding 3 mm for more than 5 seconds, were required for 5-10% of the treatment fractions. The motion and gating frequency was consistent with those observed by other real-time IGRT systems. The accuracy, or mean error, of KIM in the LR, SI and AP directions were 0.1, 0.3, and -0.5 mm, respectively. The precision, or standard deviation, of KIM in the LR, SI and AP directions were 0.5, 0.3 and 0.4 mm, respectively. The fifth and 95th percentile...